



CARIBBEAN EXAMINATIONS COUNCIL

# CSEC<sup>®</sup> Chemistry

**SYLLABUS  
SPECIMEN PAPER  
MARK SCHEME  
SUBJECT REPORTS**

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## **CSEC Chemistry Free Resources**

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## Chemistry

Chemistry is concerned with the physical and chemical properties of substances and the interaction of energy and matter. The study of Chemistry involves an investigation into chemical reactions and processes. The discipline seeks to explain and predict events at the atomic and molecular level. Through the principles of Chemistry, students will understand everyday life, nature and technology, and the significance of the well-being of man and the environment.

The CSEC Chemistry syllabus is redesigned to allow students to work individually and with others in practical, field and interactive activities that are related to theoretical concepts in the course. It is expected that students will apply investigative and problem-solving skills, effectively communicate scientific information and appreciate the contribution that a study of chemistry makes to their understanding of the world. The syllabus places greater emphasis on the understanding and application of chemical concepts and principles and different learning styles and needs, so that students will develop skills that will be of long term value in an increasingly technological world, rather than focusing on large quantities of factual information. In addition, it encourages the use of various teaching and learning strategies while at the same time catering to multiple intelligences.

The syllabus is divided into three sections, namely:

- Section A Principles of Chemistry
- Section B Organic Chemistry
- Section C Inorganic Chemistry





## CARIBBEAN EXAMINATIONS COUNCIL

Caribbean Secondary Education Certificate  
CSEC®

# CHEMISTRY SYLLABUS

Effective for examinations from May–June 2015

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# Chemistry Syllabus

## ◆ RATIONALE

*The application of scientific principles and the conduct of relevant research are of significant importance in identifying, assessing and realising the potential of the resources of Caribbean territories. A good foundation in the sciences will help citizens of the Caribbean to respond to the challenges of a rapidly changing world using the scientific approach.*

*Chemistry is concerned with the physical and chemical properties of substances and the interaction of energy and matter. The study of Chemistry involves an investigation into chemical reactions and processes. The discipline seeks to explain and predict events at the atomic and molecular level. Through the principles of Chemistry, students will understand everyday life, nature and technology, and the significance of the well-being of man and the environment.*

*The CSEC Chemistry Syllabus is redesigned to allow students to work individually and with others in practical, field and interactive activities that are related to theoretical concepts in the course. It is expected that students will apply investigative and problem-solving skills, effectively communicate scientific information and appreciate the contribution that a study of chemistry makes to their understanding of the world. The syllabus places greater emphasis on the understanding and application of chemical concepts and principles and different learning styles and needs, so that students will develop skills that will be of long term value in an increasingly technological world, rather than focusing on large quantities of factual information. In addition, it encourages the use of various teaching and learning strategies while at the same time catering to multiple intelligences.*

*It contributes to the development of the Ideal Caribbean Person as articulated by the CARICOM Heads of Government in the following areas: respect for human life, awareness of the importance of living in harmony with the environment; demonstrates multiple literacies, independent and critical thinking and the innovative application of science and technology to problem solving. In keeping with the UNESCO Pillars of Learning, on completion of this course of study, students will learn to do, learn to be and learn to transform themselves and society.*

## ◆ AIMS

This syllabus aims to:

1. appreciate and understand natural phenomena and the ways in which materials behave;
2. be aware of the power, impact and influence which Chemistry has in a modern scientific world and to emphasise that there is a responsibility that Chemistry be used for the good of the society and for the preservation of the environment;
3. appreciate, understand and use methods of science;

4. see the relevance of Chemistry to everyday life;
5. appreciate and understand the role of Chemistry in enabling materials to be used in the service of mankind, in the Caribbean and elsewhere;
6. understand basic chemical concepts in sufficient depth to provide an adequate foundation for specialisation;
7. develop the spirit of inquiry and to continue the search for new ways in which materials may be used in the service of mankind;
8. appreciate the inter-relationships among Chemistry, Biology, Physics, Mathematics and other subjects;
9. make use of chemical data, concepts, principles and terminology in communicating chemical information;
10. develop the ability to work independently and collaboratively with others when necessary;
11. appreciate the significance and limitations of science in relation to social and economic development;
12. integrate Information and Communication Technology (ICT) tools and skills into the teaching and learning of chemical concepts.

## ◆ CANDIDATE POPULATION

The syllabus is designed for students intending to pursue further studies in Science at the tertiary level as well as students whose formal study of the subject is unlikely to proceed further.

### CANDIDATE REQUIREMENTS

1. Candidates should be exposed to at least three years of science at the secondary level, which should provide an introduction to basic scientific principles.
2. Candidates should be concurrently studying or have done:
  - (a) CSEC Mathematics or its equivalent;
  - (b) CSEC English A (English Language) or its equivalent.

It is assumed that students will be able to:

1. make calculations involving addition, subtraction, multiplication and division of quantities;
2. use significant figures, estimate orders of magnitude;
3. express fractions as percentages and vice versa;
4. use indices, transform decimal notation to powers of ten (standard form);
5. substitute values into equations;

6. manipulate formulae;
7. sketch curves (elementary), plot results graphically, select their own scales; determine gradients of curves and straight lines;
8. extrapolate and interpolate (from data);
9. perform simple operations involving ratio and proportion;
10. perform simple operations involving variation;
11. perform simple operations involving rates of change;
12. use pie charts, bar charts and histograms in representing data.

#### **CLASS SIZE**

It is recommended that practical classes accommodate a maximum of **twenty-five** students.

#### **◆ SUGGESTED TIME-TABLE ALLOCATION**

It is recommended that a minimum of five 40-minute periods per week, including one double period, be allocated to the subject over a two-year period.

#### **◆ ORGANISATION OF THE SYLLABUS**

The syllabus is divided into three sections, namely:

SECTION A - Principles of Chemistry

SECTION B - Organic Chemistry

SECTION C - Inorganic Chemistry

#### **◆ SUGGESTIONS FOR TEACHING THE SYLLABUS**

*It is recommended that Section A be taught first. However, in teaching each section, teachers need not follow the sequence given. SI units and IUPAC conversion of nomenclature should be used throughout.*

*Teachers are strongly encouraged to use **inquiry-based** strategies to teach chemical concepts. Teachers should ensure that their lessons stimulate the students' curiosity and facilitate critical thinking and problem solving. This will help students view Chemistry as a dynamic and exciting investigative process. The provision of cooperative and collaborative activities is encouraged.*

*The general and specific objectives indicate the scope of the content including practical work that should be covered. However, unfamiliar situations may be presented as stimulus material in examination questions.*

*This syllabus caters to varying teaching and learning styles, with specific attention made to ensure the interrelatedness of concepts. The fourth column entitled, "Skills and Interrelationships" states which specific objectives are best suited for Observation, Recording and Reporting (ORR), Manipulation and Measurement (MM), Analysis and Interpretation (AI), and Planning and Designing (PD) skills. It also highlights connections between chemical concepts and fields of Biology, Physics, Mathematics and Agricultural Science. Whenever possible, a variety of teaching and learning strategies suitable to varying learning needs of students should be employed with special attention given to the identification of variables and the use of controls in chemical investigations. The need for repeated investigations and observations to arrive at meaningful conclusions should be emphasised.*

*In addition to developing a solid foundation of factual information, teachers are encouraged to emphasise the application of scientific concepts and principles and minimise memorisation and rote learning. In order to make the course as relevant as possible, every opportunity should be taken to help students make the connections between chemistry and their environment.*

*The role of the teacher is to facilitate students' learning accurate and unbiased information that will indirectly contribute to a more scientifically literate citizenry that is capable of making educated decisions regarding the world in which we live.*

## ◆ CERTIFICATION AND DEFINITION OF PROFILES

The syllabus will be examined for General Proficiency certification.

In addition to the overall grade, there will be a profile report on the candidate's performance under the following headings:-

1. Knowledge and Comprehension;
2. Use of Knowledge;
3. Experimental Skills.

### **Knowledge and Comprehension (KC)**

	The ability to:
Knowledge	identify, remember, grasp the meaning of basic facts, concepts and principles;
Comprehension	select appropriate ideas, match, compare and cite examples of facts, concepts and principles in familiar situations.

### **Use of Knowledge (UK)**

	The ability to:
Application	use facts, concepts, principles and procedures in unfamiliar situations; transform data accurately and appropriately; use common characteristics as a basis for classification; use formulae accurately for computations;



Analysis and Interpretation	identify and recognise the component parts of a whole and interpret the relationships between those parts; identify causal factors and show how they interact with each other; infer, predict and draw conclusions; make necessary and accurate calculations and recognise the limitations and assumptions inherent in the collection and interpretation of data;
Synthesis	combine component parts to form a new meaningful whole; make predictions and solve problems;
Evaluation	make reasoned judgements and recommendations based on the value of ideas and information and their implications;
Environmental	show concern and awareness for the environment and the conservation of natural resources.

### **Experimental Skills (XS)**

The ability to:

Observation/Recording/ Reporting	use the senses and extensions of them to perceive objects and events accurately; present a written report, drawing or other graphical representation, which is clear, concise, accurate and pertinent to the investigation; report and recheck unexpected results;
Drawing	make large, clear, labelled line representations of apparatus or models;
Manipulation/ Measurement	set up, use carefully and competently simple laboratory apparatus and measuring instruments; appropriately prepare materials for observation/investigation; master separation techniques; use materials economically;
Planning and Designing	develop hypotheses and devise means of carrying out investigations to test them; plan experimental procedures and operations in appropriate sequence; identify variables, state expected results, identify precautions and possible sources of error. It is expected that some of the planning and designing activities will be carried out <i>to help students develop this skill</i> . However, the reports of these activities are no longer plans and cannot be assessed as Planning and Design. They can be marked for other skills, for example, ORR.

## ◆ FORMAT OF THE EXAMINATIONS

<b>Paper 01</b> (1 hour 15 minutes)	An objective test consisting of 60 multiple choice items.
<b>Paper 02</b> (2 hours 30 minutes)	One compulsory data analysis question, two structured questions and three extended response questions.
<b>Paper 03/1</b> School-Based Assessment (SBA)	School-Based Assessment will evaluate the achievement of the candidate in the Experimental Skills and Analysis and Interpretation involved in the laboratory and fieldwork. Candidates will be required to keep a separate practical workbook. CXC will require a sample of these for external moderation.
<b>Paper 03/2</b> Assessment for Private Candidates only (2 hours and 10 minutes)	Alternate to the School-Based Assessment for private candidates. This paper will examine the same skills as those tested in Paper 03/1. The focus, therefore, will be on Experimental Skills and Use of Knowledge (Analysis and Interpretation).

### NOTES ON THE EXAMINATIONS

1. The use of non-programmable calculators will be permitted in the examination. The use of a calculator to recall previously stored information during an examination is prohibited.
2. Copies of the Periodic Table will be provided if necessary.
3. SI units will be used on all examination papers.

### WEIGHTING OF PAPERS AND PROFILES

The percentage weighting of the examination components and profiles is as follows:

**Table 1- Percentage Weighting of Papers and Profiles**

<b>PROFILES</b>	<b>PAPER 01</b> Multiple Choice	<b>PAPER 02</b> Structured and Data Analysis	<b>PAPER 03</b> SBA	<b>TOTAL RAW</b>	<b>TOTAL %</b>
Knowledge and Comprehension	50	35	-	85	43
Use of Knowledge	10	55	10	75	37
Experimental Skills	-	10	30	40	20
<b>TOTAL %</b>	<b>60</b>	<b>100</b>	<b>40</b>	<b>200</b>	<b>100</b>

## ◆ REGULATIONS FOR RESIT CANDIDATES

Resit candidates must complete Papers 01 and 02 and Paper 03 of the examination for the year for which they re-register. Resit candidates may elect not to repeat the School-Based Assessment component, provided they re-write the examination no later than two years following their first attempt.

*Candidates may opt to complete the School-Based Assessment (SBA) or may opt to re-use another SBA score which satisfies the condition below.*

*A candidate who re-writes the examination within two years may re-use the moderated SBA score earned in the previous sitting within the preceding two years. Candidates re-using SBA scores in this way must register as "Resit candidates" and provide the previous candidate number.*

All resit candidates may enter through schools, recognized educational institutions, or the Local Registrar's Office.

## ◆ REGULATIONS FOR PRIVATE CANDIDATES

Private candidates must be entered for examination through the Local Registrar in their respective territories and will be required to sit Papers 01, 02, and EITHER Paper 03/1 OR Paper 03/2.

Paper 03/2 is a practical examination designed for candidates whose work cannot be monitored by tutors in recognised educational institutions. The Paper will be of 2 hours and 10 minutes duration and will consist of three questions. Questions will test the Experimental Skills and Use of Knowledge (Analysis and Interpretation) profiles and will incorporate written exercises and practical activities.

## ◆ THE PRACTICAL APPROACH

*The syllabus is designed to foster the use of inquiry-based learning through the application of the practical approach. Students will be guided to answer scientific (testable) questions by a process of making observations, asking questions, doing experiments and analysing and interpreting data. The CXC CSEC Chemistry syllabus focuses on the following skills.*

### 1. Planning and Designing (PD)

*Student's ability to:*

- (a) *Ask questions: how, what, which, why or where. (Students must be guided by their teachers to ask scientific questions based on a stated problem).*

*Sample Problem: It has been observed that galvanized roofs on beach houses corrode faster than those on houses inland.*

*Example: Why do galvanized roofs on beach houses corrode faster than those on houses inland?*

- (b) *Construct a hypothesis; the hypothesis must be clear, concise and testable.*

*Example: Iron rusts faster in the presence of salt water.*

- (c) *Design an experiment to test the hypothesis Experimental reports must include the following:*
- (i) *problem statement;*
  - (ii) *aim;*
  - (iii) *list of materials and apparatus to be used;*
  - (iv) *clear and concise step by step procedure;*
  - (v) *manipulated and responding variables;*
  - (vi) *controlled variables;*
  - (vii) *observations to be made or measurements to be taken;*
  - (viii) *suggested display of results(for example, graphs tables ;*
  - (ix) *proposed use of results;*
  - (x) *possible limitations, assumptions;*
  - (xi) *precautions to be taken.*

2. Measurement and Manipulation (MM)

*Student's ability to:*

- (a) *Handle scientific equipment competently.*

*The list of equipment includes:*

- (i) *Bunsen burner;*
- (ii) *measuring cylinder;*
- (iii) *beakers;*
- (iv) *thermometer;*
- (v) *ruler;*
- (vi) *stop watch/clock;*
- (vii) *balance;*
- (viii) *boiling tube;*
- (ix) *burette;*
- (x) *pipette;*

- (xi) conical flask;
- (xii) syringe;
- (xiii) voltmeter;
- (xiv) ammeter.

*This list is not exhaustive.*

- (b) Use of appropriate apparatus.
- (c) Take accurate measurements.

### 3. Observation, Reporting and Recording (ORR)

#### (a) Recording

*Student's ability to record observations and to collect and organize data. Observations and data may be recorded in the following format.*

- (i) *Prose*  
*Written description of observations in the correct tense.*
- (ii) *Table (Neatly enclosed)*  
*Numerical: physical quantities in heading, correct units stated in heading, symbols, decimal points.*  
*Non-numerical: headings correct, details present.*
- (iii) *Graph*  
*Axes labelled with units, correct scales, correct plotting, smooth curves/best fit lines.*
- (iv) Drawing of apparatus as set up for use.

#### (b) Reporting

*Student's ability to prepare a comprehensive written report on their assignments using the following format:*

- (i) **Date** (date of experiment).
- (ii) **Aim** (what is the reason for doing the experiment).
- (iii) **Apparatus and Materials** (all equipment, chemicals and materials used in the experiment must be listed).
- (iv) **Method/Experimental Procedure** (step-by-step procedure written in the past tense, passive voice).
- (v) **Results and Observations** (see (a) above: Recording).
- (vi) **Discussion and Conclusion** (see 4: Analysis and Interpretation).

4. Analysis and Interpretation

*Student's ability to:*

- (a) identify patterns and trends;*
- (b) make accurate calculations;*
- (c) identify limitations and sources of error;*
- (d) make a conclusion to either support or refute the hypothesis;*
- (e) compare actual results with expected results if they are different;*
- (f) suggest alternative methods or modifications to existing methods;*
- (g) analyse and interpret results and observations, and make conclusions.*

## ◆ SECTION A - PRINCIPLES OF CHEMISTRY

*Section A is designed as an introduction to fundamental chemical concepts and principles. A study of the particulate nature of matter, structure, bonding, chemical properties and physical properties of elements, compounds and mixtures is included as well as certain quantitative properties. Comprehension of these concepts and principles will help students appreciate the importance of chemistry as it relates to the environment and the daily activities of man.*

### GENERAL OBJECTIVES

On completion of this Section, students should:

1. be aware that matter is made up of particles;
2. understand that different types of mixtures can be separated based on the properties of the components;
3. be familiar with the concept of the atom as the basic building block of matter;
4. appreciate that matter can be classified based on physical or chemical properties;
5. be aware of the different forces of attraction that exist between particles;
6. understand the mole as the unit for comparison of amounts of matter;
7. appreciate that properties of chemicals will affect their reactions;
8. assess the impact of certain materials on living systems and the environment;
9. be familiar with the composition of certain materials and develop the ability to make reasoned choices concerning their use;
10. understand that the rate at which a chemical reaction proceeds is dependent on a number of physical factors;
11. appreciate that energy changes occur during the course of a chemical reaction;
12. *appreciate the importance of chemistry to the environment.*

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
<b>1. STATES OF MATTER</b>			
Students should be able to:			
1.1 explain how evidence supports the particulate theory of matter;	<i>Evidence obtained from practical work involving processes, such as diffusion and osmosis. Use of salt or sugar to control garden pests and as a preservative.</i>	<i>Experiments of diffusion of ammonia and hydrogen chloride gases in cylindrical tube. Osmosis of Pawpaw (green) strips in a container of distilled water. Potassium manganate (VII) in water.</i>	<i>Biology- Osmosis, diffusion. Physics-Kinetic Theory. Skills: ORR; PD.</i>
1.2 distinguish among the three states of matter;	<i>Arrangement of particles, energy of particles, strength of forces of interaction. Consideration of physical characteristics of states.  Example: Volume, density, compressibility.</i>		
1.3 explain the changes between the three states of matter in terms of energy and arrangement of particles.	<i>Consideration of freezing, melting, boiling, evaporation, sublimation, condensation; heating and cooling curves.</i>	<i>Heat the following ice, water, butter, iodine (in a fume hood).</i>	<i>Physics - Specific latent heat.  Skills: MM; AI; ORR.</i>
<b>2. MIXTURES AND SEPARATIONS</b>			
2.1 distinguish between pure substances and mixtures;	<i>Elements, compounds, atoms, molecules, fixed composition, properties, variable composition, variable properties.</i>	<i>Compare boiling point of pure water and sodium chloride solution.</i>	<i>Biology – Solutions in life processes.  Skill: MM.</i>



## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP	
Students should be able to:				
2.2	<i>distinguish among solutions, suspensions and colloids;</i>	<i>Reference to particle sizes, passage of light, sedimentation.</i>	<i>Filtration, use of lamp light to view particles.</i>	<i>Skills: ORR, MM.</i>
2.3	<i>identify different types of solutions;</i>	<i>Types of solutions: solid in liquid, solid in solid, gas in liquid, liquid in liquid, gas in gas.</i>	<i>Observe examples of each type of solution.</i>	
2.4	<i>investigate the effect of temperature on solubility of solids in water;</i>	<i>Examples showing that a decrease in solubility with increasing temperature <b>will not</b> be required.</i>	<i>Determine the solubility of a solute in water, for example, potassium nitrate.</i>	<i>Biology – Transport system. Skills: AI; ORR; MM.</i>
2.5	<i>apply suitable separation techniques based on differences in properties of the components of mixtures;</i>	<i>Properties to be included: particle size, boiling point, crystalline structure, solubility and solute mobility in solvent. Include line drawing to represent the separation process. Refer to SO B1.2, B3.8, C5.8.</i>	<i>Use of simple filtration, simple and fractional distillation, paper chromatography, and the separating funnel.</i>	<i>Biology – Function of the kidney, digestive system. Skills: MM; ORR.</i>
2.6	<i>describe the extraction of sucrose from sugar cane.</i>	<i>A simple treatment of the following crushing, precipitation, filtration, vacuum distillation, crystallisation, centrifugation.</i>	<i>A field visit to a sugar producing plant.</i>	<i>Physics – Gas Laws, circular motion, Specific latent heat.</i>

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
<b>3. ATOMIC STRUCTURE</b>			
3.1 describe with illustrations, the structure of atoms of atomic number 1 to 20;	The atom as consisting of three basic particles: protons, neutrons and electrons arranged in shells. No consideration of orbitals is expected.	Make models.	Physics-Particles in the atom.
3.2 state properties of electrons, protons and neutrons;	Properties related to relative mass and relative charge only.		
3.3 define atomic number and mass number;			Physics – Particles in the atom.
3.4 define relative atomic mass;	Relative atomic mass based on carbon-12 isotope.		
3.5 interpret notations of the form $\begin{matrix} a & c \\ & X \\ b & d \end{matrix}$	a – mass number; b – atomic number; c - charge; d - number of items in the entity; X – symbol of atom.		
3.6 define isotopy;	Isotopes as atoms with the same number of protons and different number of neutrons.		Physics- Radioactivity.
3.7 list uses of radioactive isotopes.	At least three uses of radioactive isotopes; for example, carbon dating, radiotherapy, tracers, pacemakers and energy generation.		Physics- Radioactivity.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

### 4. PERIODIC TABLE AND PERIODICITY

4.1	<i>explain the basis for the arrangement of elements in the periodic table;</i>	<i>Mention historical development of the periodic table, for example, contributions from Mendeleev and Dobereiner. Classification based on atomic number, atomic structure. Arrangement in periods and groups.</i>	Physics-Structure of the atom.
4.2	<i>explain trends in Group II;</i>	<i>Ease of ionisation, reactivity with oxygen, water, and dilute hydrochloric acid.</i>	<i>Reactions of magnesium and calcium with water, air, and dilute hydrochloric acid.</i> Skills: ORR; AI.
4.3	<i>explain trends in Group VII;</i>	<i>Consideration of the following properties: physical state at room temperature, strength of oxidising power.</i>	<i>Carry out simple displacement reactions with chlorine, bromine and iodine. Observe the physical state of these elements.</i> Skills: ORR, AI.
4.4	<i>identify trends in period 3;</i>	<i>Metallic to semi-metallic to non-metallic properties. Refer to SO A7.1.</i>	
4.5	<i>predict properties of unknown elements based on the position in periodic table.</i>	<i>Plan and design an investigation of the position of element X in the periodic table.</i>	Skill: PD.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
<b>5. STRUCTURE AND BONDING</b>			
5.1 explain the formation of ionic and covalent bonds;	Draw dot and cross diagrams to show ionic and covalent bonding. Refer to SO B2.1.		
5.2 predict the likelihood of an atom forming an ionic or a covalent bond based on atomic structure;			
5.3 write formulae to represent ions, molecules and formula units;			
5.4 explain metallic bonding;	<i>Arrangement of cations and mobile electrons.</i> Refer to SO C1.1.		Physics-Particles in the atom.
5.5 describe ionic crystals, simple molecular crystals and giant molecular crystals;	Make diagrammatic representations of sodium chloride, graphite and diamond.	<i>Make models of sodium chloride, graphite and diamond.</i>	
5.6 distinguish between ionic and molecular solids;	<i>Use melting point, solubility in water and organic solvents, and conductivity.</i>	Investigate melting point and solubility of solids and conductivity of resulting solutions.	Physics – Electricity, specific latent heat. Biology – Life processes.  <i>Skills: ORR; MM; AI.</i>
5.7 relate structure of sodium chloride, diamond and graphite to their properties and uses;	<i>Use melting point, solubility in water, conductivity, hardness and lubricating power.</i>		Physics - Electricity, latent heat. Biology - Solutions in life processes.
5.8 explain the term allotropy.	<i>Reference to the allotropes of carbon – diamond and graphite.</i>		

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

### 6. MOLE CONCEPT

6.1	define mole and molar mass;	<i>The mole as the amount of substance that contains <math>6.0 \times 10^{23}</math> (the Avogadro's constant) particles in that substance. Molar mass - mass of 1 mole of a substance in <math>\text{g mol}^{-1}</math>.</i>	<i>Observe and compare the masses of 1 mole of different substances.</i>	Physics-Kinetic Theory. Skills: MM, AI.
6.2	<i>perform calculations involving the mole;</i>	<i>Calculations from mass to moles and moles to mass and percentage composition by mass.</i>  <i>Calculate relative molecular mass or relative formula mass given atomic masses.</i>  <i>No definitions are required for the relative masses. Distinguish between molar mass and relative masses.</i>		
6.3	state Avogadro's Law;	Calculations involving molar volumes. [rtp and stp].		
6.4	state the Law of Conservation of Matter;			
6.5	write balanced equations;	<i>Use of both ionic and molecular equations (including state symbols) to represent chemical reactions referred to in the syllabus.</i>	<i>Use simple chemical reactions to illustrate.</i>  <i>Refer to SO C1.1, C1.2, C6.1.</i>	Skills: ORR, AI.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

6.6	apply the mole concept to equations, both ionic and molecular;	Calculations involving masses and volumes. Refer to SO A7.11.	
6.7	define the term standard solution.	<i>Molar concentration and mass concentration.</i> Refer to SO A7.11.	<i>Prepare standard solutions.</i>  <i>Skills: MM; AI.</i>
<b>7. ACIDS, BASES AND SALTS</b>			
7.1	define acid, acid anhydride, base, alkali, salt, acidic, basic, amphoteric and neutral oxides;	Consideration of proton donor or acceptor and replaceable hydrogen. <i>Relate to basic and acidic oxides.</i> Refer to SO A4.4.	
7.2	relate acidity and alkalinity to the pH scale;	pH scale - No formal definition of pH required.  Refer to SO C6.3.	Carry out simple exercises with litmus paper and universal indicator.  Biology - Digestion, blood, enzyme activity.  <i>Skill: ORR.</i>
7.3	discuss the strength of acids and alkalis on the basis of their completeness of ionisation;	Degree of ionisation linked to strength and the pH of the solution.	Use pH meter.
7.4	<i>investigate the reactions of non-oxidising acids;</i>	<i>Reactions of acids with metals, carbonates, hydrogen carbonates, bases.</i> Refer to SO C1.2, C5.3.	<i>Practicals to demonstrate reactions of acids. Demonstrate reactions with antacids, baking powder, fire extinguishers.</i>  Biology – Use of antacids.  <i>Skills: ORR; PD; AI.</i>

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
7.5 list examples of acids in living systems;	Vitamin C (ascorbic acid), methanoic acid (in ants), lactic acid (build-up in muscles). Neutralisation of Vitamin C with sodium hydrogen carbonate. Formula of Vitamin C not required. The treatment of ant stings, use of vinegar in food preservation due to low pH. Use of lime juice to remove rust stains.	Plan, design and conduct an investigation to compare the vitamin C content of a named fruit juice before and after heating.	Biology – Nutrition, respiration. Skills: PD; ORR, AI.
7.6 investigate the reaction of bases with ammonium salts;	Refer to SO A 7.10, SO C5.2.		
7.7 identify an appropriate method of salt preparation based on the solubility of the salt;	A general knowledge of the solubility of sulfates, nitrates, chlorides, carbonates and bases. Uses of salts in everyday life.	Prepare insoluble salts by precipitation; prepare soluble salts by direct combination and by replacing hydrogen ions of an acid directly or indirectly by a metal or ammonium radical.	Skills: MM; PD.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
7.8 list the uses and dangers of salts;	<i>Refer to action of baking powder, calcium carbonate for the manufacture of cement. For food preservation: sodium chloride, sodium nitrite, sodium nitrate, sodium benzoate. For medical uses: plaster of Parris (calcium sulfate), Epsom salts (magnesium sulfate). Sodium nitrate is implicated in causing brain damage in infants and also suspected to be carcinogenic.</i>	<i>Use of universal indicator, pH meter reaction with carbonates.</i>	<i>Skills: ORR; PD.</i>
7.9 distinguish between acid salts and normal salts;	<i>Basicity of acids.</i>		
7.10 investigate neutralisation reactions using indicators and temperature changes;	<i>Use of colour change of indicators and temperature changes to determine neutralisation point. Refer to the action of toothpaste in neutralising acids in the mouth. For example, fluoride ions replacing hydroxide ions in the enamel of the tooth. Effect of adding lime to soil. Effect of adding lime and an ammonium fertiliser to soil at the same time. Refer to SO A 7.6, A11.3.</i>	<i>Carry out neutralisation reactions using indications and thermometers.</i>	<i>Physics – Fundamental quantities and units.  Skills: ORR; AI; PD; MM.</i>



## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
7.11 perform calculations using volumetric analysis data.	(a) Number of moles reacting. (b) The mole ratio in which the reactants combine. (c) The molar concentration and mass concentration of reactants. Refer to SO A6.6, A6.7.	Acid-Base titrations.	Skills: MM, AI.
<b>8. OXIDATION – REDUCTION REACTIONS</b>			
8.1 investigate the action of common oxidising and reducing substances in everyday activities;	Action of bleach (stain removal, browning of cut fruits and rusting. Sodium sulfite or sulfur dioxide used as food preservatives.		
8.2 define oxidation and reduction;	Loss and gain of electrons and a change in oxidation number.		
8.3 deduce oxidation number from formulae;			
8.4 identify oxidation and reduction reactions including reactions at electrodes;	Refer to SO A9.8.		Skills: ORR; AI.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
8.5 distinguish between oxidising and reducing agents;	Equations involving formulae for potassium chromate(VI), potassium manganate(VII) and household bleach <b>are not required.</b>  Inclusion of at least one example of a substance, which can behave both as an oxidising and a reducing agent. Refer to SO B3.7, C6.3.	Perform reduction and oxidation reactions with potassium manganate (VII) iron(II)sulfate, potassium chromate(VI), hydrogen peroxide and potassium iodide. <b>Concentrated hydrogen peroxide should be handled with care.</b>	Skills: ORR; MM; AI; PD.
8.6 perform tests for oxidising and reducing agents.	Refer to SO C6.3.		Skills: ORR; AI; MM; PD.
<b>9. ELECTROCHEMISTRY</b>			
9.1 conduct investigations leading to the classification of substances as conductors or non-conductors;	Low voltage supplies only. Plastic and metals.		Physics – Current, electricity.
9.2 distinguish between metallic and electrolytic conduction;	Reference to mobile electrons in metals and mobile ions in solution.	Use simple circuits including plastic, metals or solutions.	Physics – Current, electricity.  Skills: AI; MM; PD.
9.3 classify electrolytes as strong or weak based on their conductivity;	Use of acids, salts and alkalis as examples of electrolytes.		Physics – Current, electricity.
9.4 define electrolysis, cathode, anode, cation, anion;			Physics – Current, electricity.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
9.5	identify ions present in electrolytes;		
9.6	predict the electrode to which an ion will drift;		
9.7	predict chemical reactions making use of electrochemical series;	Consideration of gain or loss of electron and formation of cation.	
9.8	<i>discuss the electrolysis of certain substances;</i>	<p><i>Principles related to:</i></p> <p>(a) Concentration of electrolyte.</p> <p>(b) Type of electrode (active and inert).</p> <p><i>Position of ions in the electrochemical series with respect to the named substances. Refer to SO A8.4.</i></p>	<p>Carry out electrolysis of the following substances: dilute sulfuric acid, concentrated aqueous sodium chloride, dilute aqueous sodium chloride, aqueous copper(II)sulfate using carbon or platinum and copper electrodes. One fused halide, for example, lead (II) bromide, using inert electrodes. Draw simple line diagrams representing electrolytic cell.</p> <p>Physics – Current, electricity. <i>Skills: ORR; AI.</i></p>
9.9	define the Faraday constant;	Approximate value of the Faraday constant as $96\,500\text{ C mol}^{-1}$ (coulombs per mole) of electrons.	Physics – Current, electricity.
9.10	<i>calculate the masses and volumes of substances liberated during electrolysis;</i>	<p>Quantity of electricity dependent on the current and time.</p> <p><math>Q = It.</math></p>	Physics – Current, electricity.

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
9.11 describe industrial applications of electrolysis.	Reference to: (a) metallic extraction (based on position in electrochemical series); (b) purification; (c) electroplating; (d) anodising. Refer to SO C2.3.		Physics – Current electricity.
<b>10. RATES OF REACTION</b>			
10.1 define rate of reaction;	The change in concentration of reactant or product with time at a stated temperature.		
10.2 identify the factors which affect the rate of reaction;	Factors: (a) concentration; (b) temperature; (c) surface area; (d) presence or absence of a catalyst. The danger of explosive combustion of finely divided substances, for example, flour in flour mills. Consideration of the change in rate of reaction as the reaction proceeds.	Carry out exercises varying one factor at a time while maintaining the others constant, for example: (a) magnesium strips and dilute acid; (b) potassium iodide and hydrogen peroxide; (c) sodium thiosulfate and dilute acid; (d) marble chips and dilute hydrochloric acid.	Biology- Enzymes in biological systems.  Skills: AI; ORR; PD; MM.
10.3 predict the effect of factors on rates of reaction from given data;			
10.4 interpret graphical representation of data obtained in studying rates of reaction.	Include graphs of (a) Concentration (volume; mass) vs. time; (b) Concentration Vs $1/t^5$ (c) rate vs time.		

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

### 11. ENERGETICS

11.1	distinguish between exothermic and endothermic reactions;	Energy content of products and reactants. <i>Bond breaking being endothermic; bond forming being exothermic; temperature change in surroundings.</i> Use of $\Delta H$ notation.	Perform investigations to demonstrate endothermic and exothermic changes, for example, potassium nitrate and water, sodium hydroxide pellets and water.	Physics-Thermal energy.  <i>Skills: MM; AI; ORR.</i>
11.2	draw energy profile diagrams to illustrate endothermic and exothermic change;	Simple energy profile diagrams including energy barrier. Include the action of catalyst using energy profile diagrams.		Physics-Thermal energy.
11.3	calculate energy changes from experiments or from experimental data.	Reference to heat of solution and heat of neutralisation of strong acid and strong base.  <i>Assumptions: density and specific heat capacity of pure water; negligible heat loss/gain from surroundings.</i> <i>Refer to SO A7.10.</i>	Carry out experiments by reacting metals with acids, volumetric analysis of alkali and acid. Record temperature changes. <i>End point of thermometric titration determined from the intersection of lines from the graph obtained.</i>	Physics - Thermal energy.  <i>Skills: ORR; AI.</i>

## SECTION A - PRINCIPLES OF CHEMISTRY (cont'd)

### ***Suggested Teaching and Learning Activities***

*To facilitate students' attainment of the objectives of this Section, teachers are advised to engage students in the teaching and learning activities below. These activities are designed to promote inquiry-based learning and cater to students with various learning styles.*

- 1. Take a trip to a sugar producing plant to understand the processes involved in the manufacture of sugar.*
- 2. Look at a video clip on the processes involved in the manufacture of sugar from a sugar producing plant.*
- 3. Create models of structures of atoms using everyday materials.*
- 4. Use the internet to examine 3D structures of atoms.*
- 5. Conduct research on the development of the Periodic Table and make group presentations.*
- 6. Use of large Periodic Table chart to examine the elements.*
- 7. Construct 3D models of sodium chloride, diamond and graphite using simple everyday materials.*
- 8. Conduct research on the use of salts in everyday life, for example, preservatives, controlling pests, medicines.*
- 9. Create posters showing the uses of radioactive isotopes and the dangers of radioisotopes.*
- 10. Use role play to demonstrate the energy of particles in the different states of matter.*
- 11. Use the internet to conceptualise and stir interest in understanding the mole concept.*
- 12. Use role play to demonstrate/atoms in bonding.*
- 13. Research, present and discuss acid-base reactions and oxidation-reduction reactions in everyday life.*
- 14. Create pamphlets to alert the school community on the dangers of chemicals used in everyday life.*
- 15. Students bring labels from home in order to stimulate discussions and analyse chemical information.*
- 16. Use of video clips explaining the application of electrolysis in electroplating, anodising and purification.*
- 17. Use of social networking (Facebook) to share and discuss information.*

## ◆ SECTION B – ORGANIC CHEMISTRY

Section B involves the study of the sources and nature of the compounds of carbon. The classification of the carbon compounds in terms of some functional groups, their structures, physical and chemical properties and their uses should also be presented.

### GENERAL OBJECTIVES

On completion of this Section, students should:

1. *understand some of the processes involved in the formation of carbon compounds from natural sources;*
2. *relate bonding properties of carbon to simple organic compounds;*
3. *understand the patterns of reactions of the various homologous series of carbon compounds;*
4. *understand the general pattern involved in the nature and formation of polymers;*
5. *relate the properties of carbon compounds to their uses.*

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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#### 1. SOURCES OF HYDROCARBON COMPOUNDS

Students should be able to:

- |     |  |  |  |
|-----|--|--|--|
| 1.1 | identify natural gas and petroleum as natural sources of hydrocarbons;                                 |  | Physics-Forms of Energy.<br>Biology-Ecology;<br>Natural resources. |
| 1.2 | list the main uses of at least three fractions obtained from the fractional distillation of petroleum; | Uses should include fuels, petrochemicals, lubricants.<br><i>Refer to SO A2.5.</i> | Physics-Forms of Energy.<br>Biology-Ecology.                       |
| 1.3 | describe cracking of petroleum fractions.  | Thermal and catalytic cracking of alkanes.   |  |

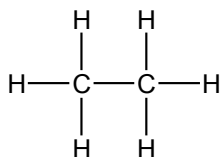
## SECTION B – ORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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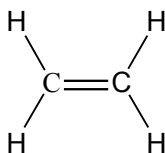
### 2. ORGANIC CHEMISTRY - AN INTRODUCTION

Students should be able to:

- 2.1 illustrate that carbon atoms can form single and double bonds, branched and unbranched chains and ring compounds;



*Illustrate various molecular structures using models.*

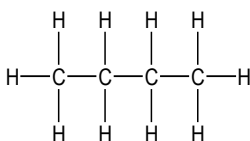


*Carbon atoms form four bonds.*

*Refer to SO A5.1.*

- 2.2 write formulae to represent simple organic compounds;

Structures to be represented by the condensed formulae  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$  and fully displayed (structural) formulae:



- 2.3 list the general characteristics of a homologous series;

- 2.4 write general and molecular formulae for members of a given homologous series;

*Alkanes, alkenes, alcohols and alkanoic (carboxylic) acid.*



## SECTION B – ORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

2.5 deduce the homologous series given the fully displayed and condensed formulae of compounds;

2.6 write fully displayed structures and names of branched and unbranched alkanes and unbranched alkenes, alcohols, and alkanolic acid; *IUPAC notation structure limited to compounds of up to 6 carbon atoms.* Use molecular models.

2.7 define structural isomerism;

2.8 write the fully displayed structures of isomers given their molecular formulae. *Limited to structural isomerism for alkanes and alkenes up to 6 carbon atoms.*

### 3. REACTIONS OF CARBON COMPOUNDS

3.1 describe the reactions of alkanes and alkenes; *The chemical reactions considered should be: burning and halogenation of alkanes and alkenes; hydration and hydrogenation for alkenes. Equations and conditions for reactions are required.* *Demonstrate burning of appropriate hydrocarbons for example (hexane, hexene).* Physics-Forms of energy. Biology - Ecology.

3.2 relate the characteristic reactions of alkanes and alkenes to their structures; *Emphasis should be placed on the dominance of substitution in alkanes and addition in alkenes.*

## SECTION B – ORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
3.3 distinguish between alkanes and alkenes;	<i>Carbon-Carbon double bond (C=C) associated with unsaturation.</i>	Test for unsaturation (burning is not acceptable). Use bromine solution or acidified potassium manganate (VII).	<i>Skill: ORR; AI; PD.</i>
3.4 relate the properties of hydrocarbons to their uses;	Alkanes as fuels and solvents and alkenes as the starting material for a wide range of polymers ( <i>for example, plastics</i> ) <i>biogas production from decomposition of manure.</i> <i>Refer to SO B4.2.</i>		Physics - Energy. Biology - Ecology.
3.5 identify alcohols, acids and esters by their functional groups;	<i>Alcohol : R-OH,</i> <i>Acid: R-COOH,</i> <i>Ester: COO-R</i> <i>where R represents an alkyl group.</i>		
3.6 relate the properties of alcohols, acids and to their functional groups;	<i>The presence of hydroxyl (- OH) groups linked to solubility and volatility.</i>	Investigate solubility of alcohols and acids in water.	<i>Skills: ORR; AI.</i>
3.7 describe the reactions of ethanol;	<i>Combustion, reaction with sodium, dehydration. Oxidation by reaction with potassium chromate (VI), (KMnO<sub>4</sub>). Reaction with organic acids to form esters. Equations and conditions for reactions are required.</i> <b>Equations for the conversion to acid are not required.</b> <i>Refer to SO A8.5.</i>	Demonstration of the principles of the breathalyser test, formation of esters and reaction of sodium with ethanol.	Physics - Forms of energy. Biology - Ecology.

## SECTION B – ORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
3.8 describe the fermentation process by which ethanol is produced from carbohydrates;	<i>Fermentation of a suitable carbohydrate, for example, glucose. Equation is required. Reference to wine-making and rum manufacture.</i>  Draw line diagrams of the distillation process in the laboratory. Refer to SOA2.5.	Prepare a sample of ethanol.	Biology - Aerobic and anaerobic respiration.  <i>Skills: ORR; AI.</i>
3.9 describe the reactions of ethanoic acid;	<i>Condensation reactions with alcohols (ester formation) Reactions with metals, oxides, hydroxides, and carbonates. Equations and conditions of reactions are required.</i>	Esterification with appropriate alcohols and carboxylic acids.	
3.10 explain hydrolysis of esters including saponification;	<i>Equation for hydrolysis of an ester. Include saponification of fats and oils.</i>	Preparation and hydrolysis of a suitable ester, for example, ethyl ethanoate. Preparation of a sample of soap.	<i>Skills: ORR; AI; MM.</i>
3.11 compare soapy and soapless detergents;	<i>Compare effect on hard and soft water, environmental impact. Refer to SO C5.5, C5.6, C5.7.</i>	A comparison of the effect of soaps and soapless detergents on hard water.	<i>Skills: ORR; AI.</i>
4.1 define polymers;	<i>Polymers as macromolecules produced from 50 or more monomers.</i>		

## SECTION B – ORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

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| 4.2 | distinguish between addition and condensation as reactions in the formation of polymers; | <i>Addition – polyalkenes<br/>Condensation – polyamides<br/>polyesters<br/>polysaccharides.<br/>The mechanism of polymerization is <b>NOT</b> required.<br/>Refer to SO B3.4.</i>                  |  |
| 4.3 | state at least one use of each of the following types of polymers.                       | <i>Polyalkene<br/>Polyamide<br/>Polyester<br/>Polysaccharide.<br/>A named example is required in each case, for example, polyvinyl chloride (PVC) used in pipe fittings.<br/>Refer to SO C5.5.</i> |  |

### **Suggested Teaching and Learning Activities**

To facilitate students' attainment of the objectives of this Section, teachers are advised to engage students in the teaching and learning activities below. These activities are designed to promote inquiry-based learning and cater to students with various learning styles.

1. Take a trip to a petroleum industry and examine the chemical processes or view a video clip of the processes involved in the separation of crude oil.
2. Take a trip to observe the processes in the manufacture of alcohol.
3. Assess the impact of organic compounds used in everyday life on human health, society and the environment, for example, plastics, food additives, pharmaceuticals, detergents.
4. Propose a course of action to reduce the use of compounds that are harmful to human health and the environment.
5. Create models showing 3D structures of organic compounds.
6. Carry out a project to demonstrate the production of methane gas from manure/compost.
7. Invite a policeman to demonstrate the use of the breathalyser machine to test for alcohol.
8. View samples of each type of polymers.

## ◆ SECTION C – INORGANIC CHEMISTRY

*Metals and non-metals are two types of elements which, based on their reactivity, can exist as free elements or in a combined state as compounds. The methods of extraction of metals and the laboratory preparation of some non-metals are investigated. A study of the physical properties, chemical properties and the uses of metals, non-metals and their compounds is integrally linked to their impact on living systems and the environment.*

### GENERAL OBJECTIVES

On completion of this Section, students should:

1. understand the features which characterise metals and non-metals;
2. understand the relationship between the method of extraction of a metal and its reactivity;
3. develop or determine an order of reactivity of the metals;
4. *be familiar with laboratory methods of preparation and collection of non-metals and their compounds;*
5. appreciate the relationship between metals and non-metals and their uses;
6. *understand the characteristics by which specific metals, non-metals and their ions can be identified;*
7. *appreciate that metals, non-metals and their compounds impact on the environment;*
8. appreciate that metals, non-metals and their compounds impact on living systems;
9. *appreciate the impact that man's activities have on the environment and apply the knowledge of chemistry for the good of society.*

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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#### 1. CHARACTERISTICS OF METALS

Students should be able to:

1.1 describe the physical and chemical properties of metals;	Physical properties melting point, boiling point, conductivity, lustre, hardness, <i>density</i> . Chemical properties to include action of oxygen, water, dilute hydrochloric acid, dilute sulfuric acid. <i>Refer to SO A5.4.</i>	Physical examinations and reactions of various metals, including zinc, iron, sodium, calcium, magnesium, aluminium, copper. Reaction of acids with sodium and calcium should not be attempted.	Physics - Specific latent heat, current, electricity.  <i>Skills: ORR; AI; MM.</i>
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## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

1.2	describe the reactions of metallic oxides, hydroxides, nitrates and carbonates.	<i>Equations are required. Reaction with dilute acid, action of heat. Refer to SO A7.4, A6.5.</i>	The action of dilute sulfuric acid and hydrochloric acid on metallic oxides and hydroxides. The action of heat on nitrates, carbonates and hydroxides.	Skills: ORR; AI; MM.
<b>2. REACTIVITY AND EXTRACTION OF METALS</b>				
2.1	discuss the reactivity of metals;	<i>Reactivity based on displacement reactions, reactions with oxygen, relative ease of decomposition of their nitrates, carbonates, oxides and hydroxides.</i>	Refer to practical activities at SO C1.1 and 1.2.	Skills: ORR; AI; MM.
2.2	deduce the order of reactivity of metals based on experimental results or data supplied;		Refer to practical activities at SO C1.1, 2.2.	Skills: ORR; AI; MM; PD.
2.3	describe the extraction of aluminum and iron.	<i>Relate the principles underlying the extraction of a metal to its position in the electrochemical series; details of purification of the raw materials not required. Use of carbon or hydrogen in the extraction of iron.</i>		
<b>3. USES OF METALS</b>				
3.1	explain why metal alloys are often used in place of the metals;	<i>Consideration of aluminum alloys, steel and solder.</i>		

## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

3.2	relate the properties of the metals (aluminum, lead, iron) and their alloys to their uses.	<i>Consideration of aluminum alloys, steel and solder. Reference to the use of lead in batteries. Use of metal cans as storage containers.</i>	Physics – Current, electricity.
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### 4. IMPACT OF METALS ON LIVING SYSTEMS AND THE ENVIRONMENT

4.1	investigate the conditions necessary for the corrosion of metals;	<i>Reference to iron and aluminum.</i>	Experiments with iron and aluminium under various conditions to show that air and water are necessary for corrosion.
4.2	explain the importance of metals and their compounds on living systems and environment;	<i>Organometallic compounds such as chlorophyll (containing magnesium) and haemoglobin, (containing iron). Importance of trace metals, for example, zinc.</i>	Biology - Transport, nutrition.
4.3	discuss the harmful effect of metals and their compounds to living systems and the environment.	<i>Reference to toxicity of certain metals example: Lead (Lead compounds in car exhaust fumes, and paints, disposal of vehicular batteries), arsenic (for mining), cadmium (disposal of nickel-cadmium batteries), and mercury (disposal of thermometers in hospitals and labs, mercury content in fish). Problem of disposal of solid waste (metals).</i>	

## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
<b>5. NON-METALS</b>			
5.1 describe the physical and chemical properties of non-metals;	<i>Hydrogen, chlorine, oxygen, carbon, sulfur, nitrogen. Reactions with oxygen and metals, oxidising and reducing properties. Physical properties (melting point, boiling point, conductivity, luster, hardness, density).</i>	<i>Burning of sulfur and carbon conductivity of carbon and sulfur.</i>	Biology – Photosynthesis, nitrogen cycle, Physics – Specific latent heat, current electricity.
5.2 describe the laboratory preparation of gases;	<i>Preparation of O<sub>2</sub>, CO<sub>2</sub>, NH<sub>3</sub>. Relate methods of drying and collection to the properties of gas (density, solubility and reaction with drying agents).</i>  <i>Preparation of gases, line drawings of apparatus used. Refer to SO A7.6.</i>		<i>Skills: ORR; Al, MM.</i>
5.3 explain the use of gases based on their properties;	<i>Example: carbon dioxide in fire extinguishers, oxygen in hospitals and for welding. Refer to SO A7.4.</i>		
5.4 list uses of the non-metals: carbon, sulfur, phosphorus, chlorine, nitrogen, silicon and their compounds;	Inclusion of insecticides, strengthening of plastics with fibre, jewellery, tyre manufacture, matches, phosphate and other fertilisers (NPK), bleaches, glass, ceramics.		Biology - Nutrition; soils, fertilisers.



## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
Students should be able to:			
5.5	discuss the harmful effects of non-metal on living systems and the environment;	<i>Pollution and role played by sulfur dioxide, carbon monoxide, hydrogen sulfide, oxide of nitrogen, carbon dioxide, chlorofluoro carbons, nitrates, phosphates, herbicides and pesticides; problem of disposal of solid waste (non-metal, example, plastics). Refer to SO B3.11, B4.3.</i>	<i>Biology - Ecology.</i>
5.6	relate the unique properties of water to its functions in living systems;	<i>Include density changes, solvent properties, specific heat capacity, volatility. Refer to SO B 3.11.</i>	<i>Physics-Specific heat capacity, density.</i>
5.7	discuss the consequences of the solvent properties of water;	<i>Hardness of water (temporary and permanent). Leaching. Refer to SO B 3.11.</i>	<i>Biology – Ecology.</i>
5.8	describe the methods used in the treatment of water for domestic purposes;	<i>Boiling, filtering, chlorinating, softening. Include equations for softening water. Refer to SO A2.5.</i>	<i>Biology – Role of decomposers.</i>

## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

5.9 *define Green Chemistry;* *Green Chemistry is the utilization of a set of principles that reduces or eliminates the use of generations of hazardous substances in the design, manufacture and application of chemical products. Refer to SO C4.3, C5.5.*

5.10 *outline the principles of Green Chemistry.* *In-depth study of the principles is not required.*

### 6. QUALITATIVE ANALYSIS

6.1 identify cations - $\text{Pb}^{2+}$ , $\text{Al}^{3+}$ , $\text{Ca}^{2+}$ , $\text{Zn}^{2+}$ , $\text{Fe}^{3+}$ , $\text{Fe}^{2+}$ , $\text{NH}_4^+$ , $\text{Cu}^{2+}$ ;	The following criteria to be used for identification; (a) metallic ions - colour, solubility of the hydroxides in: (i) aqueous sodium hydroxide refer to SO A7.1; (ii) aqueous ammonia or a suitable confirmatory test.	Appropriate experimental activities based on criteria in "Content/ Explanatory Notes".  <i>Use of Potassium Iodide.</i>  Use of potassium iodide identity of $\text{Pb}^{2+}$ ions.	<i>Skills: AI; ORR; PD.</i>
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**SECTION C – INORGANIC CHEMISTRY (cont'd)**

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

- (b) ammonium ion, evolution of ammonia gas after treatment with aqueous sodium hydroxide and warming.

Ionic equations are required.  
Refer to SO A6.5.

6.2 identify anions -  $\text{CO}_3^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{Cl}^-$ ;

The following criteria to be used for identification:

- (a) evolution and identification of gases produced when compounds containing the anions are:  
(i) heated strongly,  
(ii) treated with acid (dilute and concentrated);  
(b) *colour and solubility of the silver halide in aqueous ammonia or lead halide;*  
(c) colour of precipitate formed when anion reacts with a solution containing barium ions;  
(d) solubility of the precipitate formed in (c), in dilute acids.

Use criteria listed under "Content/ Explanatory Notes" to conduct simple experiments.

*Skills: ORR; AI; PD.*

**SECTION C – INORGANIC CHEMISTRY (cont'd)**

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

6.3	identify gases - H <sub>2</sub> , O <sub>2</sub> , CO <sub>2</sub> , NH <sub>3</sub> , SO <sub>2</sub> , Cl <sub>2</sub> , NO <sub>2</sub> , H <sub>2</sub> O;	<p>The following criteria to be used for identification:</p> <ul style="list-style-type: none"> <li>(a) colour;</li> <li>(b) odour;</li> <li>(c) reaction with a lighted or a glowing splint:               <ul style="list-style-type: none"> <li>(i) reaction with moist litmus paper;</li> <li>(ii) reaction with dry cobalt chloride paper/<i>anhydrous copper(II) sulfate</i>;</li> <li>(iii) reaction with acidified potassium manganate (VII) acidified potassium dichromate (VI);</li> <li>(iv) reaction with a glass rod dipped in concentrated aqueous ammonia or concentrated hydrochloric acid;</li> </ul> </li> </ul>	Standard laboratory tests for the gases.	<p>Biology Photosynthesis, respiration.</p> <p><i>Skills: ORR; AI; PD.</i></p>
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## SECTION C – INORGANIC CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	CONTENT/ EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES	SKILLS AND INTER- RELATIONSHIP
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Students should be able to:

- (v) *hydroxide reactions with lime water/ aqueous calcium.*  
*Refer to SO A7.2, A8.5, A8.6.*

### **Suggested Teaching and Learning Activities**

*To facilitate students' attainment of the objectives of this Section, teachers are advised to engage students in the teaching and learning activities below. These activities are designed to promote inquiry-based learning and cater to students with various learning styles.*

- 1. View video clips on the extraction of iron and aluminum.*
- 2. Students display samples of alloys used at home.*
- 3. Use of different forms of presentations by students to demonstrate an understanding of the dangers of metals and non-metals on living systems and the environment.*
- 4. Use of group presentations and projects to explore "Green Chemistry".*
- 5. View the following websites:*

*<http://www.rsc.org/Education/Teachers/Resources/Practical>  
<http://www.brainpop.com/science/>  
<http://www.bbcscience.net>  
<http://www.bbc.co.uk/schools/gscelutesize/chemistry/>  
<http://portal.acs.org/portal/acs/corg>.*

## ◆ GUIDELINES FOR THE SCHOOL-BASED ASSESSMENT

### RATIONALE

School-Based Assessment (SBA) is an integral part of student assessment in the course covered by this syllabus. It is intended to assist students in acquiring certain knowledge, skills and attitudes that are critical to the subject. The activities for the School-Based Assessment are linked to the “Suggested Practical Activities” and should form part of the learning activities to enable the student to achieve the objectives of the syllabus.

During the course of study of the subject, students obtain marks for the competence they develop and demonstrate in undertaking their SBA assignments. These marks contribute to the final marks and grades that are awarded to students for their performance in the examination.

The guidelines provided in this syllabus for selecting appropriate tasks are intended to assist teachers and students in selecting assignments that are valid for the purpose of the SBA. These guidelines are also intended to assist teachers in awarding marks according to the degree of achievement in the SBA component of the course. In order to ensure that the scores awarded by teachers are not out of line with the CXC standards, the Council undertakes the moderation of a sample of SBA assignments marked by the teacher.

School-Based Assessment provides an opportunity to individualise a part of the curriculum to meet the needs of students. It facilitates feedback to the students at various stages of the experience. This helps to build the self-confidence of the students as they proceed with their studies. School-Based Assessment further facilitates the development of essential investigative and practical skills that allow the students to function more effectively in their chosen vocation and everyday life. School-Based Assessment therefore, makes a significant and unique contribution to the development of relevant skills of the students. It also provides an instrument for testing them and rewarding them for their achievements.

### PROCEDURES FOR CONDUCTING SBA

**SBA assessments should be made in the context of normal practical coursework exercises.** *It is expected that the exercises would provide authentic learning experiences.* Assessments should only be made after candidates have been taught the skills and given enough opportunity to develop them. **Sixteen** practicals over the two-year period would be considered the minimum number for candidates to develop their skills and on which to base realistic assessments. **These practicals MUST include all of the following:**

1. *separation techniques;*
2. *acids, bases and salts;*
3. *redox reactions and electrolysis;*
4. *qualitative analysis;*
5. *volumetric analysis;*
6. *rates of reaction;*
7. *energetics;*
8. *saturated and unsaturated hydrocarbons.*

Each skill must be assessed at **least three times** over the two-year period. Candidates should be encouraged to do corrections so that misconceptions will not persist. As the assessment of certain skills, especially those requiring on-the-spot observation or involve looking at several behaviours or criteria, teachers are advised to select not more than two skills to be assessed in any activity. The practical exercises selected to be used for assessment should make adequate demands on the candidates and the skills assessed should be appropriate for the exercises done. For the assessment of written work, the practical selected should be one that can be completed in the time allotted for the class and **the notebooks should be collected at the end of the period.**

Candidates who have not been assessed over the two-year period will be deemed absent from the whole examination. Under special circumstances, candidates who have not been assessed at all points may, at the discretion of CXC, have their marks pro-rated (adjusted proportionately).

**1. In preparation for an SBA practical, the teacher should:**

- (a) select tasks which must be chosen from the **eight** (8) topics on page 42 and should be related to a given syllabus objective. These tasks may be chosen from the “Suggested Practical Activities” and should fit in with the normal work being done in that class;
- (b) list the materials including quantities and equipment that will be needed for each student;
- (c) carry out the experiment beforehand, if possible, to ascertain the suitability of materials and the kind of results (observations, readings) which will be obtained, noting especially any unusual or unexpected results;
- (d) list the steps which will be required by the candidates in performing the experiment. From this it will be clear to the teacher how the candidates should be arranged in the laboratory, whether any sharing of equipment or materials is necessary, the skills which can be assessed from the practical, and the instructions to be given;
- (e) list the skills that may be assessed (for example, observation/recording/reporting, analysis and interpretation). **No more than two practical skills should be assessed from any one activity;**
- (f) select the skills to be assessed on this occasion. Skills other than those required for that year should also be included for teaching purposes;
- (g) work out the criteria for assessing each skill. This will form the basis of a mark scheme and a checklist.

**2. The teacher should carry out the assessment and record the marks.**

This is the most critical step in the assessment process. For a teacher to produce marks that are reliable, the marking must be consistent for all candidates and the marks should reflect the standard of performance at the level. The teacher must be able to justify the marks, and this occurs when there is a fixed set of conditions, factors or criteria for which the teacher looks. Marks should be submitted electronically to CXC on the SBA form provided. *The forms should be dispatched through the Local Registrar by the Moderator to reach CXC by 30 April in the year of the examination.*

## ASSESSMENT OF PRACTICAL SKILLS

School-Based Assessment will assess skills under the profiles Experimental Skills and Use of Knowledge (Analysis and Interpretation only).

The assessment will be conducted during Terms 1 - 5 of the two-year period following the programme indicated in the Table below.

### SBA SKILLS TO BE ASSESSED FOR CXC MODERATION

PROFILE	SKILLS	YEAR 1		YEAR 2		TOTAL		
		NO. OF TIMES SKILLS TO BE ASSESSED	MARKS	NO. OF TIMES SKILLS TO BE ASSESSED	MARKS	NO. OF TIMES SKILLS TO BE ASSESSED	MARKS	
XS	Manipulation/ Measurement	1	10	2	20	3	30	90 <b>(30*)</b>
	Observation/ Recording/ Reporting	1	10	2	20	3	30	
	Planning and Designing*	2	20	1	10	3	30	
UK	Analysis and Interpretation	2	20	1	20	3	40	40 <b>(10*)</b>
	<b>TOTAL</b>	6	60	6	70	12	130	<b>(40*)</b>

**\*Weighted mark**

*Investigative project to be done in Year 2.*

*The investigative project would be assessed for two skills, Planning and Design and Analysis and Interpretation.*

**Students who are pursuing two or more of the single science subjects (Biology, Chemistry, Physics) may opt to carry out ONE investigation\* only from any of these subjects.  
[ONLY the marks for the investigation can be transferred across subjects.]**



## Assessment of Investigation Skills

### Proposal (Planning and Design)

The maximum marks available for the Proposal is **10 marks**

The format for this part is shown below

Observation/Problem/Research question stated	
Hypothesis	2 marks
Aim	1 mark
Materials and Apparatus	1 mark
Method	2 marks
<i>Controlled variables</i>	1 mark
<i>Expected Results</i>	2 marks
<i>Assumptions, Precautions/ Limitations</i>	1 mark

**TOTAL** **10 marks**

### Implementation (Analysis and Interpretation)

The maximum marks available for the Implementation is **20 marks**

The format for this part is shown below.

Method	1 mark
Results	4 marks
Discussion	5 marks
Limitation	3 marks
Reflection	5 marks
<i>Conclusion</i>	2 marks

**TOTAL** **20 marks**

## REPORTING FORMAT OF INVESTIGATION

### **PART A THE PROPOSAL (Planning and Design)**

**Statement of the Problem** – Can be an observation, a problem

**Hypothesis**

**Aim** – Should be related to the hypothesis

**Materials and Apparatus**

**Method** – Should also include variables

Assumptions/Precautions

Expected Results

### **PART B THE IMPLEMENTATION (Analysis and Interpretation)**

**Method** - Linked to Part A (change of tense)

**Results**

**Discussion** – Explanations/Interpretations/Trends

**Limitations**

**Reflections**

**Conclusion**

## CRITERIA FOR ASSESSING INVESTIGATIVE SKILLS

### **A. PLANNING AND DESIGN**

<b>HYPOTHESIS</b>		<b>2</b>
- Clearly stated	1	
- Testable	1	
<b>AIM</b>		<b>1</b>
- Related to hypothesis	1	
<b>MATERIALS AND APPARATUS</b>		<b>1</b>
- Appropriate materials and apparatus	1	
<b>METHOD</b>		<b>2</b>
- Suitable	1	
- At least one manipulated or responding variable	1	
<b>CONTROLLED VARIABLE</b>		<b>1</b>
-Controlled variable stated	1	
<b>EXPECTED RESULTS</b>		<b>2</b>
- Reasonable	1	
- Link with method	1	
<b>ASSUMPTIONS/PRECAUTIONS/POSSIBLE SOURCES OF ERRORS</b>		<b>1</b>
- Any one stated	1	

**TOTAL** **(10)**

**B. ANALYSIS AND INTERPRETATION**

<b>METHOD</b>		<b>1</b>
Linked to Proposal, Change of tense		
<b>RESULTS</b>		<b>4</b>
- <i>Correct formulae and equations:</i>	2	
<i>Accurate (2)</i>		
<i>Acceptable (1)</i>		
- <i>Accuracy of data:</i>	2	
<i>Accurate (2)</i>		
<i>Acceptable (1)</i>		
<b>DISCUSSION</b>		<b>5</b>
- <i>Explanation</i>	2	
<i>Development of points:</i>		
<i>Thorough (2)</i>		
<i>Partial(1)</i>		
- <i>Interpretation</i>	2	
<i>Fully supported by data (2)</i>		
<i>Partially supported by data (1)</i>		
- <i>Trends</i>	1	
<i>Stated</i>		
<b>LIMITATIONS</b>		<b>3</b>
-Sources of error identified	1	
-Precautions stated	1	
-Limitation stated	1	
<b>REFLECTIONS</b>		<b>5</b>
- <i>Relevance between the experiment and real life</i>	1	
<i>(Self, Society or Environment)</i>		
- <i>Impact of knowledge gain from experiment on self</i>	1	
- <i>Justification for any adjustment made during experiment</i>	1	
- <i>Communication of information</i>	2	
<i>(Use of appropriate scientific language, grammar and clarity of</i>		
<i>expression all of the time (2); some of the time (1)</i>		
<b>CONCLUSION</b>		<b>2</b>
- <i>Stated</i>	1	
- <i>Related to the aim</i>	1	
<b>TOTAL</b>		<b>(20)</b>

## EXAMPLAR OF INVESTIGATIVE PRACTICAL

### EXEMPLAR 1

#### Part A THE PROPOSAL

##### Observation

Whenever an uncovered carbonated beverage is left exposed at room temperature the beverage goes 'flat' (that is, loses its fizz) within a few hours but when an uncovered carbonated beverage is stored in a refrigerator it remains fizzy for much longer.

**Hypothesis:** The higher the temperature of an uncovered carbonated drink the faster the drink will lose carbon dioxide gas.

**Aim:** To determine if increasing the temperature causes an uncovered carbonated beverage to lose carbon dioxide gas at a higher rate.

**Materials/Apparatus:** A sealed bottle of a carbonated beverage, cold water, 3 boiling tubes, 3 delivery tubes with rubber bungs, three test tube racks, a 60 °C water bath, an ice- bath, 3 thermometers, three measuring cylinder, three retort stands with clamps, 3 graduated syringes and a timing device.

##### Method

1. All apparatus will be cleaned and dried before beginning the experiment.
2. Label each boiling tube as follows: R- for room temperature, C- for cold and H- for hot. Measure 20 cm<sup>3</sup> of the carbonated beverage and pour slowly into each boiling tube.
3. Leave the uncovered boiling tube labeled R on the counter at room temperature. Place the uncovered tube labeled C into an ice-bath and the uncovered tube labeled H into a 60°C water bath. Record the temperature of each beverage in a table and leave each tube undisturbed for 30 minutes.
4. After the 30 minutes has passed for each beverage, securely fit the tube with a rubber bung and delivery tube. Keep the shaking of the tube to a minimum during this set-up process. The open end of the delivery tube will be attached to a graduated syringe and the boiling tube shaken for two minutes. Record the volume reached by the gas in a suitable table. Repeat the same procedure for each tube.

Precaution: Carbonated beverage was poured slowly down the sides of the boiling tube to minimise loss of gas.

##### Expected Results

It is expected that the carbonated beverage labeled H will produce the least volume of gas, beverage R will produce more gas than H but less than C and beverage C will produce the highest volume of gas.

## **PART B- THE IMPLEMENTATION**

### **Introduction**

Whenever an uncovered carbonated beverage is left exposed at room temperature the beverage goes 'flat' (that is, loses its fizz) within a few hours but when an uncovered carbonated beverage is stored in a refrigerator it remains fizzy for much longer.

The gas responsible for the fizz of a carbonated drink is carbon dioxide and the lower the carbon dioxide content of a drink the 'flatter' the drink will be.

In this experiment the relationship between the temperature and the carbon dioxide content of a carbonated drink will be explored so as to offer an explanation to the observation made.

### **Method**

1. All apparatus was cleaned and dried before beginning the experiment.
2. Each boiling tube was labeled as follows: R- for room temperature, C- for cold and H- for hot.
3. 20 cm<sup>3</sup> of the carbonated beverage was measured and poured slowly into each boiling tube.
4. The uncovered boiling tube labeled R was left on the counter at room temperature, the uncovered tube labeled C was placed into an ice-bath and the uncovered tube labeled H was placed into a 60°C water bath. The temperature of each beverage was recorded in a table and each tube was left undisturbed for 30 minutes.
5. After 30 minutes had passed for each beverage, the tube was securely fitted with a rubber bung and delivery tube. Shaking of the tube was kept to a minimum during this set-up process. The open end of the delivery tube was attached to a graduated syringe and the boiling tube was shaken for two minutes. The volume reached by the gas was recorded in a suitable table. The same procedure was repeated for each tube.

### **Results**

**TABLE SHOWING THE VOLUME OF CARBON DIOXIDE GAS COLLECTED AT VARIOUS TEMPERATURES**

<b>Boiling Tube</b>	<b>Temperature (°C)</b>	<b>Volume of CO<sub>2</sub> gas (cm<sup>3</sup>)</b>
R	30	
H	60	
C	2	

### **Discussion**

From this experiment, it was determined that as the temperature increased the carbon dioxide content of the drink decreased. The drink which was kept at the highest temperature lost the most gas in the allotted time period.

When a carbonated drink is left uncovered, the decrease in pressure causes the gas particles to leave the solution at the surface faster. Also, increasing the temperature gives the gas particles more kinetic energy and increases the rate at which these particles leave the drink's surface.

Particles possess more kinetic energy at higher temperatures than at lower temperatures. Hence, more gaseous particles will leave the surface of a drink at room temperature than at a lower temperature.

Therefore it is clear that when the carbonated drink was left at room temperature the loss of  $\text{CO}_2$  would have occurred more readily than if the same drink was kept in a refrigerator and as a result the drink at room temperature would become flat much sooner than one stored at colder temperatures.

### **Limitations**

Every effort was made to reduce experimental error as much as possible. Shaking of the beverage during measuring was minimized and the temperatures were monitored strictly. However, the following situations may have contributed to experimental error:

1. Loss of gas as an undetermined amount of gas was lost during the pouring of the beverage into the measuring cylinder.
2. Loss of gas occurred during the assembling of the delivery tube to the graduated syringe.

### **Reflections**

Whenever an uncovered carbonated beverage is left exposed at room temperature, the beverage goes flat (it loses its fizz) within a few hours but when an uncovered carbonated beverage is stored in a refrigerator it remains fizzy for much longer.

From the experiment, I have learnt that the reason carbonated drinks go flat faster at room temperature is because of the higher temperature which gives the gas particles enough energy to leave the drink's surface faster. Therefore, based on scientific fact it is better to store a carbonated drink at low temperatures as this will preserve its  $\text{CO}_2$  content for much longer.

This experiment was carried out as designed in the plan.

### **Conclusion**

Increasing the temperature of an uncovered carbonated drink causes the drink to lose carbon dioxide faster.

## **Exemplar 2**

### **Part A THE PROPOSAL**

#### **Observation**

While on a field trip to the local Botanical Gardens, an observation was made that all the rocks in the river which flowed through this garden had shiny, rusty-brown surfaces. The villagers claim that the water flowing through the gardens contains iron compounds and that the rocks had these compounds deposited from the water on their surfaces.

**Hypothesis:** The rusty brown solid on the rock surfaces is a compound of iron.

**Aim:** To determine if the deposit on the surfaces of the river rocks is a compound of iron.

**Materials/Apparatus:** A sample of the rock from the river bed, a sample of rock from the river shore, knife, test tube and test tube rack, 2 M H<sub>2</sub>SO<sub>4</sub> solution, sodium hydroxide solution, measuring cylinder and a teat pipette.

### **Method**

1. All apparatus will be cleaned and dried before beginning the experiment.
2. The knife will be used to remove some of the deposit from the surface of the river rock. The deposit will be placed into a test tube. 4 cm<sup>3</sup> of acid will be added to the test tube and the tube will be shaken. The mixture will be decanted to isolate any undissolved particles. To the filtrate, sodium hydroxide solution will be added dropwise until in excess. Repeat the experiment using the sample of rock from the river shore.
3. All observations will be recorded and tabulated.

Assumption: There is enough iron compound in the rock deposit to react with the acid.

### **Expected Results**

It is expected that if an iron compound is present, the iron compound from the deposit will react in the acid to give a pale yellow solution. When the solution is tested with the sodium hydroxide dropwise, a rusty-brown precipitate will form which will be insoluble in excess.

## **PART B - THE IMPLEMENTATION**

### **Introduction**

While on a field trip to the local Botanical Gardens, an observation was made that all the rocks in the river which flowed through this garden had shiny, rusty-brown surfaces. The villagers claim that the water flowing through the gardens contains compounds of iron and that the rocks had iron compounds deposited from the water on their surfaces.

Fe<sup>3+</sup> ions which are present in iron compounds will precipitate out as iron (III) oxide which is rusty brown in colour. This compound coats the rocks, making them appear as shiny rusty brown surfaces.

It is suspected that the water contains iron (III) ions which will form a rusty brown deposit. The purpose of this experiment is to determine if this is the case.

### **Method**

All pieces of apparatus were cleaned and dried before beginning the experiment.

The knife was used to remove some of the deposit from the surface of the river rock. The deposit was placed into a test tube. 4 cm<sup>3</sup> of acid was added to the test tube and the tube was shaken to dissolve as much of the deposit as possible. The mixture was filtered to isolate any undissolved particles. To the filtrate, sodium hydroxide solution was added dropwise until in excess.

All observations were recorded and tabulated.

## Results

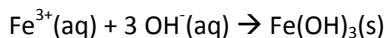
TABLE SHOWING THE OBSERVATIONS WHEN SODIUM HYDROXIDE SOLUTION WAS ADDED DROPWISE AND IN EXCESS

<b>OBSERVATION WITH DILUTE NaOH (aq)</b>	
<b>Dropwise</b>	<b>Excess</b>
A rusty-brown precipitate formed.	The rusty-brown precipitate remained insoluble.

## Discussion

Mineral water is obtained from a mineral spring and contains various minerals such as salts and even compounds of sulfur. Other compounds found in mineral water are iron compounds, the levels of which may vary depending on the time of year and the pH of the water. During certain times of the year the river water becomes more acidic and this causes an increase in the amount of iron salts from the soil dissolved in the river water. Some of those salts can then precipitate onto the river rocks and change the regular appearance of the rocks' surfaces.

The rusty brown solid is likely to be iron(III) oxide which reacts with the sulfuric acid forming a soluble iron(III) salt which is a pale yellow solution. By performing qualitative analysis on a sample of the deposit it was determined that the rusty-brown deposit on the rock contained iron(III) ions due to the presence of an iron(III) salt. Iron(III) salt solutions form the rusty-brown, insoluble iron(III) hydroxide precipitate with sodium hydroxide solution. As shown by the equation below:



## Limitations

The reaction between the iron compound and the acid produced a small amount of iron(III) ion solution. Iron compounds will react with sulfuric acid to form soluble salts which can then be tested using aqueous sodium hydroxide. If small amounts of the iron(III) ions are produced in the reaction between the acid and the deposit, then the resulting solution may not have sufficient iron(III) ions to produce a visible precipitate with sodium hydroxide.

## Reflections

Mineral springs produce water which contains a number of dissolved salts, one of which is a compound of iron. The rusty brown deposits on the rocks are likely to be iron(III) oxide which will react with acids to produce iron(III) ion solutions.

It is believed that mineral water has medicinal properties because of the presence of some compounds such as compounds of iron.

Knowledge of the iron content of water allows decisions to be made as to the benefits of using this water for health purposes.

It was decided that filtration would replace decantation as suggested in the proposal to ensure that the suspended particles were completely removed.



## Conclusion

Iron compounds were found to be deposited on the river rocks. . The results of the test support the villagers' claims. Iron compounds are indeed present in the river water.

## RECORD KEEPING

Each candidate is required to keep a practical workbook containing all practicals done over the two-year period prior to the examination. Those assessed for CXC will be used to determine the standard of marking by the teacher. **A mark scheme must be provided for each practical assessed for CXC.** All practicals should be dated and an index made by the candidates of the practicals done. Those assessed for CXC should be clearly indicated along with the marks awarded for each skill. **This must include the identity of unknowns and expected readings.**

Candidates' workbooks should be durable and neatness should be encouraged. The pages should be numbered and all exercises should be dated. The workbook should contain a contents page providing the following information concerning the practicals:

1. page number;
2. date;
3. aim of practical;
4. an indication using an asterisk, of which practicals were assessed for CXC;
5. the skills assessed.

A possible format is given below:

Page No.	Date	Aim of Practical	Skills Assessed
8	2013-10-02	Separation of mixtures- oils and water, dyes in screened methyl orange, ammonium chloride and sodium chloride	
*9	2013-10-23	To observe the effect of heat on nitrates	Man./Meas.

Note: The asterisk (\*) indicates practical assessed for CXC.

A breakdown of the skills assessed and the marks awarded should be given at the end of the report for each SBA practical (for example):

Manipulation and Measurement (mm)	6/10
Observation, Recording, Reporting (ORR)	8/10

CXC will require a sample of practical workbooks for moderation. Teachers are reminded that **the marks awarded for each practical skill should be in the candidate's workbook** and that accuracy in recording marks on CXC mark sheets is essential.

Additional workbooks may be requested. The school should therefore retain all other practical workbooks until at least three (3) months after the publication of examination results. Candidates' workbooks should show evidence of conducting test some of the experiments, which they have planned and designed.

## **Moderation of School-Based Assessment**

*The reliability (consistency) of the marks awarded by teachers on the School-Based Assessment is an important characteristic of high quality assessment. To assist in this process, the Council undertakes on-site moderation of the School-Based Assessment conducted by visiting external Moderators.*

*The Moderator will make a first visit in Term 3 of Year 1. Teachers must make available to the Moderator **ALL** Assessment Sheets (Record of Marks, Mark Schemes and the proposal for the Investigation).*

*During the Term 2 of Year 2, the Moderator will make a second visit. Teachers must make available to the Moderator **ALL** Assessment Sheets (Record of Marks, Mark Schemes and the report on the Investigation). **Teachers are NOT required to submit to CXC samples of candidates' work, unless specifically requested to do so by the Council BUT will be required to submit the candidates' marks electronically.***

*The Moderator will remark the skills, and investigation reports for a sample of five candidates, who are selected using the guidelines listed below.*

1. *Candidates' total marks on the SBA are arranged in descending order (highest to lowest).*
2. *The sample comprises the work of the candidates scoring the:*
  - (a) *highest Total mark;*
  - (b) *middle Total mark;*
  - (c) *lowest Total mark;*
  - (d) *mark midway between the highest and middle Total mark;*
  - (e) *mark midway between the middle and lowest Total mark;*
3. *The candidates selected above may be required to demonstrate some practical skills.*

*Teachers' marks may be adjusted as a result of the moderation and feedback will be provided by the Moderator to the teachers.*

*The Moderator may re-mark the assignments of additional candidates. Where the total number of candidates is five or fewer, the Moderator will remark **ALL**.*

*On the first visit, the Moderator will re-mark a sample of the Year 1 candidates. A copy of this report must be retained by the teacher, and be made available to the Moderator during Term 2 of Year 2.*

*The Moderator will submit the Assessment Sheets, moderation of SBA Sample and the moderation reports to the Local Registrar by April 30 of the year of the examination. A copy of the Assessment Sheets and candidates' work must be retained by the school for three months after the examination results are published by CXC.*

*School-Based Assessment Record Sheets are available online via the CXC's website [www.cxc.org](http://www.cxc.org).*

*All School-Based Assessment Record of marks must be submitted online using the SBA data capture module of the Online Registration System (ORS).*

## EXAMPLE OF A POSSIBLE SBA PRACTICAL

**Aim:** Finding the end of a neutralisation reaction by measuring temperature changes.

**Apparatus:** 2 mol dm<sup>-3</sup> sodium hydroxide solution.  
2 mol dm<sup>-3</sup> hydrochloric acid solution.  
Thermometer (0-110 °C, 1 °C gradations).  
Styrofoam cup.  
25 cm<sup>3</sup> or 20 cm<sup>3</sup> pipette. (Measuring cylinder can be used if pipettes are unavailable)  
Burette (Test tube calibrated to measure 5 cm<sup>3</sup> or syringe or any other suitable measuring container).

**Procedure:**

1. Pipette 25 cm<sup>3</sup> of the sodium hydroxide solution into the Styrofoam cup. Measure and record the temperature of this solution.
2. Fill the burette to the 0 mark with the acid and deliver 5 cm<sup>3</sup> of acid into the alkali all at once. Stir with the thermometer and record the highest temperature reached. WITHOUT DELAY, add a second 5 cm<sup>3</sup> of the acid, stir and record the highest temperature reached. Repeat the procedure until a total of 40 cm<sup>3</sup> of acid has been added.
3. Record your readings in an appropriate table.

### Activities:

1. Plot a graph of total volume of acid added (x-axis) against the temperature (y-axis) and draw two best-fit lines.
2. Account for the shape of the graph you have obtained.
3. Use your graph to determine the total volume of acid needed to neutralise exactly 25 cm<sup>3</sup> of alkali.
4. Determine likely sources of error in this procedure for determining the end-point of a neutralisation reaction.
5. Write the ionic equation for the neutralisation reaction.

### MARK SCHEME

Skills assessed: Observation/Recording/Reporting, Analysis and Interpretation.

#### Temperature change during neutralisation

##### 1. Observation/Recording/Reporting

Table

- |     |  |   |
|-----|--|---|
| (a) | Neatly enclosed table.   | 1 |
| (b) | Headings with units.   | 1 |
| (c) | Data written correctly to a consistent number of decimal places. | 1 |

- |     |   |                 |
|-----|---|-----------------|
| (d) | Graph.  |                 |
|     | (i) Labelling of axes with units                  | 2               |
|     | (ii) Selecting a suitable scale for x and y axes. | 2               |
|     | (iii) Plotting accurately.                        | 2               |
|     | (iv) Drawing best fit intersecting lines.         | <u>1</u>        |
|     |   | <b>10 Marks</b> |

## 2. Analysis and Interpretation

- |     |  |                 |
|-----|--|-----------------|
| (a) | Deducing that for the portion of the graph sloping upwards:  |                 |
|     | (i) reaction is incomplete;  | 1               |
|     | (ii) amount of heat given off increases as more reactant (acid) is available.                                  | 1               |
| (b) | Deducing that for the portion of graph sloping downwards:  |                 |
|     | (i) reaction is complete;  | 1               |
|     | (ii) temperature falls as more reactant is added.  | 1               |
| (c) | Deducing that reaction is complete when highest temperature is reached, hence peak in graph.                   | 1               |
| (d) | Reading off volume of acid corresponding to highest temperature reached.                                       | 2               |
| (e) | Two likely sources of error (for example, heat loss to surroundings, incomplete transfer of acid).             | 2               |
| (f) | Ionic equation   | <u>1</u>        |
|     | $\text{H}^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})} \rightarrow \text{H}_2\text{O}(\text{l}) + \text{heat.}$ |                 |
|     |  | <b>10 Marks</b> |

## Manipulation and Measurement

Aim: To investigate how the solubility of potassium nitrate crystals varies with temperature.

Apparatus and Materials: Boiling tube, test tube holder, Bunsen burner, glass rod, measuring cylinder, thermometer, matches, potassium nitrate, distilled water, tap water, ice.

- Procedure:
- Place 5 g of  $\text{KNO}_3$  crystals into a boiling tube.
  - Using a measuring cylinder, pour  $3.0 \text{ cm}^3$  of distilled water into the  $\text{KNO}_3$ .
  - Heat the contents of the boiling tube carefully over Bunsen flame while stirring until all the solid dissolves.
  - Remove the boiling tube carefully from the flame. Place the thermometer in the boiling tube. Allow the boiling tube to cool and record the temperature at which the crystals first appear.
  - Add to the contents of the boiling tube a further  $3.0 \text{ cm}^3$  of distilled water and repeat the above procedure, noting the temperature at which crystals first appear.
  - Repeat the procedure adding a further  $3.0 \text{ cm}^3$  portions of water to obtain a total volume of  $15 \text{ cm}^3$ .

Results: Record the results in a table with the following headings (include appropriate units).

Volume of H <sub>2</sub> O Added to 5 g KNO <sub>3</sub>	Temperature at Which Crystals Appear	Mass of KNO <sub>3</sub> dissolved in 100 g of H <sub>2</sub> O (Solubility)
--	--------------------------------------	--

Analysis of Results:

Calculate the solubility of KNO<sub>3</sub> at for each volume of water using the equation below.

3.0 cm<sup>3</sup> of H<sub>2</sub>O dissolves 5 g of KNO<sub>3</sub>

100 cm<sup>3</sup> of H<sub>2</sub>O dissolves  $5 \times 100 = 166.6$  g

Plot graph of temperature at which crystals form (x-axis) vs solubility in 100 g of water (y-axis) and draw the best-fit curve.

Use your graph to determine:

1. the solubility of KNO<sub>3</sub> at 45°C;
2. the mass of KNO<sub>3</sub> that would crystallize when a solution of KNO<sub>3</sub> cools from 65°C to 35°C.

Discussion:

Define solubility.

Account for the shape of the graph you have obtained.

### MARK SCHEME

NB. This lab may be assessed for ORR and AI.

#### Skill Assessed: Manipulation and Measurement

- |     |   |   |
|-----|---|---|
| (a) | Correct use of balance (scale).   | 1 |
| (b) | Placing measuring cylinder on flat surface.   | 1 |
| (c) | Taking reading at eye level.  | 1 |
| (d) | Correctly lighting Bunsen burner.<br>(closing air hole, striking match, turning on gas, lighting burner, opening air hole, adjusting gas to control height of flame). | 4 |
| (e) | Carefully heating contents of boiling tube with stirring by holding tube away from self and others.   | 1 |
| (f) | Holding thermometer upright for reading.  | 1 |
| (g) | Making sure that the bulb of the thermometer is submerged and not touching the walls of the container.  | 1 |

**10 Marks**

#### Planning and Design

Problem:

In a café, sugar is provided in a single package cube. Each customer is given one package per order. Each cube contains 5 g of sugar. The manager notices that there is sugar left in the bottom of many of the used iced tea cups but not in the bottom of the hot tea cups.

Propose an hypothesis to explain this observation. Plan and design an experiment to test this hypothesis.

### Skills Assessed: Planning and Design

<b>Hypothesis:</b>	Clearly stated with ONE variable, testable.	2
<b>Aim:</b>	Related to hypothesis and problem statement, method to be used specified	2
<b>Apparatus and Materials:</b>	All essential ones stated.	2
<b>Procedure:</b>	Logical sequence of steps, written in present or future tense, workable or feasible to test hypothesis.	4
<b>Variables:</b>	(Manipulated, controlled and responding): Clearly stated or implied	3
<b>Data to be collected:</b>	Observations, measurements or qualitative data which will prove or disprove hypothesis.	2
<b>Treatment/ Interpretation of data:</b>	Shows link between how data to be collected proves or disproves hypothesis.	2
<b>Assumptions, Limitations, Precautions.</b>		3
		<b>20 marks (scale to 10)</b>

### Conversion of marks to the 11-point scale

The 11-point scale ranges from 0 to 10 thus the maximum mark for each skill at any assessment point is 10. Always marking out of 10 or multiples of 10 makes conversion easy but this is not necessary, as this may be readily calculated. Conversion of the scale can be done for each assessment but this is not the only possibility. The raw marks out of the totals used must be recorded and these marks totalled for each skill and the conversion done only when their submission to CXC is required.

The following hypothetical result for the assessment of a student on a particular skill may be used as an example. If the marks obtained for observation/recording/reporting are:

5/7, 4/6, 5/5, 7/9, 6/8

The total marks are out of a possible 35 marks. This may be converted by calculations as follows:

$$\frac{27}{35} \times 10 = 7.71 \text{ (approximately)}$$
$$= 8 \text{ for CXC purposes.}$$

### VALIDITY AND RELIABILITY OF TEACHERS' MARKS

The reliability of marks awarded is a significant factor in SBA and has far-reaching implications for the candidate's final grade. Teachers are asked to note the following:

1. The criteria for assessing a skill should be clearly identified. A mark scheme must be submitted with the sample of books sent for moderation. Failure to do this could result in the candidates being unavoidably penalised.

2. The relationship between the SBA marks in the practical workbooks and those submitted to CXC on the SBA forms must be clearly shown. It is important that the marks awarded reflect the degree of mastery of the skills assessed.
3. Workbooks should contain all practical work and those exercises used for SBA marks should be clearly identified. At least eight exercises should be undertaken.
4. The standard of marking must be consistent, hence the need for a mark scheme.
5. Collaboration among teachers especially in the same centre is urged to minimise the discrepancy in the standard of assessment among teachers.

### **STRATEGIES FOR ASSESSING THE PLANNING AND DESIGN SKILL**

The Planning and Designing skill is intended to test students' ability to develop hypotheses and devise means of carrying out investigations to test them, plan experimental procedures and operations in appropriate sequence, identify variables, state expected results and identify precautions and possible sources of error. It is expected that some activities related to the planning and designing skill will be carried out. However, the reports of these activities are no longer plans and cannot be assessed as planning and design (PD). They can be marked for other skills, for example, observation, recording and reporting (ORR).

The assessing of Planning and Designing is not intended to test the students' research ability but rather their ability to use known procedures in a novel situation, or to make a novel use of a known procedure. Developing this skill to a good standard requires an understanding of the concepts involved. It requires much practice before it is assessed.

The following steps are recommended to ensure that this important skill is developed by students and properly tested by the teacher (See Guidelines for the School-Based Assessment for further details):

1. The problem selected should preferably be one which allows for different feasible routes to a solution, and should give opportunities for resourcefulness.
2. Less than full instructions should be given for typical experiments. The fewer the Instructions the greater the test of the student's ability to plan and design.
3. Allow candidates to plan the sequence of steps in the identification of unknown substances. For example, candidates could be given test tubes of substances labelled A, B, C and so on, and be required to decide from a separate list of the names of the substances (not given in the correct order) the identity of each one using only the substances given in the test tubes, or a given set of reagents.

They should be required to prepare a clear logical plan of the procedure before carrying out the investigation. This should include a list of requirements, precautions necessary, and the significance of each step proposed. They should then be required to explain how the results will be interpreted, including the relevant equations.

## CARIBBEAN EXAMINATIONS COUNCIL

### SCHOOL-BASED ASSESSMENT IN CHEMISTRY

NAME OF SCHOOL: \_\_\_\_\_ SCHOOL CODE: \_\_\_\_\_ YEAR OF FINAL EXAMINATION: \_\_\_\_\_

NAME OF TEACHER: \_\_\_\_\_ TERRITORY: \_\_\_\_\_

REGISTRATION NUMBER	CANDIDATES NAME	YEAR 1				TOTAL	YEAR 2				TOTAL	TOTAL		COMMENTS	
		XS MM	XS ORR	XS PD	UK AI	Year 1	XS MM	XS ORR	XS PD	UK AI	Year 2	PROFILE			OVERALL
		P3 (10)	P3 (10)	P3 (20)	P2 (20)	60	P3 (20)	P3 (20)	P3 (10)	P2 (20)	70	P3 (90)	P2 (40)		

TEACHER'S SIGNATURE: \_\_\_\_\_

PRINCIPAL'S NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

PRINCIPAL'S SIGNATURE: \_\_\_\_\_



## ◆ LIST OF SUGGESTED CHEMICALS

1. Aluminium foil.
2. Aluminium powder.
3. Aluminium Ammonium Sulfate.
4. Aqueous Ammonia,  $3 \text{ mol dm}^{-3}$ .
5. Ammonium Chloride or Ammonium Carbonate.
6. *Ammonium Nitrate*.
7. Barium Chloride or Barium Nitrate  $0.25 \text{ mol dm}^{-3}$ .
8. Bromine.
9. Calcium.
10. Calcium Carbonate, (powdered or precipitated).
11. Calcium Chloride, anhydrous.
12. Calcium Hydroxide saturated solution (filtered).
13. Calcium Nitrate.
14. Charcoal powder.
15. Copper (turnings or powder).
16. Copper, thick wire or strips.
17. Copper (II) Carbonate.
18. Copper (II) Nitrate.
19. Copper (II) Oxide.
20. Copper (II) Sulfate.
21. Ethanoic (acetic) Acid.
22. *Hydrochloric Acid*  $2 \text{ mol dm}^{-3}$ ,  $6 \text{ mol dm}^{-3}$ .

## LIST OF SUGGESTED CHEMICALS (cont'd)

23. Hydrogen Peroxide, 20 volume.
24. *Distilled water.*
25. Iodine (resublimed).
26. Iodine solution.
27. Iron nails.
28. Iron (II) Ammonium Sulfate.
29. Iron (II) Sulfide.
30. Iron (III) Chloride.
31. Lead foil.
32. Lead (II) Bromide or Lead(II)Iodide .
33. Lead Ethanoate.
34. Lead (II) Nitrate.
35. Lead (II) Oxide.
36. Litmus paper, blue and red.
37. Magnesium ribbon.
38. Manganese (IV) Oxide.
39. Marble chips.
40. Methyl orange or screened methyl orange.
41. Nitric Acid  $2 \text{ dm}^{-3}$ .
42. Phenolphthalein.
43. Potassium Bromide or Sodium Bromide.
44. Potassium Carbonate.

## LIST OF SUGGESTED CHEMICALS (cont'd)

45. Potassium Iodide  $0.5 \text{ mol dm}^{-3}$ .
46. Potassium Nitrate.
47. Potassium Permanganate (manganate (VII)).
48. Silver Nitrate  $0.1 \text{ mol dm}^{-3}$ .
49. Sodium.
50. Sodium Carbonate.
51. Sodium Carbonate hydrated (washing soda).
52. Sodium Chloride.
53. Sodium Hydrogen Carbonate.
54. Sodium Hydroxide  $2 \text{ mol dm}^{-3}$ , pellets.
55. Sodium Sulfate.
56. Sodium Sulfite.
57. Sodium Thiosulfate.
58. Steel wool.
59. Sulfuric Acid  $3 \text{ mol dm}^{-3}$ ,  $6 \text{ mol dm}^{-3}$
60. Universal indicator paper.
61. Universal indicator solution.
62. Zinc granulated or powdered.
63. Zinc Carbonate.
64. Zinc Oxide.
65. Zinc Nitrate.
66. Zinc Sulfate.
67. Ethanol.
68. *Sulfur powder.*

## ◆ SUGGESTED EQUIPMENT LIST

1. Balance ( $\pm 0.1\text{g}$ ).
2. Beakers ( $100\text{ cm}^3$ ,  $250\text{ cm}^3$ ,  $400\text{ cm}^3$ ).
3. Boiling tubes.
4. Bunsen burners.
5. Burettes ( $50\text{ cm}^3$ ).
6. Burette brushes.
7. Burette clamps or clips.
8. Capillary tubes (melting point tubes).
9. Conical flasks ( $250\text{ cm}^3$ ).
10. Crucible tongs.
11. Distillation apparatus (*simple and fractional*)
12. Dropper or teat pipettes.
13. Evaporating dishes.
14. Filter funnels.
15. Filter paper.
16. First Aid kit (1 per lab.).
17. *Fire Extinguisher (1 per lab)*
18. Gas syringes ( $100\text{ cm}^3$ ).
19. Glass rods.
20. Glass tubing.
21. Measuring cylinders ( $20\text{ cm}^3$ ,  $100\text{ cm}^3$ ) ( $1000\text{ cm}^3$  for teachers use only).
22. *Pipette fillers.*
23. Pipettes ( $25\text{ cm}^3$ ,  $20\text{ cm}^3$ ).
24. Reagent bottles.

## SUGGESTED EQUIPMENT LIST (cont'd)

25. Retort stands.
26. Rubber tubing.
27. Separating funnel.
28. Simple electrolysis apparatus (electrodes, cells, wire).
29. Spatulas.
30. Stoppers or Bungs.
31. Test tubes (125 mm x 15 mm).
32. Test tube brushes.
33. Test tube holder.
34. Test tube racks.
35. Thermometers (1° C grad.).
36. Tripods.
37. Volumetric flasks (250 cm<sup>3</sup>, 1dm<sup>3</sup>, 2dm<sup>3</sup>, - for teacher's use).
38. Wash bottles.
39. Watch glasses.
40. Wire gauzes.
41. Delivery tubes.
42. Boss heads.
43. Crucibles.
44. Stop watches.
45. Gas jars.
46. Splints.
47. Pneumatic trough.
48. *Beehive shelf.*

## ◆ RESOURCES

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## ◆ GLOSSARY

WORD/TERM	DEFINITION/MEANINGS	NOTES
annotate	add a brief note to a label	{simple phrase of a few words}
apply	use knowledge and principles to solve problems	{make inferences and conclusions; UK}
assess	present reasons for the importance of particular structures, relationships or processes	{compare the advantages and disadvantages or the merits and demerits of a particular structure, relationship or process; UK}
calculate	arrive at the solution to numerical problem	{steps should be shown; units must be included; UK}
cite	quote or refer to	{KC}
classify	divide into groups according to observable characteristics	{UK}
comment	state opinion or view with supporting reasons	{UK}
compare	state similarities and differences	{an explanation of the significance of each similarity and difference stated may be required for comparisons which are other than structural; UK}
construct	use a specific format to make or draw a graph, histogram, pie chart or other representation using data or material provided or drawn from practical investigations, build (for example, a model) draw scale diagram	{such representation should normally bear a title, appropriate headings and legend; UK}
deduce	make a logical connection between two or more pieces of information; use data to arrive at a conclusion	{UK}
define	state concisely the meaning of a word or term	{this should include the defining equation or formula where relevant; KC}
demonstrate	show, direct attention to...	{KC}
derive	to deduce, determine or extract from data by a set of logical steps some relationship, formula or result	{this relationship etc. may be general or specific; KC}

WORD/TERM	DEFINITION/MEANINGS	NOTES
describe	provide detailed factual information on the appearance or arrangement of a specific structure or the sequence of a specific process	{descriptions may be in words, drawings or diagrams or any appropriate combination. Drawings or diagrams should be annotated to show appropriate detail where necessary; KC}
determine	find the value of a physical quality	{UK}
design	plan and present, with appropriate practical detail	{where hypotheses are stated or when tests are to be conducted, possible outcomes should be clearly stated the way in which data will be analyzed and presented; XS}
develop	expand or elaborate on an idea or argument with supporting reasons	{KC/UK}
differentiate or distinguish (between or among)	state or explain briefly those differences between or among items which can be used to define the items or place them into separate categories	{KC}
discuss	present reasoned argument; consider points both for and against; explain the relative merits of a case	{UK}
draw	make a line representation of apparatus which shows accurate relationship between the parts	{A diagram is a simplified representation showing the relationship between components; KC/UK}
estimate	make an approximate quantitative judgement	{UK}
evaluate	weigh evidence and make judgements based on given criteria	{the use of logical supporting reasons for a particular point of view is more important than the view held; usually both sides of an argument should be considered; UK}
explain	give reasons, based on recall, to account for	{KC}
find	locate a feature or obtain as from a graph	{UK}
formulate	devise a hypothesis	{UK}
identify	name or point out specific components or features	{KC}



WORD/TERM	DEFINITION/MEANINGS	NOTES
illustrate	show clearly by using appropriate examples or diagrams, sketches	{KC/UK}
investigate	use simple systematic procedures to observe, record data and draw logical conclusions	{XS}
label	add names to identify structures or parts indicated by pointers	{KC}
list	itemise without detail	{KC}
measure	take accurate quantitative readings using appropriate instruments	{XS}
name	give only the name of	{no additional information is required; KC}
note	write down observations	{XS}
observe	pay attention to details which characterise reaction or change taking place; to examine and note scientifically	{observations may involve all the senses or extensions of them but would normally exclude the sense of taste; XS}
plan	prepare to conduct an exercise	{XS}
predict	use information provided to arrive at a likely conclusion or suggestion possible outcome	{UK}
record	write an accurate description of the full range of observations made during a given procedure	{this includes the values for any variable being investigated; where appropriate, recorded data may be depicted in graphs, histograms or tables; XS}
relate	show connections between; explain how one set of facts or data depend on others or are determined by them	{UK}
sketch	Make a simple freehand diagram showing relevant proportions and any important details	{KC}
state	provide factual information in concise terms omitting explanations	{KC}

<b>WORD/TERM</b>	<b>DEFINITION/MEANINGS</b>	<b>NOTES</b>
suggest	offer an explanation deduced from information provided or previous knowledge. (... an hypothesis; provide a generalisation which offers a likely explanation for a set of data or observations.)	{no correct or incorrect solution is presumed but suggestions must be acceptable within the limits of scientific knowledge; UK}
test	to find out following set procedures	{XS}

### **KEY TO ABBREVIATIONS**

- KC - Knowledge and Comprehension
- UK - Use of Knowledge
- XS - Experimental Skills

**Western Zone Office**  
**24 September 2012**

**CARIBBEAN EXAMINATIONS COUNCIL®**

**Caribbean Secondary Education Certificate  
(CSEC)®**



# **CHEMISTRY**

**Specimen Papers and Mark Schemes/Keys**

Specimen Papers:	Paper 01 Paper 02 Paper 03/2
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Mark Schemes/Keys:	Paper 02 Paper 03/2
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**FORM 01212010/SPEC 2012****CARIBBEAN EXAMINATIONS COUNCIL****CARIBBEAN SECONDARY EDUCATION CERTIFICATE®  
EXAMINATION****CHEMISTRY****SPECIMEN PAPER****Paper 01 – General Proficiency***1 hour 15 minutes***READ THE FOLLOWING INSTRUCTIONS CAREFULLY.**

1. This paper consists of 60 items. You will have one hour and 15 minutes to answer them.
2. In addition to this test booklet, you should have an answer sheet.
3. Each item in this test has four suggested answers, lettered (A), (B), (C) and (D). Read each item you are about to answer and decide which choice is best.
4. On your answer sheet, find the number which corresponds to your item and shade the space having the same letter as the answer you have chosen. Look at the sample item below.

## Sample Item

The SI unit of length is the

- (A) metre
- (B) newton
- (C) second
- (D) kilogram

Sample Answer

The best answer to this item is “metre”, so answer space (A) has been shaded.

5. If you want to change your answer, erase it completely before you fill in your new choice.
6. When you are told to begin, turn the page and work as quickly and as carefully as you can. If you cannot answer an item, omit it and go on to the next one. You can return to the omitted item later. Your score will be the total number of correct answers.
7. You may do any rough work in this booklet.
8. Figures are not necessarily drawn to scale.
9. The use of silent electronic calculators is allowed.

**DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.**

Items 1 - 2 refer to the table below which presents two physical properties of four substances at room temperature (28 °C) . In answering the items, each of the options below may be used once or not at all.

Substance	Melting Point (°C)	Boiling Point (°C)
P	-285	-183
Q	800	1400
R	190	180
S	-20	350

- (A) P only
- (B) R only
- (C) P and S only
- (D) Q and R only

Which substance(s)

1. will have fast moving particles?
2. will be solid(s)?
3. At a stage in the process of extracting sucrose from sugar cane, *lime* is added to the sucrose solution in order to
  - (A) lower the pH of the solution
  - (B) raise the pH of the solution
  - (C) stop the sucrose changing into sugars
  - (D) increase the percentage of sugar that would crystallize out

4. A mixture of copper(II) chloride solution and copper(II) oxide could BEST be separated by

- (A) distilling the mixture
- (B) heating the mixture and condensing
- (C) shaking with excess water and then filtering
- (D) shaking with excess water followed by fractional distillation

5. Which of the following halogens is a liquid at room temperature?

- (A) Bromine
- (B) Fluorine
- (C) Chlorine
- (D) Iodine

6. Which of the following compounds does NOT consist of individual molecules?

- (A) Ethane
- (B) Ethanol
- (C) Hydrogen chloride
- (D) Sodium chloride

7. Which of the following salts are soluble in water?

- I. Ammonium carbonate
- II. Barium sulfate
- III. Lead nitrate

- (A) I and II only
- (B) I and III only
- (C) II and III only
- (D) I, II and III

---

8. The ionic equation between zinc and sulfuric acid can BEST be represented by

- (A)  $\text{Zn(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- (B)  $\text{Zn(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{H}_2(\text{g})$
- (C)  $\text{Zn(s)} + \text{H}_2\text{SO}_4 \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{H}_2(\text{g})$
- (D)  $\text{Zn(s)} + 2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{H}_2(\text{g})$

9. In which of the following compounds does manganese have an oxidation number of +7?
- (A) MnO
  - (B) MnO<sub>2</sub>
  - (C) Mn<sub>2</sub>O<sub>3</sub>
  - (D) KMnO<sub>4</sub>

Items 10 - 12 refer to the following information.

A compound when treated with aqueous sodium hydroxide and warmed gives off a colourless gas which turns moist red litmus paper blue.

10. The gas given off is
- (A) ammonia
  - (B) sulfur dioxide
  - (C) nitrogen dioxide
  - (D) hydrogen sulfide
11. The aqueous sodium hydroxide is acting as
- (A) a base
  - (B) an acid
  - (C) a catalyst
  - (D) a reducing agent
12. The compound is MOST LIKELY
- (A) iron(III) oxide
  - (B) sodium nitrate
  - (C) ammonium nitrate
  - (D) aluminium hydroxide
13. Which of the following can act as oxidising agents?
- I. Metallic ions
  - II. Metallic atoms
  - III. Non-metallic atoms
- (A) I only
  - (B) II only
  - (C) I and III only
  - (D) II and III only

14. In the electrolysis of concentrated copper(II) chloride solution using carbon electrodes, the substance formed at the anode is
- (A) carbon
  - (B) copper
  - (C) oxygen
  - (D) chlorine

15. Which of the following substances will NOT conduct electricity?
- (A) Solid calcium
  - (B) Molten calcium
  - (C) Solid calcium chloride
  - (D) A solution of calcium chloride in water

16. Which of the following statements about isotopes is NOT true?
- (A) Diseases can be diagnosed and treated using radioisotopes.
  - (B) The age of archaeological specimens can be determined using C-12 dating.
  - (C) In artificial pacemakers, plutonium-238 is used in the thermoelectric batteries.
  - (D) Nuclear power stations use the fission of uranium-235 as a source of energy.

17. Which of the properties below will decrease down the group F, Cl, Br, and I?
- I. Atomic radius
  - II. Electronegativity
  - III. Oxidising power
- (A) I only
  - (B) I and II only
  - (C) II and III only
  - (D) I, II and III

18. The layer-like arrangement of graphite and the weak bonds between the layers determine that graphite is

(A) colourless and transmit light  
(B) very hard with a high density  
(C) greasy and used as a lubricant  
(D) a good conductor of electricity

19. Which of the following copper(II) compounds is LEAST suitable for preparing copper(II) sulfate by reacting with dilute sulfuric acid?

(A) Oxide  
(B) Chloride  
(C) Carbonate  
(D) Hydroxide

20. Which of the following statements would be correct if diamond and graphite are allotropes?

I Both can be represented by the symbol C.  
II Both have a relative atomic mass equal to that of carbon.  
III They have similar physical properties.

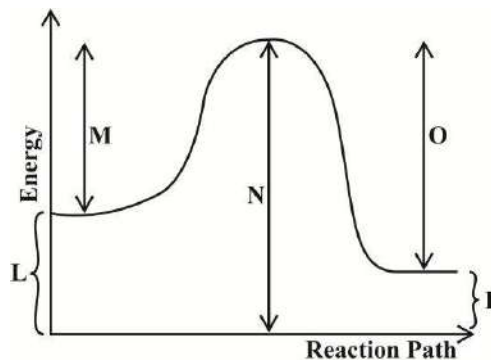
(A) I and II only  
(B) I and III only  
(C) II and III only  
(D) I, II and III

21. Which of the following bonds can be formed by an atom of hydrogen?

I. An ionic bond by losing an electron  
II. An ionic bond by gaining an electron  
III. A covalent bond by sharing a pair of electrons

(A) I and II only  
(B) I and III only  
(C) II and III only  
(D) I, II and III

Items 22 - 24 refer to the following energy-profile diagram.



22. Which letter in the diagram denotes the energy necessary for the reaction to take place?

(A) L  
(B) M  
(C) N  
(D) O

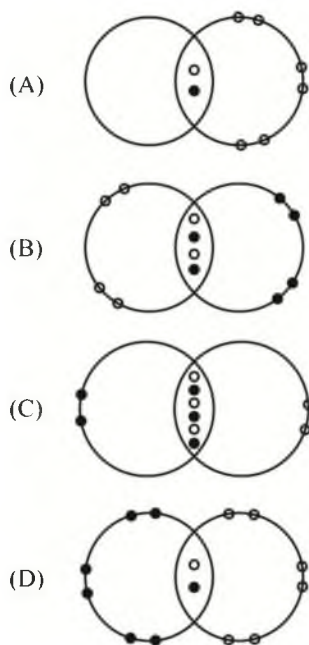
23. Which of the following equations is correct for  $\Delta H$  (enthalpy change)?

(A)  $\Delta H = P - L$   
(B)  $\Delta H = O - M$   
(C)  $\Delta H = L - M$   
(D)  $\Delta H = M - N$

24. Which of the following statements about the forward reaction is NOT true?

(A)  $\Delta H$  is negative.  
(B) The reaction is exothermic.  
(C) The energy content of the product is greater than that of the reactant.  
(D) The energy necessary for the reverse reaction is greater than that for the forward reaction.

25. Which of the following diagrams BEST illustrates bonding of nitrogen?



26. Oxygen,  ${}^8_{16}\text{O}$ , occurs before neon,  ${}^{10}_{20}\text{Ne}$ , in the periodic table because oxygen

- (A) is a better oxidising agent than neon  
(B) has fewer protons on its atom than neon  
(C) reacts with metals more readily than neon  
(D) has a smaller relative atomic mass than neon

Items 27 - 30 refer to the following information.

A piece of calcium is added to some distilled water in a container and the following observations are recorded.

- The reaction is rapid.
- Bubbles of gas evolve.
- A white suspension forms.
- Temperature increases.

27. The gas evolved would be expected to

- (A) relight a glowing splint  
(B) decolourize acidified aqueous potassium manganate(VII)  
(C) give a 'pop' with a lighted splint  
(D) turn acidified aqueous potassium dichromate green

28. Calcium forms a white suspension in water because its

- (A) hydroxide is slightly soluble  
(B) carbonate is insoluble  
(C) oxide is slightly soluble  
(D) sulfate is insoluble

29. A sample of the suspension is filtered and the pH of the filtrate determined. The expected pH of the filtrate should be approximately

- (A) 3  
(B) 5  
(C) 7  
(D) 10

30. The increase in temperature shows that

- (A) bonds in the products are formed  
(B) bonds in the reactants are broken  
(C) the products contain less energy than the reactants  
(D) the reactants contain less energy than the products



31. Which of the following quantities of acid can exactly neutralise 40 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> sodium hydroxide?

- I. 10 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> hydrochloric acid
- II. 10 cm<sup>3</sup> of 4.0 mol dm<sup>-3</sup> sulfuric acid
- III. 20 cm<sup>3</sup> of 4.0 mol dm<sup>-3</sup> nitric acid

- (A) I only
- (B) II only
- (C) I and II only
- (D) II and III only

32. Epsom salts (magnesium sulfate) is widely used. Which of the following statements are true of this salt?

- I. It relaxes the muscles.
- II. It sedates the nervous system.
- III. It is used as a supplement for plant growth.

- (A) I and II only
- (B) I and III only
- (C) II and III only
- (D) I, II and III

33. Which of the following acids is important for healing wounds?

- (A) Lactic
- (B) Ascorbic
- (C) Ethanoic
- (D) Methanoic

34. Which of the following classifications is correct?

	<b>BASIC OXIDE</b>	<b>ACIDIC OXIDE</b>	<b>NEUTRAL OXIDE</b>
(A)	Sodium oxide	aluminium oxide	water
(B)	Sodium oxide	carbon dioxide	sulfur (IV) oxide
(C)	Sulfur(IV) oxide	calcium oxide	carbon monoxide
(D)	Copper(II) oxide	carbon dioxide	carbon monoxide

---

Items **35 – 38** refer to the following options.

- (A) Propene
- (B) Methane
- (C) Bitumen
- (D) Medicinal paraffin

Match EACH item below with one of the options above. Each may be used once, more than once or not at all.

- 35. Is a major constituent of natural gas.
- 36. Is the residue in the fractional distillation of petroleum.
- 37. Requires the least oxygen per mole for complete combustion.
- 38. Is used in making plastics.

39. An organic compound X has a relative molecular mass between 40 and 50. On shaking it with bromine, the mixture quickly turns colourless. From this information, X could be

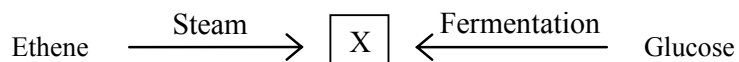
- (A) C<sub>2</sub>H<sub>4</sub>
- (B) C<sub>3</sub>H<sub>6</sub>
- (C) CH<sub>3</sub>CO<sub>2</sub>H
- (D) C<sub>2</sub>H<sub>5</sub>OH

40. Ethanol may be used as a fuel because it

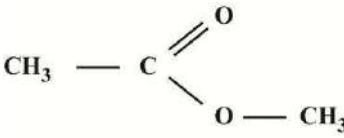
- (A) is easily converted to ethane
- (B) is easily converted to carbon
- (C) has a low heat of formation
- (D) has a high heat of combustion

41. Unsaturated compounds show addition reactions but saturated compounds do not because
- (A) saturated compounds contain double bonds
  - (B) unsaturated compounds contain multiple bonds
  - (C) unsaturated compounds contain single C-C bonds only
  - (D) saturated compounds are much more reactive than unsaturated compounds

42. The diagram below shows some reactions.



What is the product X?

- (A) Carbon
  - (B) Ethane
  - (C) Ethanol
  - (D) Carbon dioxide
- 
43. What is the name of the following compound?
- 
44. Which of the following substances is a well-known polyamide?
- (A) Nylon
  - (B) Plastic
  - (C) Bakelite
  - (D) Polystyrene
- (A) Ethyl ethanoate
  - (B) Ethyl methanoate
  - (C) Methyl ethanoate
  - (D) Methyl propanoate
45. Which of the following equations represents a condensation reaction?
- (A)  $\text{CH}_3\text{CH}_2\text{CH}_3 + \text{Br}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{HBr}$
  - (B)  $\text{CH}_3\text{CH}=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3-\text{CH}_2-\text{CH}_2\text{Br}$
  - (C)  $\text{CH}_3\text{CH}_2\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{COONa} + \text{H}_2\text{O}$
  - (D)  $\text{CH}_3\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$

46. Which of the following names is correct for the compound whose formula is  $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2\text{OH}$ ?
- (A) n-propanol  
(B) n-butanol  
(C) 2-propanol  
(D) 2-butanol
47. Addition of hydrochloric acid to a solution of metallic nitrate gives a white precipitate which is insoluble in water but soluble in aqueous ammonia. The metallic nitrate is **LIKELY** to be
- (A) silver nitrate  
(B) lead(II) nitrate  
(C) barium nitrate  
(D) zinc nitrate
48. A colourless gas with a pungent odour turns blue litmus paper red and turns filter paper dipped in acidified potassium dichromate from orange to green.
- This gas is
- (A) ammonia  
(B) chlorine  
(C) sulfur dioxide  
(D) nitrogen dioxide
49. Cryolite is important in the extraction process because it
- (A) functions as the electrolyte  
(B) reacts with oxygen  
(C) protects the carbon anode  
(D) lowers the melting point of the electrolyte
50. During electrolysis the carbon anode tends to
- (A) react with the cryolite  
(B) be oxidised by oxygen  
(C) dissolve in the electrolyte  
(D) be oxidised by fluorine from cryolite
51. Which of the following materials is used for the cathode?
- (A) Iron  
(B) Carbon  
(C) Copper  
(D) Mercury
- 
52. A white metallic hydroxide, X, undergoes no colour change when heated. It dissolves in both dilute sulfuric acid and sodium hydroxide solutions. The metallic hydroxide is **MOST** likely
- (A)  $\text{Al}(\text{OH})_3$   
(B)  $\text{Zn}(\text{OH})_2$   
(C)  $\text{Pb}(\text{OH})_2$   
(D)  $\text{Ca}(\text{OH})_2$
53. Which of the following elements is **MOST** electropositive?
- (A) Zinc  
(B) Calcium  
(C) Aluminium  
(D) Magnesium
54. To positively identify sulfur dioxide gas, a strip of paper is soaked in an aqueous solution of
- (A) blue litmus  
(B) iron(II) sulfate  
(C) lead(II) ethanoate  
(D) potassium dichromate(VI)

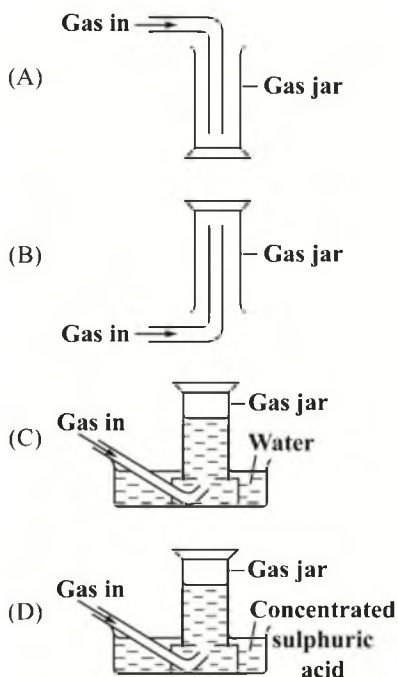
55. Which of the following substances can cause temporary hardness of water?

- (A) Calcium carbonate
- (B) Magnesium carbonate
- (C) Calcium hydrogen carbonate
- (D) Sodium hydrogen carbonate

56. Which of the following reactions is likely to take place MOST readily?

- (A)  $\text{Zn(s)} + \text{Pb(NO}_3)_2(\text{aq}) \rightarrow \text{Zn(NO}_3)_2(\text{aq}) + \text{Pb(s)}$
- (B)  $\text{Zn(s)} + \text{Fe(NO}_3)_2(\text{aq}) \rightarrow \text{Zn(NO}_3)_2(\text{aq}) + \text{Fe(s)}$
- (C)  $\text{Zn(s)} + \text{Cu(NO}_3)_2(\text{aq}) \rightarrow \text{Zn(NO}_3)_2(\text{aq}) + \text{Cu(s)}$
- (D)  $\text{Zn(s)} + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Zn(NO}_3)_2(\text{aq}) + 2\text{Ag(s)}$

Items 57 – 58 refer to the following diagrams which illustrate four methods of collecting gases. Choose the diagram, (A), (B), (C) or (D), which corresponds to each item. Each diagram may be used once, more than once or not at all.



Which of the above methods is suitable for collecting

- 57. moist oxygen?
- 58. carbon dioxide?

Item 59 – 60 refer to the following information.

A solution of iron(II) sulfate is added until in excess to a solution of barium nitrate. The precipitate produced is filtered off and water is added to the residue in the filter paper.

59. The colour of the precipitate produced is

- (A) green
- (B) white
- (C) orange
- (D) yellow

60. With which of the following solutions would the filtrate produce a precipitate?

- I. Barium chloride
- II. Aqueous ammonia
- III. Sodium hydroxide

- (A) I and II only
- (B) I and III only
- (C) II and III only
- (D) I, II and III

**END OF TEST**

**IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK FIRST**

CARIBBEAN EXAMINATIONS COUNCIL  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE®  
EXAMINATION

CHEMISTRY

SPECIMEN PAPER

Paper 02 – General Proficiency

*2 hours 30 minutes*

**READ THE FOLLOWING INSTRUCTIONS CAREFULLY.**

1. This paper consists of SIX compulsory questions.
2. Write your answers in THIS booklet.
3. For Section A, write your answer to EACH question in the space provided after each part of the question.
4. For Section B, write your answers in the spaces provided at the end of the entire question.
5. The use of silent, non-programmable calculators is allowed.
6. Return this booklet at the end of the examination.

**DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.**

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## SECTION A

Answer ALL Questions.

Write your answers in the spaces provided for each part of the question.

Do NOT spend more than 30 minutes on Question 1.

1. (a) Steve knows that hydrogen peroxide decomposes to produce oxygen and water, and that catalysts can be used to speed up this reaction.

Steve conducted a series of experiments to investigate the effect of the mass of catalyst on the rate of decomposition of hydrogen peroxide. For each experiment, he combined a different mass of the catalyst, manganese dioxide ( $\text{MnO}_2$ ), with  $50 \text{ cm}^3$  of  $0.8 \text{ mol dm}^{-3}$  hydrogen peroxide solution and measured the volume of oxygen produced. He then calculated the rate of the reaction for each quantity of catalyst used and recorded the information in Table 1.

TABLE 1: RATE OF REACTION BY MASS OF MANGANESE DIOXIDE

Mass of Manganese Dioxide (g)	Rate of Reaction ( $10^{-3} \text{ g O}_2 \text{ s}^{-1}$ )
0.7	0.6
1.0	1.3
2.0	2.5
3.0	3.8
4.0	5.0

- (i) Define the term 'rate of reaction'.

\_\_\_\_\_  
\_\_\_\_\_  
(1 mark)

- (ii) Write a **balanced** chemical equation to show the decomposition of hydrogen peroxide.

\_\_\_\_\_  
(2 marks)

- (iii) Use the axes in Figure 1 on page 3 to plot a graph showing rate of reaction versus mass of manganese dioxide.

(3 marks)

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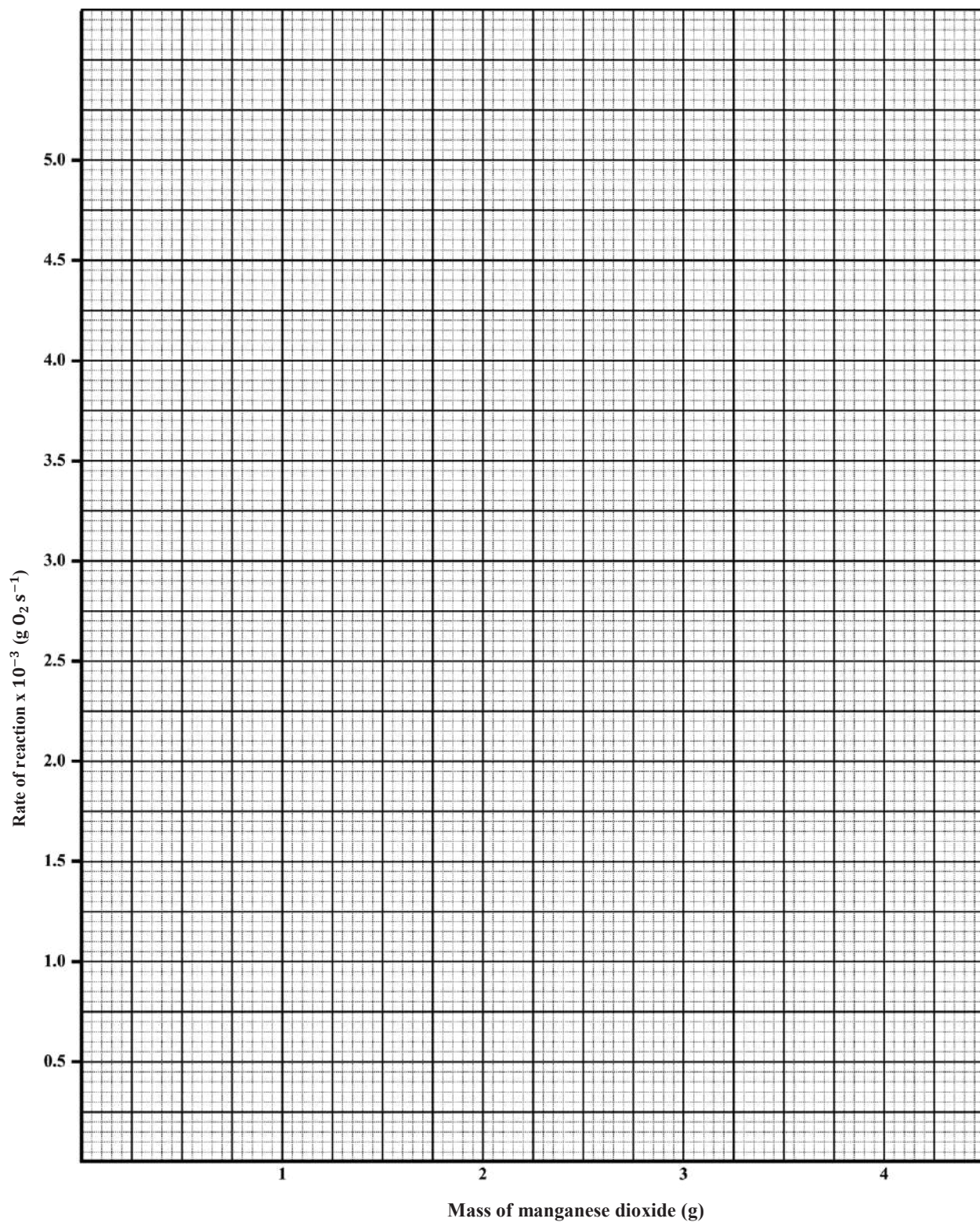


Figure 1. Rate of reaction versus mass of manganese dioxide

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- (iv) From the graph, describe the relationship between the rate of reaction and the mass of the catalyst.

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**(2 marks)**

- (v) Explain how the catalyst affects the rate of the reaction as described in (a)(iv).

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**(2 marks)**

- (vi) From the graph, determine the mass of oxygen produced after 10 s using 3.5 g of the catalyst.

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**2 marks)**

- (vii) Draw a diagram of the apparatus that Steve should use for conducting this experiment and collecting the gas.

**(3 marks)**

- (viii) Steve conducted another experiment to compare the rate of decomposition of  $0.3 \text{ mol dm}^{-3}$  hydrogen peroxide using the same amounts of  $\text{MnO}_2$ . On the same axes in Figure 1, sketch a graph to show how the rate of production of oxygen compares with that from Experiment 1.

**(2 marks)**



- (b) Tara needed to identify an unknown compound, X. She carried out a number of tests on an aqueous solution of X and recorded some of her results in Table 2. Complete Table 2 by inserting the missing inferences.

**TABLE 2: OBSERVATIONS AND INFERENCES**

<b>Test</b>	<b>Observation</b>	<b>Inference</b>
To a sample of Solution X, aqueous ammonia was added until in excess.	Light blue precipitate is soluble in excess to produce deep blue solution.	<b>(1 mark)</b>
Powdered zinc was added to a sample of Solution X.	A red/brown solid is produced and the blue liquid gets paler.	Ionic equation is required. <b>(3 marks)</b>

- (c) Tara has a sample of sodium chloride which became contaminated by a small amount of sand and iodine crystals. List the steps that Tara should perform to remove the iodine and sand from the mixture in order to obtain pure sodium chloride.

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**(4 marks)**

**Total 25 marks**

2. (a) Study Table 3 which presents a portion of the periodic table with Q, R, T, W and X representing some elements, and answer the questions which follow.

**TABLE 3: REPRESENTATION OF THE PERIODIC TABLE**

<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>	<b>VI</b>	<b>VII</b>	<b>VIII</b>
${}^3\text{Li}$							${}_{20}\text{Ne}$
	X				Q	R	
W	${}_{20}\text{Ca}$						T

- (i) Identify an alkaline-earth metal.

\_\_\_\_\_ (1 mark)

- (ii) Which of the elements shown has the HIGHEST atomic number?

\_\_\_\_\_ (1 mark)

- (iii) Which element will form ions with oxidation number of  $-2$ ?

\_\_\_\_\_ (1 mark)

- (iv) R reacts with W to form a compound.

- a) What type of bonding takes place when R reacts with W?

\_\_\_\_\_ (1 mark)

- b) Draw a dot and cross diagram to show the bonding between R and W.

**(3 marks)**

- (v) R reacts vigorously with water to form a solution. A gas is evolved.
- a) What would you observe when the solution is tested with red or blue litmus paper?

\_\_\_\_\_

(1 mark)

- b) Describe a suitable test to identify the gas evolved in (a) (v) .

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2 marks)

- (b) (i) Define the term 'heat of neutralization'.

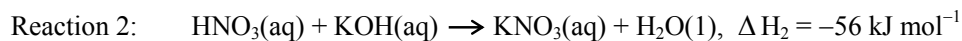
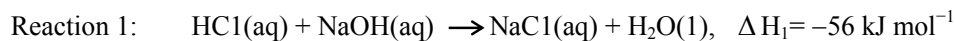
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2 marks)

The equations below represent the reactions between strong acids and strong alkalis.



- (ii) Write an ionic equation to represent ONE of the reactions.

\_\_\_\_\_

(2 marks)

- (iii) The values  $\Delta H_1$  and  $\Delta H_2$  are approximately the same. Suggest a reason for this.

\_\_\_\_\_

(1 mark)

**Total 15 marks**

3. Pentane and pentene are two hydrocarbons.

(a) (i) Write the name of the homologous series for:

Pentane \_\_\_\_\_

Pentene \_\_\_\_\_

**(2 marks)**

(ii) Draw the FULLY displayed unbranched structure of pentane.

**(2 marks)**

(iii) Write a **balanced** chemical equation to show the conversion of pentene to pentane.

\_\_\_\_\_ **(2 marks)**

(b) (i) Define the term 'structural isomerism'.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**(2 marks)**

(ii) Draw a FULLY displayed structure of **another** isomer with the SAME molecular formula as pentane.

**(2 marks)**

(iii) State the name of the isomer in (b) (ii).

\_\_\_\_\_ **(1 mark)**

GO ON TO THE NEXT PAGE

- (c) (i) What chemical tests may be used to distinguish between pentane and pentene?

Reagents \_\_\_\_\_

Observations \_\_\_\_\_

\_\_\_\_\_ (2 marks)

- (ii) State ONE use of:

Pentane \_\_\_\_\_

Pentene \_\_\_\_\_

(2 marks)

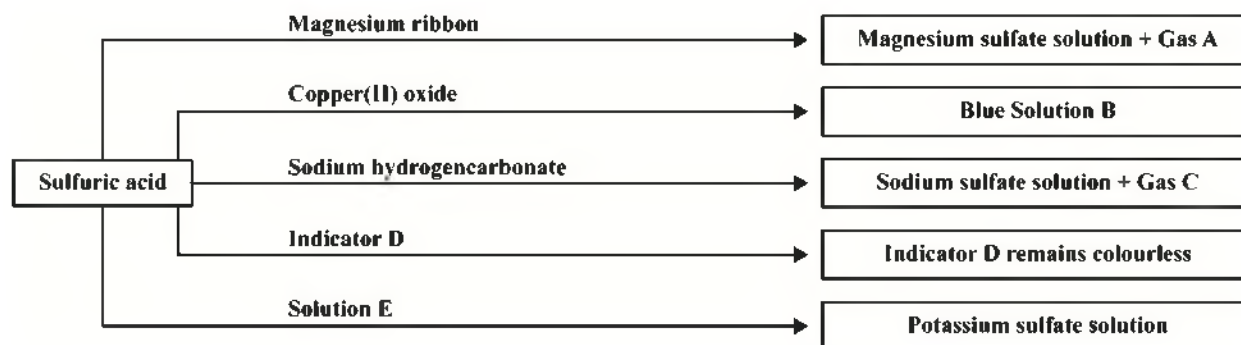
**Total 15 marks**

**SECTION B**

**Answer ALL questions in this section.**

**Write your answers in the spaces provided at the end of the question.**

4. (a) Figure 2 shows some reactions of dilute sulfuric acid. Use the figure to answer the questions which follow.



**Figure 2. Some reactions of dilute sulfuric acid.**

Identify EACH substance labeled A, B, C, D and E respectively.

**(5 marks)**

- (b) Some people suffer from indigestion when their stomach produces excess acid. The label on a household brand of indigestion tablet is shown below.

<p style="text-align: center;"><b>INDIGESTION TABLETS</b></p> <p style="text-align: center;">CONTAINS: Magnesium carbonate</p> <p style="text-align: center;"><b>INSTRUCTIONS:</b></p> <p style="text-align: center;">Take 1 or 2 tablets as required.</p> <p style="text-align: center;">Chew properly before swallowing.</p>
--

- (i) Magnesium carbonate is insoluble in water. Magnesium carbonate is mixed with water and strips of blue litmus paper are dipped into the mixture. What colour change is observed in the litmus paper?

**(1 mark)**

- (ii) Explain why the instructions suggest that the tablets be chewed before swallowing?

**(2 marks)**

- (iii) The acid present in the stomach is hydrochloric acid. Write a balanced equation for the reaction taking place in the stomach when the tablet is swallowed.

**(2 marks)**

**GO ON TO THE NEXT PAGE**

- (iv) Name this type of reaction. **(1 mark)**
  
- (v) A gas is produced from the reaction in 4(b)(iii). How can you test for this gas in the laboratory? **(2 marks)**
  
- (c) Car batteries contain strong sulfuric acid. In treating a spillage from a car battery, washing soda is added to the affected area. Write an ionic equation to show the reaction of washing soda with sulfuric acid. **(2 marks)**

**Total 15 marks**

**Write the answer to Question 4 here.**

- (a)
  - (i) Gas A \_\_\_\_\_
  - (ii) Solution B \_\_\_\_\_
  - (iii) Gas C \_\_\_\_\_
  - (iv) Indicator D \_\_\_\_\_
  - (v) Solution E \_\_\_\_\_

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5. Iron can be extracted from its ore by reduction.
- (a) (i) Define 'reducing agent' in terms of oxidation number. **(2 marks)**
- (ii) Name a reducing agent that could be used to extract iron from its ore. **(1 mark)**
- (iii) Write a **balanced** chemical equation to show the reduction of iron ore with the reducing agent you have named in 5(a)(ii). **(2 marks)**
- (b) Compounds containing iron(II) ions can act as reducing agents.
- (i) What would be observed when iron(II) ions react with hydrogen peroxide. **(2 marks)**
- (ii) Write an ionic half equation to show iron(II) ions acting as reducing agents. **(2 marks)**
- (iii) With reference to oxidation numbers, explain why the equation below is a redox reaction.  
$$\text{Fe(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{Cu(s)} + \text{FeSO}_4(\text{aq})$$
 **(3 marks)**
- (iv) What colour change would you expect to see in the reaction above? **(1 mark)**
- (c) Describe ONE harmful effect on the body of EACH of the following
- (i) Lack of iron **(1 mark)**
- (ii) Carbon monoxide **(1 mark)**

**Total 15 marks**

**Write the answer to Question 5 here.**

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6. (a) Water has been shown to have unique properties which relate to many of its uses in living systems.
- (i) Draw a dot and cross diagram to show the bonding in the water molecule. **(2 marks)**
  - (ii) State THREE properties of water which can be considered **unique**. **(3 marks)**
  - (iii) Relate ONE of the properties you have stated in 6(a)(ii) to the structure and bonding of water molecules. **(2 marks)**
- (b) “The properties of water contribute to the problem of water pollution”.
- (i) State TWO reasons to support this statement. **(2 marks)**
  - (ii) List THREE **major** sources of water pollution. **(3 marks)**
  - (iii) The use of natural cleaners is one method of reducing water pollution and is considered one way of applying the principles of ‘Green Chemistry’. Explain why this is one way of applying ‘Green Chemistry’. **(3 marks)**

**Total 15 marks**

**Write the answer to Question 6 here.**

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EXAMINATION

CHEMISTRY

SPECIMEN PAPER

Paper 032 – General Proficiency

*2 hours 10 minutes*

**READ THE FOLLOWING INSTRUCTIONS CAREFULLY.**

1. Answer ALL questions on this paper.
2. Use your answer booklet when responding to the questions. For EACH question, write your answer in the space indicated and return the answer booklet at the end of the examination.
3. You may use a silent, non-programmable calculator to answer the questions.
4. You are advised to take some time to read through the paper and plan your answers.

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**DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.**

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1. (a) M is a  $0.07 \text{ mol dm}^{-3}$  sodium hydroxide solution. P is a solution made by diluting  $100 \text{ cm}^3$  of vinegar to  $1000 \text{ cm}^3$  with distilled water.

Titrate  $25 \text{ cm}^3$  portions of M with P using the indicator provided. These results will be used to determine the concentration of ethanoic acid in the vinegar before dilution.

- (i) Record your titration (burette) readings in Table 1.

**TABLE 1: TITRATION READINGS**

Burette Reading	Titration Number			
	1	2	3	
Final Reading ( $\text{cm}^3$ )				
Initial reading ( $\text{cm}^3$ )				
Volume of P used ( $\text{cm}^3$ )				

**(8 marks)**

- (ii) Describe the colour change of the indicator at the end point.

\_\_\_\_\_ **(1 mark)**

- (iii) Record the volume of P to be used in calculation.

\_\_\_\_\_ **(1 mark)**

- (iv) Write an equation for the reaction between ethanoic acid and sodium hydroxide.

\_\_\_\_\_ **(2 marks)**

- (v) Calculate the number of moles of sodium hydroxide in  $25 \text{ cm}^3$  of Solution M.

**(1 mark)**

- (vi) Calculate the number of moles of ethanoic acid in the volume of Solution P used.

**(1 mark)**

GO ON TO THE NEXT PAGE

(vii) Calculate the concentration, in  $\text{mol dm}^{-3}$ , of ethanoic acid in Solution P.

**(2 marks)**

(viii) Calculate the concentration, in  $\text{mol dm}^{-3}$ , of the original vinegar (before dilution).

**(1 mark)**

(b) You are provided with TWO solutions labelled R and S, and a solid T. Perform the following tests on R, S and T and record your observations in Table 2.

**TABLE 2: TESTS AND OBSERVATIONS**

Test	Observations		
	R	S	T
(i) In a test tube, add approximately $4 \text{ cm}^3$ of water to a spatula full of solid T and swirl the tube until there is no further change. To separate portions of R, S and the mixture of T obtained in (i), carry out tests (ii) – (iv).			<b>(1 mark)</b>
(ii) Add aqueous ammonia gradually until in excess.	<b>(2 marks)</b>	<b>(2 marks)</b>	<b>(2 marks)</b>
(iii) Add a few drops of aqueous potassium iodide.	<b>(1 mark)</b>	<b>(1 mark)</b>	

**Total 26 marks**

2. The data collected from an experiment to compare the effect of temperature on the solubility of two salts, Z and Q, are presented in Table 3.

**TABLE 3: SOLUBILITIES OF Z AND Q AT VARIOUS TEMPERATURES**

Temperature (°C)		0	20	40	60	80
Solubility (g per 100 g water)	Z	18	10	8	4	2
	Q	8	25	48	64	85

- (a) Using the graph paper provided on page 5, plot the data for the solubilities of Z and Q given in Table 3. Use 2 cm to represent 10 °C and 1 cm to represent 10g/100g of water.

**(6 marks)**

- (b) Describe the effect of increasing temperature on the solubilities of Z and Q respectively.

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**(2 marks)**

From your graph, determine

- (c) which salt is more soluble at 10 °C

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**(1 mark)**

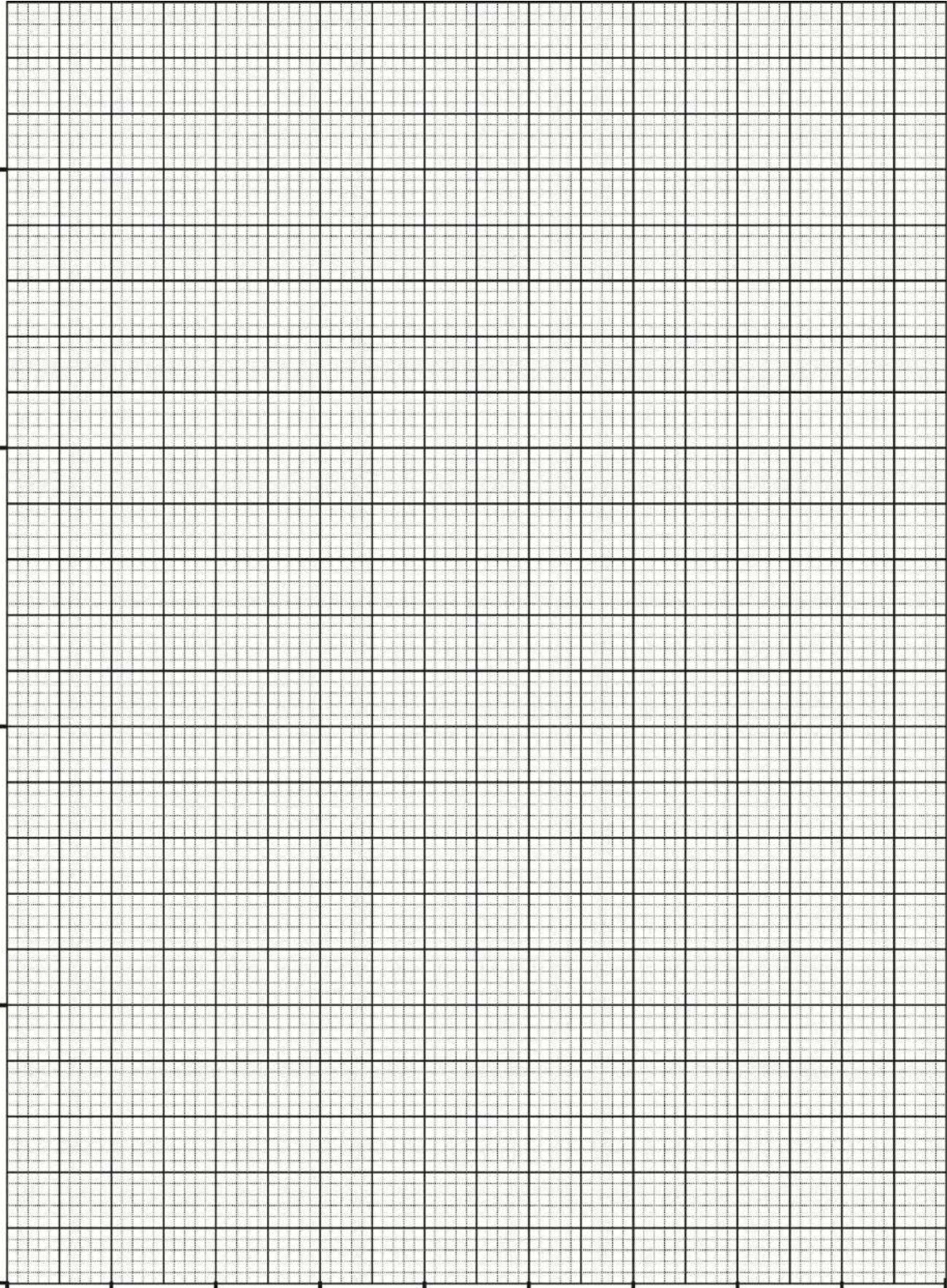
- (d) the temperature at which the solubility of Z and the solubility of Q are equal.

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**(1 mark)**

**Total 10 marks**





3. Garcia conducted an experiment to compare the rate of reaction between iron and magnesium with dilute hydrochloric acid. The rate of reaction was determined by comparing the rate of formation of the gaseous product when the two metals react with dilute acid.

(a) Describe a possible procedure that Garcia might have used for successfully conducting this experiment. In your response you should:

(i) State the manipulated (independent) and control variables.

Manipulated (Independent) variable - \_\_\_\_\_

\_\_\_\_\_

Control variable - \_\_\_\_\_

\_\_\_\_\_

**(2 marks)**

(ii) Outline the steps Garcia would take in carrying out this experiment.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**(3 marks)**

(iii) Draw a diagram to show how the apparatus would be arranged for conducting the experiment.

**(3 marks)**

- (iv) Sketch a graph to show how the rate of reaction between the two metals would differ.

**(2 marks)**

- (b) Describe a confirmatory test for the gaseous product of the reaction.

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**(2 marks)**

**Total 10 marks**

**END OF TEST**

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Item	Specific Objective	Key
1	A 1.3	A
2	A 1.3	D
3	A 2.6	B
4	A 2.5	C
5	A 4.3	A
6	A 5.2	D
7	A 7.7	B
8	A 6.5	A
9	A 8.3	D
10	C 5.2	A
11	A 7.6	A
12	C 5.2	C
13	A 8.5	C
14	A 9.8	D
15	A 9.2	C
16	A 3.7	B
17	A 4.3	C
18	A 5.7	C
19	A 7.7	B
20	A 5.8	A
21	A 5.2	D
22	A 11.2	B
23	A 11.1	A
24	A 11.1	C
25	A 5.1	C
26	A 4.1	B
27	C 6.3	C
28	C 1.1	A
29	A 7.2	D
30	A 11.1	C

Item	Specific Objective	Key
31	A 7.11	D
32	A 7.8	D
33	A 7.5	B
34	A 7.1	D
35	B 1.1	B
36	B 1.2	C
37	B 3.1	B
38	B 4.3	A
39	B 3.3	B
40	B 3.7	D
41	B 3.3	B
42	B 3.8	C
43	B 3.10	C
44	B 4.3	A
45	B 3.9	D
46	B 2.6	B
47	C 6.2	A
48	C 6.3	C
49	C 2.3	D
50	C 2.3	B
51	C 2.3	B
52	C 1.2	A
53	C 2.1	B
54	C 6.3	D
55	C 5.7	C
56	C 2.1	D
57	C 5.2	C
58	C 5.2	A
59	C 6.2	B
60	C 6.1	D

01212020/SPECIMEN PAPER/MS/2012

C A R I B B E A N E X A M I N A T I O N C O U N C I L

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CHEMISTRY

PAPER 02 - MARK SCHEME

SPECIMEN

CHEMISTRY  
PAPER 02 - GENERAL PROFICIENCY  
MARK SCHEME

Question 1

**Specific objectives: A2.5, 6.5, 6.6, 10.1, 10.3, 10.4,; C2.1, 5.2, 6.1**

- (a) (i) The rate of change in concentration of reactant or product with time.
- (ii)  $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- (iii) 4-5 points correctly plotted 2XS  
2-3 points correctly plotted 1XS  
Straight line 1xs
- (iv) The reate of production of oxygen increases with the mass of catalyst. The rate of production of oxygen is directly proportional to the mass of catalyst used.
- (v) The catalyst lowers the activation energy of the reaction causing more molecules to participate in the reaction per unit time.
- (vi) Reading from graph =  $4.4 \times 10^{-3} \text{ g s}^{-1}$  1UK  
Mass of  $\text{O}_2$  after 10 s =  $10 \times 4.4 \times 10^{-3}$  1 UK
- (vii) Airtight apparatus; gas collected over water, graduated collection device
- (viii) Straight line going through origin; smaller slope than in first plot.

(b) .

Test	Observation	Inference
To a sample of Solution X, aqueous ammonia was added until in excess	Light blue precipitate soluble in excess to produce deep blue solution	$\text{Cu}^{2+}$ ions are present (1UK)
Powdered zinc was added to a sample of Solution X	A red/brown solid is produced and the blue liquid gets paler	Copper metal produced $\text{Cu}^{2+}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Zn}^{2+}(\text{aq})$ (3UK)  Ionic equation is required.

- (c) 1. Warm gently and the iodine sublimes. (1)  
2. Add water to the remaining mixture and mix. (1)  
3. Filter to remove the sand. (1)  
4. Heat to remove the water and leave the salt. (1)

4XS

**Total 25 marks**

KC	UK	XS
1	2	3
2	2	3
2	2	3
	2	4
		4
<b>3</b>	<b>12</b>	<b>10</b>



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MARK SCHEME

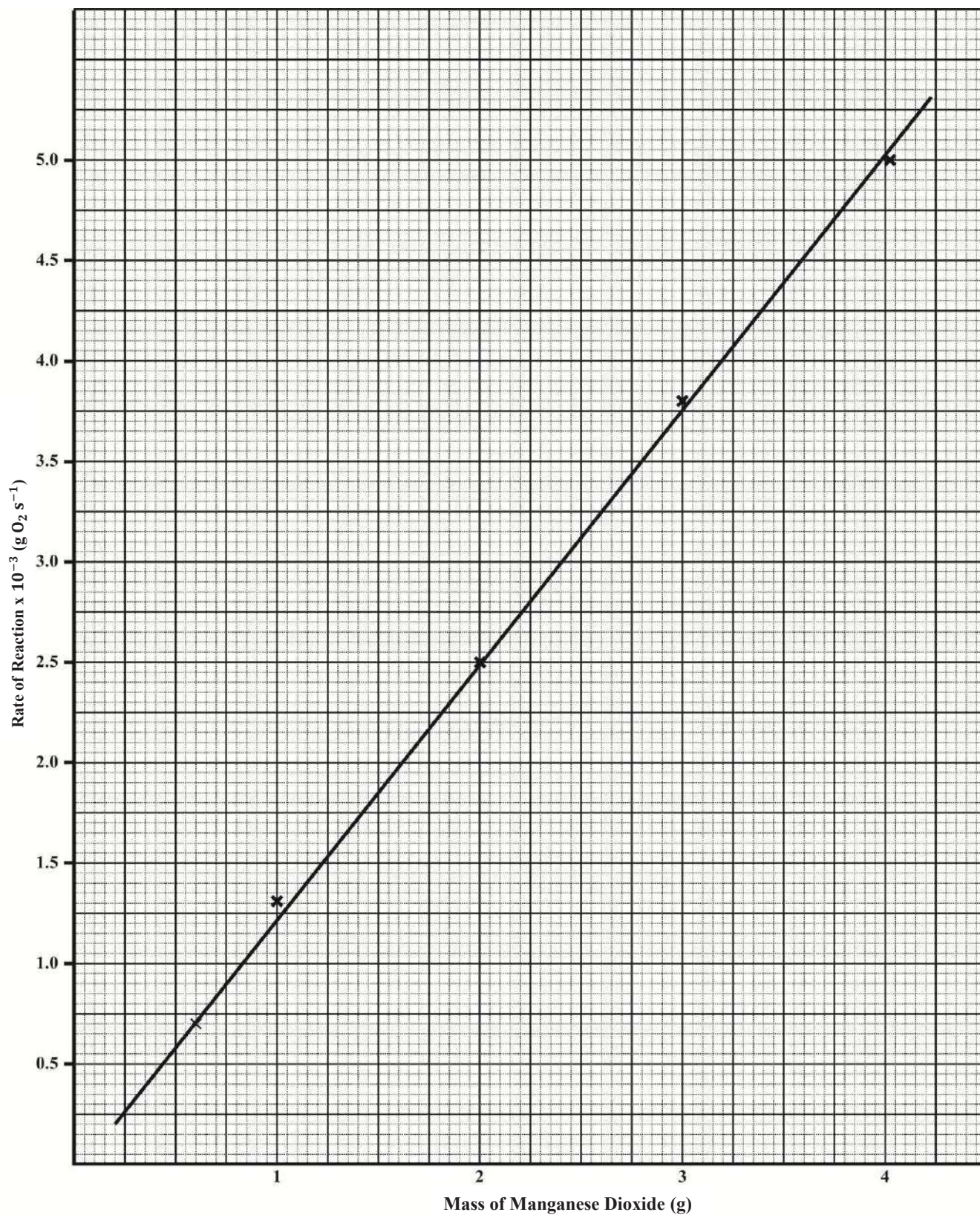


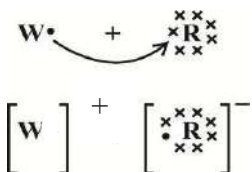
Figure 1. Rate of reaction versus mass of manganese dioxide

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MARK SCHEME

Question 2.

**Specific objectives: A4.1, 4.5, 5.1, C1.1, 6.3, A 11.3, 6.5**

- (a) (i) X  
(ii) T  
(iii) Q  
(iv) a) Electrovalent or ionic bonding



- (v) (a) Red litmus turns blue, blue litmus unchanged.  
(b) Hold a lighted splint in gas. The flame goes out with a 'pop' sound - hydrogen.
- (b) (i) The heat of neutralization is the energy change per mole of H<sub>2</sub>O formed during the neutralization of an acid by a base.  
(ii) H<sup>+</sup>(aq) + OH<sup>-</sup>(aq) → H<sub>2</sub>O (l)  
(iii) ΔH<sub>1</sub> and ΔH<sub>2</sub> are the same because in each case, one mole of water is formed.

KC	UK
1	
1	
1	
	1
	3
	1
2	
2	
	2
	1
<b>Total 15 marks</b>	<b>7</b>
	<b>8</b>



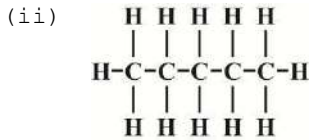
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MARK SCHEME

Question 3

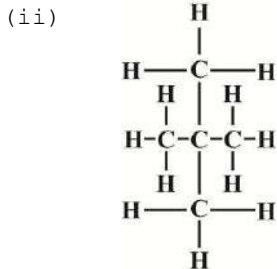
**Specific Objectives:** B2.2 - 2.8, B3.1 - 3.4

(a) (i) alkane

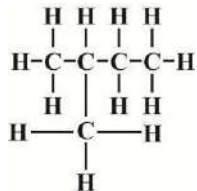
alkene



(b) (i) Structural isomerism is the occurrence of two or more organic compounds with the same molecular formula<sup>(1)</sup> but different formulae.<sup>(1)</sup>



or



(iii) 2,2-dimethylpropane or 2-methylbutane

(c) (i) Bromine water - the alkane would have no effect on bromine water. The alkene changes the reddish-brown solution to colourless.

OR

Test with  $KMnO_4$  which changes from purple to colourless upon reaction with pentene.

(ii) Fuel or solvent  
Monomer (unsaturated) to polymer

KC	UK
1	
1	
	2
	2
	2
	2
	1
	2
	2
	7
	8

TOTAL 15 marks

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MARK SCHEME

Question 4

**Specific Objectives: A7.4, 7.10, 7.5, 7.1, 6.3, 6.5**

- (a) (i) Hydrogen or H<sub>2</sub>  
 (ii) Copper sulfate or Cu SO<sub>4</sub>  
 (iii) Carbon dioxide or CO<sub>2</sub>  
 (iv) Phenolphthalein  
 (ii) Potassium hydroxide or KOH
- (b) (i) Red litmus to blue  
 (ii) Chewing: to increase surface area  
 For faster reaction  
 (iii) MgCO<sub>3</sub> + 2HCl → MgCl<sub>2</sub> + CO<sub>2</sub> + H<sub>2</sub>O Balance (1)  
 (iv) Neutralisation reaction  
 (v) CO<sub>2</sub> turns lime water(1) cloudy(1).
- (c) 2H<sup>+</sup>(aq) + CO<sub>3</sub><sup>2-</sup> → CO<sub>2</sub>(g) + H<sub>2</sub>O(l) Balanced (1)

KC	UK
1	
1	
1	
1	
1	
	1
	2
	2
1	
	2
	2
<b>6</b>	<b>9</b>

**Total 15 marks**

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MARK SCHEME

Question 5

**Specific Objectives: A8.4, 8.5; C2.3, 4.2, 5.5**

- (a) (i) A reducing agent undergoes an increase in oxidation number
- (ii) Carbon monoxide
- (iii)  $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
- (b) (i) The pale green solution becomes reddish brown/yellow
- (ii)  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$
- OR
- $\text{Fe}^2 - \text{e}^- \rightarrow \text{Fe}^{3+}$
- (iii)  $\text{Fe}^0 + \text{Cu}^{2+} \text{SO}_4^{2-} \rightarrow \text{Cu}^0 + \text{Fe}^{2+} \text{SO}_4^{2-}$   
There is a change in oxidation state for Fe and/or Cu
- (iv) Blue solution to green solution
- (c) (i) Lack of iron will affect the formation of haemoglobin which is essential for oxygen transport OR will cause anaemia.
- (ii) Carbon monoxide combines with haemoglobin resulting in death.

KC	UK
2	
1	
	2
2	
	2
	2
1	
	1
	1
	1
<b>6</b>	<b>9</b>

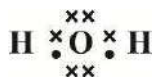
**TOTAL 15 marks**

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MARK SCHEME

Question 6

**Specific Objectives: C5.6, 5.7, 5.9, 5.10**

- (a) (i) Dot and Cross Diagram



- (ii)
- Universal solvent
  - High specific heat capacity
  - High melting and boiling point
  - Low volatility
  - Density decreases when cooled below 4°C  
(Any 3, Or any other reasonable answer)
- (iii) Universal solvent:
- Water polar so can dissolve a range of substances
  - High melting/boiling point (low volatility):  
Intermolecular forces (H-bonding) strong so lots of energy required to cause the change in state
  - Density changes: Below 4°C, presence of H-bonds prevents molecules from coming close together.  
(Or any other reasonable answer.)
- (b) (i) Water universal solvent(1) so will dissolve many pollutants.(1)
- (ii) Sources of water pollution: Farm run-off, sewage, household waste, industrial waste.  
Any three or any other reasonable answer
- (iii) Green Chemistry:
- A proactive approach to pollution prevention.
  - 'It involves designing chemical products and processes that reduce or eliminate the use and/or generation of hazardous substances'.  
([www.beyondbenign.org;24/04/2012](http://www.beyondbenign.org;24/04/2012))
  - Natural cleaners produce less waste/ produce non-toxic waste/ are biodegradable/ breakdown into harmless substances/ are less harmful thus reducing the chances of chemical accidents.  
(Any other reasonable answer.)

KC	UK
	2
3	
	2
	2
	1
	1
	1
<b>Total 15 marks</b>	<b>6</b>
	<b>9</b>

01212032/SPECIMEN/MS/2012

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MARK SCHEME

**Paper 3/2 – Question 1**

**Specific Objectives: A7.1, 7.2, 7.3, 7.4**

		UK	XS																				
(a)	(i)	3 sets of entries/volumes – 3 x 1 mark Accuracy +/- 0.1 cm <sup>3</sup> 5 mks +/- 0.2 cm <sup>3</sup> 4mks +/- 0.3 cm <sup>3</sup> 3 mks +/- 0.4 cm <sup>3</sup> 2 mks +/- 0.5 cm <sup>3</sup> 1 mk		8																			
	(ii)	Correct indicator colour Phenolphthalein - pink to colourless Methyl orange - yellow to pink		1																			
	(iii)	Correct volume of P based on burette readings	1																				
	(iv)	NaOH + CH <sub>3</sub> COOH → CH <sub>3</sub> COONa + H <sub>2</sub> O	2																				
	(v)	No. moles NaOH = (0.07 / 1000) x 25 = 0.00175 mol	1																				
	(vi)	No. moles acid = No. moles NaOH = 0.00175 mol	1																				
	(vii)	Let the volume of P used = y cm <sup>3</sup> y cm <sup>3</sup> contains 0.00175 mol acid 1000 cm <sup>3</sup> contains (0.00175/y) x 1000 mol = z	2																				
	(viii)	Concentration of original vinegar = z x 10	1																				
(b)		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Test</th> <th colspan="3">Observations</th> </tr> <tr> <th>R</th> <th>S</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>(i) Given</td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td>Pale blue solution formed.  (1 mark)</td> </tr> <tr> <td>(ii) Given</td> <td>White ppt. soluble in XS  (2 marks)</td> <td>White ppt. insoluble in XS  (2 marks)</td> <td>Blue ppt. insoluble in XS  (2 marks)</td> </tr> <tr> <td>(iii) Given</td> <td>No visible change  (1 mark)</td> <td>Bright yellow Ppt.  (1 mark)</td> <td style="background-color: #cccccc;"></td> </tr> </tbody> </table>	Test	Observations			R	S	T	(i) Given			Pale blue solution formed.  (1 mark)	(ii) Given	White ppt. soluble in XS  (2 marks)	White ppt. insoluble in XS  (2 marks)	Blue ppt. insoluble in XS  (2 marks)	(iii) Given	No visible change  (1 mark)	Bright yellow Ppt.  (1 mark)			9
	Test	Observations																					
		R	S	T																			
	(i) Given			Pale blue solution formed.  (1 mark)																			
(ii) Given	White ppt. soluble in XS  (2 marks)	White ppt. insoluble in XS  (2 marks)	Blue ppt. insoluble in XS  (2 marks)																				
(iii) Given	No visible change  (1 mark)	Bright yellow Ppt.  (1 mark)																					
<b>Total 26 marks</b>		<b>8</b>	<b>18</b>																				

CHEMISTRY  
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MARK SCHEME

**Question 2****Specific Objectives: B7.1, 7.2, 7.3**

		UK	XS
(a)	Axes – correct labels (2) Suitable Scale (1) Accuracy of Plot: 8 – 10 points accurately plotted - (3). 5 – 7 points accurately plotted - (2). 2 - 4 points accurately plotted - (1).		6
(b)	Increasing temperature causes solubility of <b>Z to decrease</b> and that of <b>Q to increase</b> .	2	
(c)	Correct reading based on candidate's graph	1	
(d)	Correct reading based on candidate's graph	1	
<b>Total 10 marks</b>		<b>4</b>	<b>6</b>

**Question 3****Specific Objectives: A 5.2, 5.3**

		UK	XS
(a)	(i)	Manipulated and control variables will be dependent on the procedure used for conducting the reaction. Award one mark for each.	2
	(ii)	<b>Steps for conducting expt.</b> <u>Clear and logical sequence of steps(1) that will yield gaseous product (1)and will allow for comparison of rates.(1)</u>  Award maximum of 1 mark if the procedure will allow for formation of gaseous product but will not allow for comparison of reaction rates.	3
	(iii)	<b>Diagram</b> should be airtight, allow for collection of gas and should show reactants added together.	3
	(iv)	Sketch graph – Axes labeled and rate of Mg greater than for Zn	2
(b)	Test for hydrogen. Use a lighted splint. Splint goes out with a “pop”.		2
<b>Total 12 marks</b>			<b>12</b>

**C A R I B B E A N      E X A M I N A T I O N S      C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION  
MAY/JUNE 2004**

**CHEMISTRY**

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**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION  
MAY/JUNE 2004**

**The Structure of the Examination**

The examination consisted of four papers. The contributions of the papers were as follows: Paper 01 (25%), Paper 02 (30%), Paper 03 (25%), Paper 04 (20%).

Paper 01 consisted of 60 compulsory multiple-choice items based on the specific objectives in Sections A and B of the syllabus. Items were assessed under the profile, Knowledge and Comprehension.

Paper 02, a structured essay paper, consisted of five compulsory questions based on the objectives specified in Sections A and B of the syllabus. Question 1 was a data analysis question. Candidates were assessed under three profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 04 represented the continuous School Based Assessment (SBA) of candidates' Experimental Skills and Use of Knowledge. Resit candidates who obtained  $\geq 50\%$  in their previous SBA had the option of carrying forward their earned marks to this Examination..

**General Comments**

A total of 9403 candidates were entered for the examination representing a 5.3 per cent increase over the 2003 candidate population.

Performance of candidates on Papers 02 and 03 was generally poorer than in 2003. However, the performance on Paper 01 was similar to that of the previous year. The total composite mark for the examination continues to show steady improvement over the last five years. In spite of this overall improved performance there seemed to have been a lack of syllabus coverage in certain critical areas. Section B.1 – the Organic Chemistry Section- seemed not to have been covered or understood by the candidates. The Organic Chemistry questions in both Papers 02 and 03 produced very low means. Also, there appeared to have been a lack of complete syllabus coverage of Units I and II in Section C of the syllabus.

The writing of molecular formulae and ionic equations still poses considerable difficulty. Incorrectly written formulae, for example,  $\text{No}_3$ ,  $\text{Mno}_4$ ,  $\text{NaCL}$ , appear in candidates' answers. Candidates should be encouraged to use state symbols when writing ionic equations.

Calculations involving electrolysis, as well as the mole concept, are still proving to be a challenge. Candidates have problems in arriving at mole ratios in which reactants combine. As such, they have difficulty carrying forward the calculations to completion.

## DETAILED COMMENTS

### Paper 01

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance in this paper was reasonably good. The range of marks varied from 6 to 59. Candidates experienced difficulties with items on the following topics:

Items	Syllabus Topics
6	Acid salts / normal salts
9 and 14	Recognizing oxidizing / reducing agents
16	Separation techniques
19	Effects of catalyst on a reaction
20	Properties of halogens
22	Examples of elements which exhibit allotropy
25	Characteristics of atoms
29	Calculation of volume of gas liberated given balanced equations
33	Calculation of number of electrons and neutrons in a charged species
37	Recognizing condensation reaction from a series of reactions
49	Collection of gases
53	Reagents for testing chloride ions

### Paper 02

Note: These comments should be read in conjunction with the question paper.

#### Question 1

This question was based on Section A (1.2, 3.4) and Section B2 (7.1, 7.2, 7.3) of the syllabus. It tested the ability of the candidate to:

- Read off volumes of gas in a gas syringe.
- Construct a suitable table from a set of given information.
- Plot a graph.
- Make deductions from a graph.
- Perform simple calculations based on the gas laws (given).
- Identify anions, cations, gases.
- Write ionic/balanced chemical equations.

Part (a) involved the assessment of UK and XS profiles and was the more popular part of the question. It was generally well done. Most candidates were able to construct appropriate fully labelled tables and to plot the graph. However, many had difficulties with the calculations in (a)(iii) and (a)(iv). In Part (v), on hot air balloons, most candidates simply described how a hot air balloon works (often correct) but without any reference to their graphs which is what they were required to do.

Some common errors/misconceptions which appeared in candidates' answer scripts were as follows:

- Failure to add  $100\text{cm}^3$  to the volume of gas in the syringe (in spite of the fact that they were instructed to do so). Such candidates were not able to plot the appropriate graph.
- Approximation (to the nearest whole number) of the volume of gas in the syringe.
- Difficulty converting degree Celsius to Kelvin.
- Joining of points on the graph, rather than drawing the line of best-fit. Some drew histograms and barcharts.
- Increase in temperature produces "more gas" rather than results in an increase in volume.
- Failure to use data from their graph in the calculations in Part (iii), in spite of being instructed to do so.

In Part (b), a question based on qualitative analysis, candidates were required to draw inferences and write ionic equations based on a given set of observations. They were also required to make observations based on given inferences. As was the case in previous years, this part of the question was very poorly answered. Many candidates either did not attempt this section or obtained 0 marks. It is recommended that more emphasis be placed on this topic and that students be given more practice in the answering of this type of question. It is critical for teachers to emphasise to students the need to describe, under the observation column in their qualitative analysis, what is observed when a reagent is added drop by drop with shaking, followed by what is observed in the presence of an excess of the reagent. Many candidates lost marks in Tests (iv) and (v) for failing to do so.

Some common errors/misconceptions were:

- The use of the word "solution" when what was intended was the word "precipitate". There is need for teachers to emphasise the difference between "precipitate" and "solution".
- The failure to balance and include state symbols in the ionic equations.
- Vague or incorrect description of colours of precipitates or gases.
- Writing of formulae, for example,  $\text{No}_2$  for  $\text{NO}_2$ .
- Automatically assuming that evolution of a "brown" gas implies bromine as the gas given off. Candidates should pay more attention to the tests carried out and the expected observations and inferences.

## Question 2

This question was based on Sections A (2.1, 2.8, 3.4, 4.1, 4.2, 6.2, 6.3, 6.8, 6.13) and B2 (1.1, 1.3) of the syllabus. It focused on the elements in Period Three of the periodic table and was designed to test the candidates' ability to:

- State the reasons for placing elements in the same period of the periodic table.
  - Draw suitable diagrams to show the arrangement of electrons in an atom, given its atomic number.
  - Predict with reasons the best reducing agent from among elements in a particular period.
  - Write formula and predict the type of bonding expected for a compound, given the atomic number of one of the elements in that compound.
  - Explain why certain elements exist as stable atoms in their natural state.
  - Predict which of the elements given would form a basic oxide, which readily dissolves in water.
- (a) This part of the question was generally well answered. Most candidates were familiar with the basis for placing elements in the same period of the periodic table (they should all have their valence electrons in the same major energy level/shell). However, a number of candidates incorrectly gave increasing atomic number/atomic mass/electrons as the reason for the elements being placed in the same period. Also, a number of candidates used the “peculiar” words “shelf” / “step” to indicate shells/energy levels.
- (b) Almost every candidate was able to correctly draw an appropriate diagram to show the arrangement of electrons (2, 8, 5) in a phosphorous atom (atomic number 15).
- (c) Many candidates incorrectly selected chlorine rather than sodium as the best reducing agent from among the elements in Group 3. This was stated in spite of the fact that they were able to correctly define what is a reducing agent. There thus appears to be a lack of proper understanding of the behaviour of a reducing agent in a redox reaction. Also, it was evident from some of the responses that candidates were not familiar with the fact that although many elements can act as reducing agents (or oxidising agents) some are more effective than others.
- (d) Many candidates were able to correctly write the formula for the expected chloride of silicon as  $\text{SiCl}_4$  and to indicate that the bonding would be covalent. However, a number of candidates were not able to fully account for the reasons for this. Typical vague responses which did not gain full marks were:
- Non-metals form covalent bonds by sharing their electrons.
  - Silicon will not gain or loose electrons (without any further explanation).
- (e) Most candidates correctly identified argon as the element that exists as stable atoms in its natural state. However, from the reasons given for this, it appears that there is a misconception that atoms are stable if they contain an even number of electrons in their valence shell. This misconception needs to be corrected in the classroom.

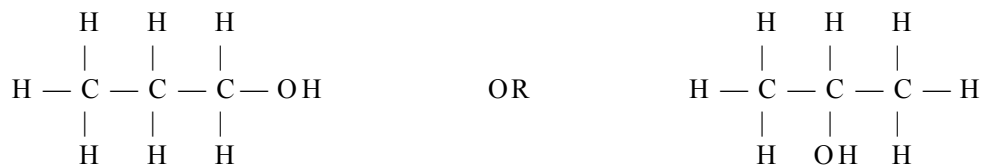
- (f) Many candidates correctly identified sodium as the element that forms an oxide which readily dissolves in water to form a solution of  $\text{pH} > 7$ . However, candidates had great difficulty writing equations to illustrate this. A number of candidates also gave sulphur as the element of choice. They proceeded to write equations illustrating the dissolving of  $\text{SO}_2$  in water to give  $\text{H}_2\text{SO}_4$ . Clearly such candidates did not understand the pH scale and acidity and alkalinity.

### Question 3

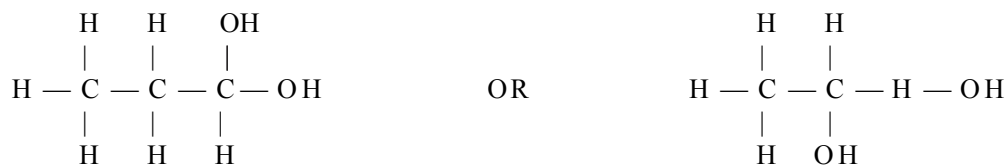
This question was based on Section B1 of the syllabus and in particular objectives 1.7, 2.1, 2.3, 2.7, 4.2 and 4.6. It was designed to test the candidates' ability to:

- Write fully displayed structures of organic compounds.
- Write the systematic name of organic compounds.
- Describe the tests for functional groups.
- Draw partial structures of polymers.
- Explain the chemical principle upon which the breath analyzer test is based.

- (a) Most candidates were able to correctly draw the fully displayed structures for  $\text{C}_3\text{H}_7\text{OH}$  as:



However, they had great difficulty in correctly naming the compound as they drew either propan-1-ol (1-propanol) or propan-2-ol (2-propanol). Perhaps the term IUPAC was not used in the classroom. Also, many students in drawing the structure of the alcohol had incorrect valencies for O and H. Thus, incorrect structures such as those shown below were often given:



- (b) Most candidates recognized compound C as alkene (propene) but many had difficulty in correctly drawing its structure. Very few were able to work out the structure of D as  $\text{CH}_3\text{CH}_2\text{OM}$  or  $(\text{CH}_3)_2\text{CHOM}$  (where M is a metal cation). Since the reagent was not specified, the use of any reactive metal was accepted. Thus, answers such as  $\text{C}_3\text{H}_7\text{OM}$  or  $(\text{C}_3\text{H}_7\text{O})_2\text{Mg}$  were credited.
- (c) Here candidates were required to describe a simple test for the presence of the functional group present in compound C (an alkene). In the selection of the reagent to be used, bromine and acidified  $\text{KMnO}_4$  were the most popular. Those candidates who selected acidified  $\text{KMnO}_4$  as the reagent had extreme difficulty in writing the equation for the reaction occurring.

Inappropriate choice of words was often used to describe the colour changes, for example, the colour of the bromine solution was “destroyed”, the bromine solution became clear (discoloured). Candidates were not credited for such descriptions of colour changes.

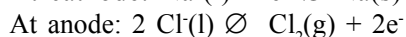
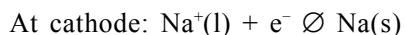
- (d) Most candidates recognized that compound C (an alkene) can readily undergo addition polymerization. However, many had difficulty in correctly drawing the partial structures of the polymer formed (a polyalkene). Common errors included:
- The presence of C=C in the repeating unit.
  - Not maintaining the quadrivalence of carbon.
  - Not indicating the extension of the polymer chain.
- (e) This part of the question focused on the chemical principle upon which the breathalyzer test works. Candidates were expected to include in their answers:
- The alcohol (ethanol) is oxidized to the aldehyde/acid.
  - The dichromate changes from orange to green.
  - The dichromate is reduced from Cr<sup>6+</sup> to Cr<sup>3+</sup>.

Many candidates, instead of focusing on the chemical principle involved, described how the test is administered to suspected drunken drivers. Such answers were not credited. Of those who focused on chemical principles, many indicated that the alcohol was the oxidising agent. A few candidates stated that KMnO<sub>4</sub> is used in the breathalyzer.

#### **Question 4**

This question was based on Sections A (3.4, 6.6, 6.20, 6.23, 6.24, 6.25, 6.27) and B2 (1.3, 5.3) of the syllabus. It was designed to test the candidates' ability to:

- Explain why electrolytes in the molten state (or when dissolved in water) and not in the solid state are used in electrolytic cells.
  - Write ionic equations for reactions occurring at the electrodes.
  - Calculate the quantity of material deposited at the electrode under specified conditions during electrolysis.
  - Account for the observed differences in the products of electrolysis of brine (concentrated aqueous sodium chloride solution) and molten sodium chloride.
- (a) (i) Most candidates obtained two of the three marks awarded to this part of the question. Many failed to state explicitly that mobile ions are necessary for the conduct of current during electrolysis. A number of candidates referred to “free” electrons or “mobile” electrons as being necessary for the conduction during electrolysis. Clearly there was “confusion” with electrical conduction in metals.
- (ii) Most candidates were able to correctly write the equations for the reactions occurring at the cathode and the anode during electrolysis of molten sodium chloride as:



In a number of cases the reverse reactions were given at the electrodes.

- (b) This part of the question required candidates to calculate the quantity of sodium deposited when 10 amperes of current is passed through the electrolytic cell for 2 hours. This part of the question was the most popular and most of the marks were obtained here. However, some candidates had difficulty converting hours to seconds. Also, some expressed their answers as 0.746 Faraday instead of in moles. The concept of a Faraday as a quantity of electricity rather than a quantity of a substance needs to be clarified in the classroom.
- (c) Most candidates were able to state two uses of chlorine. However, a number of non-specific uses (for example, used for making other chemicals, used in reactions in the lab, for making cleaners) were not credited.
- (d) This part of the question was very poorly answered. In Part (i) many candidates simply specified the products of electrolysis of molten sodium chloride or brine rather than stating the difference in the products of electrolysis of these two substances. Also, a number of candidates did not know what brine was. It was often confused for bromine. In Part (ii) candidates incorrectly stated that the  $H^+$ , which is acidic, was discharged and this made the solution basic! There appeared to be confusion with what was discharged and what was left behind during electrolysis. This should be clarified in the classroom.

### **Question 5**

This question was based mainly on Section A (1.2, 7.2, 7.3, 8.1, 8.2) of the syllabus and was designed to test the candidates' ability to:

- Define the terms exothermic and endothermic reactions.
- Use their knowledge of the states of matter and enthalpy changes to explain why the conversion of steam to water is an exothermic process.
- Draw fully labelled energy profile diagrams.
- State the factors which affect the rate of the reaction and how these factors influence the yield of ammonia.
- Calculate the heat of neutralization from appropriate experimental data.

Overall, this question was very poorly answered.

- (a) A significant number of the candidates were able to correctly define exothermic and endothermic reaction. However, it is of concern to observe the number of misconceptions which appeared in many of the candidates' answers.

These included:

- Exothermic reactions – reactions taking place outside of the cell/body/vessel.
- Endothermic reactions – reactions taking place inside of the cell/body/vessel.
- Endothermic reactions – heat needs to be added/applied; more heat is absorbed to break bonds than heat absorbed to form products; reactants are higher than products.

- (b) (i) In this part of the question, candidates were required to suggest a reason for the fact that the conversion of steam to water is an exothermic process. Most candidates simply rewrote the definition for an exothermic reaction they gave in Part (a) without any reference to the states of matter of steam (gaseous, high kinetic energy, molecules far apart, very little or no intermolecular bonding) and water (liquid state, lower kinetic energy, intermolecular bonding).
- (ii) The majority of candidates had no idea of what should have been drawn for the energy profile diagram. Drawing of distillation apparatus, water cycles, boiling water in a pot were quite common. Most of those who were capable of drawing the energy profile diagram failed to include axes/properly labelled axes / identification of the reactant and product on their diagram as steam and water.
- (c) (i) This part of the question was fairly well answered by the candidates, indicating that they were very familiar with the factors which affect the rate of a reaction.
- (ii) This part of the question required candidates to suggest how two factors which they stated in (c) (i) would affect the yield of ammonia starting with  $N_2$  and  $H_2$  (equation given). In spite of the fact that candidates were required to study the commercial synthesis of ammonia from  $N_2$  and  $H_2$ , it was realized that they were not required to be familiar with Le Chatelier's Principle. As such, candidates were credited for answers which focused on how the named factors influenced the rate of a reaction. However, factors such as enzymes, pH, surface area were not credited since they were not applicable to the synthesis of ammonia.
- (d) Very few candidates attempted this part of the question. Those who did, were only able to calculate either  $\Delta T$  or the heat change for the reaction. Many candidates did not know how to obtain the mass of the solution undergoing the reaction. Most used 50g or 1g instead of 100g.

### Paper 03

#### Question 1

This was the less popular of the two questions in Section A of the paper, having been attempted by only 21 per cent of the candidate population. The question tested the concepts and principles as outlined in objectives A3.3, 3.4, 6.5, 6.6, 6.7, 6.10 and 6.11. Most candidates who attempted the question performed poorly.

In Part (a) candidates were required to define the terms acidic salt and normal salt and to suggest a simple test to differentiate between them. It was expected that definitions would be given in terms of the replaceable hydrogen ions of an acid being partly or completely replaced by a metal or ammonium ion. Many students gave inadequate responses such as acidic salts have a pH less than 7 or that they turn blue litmus red. No mention was made of their having to be first dissolved in water and therefore these answers were given full credit. Many of the candidates who did offer an explanation based on hydrogen seemed not to know that it was REPLACEABLE hydrogen IONS and not simply due to hydrogen or hydrogen atoms that were present in the salts.

In (a) (i) any simple test such as the use of litmus, a carbonate or a metal was accepted provided that the observation for each type of salt was described. Candidates lost marks for not first



dissolving the salt(s) in water and for failing to indicate the expected result for the normal salt. In some cases candidates did not know the colour change for litmus, often confusing it with pH paper. Many also incorrectly stated that red litmus turned blue in the acid salt.

Part (b) required candidates to describe procedures for preparing samples of  $\text{Na}_2\text{SO}_4$  and  $\text{NaHSO}_4$  from 1 M  $\text{H}_2\text{SO}_4$  and 1 M NaOH. The answer should have focused around using equal volumes of acid and alkali for preparing the acid salt and using half the volume of acid to alkali for the normal salt. The solution could then be heated to concentrate it/ make a saturated solution, cooled to allow crystals to form and then the crystals could be collected. A simple test should have been included to indicate how completeness of neutralization was established. Many candidates assumed that the salts had already been prepared and attempted to describe the crystallization of the salt from solution. Others did not realize that sodium salts are soluble and referred to precipitates being formed, which were subsequently filtered off. Many illogical sequences were outlined such as drying a solution, evaporating a residue and adding sodium sulphate to sulphuric acid to get sodium sulphate. Only a very small percentage of the candidates gave the principle upon which the preparation of the salts was based, that is, complete neutralization of the acid for the normal salt and half neutralization for the acid salt. The equations were, however, generally well done.

The calculation in Part (c) was also fairly well done. Teachers must emphasise to their students that ALL working must be shown as indicated in the Instructions of the question paper. Also, they must warn their students to read the questions carefully. Some candidates used 2M NaOH in their calculations rather than the 1 M NaOH specified in the question

## **Question 2**

This was the most popular question on the paper. It was attempted by 79 per cent of the population. The question tested candidates' knowledge of atomic structure, mole concept and the particulate nature of matter as outlined in objectives A 1.1, 2.1, 2.3, 2.5, 3.1 and 3.5. There were some very good responses to this question.

The three fundamental particles present in an atom were well known by most candidates. A few confused atoms with states of matter and referred to the solid, liquid and gas in their answer. Others referred to the neutrons as the nucleus. The properties of the particles were less well-known. Candidates were familiar with the relative charges, although they made reference to the nature of the charges and not the size. For example, instead of a proton having a charge of +1, many stated that the proton is positively charged. Similarly the electron was negatively charged instead of having a charge of -1. In many cases the relative masses were omitted or referred to as size. Some candidates gave mass as the unit of relative mass, others erroneously stated that the electron has no mass. Teachers must make their students aware that as a particle, an electron must have mass. It is negligible ( $1/1836$ ) but still present.

In (a) (ii) candidates gave a variety of incorrect responses for the particle upon which the chemical properties of an element depend. Instead of electrons, many gave "protons and electrons" whilst others suggested neutrons, protons or in some cases the nucleus.

The majority of candidates gave accurate drawings of the two isotopes of potassium (called X in the question). Candidates should be discouraged from depicting the total number of protons and neutrons in their diagrams as + signs and circles in the nucleus (many drew 19 + signs and 19 circles) as this wastes valuable time and the use of  $19p$  and  $20n$  is quite sufficient. Some candidates used the mass number as the number of protons and electrons.

In Part (c) a great deal of confusion was evident in the calculation of the number of moles and atoms in 100 g of iron. The more prevalent misconceptions included:

- Number of moles = relative atomic mass / mass or 56/100
- Number of atoms = number of moles / Avogadro's number

Many candidates did not state their answers properly so that it was often unclear what was being calculated. Also, a number of them mixed up the calculations and gave the correct working for the number of moles but stated that it was the number of atoms and vice versa. Many candidates did only one calculation, although the question clearly stated that both the number of moles and the number of atoms were required. Teachers are asked to remind their students that full marks can only be obtained if answers are clearly stated.

In (d) (i) candidates seemed not to understand what 'general deductions' were so that many of them identified the process taking place in EACH of the observations and explained them individually. It was expected that candidates would have deduced that matter is made up of particles that are in random motion, and that these particles moved across a concentration gradient from a region of high concentration to one of lower concentration. In many instances, particles were not identified and candidates referred loosely to matter. Some candidates reversed the direction of motion stating that particles move from low to high concentration.

In (d) (ii) most candidates recognized the process as diffusion but very few appreciated that the perfume had to be vaporized or that the gas had to travel to Suzie's nostrils/olfactory organs to be detected.

### **Question 3**

This question was more popular than the alternative Question 4. It was attempted by 66 per cent of the candidate population. The question was centred around the homologous series of alkanes and included a calculation of the enthalpy of combustion of methane. The syllabus reference is B1. 1.4, 2.1 and 2.4 and A 5.3, 5.4 and 8.3.

In (a) (i) the characteristics of homologous series were generally well known. However, candidates must be careful when stating that the members differ from each other by a  $-\text{CH}_2$  group. The correct property is that the members differ from the preceding/ next/ successive member by a  $-\text{CH}_2$  group. Methane and hexane are members of the alkanes but they do not differ by a  $-\text{CH}_2$  group. Any three different characteristics were accepted. Some of the weaker candidates merely listed a number of different homologous series, for example, alkanes, alkenes, alcohols and gave their general formulae.

In (a) (ii) candidates needed to select a characteristic of homologous series and discuss how it could be used as a basis for separating the members of the alkane series. A labelled diagram of the apparatus was to be included in the answer. Many candidates ignored parts of the instruction and either did not choose a characteristic or did not label their diagrams. Others chose inappropriate characteristics such as similarity in chemical properties or the fact that the members differed from preceding members by a  $-\text{CH}_2$  group. Despite this, a creditable number of candidates selected the correct method of separation which was fractional distillation and correctly explained that the basis for separation was differences in boiling points. None, however, further pointed out that this method was more suitable than other methods because the variation in boiling points was slight.

Diagrams were generally poorly done. Some common errors were:

- Fractionating columns that had no surfaces for condensation such as beads, nor was there evidence of anything (for example, mesh) to keep the beads from falling into the distilling liquid.
- Condensers with improperly labelled inlets and outlets and which had no inner tube.
- Improper placement of the “pipes” for removal of fractions in an industrial tower.

In some cases candidates seemed to have confused separation of the alkanes with identification and proposed a chemical reaction such as bromination to separate them.

In Part (b) a correct molecular equation, using sunlight as catalyst was awarded full marks. Common errors in the equation included having hydrogen as a product and using chlorine atoms, Cl, instead of chlorine molecules as one of the initial reactants.

Part (c) focused on the properties of alkanes that made them useful as fuels and as a solvent to dissolve grease. Most candidates recognized that alkanes burn. Fewer indicated that they produced large quantities of heat on combustion and none recognized that to be considered a suitable fuel the products of combustion should be gaseous. The better candidates knew that the non-polar nature of the alkanes made them suitable solvents for grease. Many gave vague statements such as “like dissolves like” without any explanation of what was “like” in alkanes and grease.

The simple equation in Part (d) was well known, although quite a number of candidates lost the mark awarded for not balancing the equation. Only a small percentage of the best candidates were able to handle the calculation competently. Many assumed that methane had the density of water and therefore 100 cm<sup>3</sup> were equivalent to 100 g, or that 1kg of methane had a volume of 1000 cm<sup>3</sup>. The task was to calculate the number of moles of methane in 100 cm<sup>3</sup>, that is, 100/22400, calculate the number of moles in 1 kg (1000/16) and hence determine the amount of heat evolved by 1 kg (3.96 x No. of moles in 1kg )/ No. of moles in 100 cm<sup>3</sup>.

#### **Question 4**

This question tested the concepts and principles entailed in specific objectives A 4.6 and 4.7 and B2 2.1, 2.2 and 8.3. It was attempted by 34 per cent of the candidate population.

Part (a) tested candidates’ understanding of the role of carbon in the production of metals, in particular iron and aluminium, from their oxides. It was expected that candidates would recognize that carbon monoxide is a reducing agent used in the production of iron from iron (III) oxide but that it could not reduce aluminium oxide as aluminium is too high in the reactivity series. Additionally, carbon monoxide is produced from the reduction of carbon dioxide by carbon. The role of carbon as electrodes in the electrolysis of molten aluminium oxide was also credited. Many candidates seemed to believe that carbon monoxide could reduce both oxides. Others thought that carbon itself reduced iron (III) oxide. The balancing of the equation for the reduction of iron (III) oxide was poorly done.

Part (b) focused on the allotropes of carbon. Diagrams were inaccurate and poorly drawn. In diamond, many 3-valent carbon atoms were in evidence. Some candidates drew diamond-shaped structures where carbon exhibited a valency of four but the basic structure was not tetrahedral.

In the diagram of graphite, the hexagons were made to touch tip-to-toe, so that carbon was bonded to four other carbons in the layers instead of three. Additionally, some diagrams had quadrilaterals and pentagons in the layers instead of hexagons. Teachers should advise students that single hexagons are not acceptable as representative of a layer. A few candidates confused allotropes with isotopes and isomers.

Many candidates failed to follow instructions to relate the properties and uses to the structures of the allotropes. A significant number simply referred to the strong bonds in diamond rather than the strong COVALENT bonds that accounted for diamond's hardness and its use in drill bits. The ability of graphite to conduct electricity and its use as a lubricant were well described and explained by many candidates.

Very few candidates scored high marks in Part (c). Although a substantial number of candidates mentioned that oxides of sulphur contributed to the formation of acid rain, few recognized that the acid produced was a stronger acid than the weak carbonic acid formed when carbon dioxide dissolves in rain water. The effects of acid rain on concrete and metals were rarely discussed. Equations were generally absent. Many candidates gave an equation that showed sulphur dioxide dissolving in water to produce sulphuric (VI) acid rather than sulphuric (IV) acid. A fairly large number of responses included an equation for photosynthesis which was accompanied by the explanation that since carbon dioxide was used to manufacture food, it was not as serious a pollutant as sulphur oxides. That was not credited.

### **Question 5**

This question was based on the Cooking option in Section C of the syllabus and tested objectives C 1.4, 1.5, 1.6 and 1.7. Sixty-one per cent of the population attempted the question.

Part (a) (i) required an explanation of how a pressure cooker works. Many candidates, however, focused on describing how to use a pressure cooker. The answer was expected to include an explanation of how water boils at 100°C at normal atmospheric pressure and that in a pressure cooker the tightly sealed lid traps steam so that the pressure above the water builds up to more than normal atmospheric pressure and as a consequence the boiling point of water is raised. Many candidates also did not link the increased pressure to a higher boiling temperature.

In (a) (ii) many candidates believed that in the pressure cooker, meat was tenderized because the increased pressure "forced the amide bonds to break". These candidates did not appreciate that the essential reaction was hydrolysis of the amide bonds which was speeded up by the increased temperature. The partial diagram of the protein was poorly drawn. In some cases candidates drew only a single amide linkage. In others a di-amide was drawn whilst a few partial nylon structures were also offered. In many instances the valencies of carbon and nitrogen were not adhered to and the extensions at the ends of the partial structure were absent. Partial structure of condensation polymers should show at least three monomer units linked together with a minimum of two linkages.

Many candidates did not attempt an equation for this hydrolysis. Of those that did, many seemed not to realize that the products were amino acids. The fact that pineapples contain enzymes was known by the majority. However, many candidates incorrectly referred to the enzyme as papain instead of bromelin.

Many misconceptions were evident in (b) (i). In describing the role of yeast in the baking process, candidates did not focus on the fermentation of glucose to produce carbon dioxide and ethanol.

Instead, answers often involved the production of glucose from the hydrolysis of starches. Also, some answers included oxygen in the equation with the products of the reaction given as carbon dioxide and water. Other equations had water as a reactant. It was well known that the carbon dioxide produced aerated the dough and stretched the gluten. Candidates also were familiar with the contents of baking powder. However, many omitted to mention that water needed to be added to the mixture for the hydrogen ions of the acid to react with the hydrogen carbonate to produce carbon dioxide. Candidates were proficient at writing the corresponding equation for the reaction. Teachers must instill in students the need to include state symbols when writing ionic equations.

In (b) (ii) the majority of candidates failed to recognize that the temperature range 25 – 30°C is the optimum for yeast to produce ethanol and carbon dioxide from glucose. Higher temperatures produce other compounds such as lactic acid and ethanoic acid which alter the flavour of the baked product. There was evidence that candidates misinterpreted the question as their responses suggested that the higher temperatures they considered were baking temperatures and their explanations involved the denaturing of enzymes. This would not be likely at the temperatures that would be achieved in a room.

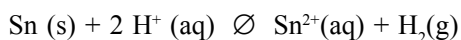
### **Question 6**

This question tested the concepts and principles in C2.2, 2.4, 2.7 and 2.8 of the syllabus. Food preservation, like cooking, the other option for study this year, seemed to be very challenging even for the most able candidate.

The question revolved around the use of sodium chloride and vinegar as preservatives, the use of tin for canning fruit juices and the conditions affecting the rate of growth of micro-organisms.

Part (a) was fairly well answered. However, in preparing their students for the option, teachers must warn against using blanket terms such as “the micro-organisms are killed” as an explanation for everything concerning food preservation. It was expected that candidates would explain the use of sodium chloride in terms of the high osmotic concentration that it produces so that micro-organisms become dehydrated as water moves from their cells to the more concentrated salt solution. Many candidates focused their answers on the dehydration of the food. Most candidates recognized that the vinegar was acidic but few related this fact to the inhibition of enzyme activity at such low pH or explained that there is an optimum pH at which enzymes function. A few candidates mentioned the destruction of the cell membrane of the micro-organisms.

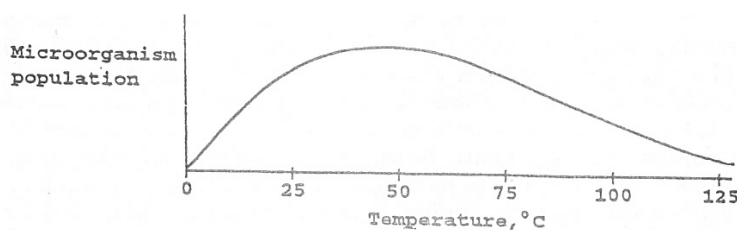
In (b) (ii) it was expected that candidates would link the pH of 2.5 to acidity and would offer an explanation of the deterioration of the tin in terms of the reaction of the tin with the acid. Many candidates thought that the can was made of iron coated with tin so that their answers concentrated on the can becoming scratched or dented so that the iron was exposed to the acid or air and rusted. The use of local jargon such as “the acid eat away the tin” should be discouraged. Candidates also did not relate the acidity of the fruit juice to the presence of H<sup>+</sup> ions so were unable to write the ionic equation:



Teachers must remind their students that when questions ask for an ionic equation, a molecular equation would not be credited. Also, it is imperative that they instill in their students the need for state symbols with all ionic equations.

In (b) (ii) the candidates were expected to line or coat the tin with an inert material such as plastic or a metal that is lower than hydrogen in the reactivity series. Many responses suggested that the tin can be replaced with plastic or glass bottles or that the juice be neutralized. It should be noted that the question clearly asked for a solution to the tin can deterioration and not an alternative to the tin can.

Part (c) required candidates to sketch three graphs to show the effect of temperature on moisture content and micro-organism population and also to show the relationship between percentage moisture and rate of spoilage. The third graph is presented below.



In the third graph, a large percentage of the candidates who recognized what the general shape of the graph should be, erroneously put the optimum temperature at  $> 50^{\circ}\text{C}$ . Also, instead of explaining the shape that they had drawn for the third graph, many candidates proceeded to describe the shape. They were expected to know that enzyme activity is affected by temperature, that there is an optimum temperature at which these enzymes operate and that at temperatures above the optimum, enzymes are denatured. They were then expected to relate the increase, maximum and decrease in the micro-organism population, shown in the graph, to this.

In (c) (ii) a number of candidates ignored the instruction to base their chosen method of preserving beans to the graphs that they had drawn and gave canning as their answer. Their explanations involved keeping air away from the micro-organisms. Drying/ freezing was expected, as these methods lower the moisture content/temperature, thus inhibiting micro-organism growth.

## Paper 04 – School Based Assessment (SBA)

### General Comments

There continues to be improvement in the candidates' performance on some skills, as well as in the overall presentation of the books for moderation. In a number of schools there has been improvement in the selection of practical activities for assessing specific skills and in the breadth of activities covered over the two years. This year the grades submitted for 59 per cent of the samples moderated were accepted. While this is commendable, signifying that many schools have taken the advice provided by previous reports on the SBA, far too many teachers continue to be challenged by the assessment of the Planning and Design skill in particular, and to a lesser extent the Analysis and Interpretation skill. It was also disturbing to note that a number of candidates did very little practical work in Year 1 and completed most of the SBA activities in Year 2. In addition, teachers seemed to be having difficulty developing suitable mark schemes, identifying suitably challenging activities and matching the selected activity with the required skills.

The standard of practical activity carried out by some schools was below that required by CXC. Many of the activities did not allow for critical thinking on the part of the candidates. For example, qualitative analysis activities that require two or three tests to confirm the presence of one anion or cation were sometimes used to assess the AI skill. In other instances routine separation activities were used and questions linked to the activity required the recall of information rather than the analysis of data.

Over the year there has been a great improvement in the number of activities being done in quantitative analysis, thermochemistry and to a lesser extent organic chemistry. However, this is not as widespread as desired. In addition, activities that include the development of graphing skills, writing balanced molecular and ionic equations, and activities related to electrolysis and redox reactions also need to be given greater attention.

Although the SBA grades are now required only at the end of Year 2, teachers are reminded that the SBA should be treated as continuous assessment and as such each skill should be assessed at least twice each year. Students should be given time to develop these skills before they are assessed. Hence, the first practical activity recorded in the students' books should not be treated as a SBA.

Teachers are again being advised to seek assistance from their colleagues in some of the more established centres as well as the Ministries of Education within their respective territories for assistance in conducting the SBA. Where possible, it may also be useful for teachers from the science department to engage in small-scale moderation exercises at their schools so as to evaluate mark schemes and the suitability of practical activities. It will also help to improve the consistency with which mark schemes are used.

The examiners have tried to provide useful comments on the standard of the SBA for each teacher in the moderation feedback report sent to each school. Teachers are encouraged to read those comments along with the more general comments that are provided in this report in order to get a more comprehensive picture of the performance of their students. Some of the specific problems encountered at moderation are outlined below.

### **Specific Comments**

#### 1. Assessment of Planning and Design Skill:

- (a) The most common problem associated with the assessment of this skill is the unsuitability of the activities selected. Teachers should note the specific description of the learning outcomes being tested by this skill as stated in the syllabus (Appendix 2 point 3). Activities that require the straight recall or reproduction of information that is available in any chemistry text book are not suitable for assessing planning and design.
- (b) Since the planning and design skill is not carried out, marks should not be awarded for conclusions such as "hypothesis confirmed". Candidates should be required to present POSSIBLE results for the hypotheses being upheld, as well as for it not being upheld by the planned investigation.
- (c) Activities selected should require application of concepts in chemistry rather than general knowledge.

- (d) Students should not present specific readings for the expected results as if the activity was actually done. Where the activity is actually conducted, it cannot be marked for Planning and Design.

2. Assessing the Observation, Recording and Reporting (ORR) Skill

- (a) It is advisable that at least one graph be assessed for ORR in each year.
- (b) There must be some link between the stated aim of the activity and the rest of the report.
- (c) For qualitative analysis, the identity of the unknown given to the students should be recorded on the mark scheme.
- (d) Students should be encouraged to develop and use tables to record data where appropriate.

3. Assessing the Analysis and Interpretation (A/I) Skill

- (a) Equations and discussions of activities should be assessed as A/I and not ORR. Teachers should pay closer attention to the writing of equations and are encouraged to correct inaccurate equations in students' books. State symbols are required for ionic equations.
- (b) The actual plotting of the graph should be assessed under ORR but calculations and interpretation of data using the graph should be treated as A/I.
- (c) For qualitative analysis, marks awarded for inference should be linked to the observations made. Also, qualitative analysis exercises that require students to conduct tests on known reagents are not suitable for assessing A/I. Rather, students should be given unknowns when testing for A/I. In conducting qualitative analyses, students should be encouraged to complete their results in tabular form.
- (d) Questions that are used to assess A/I must be on the data collected in the practical activity.

4. Table of Contents

- (a) This continues to be a sore point in many books presented for moderation. In this regard the comments made in the report on the June examinations for the past three years need to be re-emphasized. Not only is it important for students to date their work, this information should also be included in the table of contents for easy reference.
- (b) There must be some common means of identifying the practical activities in the candidates' books and those in the mark scheme.
- (c) The activities being used to compute the candidates' SBA scores for the various skills should be clearly indicated in the candidates' notebooks and mark scheme.



5. Absence of or Inappropriate Mark Schemes

- (a) Where mark schemes are unclear or incomplete, it becomes difficult to moderate the samples of books. This could work to the candidates' disadvantage, as an alternate mark scheme has to be developed to assess the candidates. Teachers are again reminded to examine the examples of the mark schemes provided in the syllabus and the CXC modules for information on how the mark schemes should be presented.
- (b) A small sample of books was sent without any mark scheme and some with mark schemes that bore no relationship to the laboratory practicals present in the candidates' books.
- (c) In a few instances teachers have submitted general mark schemes for all the skills. This practice should be discontinued and teachers should submit specific mark schemes for each activity.

6. Resit Candidates / Extenuating Circumstances

Teachers are again reminded to pay attention to the syllabus guidelines (page7) for resit candidates. If books of resit candidates are submitted for moderation then these should be clearly identified. Where circumstances such as illness or absence of staff have resulted in some adjustments to the required number of activities and the times when assessment takes place, this should be outlined in writing to the Registrar so that candidates are not penalized unnecessarily.

**C A R I B B E A N      E X A M I N A T I O N S      C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE EXAMINATION  
MAY/JUNE 2005**

**CHEMISTRY**

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**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATIONS  
JUNE 2005**

**The Structure of the Examination**

The examination consisted of three written papers. The contributions of these papers were as follows: Paper 01 (25 %), Paper 02 (30 %), and Paper 03 (25%). Paper 04, the School Based Assessment (SBA), contributed 20%.

Paper 01 consisted of 60 compulsory multiple-choice items based on the specific objectives in Sections A and B of the syllabus. Items were assessed under the profile, Knowledge and Comprehension (KC).

Paper 02, a structured essay paper, consisted of five compulsory questions based on the objectives specified in Sections A and B of the syllabus. Question 1 was a data analysis question. Candidates were assessed under three profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B, and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 04 involved the continuous assessment of candidates by teachers over a two year period. Samples of candidates' laboratory books were externally moderated by CXC. This was used as the basis for moderation of all SBA marks submitted by teachers.

**General Comments**

A total of 10 619 candidates were entered for the examination representing a 21.6% percent increase over the 2004 candidate population. Candidate performance on Paper 01 was similar to that of June 2004. However, performance on Papers 02 and 03 showed a decline.

This resulted in an overall decrease in the total composite mark for the examination. Candidates seemed to be not adequately prepared for the examination, as evidenced by the number of parts of questions left unanswered.

**DETAILED COMMENTS**

**Paper 01 – Multiple Choice**

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance in this paper continues to be generally good. The marks ranged from 0-55.

Candidates experienced difficulties with items based on the following objectives:

- A3.3 - calculations involving the mole concept
- A6.10 - solubility of salts
- A6.28 - industrial applications of electrolysis
- B1.1.3 - writing general and molecular formulae for members of a given homologous series
- B1.1.9 - writing fully displayed structures of isomers
- B2.7.1 - identification of cations
- B2.7.2 - identification of gases

### **Paper 02 – Structured Essay**

Note: These comments should be read in conjunction with the question paper.

#### **Question 1.**

This question was based on Section A (7.2 and 7.4) and Section B2 (1.1, 7.1 and 7.2) of the syllabus. It tested the ability of the candidates to:

- Read off temperature values from a thermometer
- Construct a suitable table from a given set of data (Figure 1)
- Plot a graph
- Make deductions from the graph plotted
- Write balanced chemical equations
- Identify anions, cations, and gases
- Plan and design an experiment given basic information

Part (a) involved the assessment of UK and XS profiles and was the more popular part of the question. It was generally well done. Most candidates were able to construct the required table and record the correct temperature values. Parts (i), (ii), (iii) (iv) were answered correctly by most of the candidates, but some failed to gain marks for (v). Some common errors/misconceptions which appeared in candidates' scripts were as follows:

Part (a) (i): units such as °C for temperature and s for seconds were omitted from the table headings.

Part (a) (ii): Incorrect plotting of some points, especially those not involving whole numbers where estimations had to be made, for example 55.3, 59.3, 37.6, 42.6, and 31.8 °C. In a number of cases, plotted points were either too faint, small, or too big. In drawing the curve, most candidates did not draw a smooth curve – they simply joined the points. Others drew a straight line instead. A few just plotted the points, but did not connect the points.

Part (a) (iii): most candidates confused rate with time and used these terms incorrectly in their response to conclusions to be drawn from the graph about the rate of reactions. For

example, typical responses were: “as temperature increased rate of time decreased” or “as temperature increased rate in seconds decreased”. Also many candidates used time as a manipulated variable and temperature as a responding variable. Thus responses such as, as time increased temperature decreased, and *vice versa*, instead of as temperature increased rate increased, were quite common

Part (a) (iv): Few candidates were unable to correctly read off information from the graph.

Part (a) (v): Equations were balanced incorrectly. Also there were incorrect writing of formulae such as  $\text{Na}_2\text{Cl}$ ,  $\text{NaCl}_2$ ,  $\text{Na}_2\text{Cl}_2$ ,  $\text{So}_2$ ,  $\text{NaCL}$ , and  $\text{Nacl}$ .

Part (b) was based on qualitative analysis. Candidates were required to draw inferences and write an ionic equation based on a given set of observations. A fair number of candidates answered this part of the question reasonably well. However, poor performance in questions based on qualitative analysis is still a cause for concern. Common errors in Part (b) of this question included:

Incorrect formula for ions

Omission of state symbols for iron (II) hydroxide..

Incorrect charge for anions.

It must be emphasized that **ionic equations** must be accompanied by the correct **state symbols**.

Part (c) was based on planning and design. It was very poorly answered. Candidates were given three possible routes by which ethanoic acid could be prepared. They were required to plan and design an experiment to determine which route would produce the highest yield of ethanoic acid. Most candidates focused instead on designing experiments for synthesizing ethanoic acid (which they could not do and was not required) rather than determining the quantity of ethanoic acid produced by each method.

Common errors observed were as follow:

Confusion of “hypothesis” with the “aim”, a continuing widespread problem which must be corrected

Some candidates who opted to analyse the ethanoic acid via a titration method, omitted to mention the indicator. Also, the base used was not identified. In some cases, the apparatus stated was **NOT** used or related in any way to the method described.

Many candidates only prepared the ethanoic acid and did not carry out any analysis to determine the quantity produced. In some cases ethanoic acid was used to prepare ethanoic acid, and many candidates titrated other acids with ethanoic acid!

Candidates wrote all variables, not only controlled as required.

Candidates did not specifically state the volume (%) ethanoic acid collected as data to be collected. Instead they listed all possible data they could have collected in the experiment as part of their answer.

Most candidates gave answers that suggested they actually performed the experiment rather than planned and designed the experiment.

### **Question 2.**

This question was based on Section A (2.5, 2.8, 3.3 4.1, 4.2) of the syllabus.

Most candidates appeared to be familiar with the topics being tested.

Part (a): Most candidates were able to deduce correctly the number of electrons, protons and neutrons in the given species. In addition, they were able to correctly illustrate the arrangement of the electrons and the location of the protons and neutrons in the nucleus. Some candidates laboriously drew 14 circles and 13 crosses in the nucleus in order to represent the protons and neutrons respectively.

Common errors included placing a "B" (the symbol given for species) in the centre of the atom, placing the two innermost electrons in the nucleus and drawing an incorrect arrangement or an incorrect number of electrons around the nucleus.

Part (b): A majority of candidates were able to correctly identify the element as belonging to Group 7; others gave instead the group name, "the halogens". Most of the candidates who correctly identified the group indicated that their choice was based on the electronic configuration of the element. Some candidates incorrectly stated that A had a valency of 7.

Part (c): Many candidates correctly deduced that the type of bonding expected as ionic based on the deduction that A was a nonmetal and B a metal. Only a few were able to describe correctly the electron transfer process between A and B and the subsequent attraction of the resulting cations and anions. Common errors included choosing covalent and metallic bonding between A and B and describing ionic bonding in terms of the sharing of electrons.

Parts (d) (i) and (ii): There were many incorrect answers in this section. It would appear that many candidates were unable to deduce the formula of molecules and compounds based on data from atomic structure. Some candidates use the symbols for the elements 'Al' and 'F' in writing the required formulae.

Part (d) (iii): This section proved to be very difficult to the candidates. Many candidates were unable to deduce the mole ratio between the element B and the compound formed between B and A. Some used the formula from Part (d) (i) and worked out the mass by addition. The fact that atomic masses were not formally presented may have contributed to the unsatisfactory responses.

Part (e): Most candidates attempted this section. The properties of covalent and ionic compounds appear to be well known. Common errors include stating properties without comparing reference to the two substances, A and B, that is, metals and nonmetals. Reference to solubility should include reference to the nature of the solvent (polar as against non-polar) and reference to electrical conductivity should have included the state of the substance, that is, molten and dissolved in water.

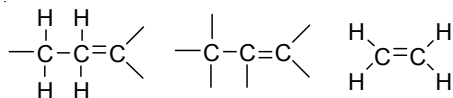
### **Question 3**

This question assessed syllabus objectives, B1 (1.3, 1.6, 1.7, 4.4, 2.1, 2.8, 2.3, 3.4, and 3.5). This question required that candidates analyze the data given in the flow chart before attempting any part of the question. Generally, the question was poorly done. Approximately 80 % of the candidates scored 0-4 marks out of a possible 16. The KC marks were easier to obtain than the UK marks.

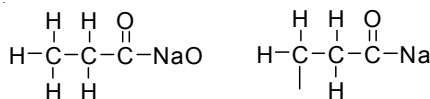
Part (a): This required candidates to draw the fully displaced structures of three organic compounds based on information given. Many candidates gave condensed structures for their answers and were

not awarded full marks. Typical errors included leaving out symbols for atoms, using the wrong case for symbols, showing carbon with three or five bonds and drawing structures with additional or less carbons than required. These errors are illustrated in the following representations.

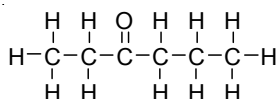
In some cases, E was incorrectly represented as:



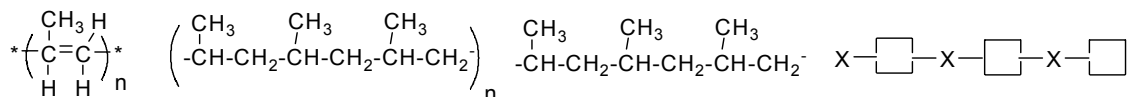
C was also incorrectly represented as:



F was also represented as:



Part (b): This part of the question required that the structure of a partial polymer be drawn with three repeating units. It was observed that most candidates drew the partial structures but illustrated them as discrete entities -there being no bonds to indicate the extension of the polymer chain. Although the linking of the monomer units occurred via linkages across the double bond many candidates drew structures which simply joined three monomer units via their carbon-carbon single bonds as illustrated below:



Part (c): Candidates were required to identify the reactions in the flow chart. This task which involved analytical skills rather than simple recall proved to be extremely difficult.

Part (d): This section was generally well done with most candidates identifying bromine as the reagent. Common errors included using bromide and chlorine as the reagent. In cases where the reagent selected was potassium manganate (VII), most candidates failed to state that it must be acidified/aqueous. They also could not write the correct chemical equation for this reaction.

Part (e): This section required candidates to state reagents and reaction conditions required to carry out specific conversions. Usually candidates failed to specify whether the reagents must be dilute/aqueous. Also, instead of stating specific names of reagents, terms such as "alkali" or "acid" were used. In addition, the term 'temperature' was very vaguely used in the description of the reaction conditions, usually "heat" or "suitable temperature" was the term being used.

#### **Question 4.**

This question assessed syllabus objectives A (6.7, 8.1, 8.2, and 8.3). This question was very poorly done. Over fifty per cent of the candidates gained less than four marks. It tested the candidate's knowledge of the following concepts and principles:

During chemical reactions, energy is required to break bonds and energy is released when bonds are formed

The overall enthalpy change of a reaction is related to the difference between the enthalpy of reactants and products

Heat of neutralisation

Strong acids/bases are completely ionised in aqueous solutions

Calculation of the number of moles of a substance given relevant data

Calculation of enthalpy change when a salt dissolves in water given relevant data

Assumption used in calculating enthalpy data

Energy profile diagram for endothermic/exothermic processes

Parts (a) and (b): Few candidates were able to gain the three marks allocated for Part (a). A mark was lost for not explicitly stating that the observed heat change occurs as a result of the DIFFERENCE between energy required to break bonds and the energy released when bonds are formed. In fact, quite a number of candidates stated that bond making process absorbs heat energy. A number of candidates misread the question and simply gave definitions of endothermic and exothermic reactions in terms of heat gain/loss with no reference to the actual question.

Part (b) (i): A concise statement of heat of neutralization was required. The expected definition was that heat is evolved when one mole of  $H^+$  ions is neutralized by one mole of  $OH^-$  ions to form one mole of water. Common unacceptable responses were:

The energy needed to form one mole of water during a reaction between an acid and a base

The heat required by a base to neutralise an acid

Part (b) (ii): Expected answer: The indicated substances are all strong acids and bases and as such are completely ionized in aqueous solutions. As such during neutralization the only reaction occurring is between  $H^+$  ions and  $OH^-$  ions to form water. Hence the molar heat of neutralization will be the same in each case. Many candidates interpreted "strong" to mean "concentrated", while others stated that an acid and a base react to produce a salt and water.

Part (c): Most candidates were able to calculate the number of moles of  $KNO_3$  used. However, few candidates were able to proceed further and correctly calculate the heat change and the enthalpy change for the reaction. By far the most common mistake was to use **M in the equation** as 112 g instead of 100 g. The majority of candidates omitted the positive sign for  $\Delta H$ , the enthalpy change. Only a small number of candidates stated an acceptable assumption used in their calculation, although it was implicitly found in the data provided for use in their calculations. Many candidates made the assumption of no heat loss/gain, ignoring what was asked in the question.



Evidence of uncertainty was seen in the energy profile diagrams drawn. Some candidates deduced the enthalpy change as exothermic, and proceeded to draw an exothermic energy profile diagram while a few presented both diagrams. A common error was the omission of  $\Delta H$  on the diagram.

### **Question 5.**

This question was based on Section A (3.4, 6.1, 6.4, and 6.10) and Section B2 (1.2 and 4.1) of the syllabus. It tested the ability of the candidate to analyse and interpret the stimulus material presented in the question. Generally, candidates omitted several parts of this question, and as a consequence scored very poorly.

Part (a) was generally well answered. However, many candidates failed to interpret the information given and confused the terms conduction and melting point.

In Part (b), the liberation of hydrogen gas was readily identified as the gas liberated when an acid reacts with a Group 2 metal. However, many candidates wrote  $H^+$  to represent hydrogen gas. The majority of candidates did not correctly identify the second product as hydroxide. Instead they identified it simply as an oxide. Some wrote  $Q^{2+}(aq)$  instead of the symbol Q in the equation.

In Part (c), formation of the oxide was correctly identified. However, many candidates failed to comprehend the concept that the oxide initially formed on the surface protected the metal underneath from further reaction. Many candidates were unable to link the term “inert” to a lack of reactivity. Instead the term “inert” was related to the achievement of a stable electronic configuration associated with the noble gases. A few candidates thought that no reaction would occur since the element Q was on Mars.

In Part (d), it was obvious that the majority of candidates were unfamiliar about the effect of heat on nitrates. Thus they failed to score in this part of the question. A few opted for a description or word equation. Those who knew the products of the equation had extreme difficulty balancing the equations.

In Part (e), it was quite clear to many candidates that the desired method of preparation of the salt involved a precipitation method. However, descriptive experimental errors resulted in an unnecessary loss of marks. The identity of the solutions used was not always clear, and retention of the residue (not the filtrate) was ambiguously stated. Other common errors observed were as follows:

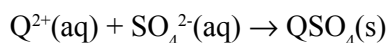
The use of barium sulphate as a source of sulphate ions in solution

The use of titration as a preparative method

Evaporation of the filtrate to retrieve the salt

The use of fractional distillation as a separation method

Finally, it must be noted that very few candidates correctly wrote the desired ionic equation:



## PAPER 03- EXTENDED ESSAYS

### Question 1

This question was by far the most popular question in Paper 03. It involved the concepts and principles outlined in objectives, Section A (1.1, 1.2, and 5.3) of the syllabus.

In (a) (i), candidates were required to describe one piece of experimental evidence for the existence of the particulate nature of matter. Questions involving experiments usually require the candidate to give experimental details and the observation or result that is expected. Many candidates did not seem to realize this and gave one or the other. Other responses were simple definitions of diffusion, osmosis or Brownian motion, none of which was credited. One of the better answers described the experiment with the pollen grains suspended in water and viewed under a microscope and the haphazard movement of the pollen grains that resulted.

Part (a) (ii) of the question was a straightforward description of the differences between the three states of matter. Candidates were asked to explain these differences in terms of arrangement of particles, forces of attraction and kinetic energy. Despite this guidance, candidates often omitted one or more of these criteria in their explanations. Teachers should remind their students of the importance of reading and re-reading their questions to ensure that all parts are answered. One common misconception which permeated a large number of answers was that solids had the greatest amount of kinetic energy and gases the least.

Many candidates wrote about the motion/speed of the particles and the compressibility of the various states. It was expected that candidates would follow the given guidelines and describe the solid state, for example, as having particles that were closely packed, with strong forces of attraction between the particles and possessing very little kinetic energy. Despite these difficulties this part of the question was fairly well answered.

In Part (b), candidates were asked to discuss how it was possible for gaseous pollutants to affect areas far removed from its source and to include the role of air molecules. Most candidates recognized that diffusion was responsible for this occurrence and gave good definitions and explanations of the process. The role of the air molecules was not as well understood, however. Some candidates used the air molecules and the pollutant particles interchangeably so that it was difficult to understand their explanations. Some referred to the pollutants bombarding the air molecules rather than the air molecules bombarding the pollutants, thus missing the significance of the transmission of the energy from the air molecules to the pollutants. It was expected that candidates would therefore deduce that the increase in kinetic energy would cause the pollutants to be more quickly transported.

In Part (c), almost every candidate was familiar with the osmosis experiment that was illustrated and stated this as the process being investigated. However, some again ignored instructions to do two drawings to show the changes that had occurred after two hours and drew only one so that they could not be fully credited. Others did not properly label their drawings and again lost marks. Still others mixed up the labels of the liquids inside the potato and in the beaker.

Explanations of the changes were often imprecise. Many candidates contented themselves with a definition of osmosis. It was often unclear, too, whether the candidates were referring to the concentration of the solution /solvent or solute.. Quite a large number of candidates believed that only

the salt particles moved. A description of what caused the changes should have included that the water particles moved along a concentration gradient from outside the potato where they were in high concentration to the inside where their concentration was lower.

The two solubility curves in Part (d) seemed to have confused some of the candidates who could not determine that X had the greater solubility at 10°C. It is recommended that more work be done with candidates on interpreting graphs. Even more candidates found Part (ii) too challenging and could not calculate the mass of substance deposited when solution Y was cooled from 80°C to 20°C. Candidates subtracted the temperatures, divided and/or multiplied by 100 and generally showed their unfamiliarity with this kind of simple calculation. The topic appeared unfamiliar to many.

## Question 2

This question involved various aspects of the topics, oxidation and reduction and electrolysis, as outlined in the syllabus objectives found in Section A (6.13, 6.14, 6.15, 6.16, 6.24, 6.25, 6.26, 6.27, and 6.28). Candidates were required to recall the uses of potassium dichromate in the laboratory and to calculate the oxidation number of chromium in it and in its reduction product, chromium (III) sulphate,  $\text{Cr}_2(\text{SO}_4)_3$ . They were also required to determine the conditions needed to electroplate a tenor pan with chromium and calculate the time needed to deposit a given mass of chromium onto it. It was attempted by only a small percentage of candidates.

Many candidates performed well in Part (a) and even some of the weaker candidates earned three out of the four allotted marks for stating a laboratory (school) use of potassium dichromate. Some however, ignored the fact that a laboratory use was required and instead mentioned its use in commercial processes. Candidates should be warned against ignoring directives in a question. Very few candidates recorded that the reagent had to be acidified before use. There was also evidence that it was confused with potassium manganate (VII). As such the colour change was often given as purple to colourless and many candidates believed that it was used to differentiate between alkanes and alkenes.

The calculation of the oxidation number of chromium in potassium dichromate was well done, most candidates obtaining the value of +6 that was expected. The calculation of the oxidation number of chromium in chromium (III) sulphate, however, proved to be much more challenging despite the fact that many of the candidates stated in (a) (i) that potassium dichromate was converted to  $\text{Cr}^{3+}$ . Impossible answers such as 21.8, 10.5 and even negative values abounded. The sign for oxidation numbers was often omitted, especially the positive sign and in many cases candidates placed the sign **AFTER** the number so that a charge instead of an oxidation number was recorded. Teachers **MUST** insist that the sign is always used in writing an oxidation number and that it is placed in front of the number. Also, teachers might encourage students where there is a compound containing a polyatomic anion such as sulphate,  $\text{SO}_4^{2-}$ , to use the following approach to calculate the oxidation number of the cation (chromium in this case) as follows:

$$\begin{aligned}2 \times \text{Cr} + 3 \times \text{charge on the anion} &= 0 \\2 \times \text{Cr} + 3 \times (-2) &= 0 \\ \text{Cr} &= +6 / 2\end{aligned}$$

This approach may be better than trying to calculate individual oxidation numbers, since it was in trying to calculate the oxidation number of sulphur that mistakes were made.

In electroplating the tenor pan in Part (c), many candidates chose chromium (III) sulphate as the electrolyte. Unfortunately, they neglected to include the state of the electrolyte (aqueous). Also, a number of candidates incorrectly selected potassium dichromate as the chromium salt. This does NOT produce a positively charged chromium ion and is therefore unsuitable. Teachers should warn their students about the use of formulae when they are not asked to do so, especially in unfamiliar circumstances such as this question. For example, some candidates gave  $\text{Cr NO}_3$  as the electrolyte and were not given the mark since chromium does not exist in the +1 oxidation state generally. They would have been credited for writing out the name chromium nitrate instead.

Most of the candidates understood that the tenor pan should be used as the cathode and a strip of pure chromium the anode. Some, however, interchanged the two electrodes whilst others used an inert anode.

Electrode equations were competently handled by many. The most common errors found were for the candidates to use  $\text{Cr}^{2+}$  rather than  $\text{Cr}^{3+}$  and for them to omit the state symbols. It is good practice for students to use state symbols for all equations but it is imperative that they do so for ionic equations.

It was expected that candidates would mention the need for the tenor pan to be thoroughly cleaned before electroplating in order that the plating would not peel off. Most candidates did just the opposite. They greased the pan, anodized it, galvanized or painted it before electroplating. Others believed that putting a really thick coat of chromium would solve the problem. This is the opposite of what should be done as thick coats tend to flake off more readily.

Two main problems were noticed in the candidates' calculations. The first was that many candidates ignored the fact that the mass was given in kilograms rather than grams and failed to multiply by 1000. Thus, instead of getting 10 moles of chromium, most got a value of 0.01 moles. The second error was to ignore the mole ratio between the chromium and the electrons from their electrode equation and to simply use a 1:1 ratio. Thus, the quantity of electricity that had passed was calculated as  $0.01 \times 96000$  or  $960c$ . The rest of the calculation was well done as most candidates seemed familiar with the relationship,  $Q = It$ .

### **Question 3**

This question was the more popular of the two questions in Section B of the paper. It assessed syllabus objectives, Section A (4.1 and 4.2) and Section B (1.7, 2.1, 2.2, 2.5, 2.8, and 3.3).

Part (a) of the question involved knowledge of the bonding in methane and an explanation of why carbon formed covalent rather than ionic bonds. Candidates recognized that carbon has 4 electrons in its valence shell, although some erroneously gave the configuration as 2.8.4. They also knew that as a result of having these four valence electrons there would be a sharing of electron pairs when it bonded with hydrogen. However, the reason for this was not clearly stated as many referred to it being easier to share than to gain or lose four electrons without any reference to the relative energy requirements of these two processes.

Most candidates did not give a complete illustration of the bonding process leading to the formation of methane from carbon and hydrogen. They drew a diagram showing the four shared electron pairs between carbon and hydrogen but failed to begin their illustration with the diagrams of the outer shells of carbon and 4 H atoms. A few candidates drew a displayed structure of the methane molecule with

dashes (-) representing the bonds. This type of drawing is not used to represent the bonding process. Instead it is used to represent structure.

In Part (b), which focused on the very familiar reaction of methane and chlorine, most candidates received full marks for knowing that the type of reaction undergone was substitution and that light was needed. A great deal of time was wasted giving the four equations that show successive substitution of the hydrogen atoms by chlorine when only one overall equation was required. One common misconception was that one of the products was hydrogen rather than hydrogen chloride.

Part (c) was the best done part of this question. Candidates were asked to identify an alkene and a carboxylic acid from a group of compounds whose formulae were given. They were then asked to draw the structures of, and name the compounds that they had identified. Some candidates gave the alkane as the alkene whilst others gave  $C_3H_8O$  as the carboxylic acid. The latter was the more common error. The drawing of the structure of the carboxylic acid proved more challenging than that of the alkene. Many candidates did not correctly draw the functional group of the acid. In naming the structures, the most common errors were as follows:

Use of the prefix -'but'- rather than-'prop'- for the alkene AND the acid

Reference to the acid as propanol rather than propanoic acid

Reference to the alkene as prop-1-ene and the acid as propan-1-oic acid

In (c) (ii) candidates were asked to differentiate between an alkane and an alkene in the first instance and an alkane and a carboxylic acid in the second instance. It was hoped that candidates would choose reactions that had some observable change. For example, in the case of the alkene and the alkane, the use of bromine dissolved in an inert solvent would produce no reaction with the alkane in the dark whilst the alkene would show an immediate decolouration. Many candidates used bromine but did not indicate the conditions of the reaction. Some candidates failed to state what would be observed with the alkane and simply stated that the alkene would decolorise the bromine. Teachers should remind their students that when comparisons are required, results for both substances must always be recorded. The equation for the reaction was straightforward and most candidates who used this reaction got the marks awarded. Candidates who used the reaction with acidified potassium manganate (VII) ran into difficulty when writing the equation as the equation for this reaction is not on the syllabus and the product, the diol, was unfamiliar.

Many reactions could have been used to differentiate between the alkane and the carboxylic acid. Candidates could have used the reaction with a reactive metal or a carbonate or the reaction with an alcohol. In each case the acid produces an observable change and the alkane gives no reaction. Supporting equations were generally poorly done as many candidates failed to balance the equations or wrote incorrect formulae for the salts produced.

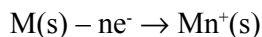
Most students recognized the process in Part (d) as cracking. A few thought that it was fractional distillation. The advantage of the process was more often than not given as "to convert large useless alkane molecules into smaller more useful alkenes". Few candidates focused on exactly what these alkenes could be used for. These would include use in making solvents, to produce polymers or for use in many of the downstream petrochemical industries.

#### Question 4

This question required candidates to apply their knowledge of the reactivity of elements in the electrochemical series. Candidates who attempted this question generally performed worse than their counterparts who attempted the alternate question in this section of the paper. The question examined syllabus objectives Section B1 (2.1, 4.1, 5.1, and 5.2).

In (a) (i) candidates were asked to explain why copper, silver and gold were used to make coins but sodium, calcium and magnesium were not. Many candidates compared the reactivities of the two sets of metals instead of stating why one group was suitable and the other group was not. For example, instead of stating that Cu, Ag and Au were unreactive, most candidates wrote that these elements were less reactive than Mg, Na and Ca. This was not considered acceptable as there are many elements that are less reactive than Mg, Na and Ca that are also not used to make coins because they are still too reactive. Most candidates also failed to indicate that to be used for making coins, a metal would have to be durable since frequent handling of coins meant that the metal would be exposed to all kinds of environments. Marks were also lost as candidates made no reference to the positions of these elements in the electrochemical series.

Only an extremely small percentage of the candidates were able to give a proper ionic equation for the reaction. The expected equation was:



The few that were able to give a correct equation used magnesium as an example. This was accepted.

Part (a) (ii) was better answered, generally. Candidates knew that zinc displaced copper from an aqueous solution of its salt because zinc is higher in the reactivity series than copper. Many also wrote correct equations for the reaction and explained that since copper is below zinc in the reactivity series, it could not displace it and so there is no reaction when a copper rod is placed in an aqueous solution of zinc sulphate. The fading of the blue colour when zinc is placed in copper (II) sulphate solution was poorly handled. Most candidates did not refer to copper *ions* being removed.

In (a) (iii), it was surprising to note how many candidates did not know that aluminium is extracted by electrolytic reduction whilst iron is extracted by chemical reduction. Furthermore, they did not appreciate that the reason for this is that aluminium, being higher in the reactivity series than iron, forms stronger bonds in its oxide and therefore requires a more powerful method of reduction. Many candidates believed that the reducing agent in the extraction of iron is coke rather than carbon monoxide.

In Part (b) as in Part (a) (i), candidates compared the reactivity of copper to that of iron in an effort to explain why copper is more useful when pure and iron is almost never used in its pure state. It was expected that the candidates would have focused on the use(s) to which **EACH** metal is put. Copper is used as a conductor and conducts electricity well when pure. When impure, this ability is diminished. In the case of iron, which is used as a construction material, when pure it is not suitable as it is too soft. Alloying it, however, increases its tensile strength and makes it more useful. Many candidates simply stated the properties of the two metals without stating the effect of the addition of impurities on these properties. For example, candidates simply stated that pure copper is a good conductor of electricity.

### **Question 5**

This question tested the concepts and principles in the first unit of Section C of the syllabus, namely the option-‘Chemistry in the Home’. It focused on the chemistry involved in cooking and tested specific objectives, Section C (1.2, 1.4, and 1.10).

In Part (a), candidates were expected to explain the role of water, gluten, leavening agents and heat in making and baking dough. In considering the role of water, it was expected that candidates would focus on the hydration of proteins in flour to form gluten, providing moisture for the fermentation of yeast and the ionization of tartaric acid in baking powder and aeration of the dough during the baking process. Some misconceptions that were noticed were that water hydrates starch to form gluten, that it reacts with baking powder and that it binds the ingredients together. The simple experiment in which dough is made and placed under running water to remove the starch could perhaps clarify this first misconception.

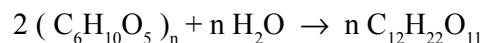
In describing the role of gluten, many candidates focused on a description of what gluten is instead of explaining what it did. For example, there were many descriptions of it being a sticky/ visco-elastic substance without further stating that it stretches and traps aerating gases giving the dough its fixed shape, or that it binds the constituents of the dough.

Many candidates spent a great deal of time writing about the components of leavening agents, especially about the baking powder rather than explaining their role. Others simply stated that leavening agents raise the dough. The better candidates described the production of carbon dioxide by fermentation (for yeast) and the action of an acid and hydrogen carbonate (for baking powder) and then stated that it was this gas that was responsible for the aeration of the dough.

Heat was thought to be responsible for cooking the dough and for making the dough edible. It was also believed that its role was to give the dough a “nice brown colour”. Although all of these do happen when dough is heated none of these were credited as being the role of heat, which has many more important functions. Some of these include: expansion of carbon dioxide and conversion of water to steam, both of which cause an increase in volume of the dough, destruction of the yeast causing fermentation to stop and coagulation of proteins.

The equations were poorly written. All the relevant equations can be found on pages 10 and 11 of the CXC module #12.

Part (b) required candidates to explain why flour which is left in a hot humid room for a long time does not turn iodine black. A relevant equation was needed to accompany the explanation. Many candidates incorrectly stated that heat destroys starch completely ignoring the role that the water played in this “destruction”. Few candidates recognized that the process that was occurring was hydrolysis although a creditable number mentioned that the starch was converted to simple sugars. The equation seemed beyond most of the candidates, who, as a result, simply omitted it. The expected equation was:



In (b) (ii), candidates seemed not to have read the question carefully and, instead of showing part of a polymer chain, showed a discrete trimer molecule. Since polymers are long chain molecules the diagram drawn should have shown continuity lines at the end of the joining together of the three monomer

units. Many candidates did not draw these lines and lost marks. Some of the incorrect structures drawn included:



### **Question 6**

This question tested the concept and principles contained in the alternative option of the first unit in Section C, namely Chemistry of Food Preservation. The specific objectives tested were Section C1 (2.6, 2.7, and 2.8).

Part (a) required candidates to copy a table of the steps of the canning process and fill in the purpose of certain steps. Many of the candidates did not know that blanching inactivates enzymes, softens the food and removes trapped air in the food. The purpose of the addition of brine/syrup, sealing and sterilization steps was, however, well understood. Candidates should be warned against the use of loose language such as “removing/ getting rid off” micro-organisms when they mean killing or destroying them. In addition, it was found that the term “impurities” was often substituted for bacteria/micro-organisms. The reason for rapid cooling, like that for blanching, was not well understood. Few candidates recognized that this step avoids significant changes in nutritional quality/flavour/colour of the food. A popular response was “to prepare the food for packaging”.

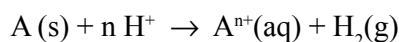
In (a) (ii), many of the candidates were familiar with niacin. They knew that it was an antibiotic that killed bacteria. Very few, however, knew that the niacin was added specifically to kill heat-resistant bacterial spores although this is given in the CXC module.

Part (b) of the question focused on the two unknown metals, A and B, which could be used to coat a steel can. Candidates were asked to determine which of these metals would be more suitable and to justify their choice in terms of the need for coating the can, the rationale for selecting one metal over the other and any possible limitations to their recommendations. Relevant equations were to be included also. This part of the question was poorly answered. It is important that teachers emphasize that when unknown metals are given, candidates are not required to identify the metals. Many of the candidates referred to A and B as tin/aluminium/lead and copper respectively.

Most candidates earned a mark for stating that iron would rust or corrode if not coated. They did not, however, develop this point to conclude that as a result, the can would become porous and bacteria and air would enter or that the can would begin to leak. It was expected that candidates would choose metal B to coat the can as this is below hydrogen in the reactivity series and is therefore less reactive than A. Furthermore, since the can is used to hold fruit juices, metal A would more likely be attacked by the acid in the juice while metal B would not react. Despite this unreactivity, metal B could still leach into the fruit juices. Another limitation was that being below hydrogen, it is most likely one of the heavy metals and as such most likely its ions would be toxic. These points eluded almost all of the candidates. The limitations quoted were often socio-economic or environmental rather than chemical in nature.

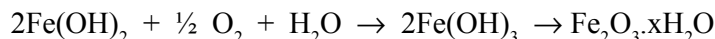
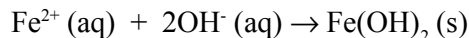
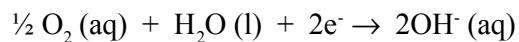
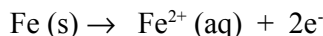
The chemical equations should have included:

1. An equation showing the reaction of metal A with acid:

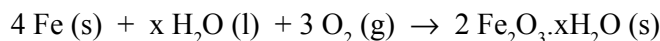




2. Equations showing the conversion of iron to rust.



These four equations could have been condensed to:



These equations seemed completely unfamiliar to most of the candidates.

### **Paper 04 - School-Based Assessment (SBA)**

#### **General Comments**

Most centres continue to perform at a high standard on the Observation, Recording and Reporting (ORR) and Manipulation and Measurement (MM) skills. However, in spite of the detailed comments in previous reports on assessing the Analysis and Interpretation (AI) and Planning and Design (PD) skills, these continue to be a major challenge for many teachers. As such, many candidates are performing poorly on these skills. In particular, many of the newer centres are having difficulty in

- developing suitable mark schemes
- using the mark schemes developed
- selecting appropriate activities for assessing PD
- identifying suitable challenging and appropriate activities
- identifying suitable criteria for assessing the skills, particularly AI and ORR
- presenting laboratory books for moderation.

In a number of cases, activities that are not considered practical activities are being used for SBA. Teachers from these centres are strongly advised to seek assistance from their colleagues in some of the more established centres as well as the Ministries of Education within their respective territories. There is also valuable information in the CXC syllabus and module on the SBA.

There are some activities that need to be given greater attention, generally. These include analyzing data presented in a graphical format, activities related to organic chemistry and redox reactions, writing balanced equations and qualitative analysis including identification of gases, cations and anions.

Some of the specific problems encountered at moderation are outlined below.

#### **1. Assessment of Planning and Design:**

- a. Assessment of this skill continues to be affected by poor selection of activities. In a few instances teachers tested concepts from biology and physics in the PD activities. Concepts tested in PD activities should be drawn from those in the chemistry syllabus. Teachers should also note that the description of the learning outcomes being tested by this skill as stated in the syllabus (Appendix 2 page 71) point to the use of “a known procedure in a novel context or a novel use of a known procedure”. Activities that

require the straight recall or reproduction of information that is available in any chemistry textbook are not suitable for assessing, planning and design. These include experiments that require students to plan and design activities to

- i. Find the heat of solution or neutralization
  - ii. Determine if rate of reaction is dependent on surface area or temperature
  - iii. Prepare gases and salts
  - iv. Prepare a sample of ethanol
  - v. Electroplate a spoon
- b. In order to test concepts teachers have to pose problems in ways that do not require straight recall of information. Rather, students should be required to use the concepts from chemistry to solve problems. Examples of the types of tasks suitable for assessing PD have been given in previous reports and also in the CXC modules and syllabus. Teachers are encouraged to review these resources for additional help.

## 2. **Assessing Analysis and Interpretation**

Assessment of this skill is affected by poor selection of activities and the use of assessment criteria which do not relate to A1 but to some other skills, usually ORR. In many instances, marks awarded for A1 do not relate to A1 but to some other skill. The following are some factors that should be considered when assessing the A1 skill.

- a. Equations and discussions of activities should be assessed as A1 and not ORR.
- b. Questions used to assess A1 should be based on data collected. For example, when conducting a chromatography experiment, questions such as "What is the purpose of chromatography?" and "What colours do you see?" are not suitable for A1. However, "Explain the reason for the different positions of the two colours in the chromatogram," is a suitable question.
- c. The actual plotting of the graph should be assessed under ORR but calculations and interpretation of data using the graph should be treated as A1.
- d. For qualitative analysis, only marks awarded for inference should be used for A1. In conducting qualitative analyses, students should be encouraged to complete their results in tabular form.

## 3. **Assessing Organization, Recording and Reporting**

- a. It is advisable that at least one graph be assessed for ORR in each year
- b. There must be some correlation between the stated aim of the activity and the rest of the report. When awarding marks for the report, teachers should ensure that the aim of the activity reflects the purpose of the exercise and the process to be used to conduct the exercise.

## 4. **Presentation of Laboratory Books**

- a. There was much improvement in the books presented for moderation this year. Tables of Content were usually present and many students dated each practical. However, teachers need to ensure that there is consistency in how the practical exercises are identified in the Tables of Content for all the samples. In some cases, practical exercises were identified by title. There were a few instances

in which the number of the practical exercise in the Table of Content did not correspond with those in the laboratory books. In other circumstances, the numbers allotted to each practical exercise did not always correspond for all the books from a given centre.

- b. The comments made regarding the dates and page numbers made in previous reports must be repeated here. Not only is it important for students to date their work, this information should also be included in the Table of Contents for easy reference.
- c. The activities being used to compute the students' SBA scores for the various skills should be clearly indicated in the students' notebooks and mark scheme. In many cases, teachers assessed each skill more than twice in one year and it was not always clear which assessments were used to determine the final score for that skill. In some instances it appeared that different activities were used to compute the scores for different students from the same centre. This should not be the case.

5. **Absence of or inappropriate mark schemes**

- a. Detailed mark schemes are essential if moderation is going to be successfully completed. Incomplete and inadequate mark schemes will undoubtedly work to the students' disadvantage. In one case of a PD activity, students were required to plan a suitable activity to determine if an unknown compound was lead (II) nitrate. The mark scheme for the activity was as follows:
  - i. Explain observation fully
  - ii. Uses background knowledge
  - iii. Identify and state limitations
  - iv. Make accurate predictions
  - v. Accurately interprets and analyses
  - vi. Conclusion related to aim.

This mark scheme is both inappropriate and inadequate. No marks are indicated for the various criteria identified. In addition, most of the criteria are vague and can be interpreted in several different ways.
- b. In a few instances teachers submitted general mark schemes for all the skills. This practice should be discontinued and teachers should submit specific mark schemes for each activity.
- c. Teachers are again reminded to examine the examples of the mark schemes provided in Appendix 2 of the syllabus for information on how the mark schemes should be presented.

6. **Re-sit candidates/extenuating circumstances**

Where books of re-sit candidates are submitted for moderation, these should be clearly identified. Where circumstances such as illness or absence of staff have resulted in some adjustments to the required number of activities and the points where assessment takes place, this should be outlined in writing to the Registrar so that students are not penalized unnecessarily.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE EXAMINATION  
MAY/JUNE 2006**

**CHEMISTRY**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATIONS  
JUNE 2006**

**The Structure of the Examination**

The examination consisted of three written papers. The contributions of these papers were as follows: Paper 01 (25 %), Paper 02 (30 %), and Paper 03 (25%). Paper 04, the School-Based Assessment (SBA), contributed 20%.

Paper 01 consisted of 60 compulsory multiple-choice items based on the specific objectives in Sections A and B of the syllabus. Items were assessed under the profile, Knowledge and Comprehension (KC).

Paper 02, a structured essay paper, consisted of five compulsory questions based on the objectives specified in Sections A and B of the syllabus. Question 1 was a data analysis question. Candidates were assessed under three profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B, and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 04 involved the continuous assessment of candidates by teachers over a two year period. Samples of candidates' laboratory books were externally moderated by CXC. This was used as the basis for moderation of all SBA marks submitted by teachers.

**General Comments**

A total of 11 194 candidates were entered for the examination representing a 5% increase over the 2005 examination candidate population. Candidates' performance on Paper 01 was marginally higher than that of 2005 while performance on Paper 02 was significantly better. However, the performance on Paper 03 showed a decline over performance in 2005.

While there was an improvement in the overall performance of candidates, there are some weaknesses that need to be addressed. Candidates have problems understanding and analyzing questions, resulting in superficial responses to questions. More specific comments on each paper are outlined below.

**DETAILED COMMENTS**

**Paper 01 – Multiple Choice**

Performance in this paper continues to be generally good. The marks ranged from 0-57. Candidates experienced difficulties with items based on the following objectives:

- A4.3 - Structure and Bonding
- A6.2 - Periodicity of Elements
- A8.1 - Energy and Energetics
- B1.4.2 - Polymers
- B2.2.2 - Extraction of Metals

## Paper 02 –Structured Essay

Note: These comments should be read in conjunction with the question paper.

### Question 1.

Part (a) required candidates to complete a Table to show the solubility of a salt X at various temperatures, plot a graph of the data, make deductions and do calculations based on the data. Part (b) tested candidates' knowledge of qualitative analysis, requiring them to complete observations or inferences for tests on an unknown solid, Q.

Part (a) involved the assessment of UK and XS profiles and was the more popular part of the question. In Part (a) (i), the majority of candidates were able to correctly complete the Table and obtained full marks for this section. However, the following should be noted:

- Some candidates had major problems reading the thermometer values, and in general all graduated values. (They could not work out the separation values).
- A few candidates stated fraction values to be used to plot a graph.
- Few candidates had problems substituting the values to find solubility.

Part (a) (ii): The majority of candidates obtained full marks for plotting the correct points on the graph. However, the following should be noted:

- Many candidates did not draw a graph after plotting the points, thus indicating deficiencies in mathematical skills (type of graph required for the relationship given).
- In a few cases, candidates used rulers to draw curves and pencils with thick points or pens.
- Candidates need to get more practice in drawing graphs using given scales. (Following instructions).

Part (a) (iii): Candidates performed fairly well in this section. However, the following should be noted:

- Candidates were expected to connect solubility with temperature as a direct relationship graph and this needs more practice.
- Candidates referred to rate of dissolving, not increased solubility of X.

Part (a) (iv): Many candidates obtained full marks in this section. However, the following points were noted:

- A few candidates did not know how to read the value at 60 °C.
- The volume of water was incorrectly calculated.
- Candidates need more knowledge in converting g to cm<sup>3</sup>, and to follow instructions given.

Part (a) (v): Many candidates obtained full marks. However, the following should be noted:

- Many candidates read off 40 °C and used this value as the correct answer.
- Many candidates did not recognize the difference between the solubilities at 60 °C and 40 °C in order to calculate the mass of precipitate formed.

Part (b): This section was either fully answered or not answered at all.

- Most candidates gave the correct observation for Test (ii).
- Many candidates rewrote the inference from Test (ii) for the inference for Test (iii). This was incorrect.
- Candidates need more practice at writing ionic equations, especially for qualitative analysis.
- Candidates loosely used “halide” to mean “halogen”, gave answers such as ‘no halogen present’ instead of the correct answer of ‘no halide ions present’.
- Many incorrectly gave the formula for a carbonate as  $\text{CO}_3^-$  and  $\text{CO}_2^-$ .
- Although many candidates correctly wrote the observation of a blue precipitate for Test (vii), the following points were noted:
  - Candidates did not give the correct observation when excess aqueous NaOH was used in this test.
  - Many candidates stated that a blue solution was formed or that a blue mixture was formed, and not a precipitate.
  - An ionic equation was given as  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$ , and not  $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$ , which was the correct answer.

Part b (viii): Many candidates gave a correct response of “a deep blue solution” for the observation, but stated “deeper blue in excess”. Many candidates couldn’t distinguish between Tests (vii) and (viii), and gave the same answer for both parts.

## **Question 2.**

This question tested the ability of the candidates to:

- Describe the structure of atoms
- Deduce the number of subatomic particles in an isotope
- Define an ionic crystal
- Draw the crystal structure of sodium chloride
- Explain differences in the physical properties of ionic and covalent substances
- Relate the structure of crystals to their properties.

While most candidates appeared to be familiar with the topic being tested, in general they scored few marks in their responses.

Part (a) (i): This question required candidates to know that different isotopes of an element would have similar chemical properties and to explain that these properties depended only on the number of valence electrons. Most candidates were able to score both marks for this section. However, several of them were unable to provide a proper explanation. Common errors included explaining the similarity in chemical properties in terms of atomic number, different properties based on different masses, suggesting different rates of chemical reaction and discussions about isotopes and radioactivity.

Part (a) (ii): This question required candidates to deduce the number of electrons, protons and neutrons on a given anion of chlorine. The majority of candidates were able to score at least one mark, usually the number of protons. Fewer candidates were able to score the marks for the number of electrons and neutrons. Common errors included ignoring the charge on the ion and inferring that the number of neutrons would be equal to the number of protons.

Part (b) (i): This question required candidates to explain the term ‘ionic crystal’. Only a minority of candidates were able to score at least one mark, the most popular responses being a lattice/three-dimensional arrangement of ions and ionic bonding between charged particles. Fewer candidates described the strong electrostatic attraction between cations and anions. Common errors included describing the crystal in terms of ionic bonding between metals and nonmetals, describing the process of crystallization and giving examples of ionic crystals.

Part (b) (ii): This question required candidates to draw the arrangement of  $\text{Na}^+$  and  $\text{Cl}^-$  on a cube. The majority of candidates placed alternate ions on the corners of the cube and on the edges or faces of the cube. Fewer candidates placed alternate ions on both edges and faces of the cube. Even fewer placed alternate ions on both edges, faces and in the centre of the cube. Common errors included similar ions placed adjacent to each other and drawing a random array of ions.

Part (c) (i): This question required candidates to explain the difference in the melting points of sodium chloride and chlorine. Only a minority of candidates stated that the forces of attraction between the particles of sodium chloride were stronger than that between particles of chlorine. Fewer candidates stated the types of bonding present in the two substances. Common errors included statements that ionic bonds are stronger than covalent bonds, that compounds have higher melting points than elements and explaining the difference in terms of heat energy requirement for melting.

Part (c) (ii): This question required candidates to explain the difference in the melting points of magnesium oxide and sodium chloride. Many candidates correctly identified the ions present and were awarded a maximum of two marks. Fewer candidates explained the difference in terms of the size of the charges on the respective ions. Common errors include explanations based on the relative reactivity of magnesium and sodium, and that magnesium oxide had a stronger bond than sodium chloride and that sodium chloride had intermolecular forces.

### **Question 3.**

Candidates were required to answer questions given the structural formulae of four organic compounds from different homologous series. In addition, candidates were given a flow chart involving an unknown reactant **E**, and unknown reactant **F**, and three unknown chemical processes related to organic chemical reactions. Questions were then asked based on reactions in the flow chart. Generally this question was fairly well done.

Parts (a) (i) and (ii): These parts of the question required candidates to name (using given labels) the structures of organic compounds belonging to the same homologous series, giving a reason for doing so. Most candidates were able to correctly identify **A** and **C** as belonging to the same homologous series of alcohols, but some included **B** in their answers, probably because in structure B, the functional group of the organic acid contains the OH group as part of the carboxylic acid group. Many candidates were able to state the homologous series to which the structures in Part (i) belong, this being the alcohols. The required answer was that they have the same functional group (-OH) or the same general formula,  $\text{C}_n\text{H}_{2n+1}\text{OH}$ . Several candidates lost a mark because they incorrectly referred to the functional group of the alcohols as a hydroxide group, an ion, a hydroxy ion, hydroxyl atom, or a hydroxyl molecule.

Part (a) (iii): This section required candidates to draw and name two structural isomers of the compound pentan-1-ol. The isomers expected included those of pentan-2-ol and pentan-3-ol as well as branched structures of butanol and propanol. This part of the question proved to be very challenging to many candidates. Structures were drawn with covalent bonds or hydrogen atoms missing. A common error was for candidates to draw bent structures of the given structure of compound C as isomers, not realizing that the naming of the isomers is based on the longest continuous carbon chain. Some candidates included  $\text{-C=C-}$  double bonds in their structural formulae, as well as cyclic compounds as possible isomers not realizing that such structures were wrong answers.

Part (b) (i): This part of the question required candidates to recognize and state the reactant and the reaction conditions for the dehydration reaction of an alcohol. The correct answer was either concentrated sulphuric acid at 170-180 °C or passing the vapour of the alcohol over hot aluminium oxide. This question was not well done. Few candidates gave the correct complete set of reagents and conditions. Some errors included:

- $\text{H}_2\text{SO}_4$  as the reagent without specifying that it must be concentrated
- $\text{H}_3\text{PO}_4$  at 300 °C as possible reagent/reaction conditions. These however, are the reagent and conditions for the hydrolysis reaction for the conversion of ethane to ethanol (compound **E**).
- Not stating the correct temperature, just simply writing heat as the answer.
- Giving ethanol as the reagent rather than concentrated sulphuric acid.



Part (b) (ii): Many candidates were able to correctly name the process involved in this reaction as fermentation or anaerobic respiration, although some candidates named the process as respiration, hence they failed to gain the mark.

Part (b) (iii): This question required candidates to recognize that the burning of an organic compound in air is a combustion reaction, which produces carbon dioxide and water. Once **E** was identified as ethanol, candidates were expected to write a balanced equation for the combustion of **E**. Many candidates were able to give the formula or draw the structure of ethanol to gain the mark. Many, however, failed to identify compound **F** as  $\text{CO}_2$ . Some responses suggested that **F** was ethanoic acid. Many candidates were able to secure the third mark by writing the correct balanced equation for the reaction.

Part (b) (iv): This question required candidates to draw the full structural formula of the ester formed from substance **B** (propanoic acid) and substance **E** (ethanol) in the flow chart. Many candidates found this question challenging. Some drew structures with the correct ester linkage, but with incorrect alkyl groups. A considerable number of candidates drew structures that did not show the ester linkage at all.

#### **Question 4.**

This question was fairly well done with about 50% of the candidates gaining more than six marks. It tested the candidates' knowledge of the following concepts and principles:

- Reactivity of metals with acids (activity series)
- Ability to write balanced equations
- Covalent bonding
- Ability to draw dot and cross diagrams for covalent compounds
- Knowledge of atomic structure and the periodic table for placement of an element based on atomic number.

Part (a) (i): Many candidates were able to identify calcium as the most reactive metal with HCl. Few candidates chose Al and some chose Be, but they were awarded no marks. This indicated to the examiners that the topic of activity series of metals was well covered by teachers. However, a few candidates incorrectly wrote  $\text{Ca}^{2+}$  as the answer, hence they were penalized.

Part (a) (ii): Many candidates wrote the correct equation for this section, however, there is a continuing problem with candidates writing wrong formulae, for example, CaCl, Hcl, and HCL; and writing hydrogen gas as 2H instead as  $\text{H}_2$ . There were also a few unbalanced equations. Teachers are encouraged to teach the correct formulae and equation writing.

Part (a) (iii): This section proved to be difficult for many candidates. There was a failure to recognize a difference in the reaction of Ca with HCl and  $\text{H}_2\text{SO}_4$  based on the difference in the solubilities of  $\text{CaCl}_2$  and  $\text{CaSO}_4$ , and the effect this property has on the completion of the reaction. Some candidates stated a difference based on (i) one acid being stronger/weaker than the other and (ii) reaction will be slower with  $\text{H}_2\text{SO}_4$  instead of vigorous initially, but then slowing down as the insoluble  $\text{CaSO}_4$  precipitates out, until reaction stops altogether (not going to completion). Candidates also failed to link the difference to the fact that  $\text{H}_2\text{SO}_4$  is dibasic and hence its reaction will be faster with Ca. Candidates tended to miss the part of the question "observable changes" and instead listed the products formed.

Part (b) (i): Some candidates ran into difficulties by selecting elements for which the bonds formed were difficult, example, C and Si, Al and P. In teaching this topic, dot and cross diagrams involving only the outer electrons make it easier for structures showing bonding to be drawn accurately. A few candidates opted to draw all electron shells of Br, but not knowing the configuration of Br. Other incorrect answers included incomplete drawings, incomplete octets, incorrect number of bonds between atoms. A few candidates tried to form covalent bonds between Na and Ca.

Part (c): Some candidates placed X correctly in Group I and Period 4. A few candidates placed Be in Period 1, and hence described X as being in Period 3. Electronic configurations make it easy for elements to be correctly placed and it should be emphasized when teaching this topic, that the number of valence electrons places an element in a particular group; while the number of occupied shells places the element in its correct period. An atomic number of 19 gives an electronic configuration of 2,8,8,1, where there are four shells (Period 4), with the outer shell having one electron, hence that atom is based in Group 1.

### **Question 5.**

Part (a) (i): Many candidates were able to respond correctly by writing any base/any ammonium salt or the chemical name/chemical formula of a base or an ammonium salt. It is noteworthy that the chemical formulae were written incorrectly frequently. There was much confusion between  $\text{NH}_3$  and  $\text{NH}_4^+$  as formulae for the ammonium ion.

Part (a) (ii): A significant number of candidates were able to correctly identify diffusion as the process notwithstanding that some had no knowledge of the answers. Other responses included Brownian motion and sublimation or evaporation.

Part (a) (iii): Numerous candidates experienced problems with “the suitability of using moist blue litmus paper”. This simply required recognition of the alkaline nature of ammonia. Hence, using blue litmus would be unsuitable and would be unaffected by ammonia gas. For some candidates, suitability meant blue litmus could be used to test for ammonia. Despite recognizing the alkaline nature of ammonia, numerous suggestions were made that blue litmus would turn red. Other candidates suggested that moist red litmus should be used and ammonia would turn it blue.

Part (a) (iv): This section required candidates to describe **ONE OTHER** chemical test to identify ammonia and to write a balanced equation to represent the chemical test. Concentrated HCl or hydrogen chloride gas on cotton wool balls held close to a test tube with ammonia produces dense white fumes was the expected answer. Some candidates gave answers such as white precipitate and dense fumes. Other answers included ammonia bubbled into aqueous copper(II) to give a deep blue solution/blue precipitate; and ammonia bubbled into a zinc salt solution to produce a white precipitate followed by a colourless solution. A number of candidates also suggested bubbling ammonia into dilute hydrochloric acid to give a white precipitate, not realising that all ammonium salts are soluble. Thus no precipitate would be formed for this reaction.

Part (b) (i): Many candidates knew the catalyst for the Haber process.  $\text{Fe}^{2+}/\text{Fe}^{3+}$  or  $\text{Fe}_2\text{O}_3$  were not accepted for finely divided iron. Infrequently,  $\text{V}_2\text{O}_5$  was mentioned. It should be noted that even though heat was mentioned, it was not a catalyst.

Part (b) (ii): It was evident that numerous candidates were unfamiliar with the importance of using a high pressure in the Haber process. Candidates were required to state that the reaction involved gases; that molecules come closer together; that there is a reduction in volume; there is frequent collisions; that the reaction occurs with a reduction in the number of molecules (from reactants to product); that a high pressure will favour the forward reaction/increase the yield of ammonia, and that the rate of reaction will be faster.

Part (b) (iii): Few candidates were able to gain the three marks for naming the reactants/products on the diagram, labelling axes of the energy profile diagram, and showing an exothermic change on an energy profile diagram. Notwithstanding, the mention of the reactants (hydrogen and nitrogen) and product (ammonia) in the question, many candidates did not write them on energy profile diagram. In many instances, when written, the diatomic nature of hydrogen and nitrogen was omitted (N instead of  $\text{N}_2$  and H instead of  $\text{H}_2$ ). Energy profile diagrams varied in structure from unlabelled axes, no axes, and even a representation of an endothermic change. Some candidates even drew elaborate flow diagrams and diagrams of the industrial preparation of ammonia to represent energy profile diagrams. In conclusion, this question was poorly answered, with over 50% of the candidates gaining three or less marks.

### Paper 03 - Extended Essay

#### Question 1.

This question was the least popular of the six questions in this paper but it elicited some very good answers. Candidates were required to:

- Prepare a dry sample of calcium nitrate
- Deduce a method of determining if the prepared salt was free of calcium carbonate
- Write chemical equations for the effect of heat on nitrates
- Chromium plate an iron rod, giving electrode equations and a circuit diagram and
- Perform simple calculations to determine the mass of substance produced during electrolysis.

In Part (a) (i), many candidates seemed to think that calcium carbonate was soluble and measured out specific volumes of it to be mixed with nitric acid. Others used a titration process. The general description expected was to add the calcium carbonate to the acid until it was in excess, filter off the excess, evaporate the filtrate to concentrate it and cool the resulting solution to cause crystallisation. Some candidates used excess nitric acid, a procedure sometimes employed at university level, but failed to evaporate the solution using a water bath, a critical step since the solution produced is very acidic. A large percentage of the candidate population failed to perform the last step which was to filter off the crystals and dry them.

Common mistakes in Part (a) (ii) included:

- Adding the salt to limewater and
- Adding aqueous barium chloride to the salt.

What was required was a test and the outcome. Many candidates added the salt to water but failed to indicate that a white solid would be observed if calcium carbonate was present. Instead, they simply stated that the salt would be insoluble.

Another popular answer was to heat the salt. It should be pointed out to students that if a mixture of a carbonate and a nitrate is heated, nitrogen dioxide as well as carbon dioxide would be evolved so that testing the emitted gas(es) with limewater would not be at all useful. The examiners expected that candidates would add acid and test the gas evolved with limewater.

Equations for the effect of heat on calcium and sodium nitrate in Part (a) (iii) were generally well done. Marks were lost mainly in balancing the equations.

Part (b) (i) was poorly answered. There were several problems with the circuit diagram. Firstly, a high number of candidates did not seem to know that the long stroke in a battery represents the positive pole and labelled the attached electrode as the “iron cathode”. Secondly, the electrodes were often not connected to a source of electricity but were simply two rods immersed in the electrolyte. Thirdly, candidates used either a carbon anode instead of chromium or simply labelled “anode” without stating what it was made of. Most candidates, however, recognized that the object to be plated, namely the iron rod, should be made the cathode. In explaining the electrolysis, many candidates indicated that  $\text{OH}^-$  would be discharged at the anode and gave equations that resulted in the formation of water and oxygen. Also, where they recognized that chromium ions would go into solution as ions, the charge on the ion was often given as  $2+$  instead of  $3+$  and the state symbols were often omitted. Teachers must emphasise the need for state symbols when ionic equations are written.

The calculation in (b) (ii) was quite well done. The main errors were the use of the relative atomic mass of chromium as 25 instead of 52 and the omission of the 3:1 mole ratio of electrons to chromium. Many candidates used a 1:1 ratio.

### **Question 2.**

This was the most popular question on the paper. It tested candidates' knowledge of the particulate nature of matter. Part (a) of the question revolved around three experiments that were set up:

- Experiment 1 was the familiar diffusion experiment with ammonia and hydrogen chloride
- Experiment 2 illustrated diffusion of  $\text{KMnO}_4$  in a beaker of water and
- Experiment 3 demonstrated osmosis in paw-paw strips placed in a beaker of water.

Candidates were required to describe what would be **observed** in the experiments, to account for their observations and suggest how the rate of change of observations in Experiment 2 could be increased. Part (b) tested their knowledge of chromatography.

As in previous years, candidates continue to demonstrate their lack of understanding of the term 'observation' and gave vague and often imprecise descriptions of what they would observe. For example, instead of describing the ammonium chloride formed in Experiment 1 as a white solid ring, many simply wrote that a 'cloud', a 'fog' or a 'smoke' would be observed. In Experiment 2 the permanganate was described as "dissolving in water until the entire solution turned purple". Some candidates confused the colour of the permanganate with that of dichromate whilst others just stated that the "permanganate crystals spread out in the water" without any reference to its colour. It was expected that candidates would observe the spreading of the purple colour of the permanganate from the bottom throughout the solution until the entire solution became a uniform colour. In Experiment 3 explanations rather than observations were generally given. Many candidates wrote about the paw-paw strips absorbing water as water moved from a region of higher concentration to one of lower concentration.

The candidates recognized that the processes occurring in Experiment 1 was diffusion and in Experiment 3 was osmosis. Many, however, referred to the process in Experiment 2 as either dissolving or Brownian Motion.

Some candidates confused the nature of matter with the states of matter and offered explanations that revolved around the permanganate and the paw-paw strips being solids, the water being a liquid and the ammonia and hydrogen chloride being gases. It was expected that candidates would explain that matter is made up of particles that are in a state of constant motion and move from a region of higher concentration to one of lower concentration. None of the candidates offered any real explanation of how matter is transported in the experiments, although a few mentioned that the medium in Experiment 1 was air and in the other two experiments it was water. They were expected to explain that the molecules in the transport media were also in constant motion and would collide with the ammonia and other particles thus pushing them along.

Part (a) (iii) garnered a variety of responses for increasing the rate of observation in Experiment 2. Candidates listed all the factors that affect the rate of reaction including using a catalyst, increasing the surface area by crushing the permanganate and increasing the amount of permanganate used. A creditable number used heat and explained that this would increase the kinetic energy of the particles causing them to move faster.

In Part (b) (i), candidates did not know that the advantage of using chromatography lies in the fact that only small amounts of the mixture are needed, that the components are not destroyed by the process or that it can be used to separate mixtures of substances with similar properties. Instead many of them focused on it being cheap and accurate. Neither of these responses was credited.

In Part (b) (ii), candidates lost marks for not labelling the starting line and the solvent front in their chromatograms. Most recognized that the pure substance would produce only one spot whilst the mixture would produce more than one. Teachers must instruct their students on the difference between a chromatogram, the actual product, and the process of chromatography as many candidates attempted to show the entire process in diagram form.

### **Question 3.**

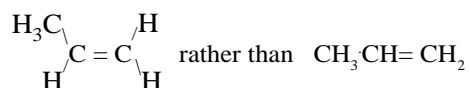
This question was slightly more popular than its counterpart in Section B. It tested candidates'

- Knowledge of the reactions of carboxylic acids
- Ability to write equations for these reactions
- Use of knowledge of bromination of alkanes and alkenes
- Knowledge of the conversion of alkenes to alcohols and polymers.

In Part (a), many candidates were able to write correct well balanced equations for the stated reactions. The main errors encountered in Part (i) were the use of  $\text{Na}^+$  instead of Na for sodium and the formation of water rather than hydrogen gas as a product of the reaction between hexanoic acid and sodium. In Part (ii), candidates had difficulty balancing the equation for the reaction between the acid and ethanol. Many also gave incorrect formulae such as  $\text{C}_2\text{H}_5\text{COOC}_6\text{H}_{11}$  and  $\text{C}_6\text{H}_{11}\text{COOH}\text{C}_2\text{H}_5$  for the ester. Additionally, quite a few candidates omitted the water from the products of the reaction.

In Part (b), the reaction between bromine and hexane was consistently referred to as either 'replacement' or 'displacement' rather than the accepted 'substitution' reaction. Also, the candidates often erroneously determined that the bubbles of gas seen to be escaping from the mixture was hydrogen rather than HBr. Another common mistake was to refer to the dense fumes formed with ammonia as ammonium chloride rather than the bromide. The equation, however, was generally well written and most candidates obtained the two marks awarded. In (b) (iii) candidates were familiar with the decolorisation of the bromine by hexane and correctly identified the reaction as an addition.

Few of the candidates recognized that the partial structure of the polymer in Part (c) should have a methyl branch and gave straight chained structure with nine carbon atoms. Teachers should try to encourage their students to write the structure of alkenes in the form:



especially when discussing the topic of polymerization so that they would more readily recognize what happens when molecules join on to each other. A majority of the candidates wrote good equations for the conversion of propene to propanol and the conditions for the reaction were well known. In Part (iii), candidates knew that the separation of the alcohol from the alkene required some form of distillation. Some drew diagrams representing simple distillation when what was required was a diagram showing fractional distillation. The diagrams were generally scrappy and were not properly labelled. In particular the condenser must be labelled with the water inlets and outlets and this was often mixed up or omitted.

### **Question 4.**

This seemed to be the most challenging question on the paper for the candidates who misinterpreted what was being asked and gave answers that were unrelated to the question. Most candidates performed poorly.

The question tested candidates' understanding of

- reduction processes used in the extraction of metals
- the relationship between the choice of extraction method employed and the position of a metal in the reactivity series
- separation methods
- factors affecting products of electrolysis and
- acidic and basic oxides.

In Part (a), many candidates were able to name a metal high in the reactivity series and one that was lower and give corresponding processes for their extraction, namely electrolysis and reduction with coke/carbon monoxide respectively. However, these candidates failed to link the position in the reactivity series with the relative reactivity of the metal or the stability of the ore. A point for teachers to note is that stating that aluminium is higher in the reactivity series than copper does not necessarily mean that aluminium is high in the series and copper is low in the series. Furthermore, they did not refer to the strength of the reduction process that was needed. As a result, the majority of candidates did not get more than two of the five marks allotted for this part of the question.

In Part (b), it was obvious that most candidates did not read the question carefully or did not realize that the ore from which the two metals were to be extracted was a **MIXTURE** of the two oxides and therefore the oxides had to be first separated from each other. From the information given, it was expected that the candidates would first add sodium hydroxide to the ore and then filter the resulting mixture. This would leave the oxide of metal B as the residue whilst the oxide of metal A would dissolve and form the filtrate which could then be heated to dryness and consequently melted. The molten mixture could then be electrolysed and the metal A would be obtained at the cathode. The oxide of metal B which remained on the filter paper could be heated with coke or in a stream of carbon monoxide to obtain the metal. Most candidates identified metal A as aluminium and B as iron and proceeded to give very detailed accounts of the extraction of these two metals. Since this was not what was required of the question these candidates scored poorly. Teachers must emphasise to their students the importance of reading questions carefully and answering what is asked and not what one expects the question to ask.

Part (c) tested whether candidates understood why metals high in the reactivity series are obtained by electrolysis of the molten rather than the aqueous salt. Candidates exhibited a general lack of understanding of this area of the syllabus. Many candidates did not seem to understand the term ‘molten’ and consistently referred to the molten salt as being “concentrated”. Few gave the ions present in each of the electrolytes and therefore could not explain that since the aqueous salt provided both  $H^+$  and  $X^+$  ions at the cathode, because hydrogen is lower in the reactivity series than X, it would be preferentially discharged. Since the molten salt contained only the one cation,  $X^+$ , X would be deposited at the cathode. Explanations often involved the preferential discharge of OH ions.

In Part (d), most candidates did not refer to the acid/base nature of the reaction between sulphur dioxide and calcium oxide as the basis for the removal of the gas from the atmosphere. Many wrote about the environmental effects of sulphur dioxide. Additionally, candidates did not recognize that salts of sulphur dioxide are sulphites and not sulphates and that  $SO_2$  would thus have to be first oxidized by the oxygen in the air to  $SO_3$ . Thus the following incorrect equation was often given as  $CaO(s) + SO_2(g) \rightarrow CaSO_4(s)$ .

### **Question 5.**

This question tested the concepts and principles in two units of the C Section of the syllabus. Since candidates were required to prepare for only one of the options in Section C2 namely Option 3 OR 4, the Council regrets the error in this question and has made every effort to ensure that candidates were not penalized in any way. Answers in this question were of a slightly higher standard than in the alternative.

In Part (a), candidates were required to discuss **TWO** physical properties of water as they related to processes occurring in living systems. **TWO** errors were predominant. Firstly, candidates ignored the instruction to relate the property to living systems, and concentrated on the relationship to the abiotic environment. For example, the presence of dissolved oxygen in an aquatic environment was not related to the process of respiration in fishes. Secondly, candidates did not identify the unique nature of water by stating whether the specific heat capacity was high or the volatility low. Rather, candidates simply stated that “because of the heat capacity of water, it helps to maintain body temperature”.

In Part (b) (i), definitions of “hard water” were often incomplete. For example, it was often stated that ‘hard water does not lather well’ with no reference to soap being made. Also, definitions referred to water containing dissolved calcium (Ca) and magnesium (Mg) rather than their IONS ( $Ca^{2+}$  and  $Mg^{2+}$ ). In Part (b) (ii), the formula for calcium hydrogen carbonate was often incorrectly given as  $CaH(CO_3)_2$  or  $CaHCO_3$ . Some candidates believed that any hydrogen carbonate would produce temporary hardness and even gave the formula for sodium hydrogen carbonate. The importance of the calcium and magnesium ions in causing permanent hardness was also unknown to many who believed that it was the sulphate ion that was responsible.

Very few candidates gained full marks for the two equations showing the removal of permanent hardness by sodium carbonate and temporary hardness by boiling. The most common error in the first equation was the incorrect formula for sodium carbonate which was often given as  $\text{NaCO}_3$ . Additionally, the absence of state symbols indicated a general lack of knowledge of the principle of precipitation for the removal of permanent hardness in water. Teachers please note that it is imperative that students write state symbols for this equation. It is a good practice to encourage them to write **ALL** equations using state symbols. In the second equation, many candidates believed that the hydrogen carbonate would decompose to the metal oxide or even the metal.

The term “compare” as given in the glossary in the syllabus requires a statement about similarities and/or differences. Thus, if candidates are asked to “compare the differences between soaps and soapless detergents on hard water” it is expected that **BOTH** substances must be discussed. Candidates often gave the effect of only one. For example, a popular answer was that soaps form a scum with hard water with no reference being made about the effect of the soapless detergent. This was the only effect that was well known by most candidates. They were expected to discuss also the cleansing action and solubilities of the calcium and magnesium salts of the two detergents.

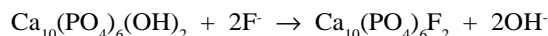
### **Question 6.**

This question tested candidates’ knowledge and understanding of the

- components of toothpaste
- action of the components of toothpaste
- advantages and disadvantages of chemical and biological pest control.

In Part (a) (i), many candidates believed that the important components of toothpaste were calcium and fluorine instead of abrasives such as calcium carbonate, fluorides, detergents and glycerol.

In (a) (ii), candidates were asked to describe, with the aid of an equation, how one component of toothpaste could strengthen the enamel of teeth. It was expected that the candidates would use the formula given for tooth enamel to write the equation:



Many candidates wrote the formula of fluorine as Fl. Others failed to realize that it was the fluorine that was responsible for strengthening the tooth, and not the calcium from the calcium carbonate. Candidates did not recognize that the replacement of the hydroxide by the fluorine was what caused the enamel to become stronger.

In (a) (iii), the majority of candidates could not explain what happens in tooth decay. They failed to appreciate that the bacteria in the plaque converted carbohydrates to acid which reacted with the enamel causing it to erode and become susceptible to bacterial infection. Many candidates knew that acid was somehow involved in the process but some thought that the acid was hydrochloric acid and others believed that the bacteria gave off the acid. A simple ionic equation showing the reaction between hydrogen and hydroxide ions was also expected to illustrate the process. Many candidates attempted complex equations involving the formula given for tooth enamel and got into difficulty.

In Part (b), the candidates were more familiar with advantages and disadvantages of chemical control than they were with biological control of pests. One misconception that was repeatedly noted was that candidates believed that chemical control was more expensive than biological control.

## Paper 04 – School-Based Assessment (SBA)

### General Comments

The improvement in the quality of the laboratory books and mark schemes submitted for moderation are two of the factors which made the moderation exercise a much easier process than in previous years. Teachers are commended for the efforts that have been made to conduct more than the recommended minimum number of practicals and also for engaging students in a wide range of practical activities.

While there was some improvement in the quality of the mark schemes generally, there still continues to be a problem with some of the criteria for assessing ORR and AI as well as the types of tasks suitable for Planning and Design. In addition, at least 28 centres submitted no mark schemes.

There was slight improvement in the quality of the books from some of the newer centres. However, many of these teachers are still not clear on the standard of practical activities that is required for the SBA. In a number of cases, one practical activity is being used to assess more than two skills. In addition to paying careful attention to the moderation feedback report, teachers with limited experience in conducting SBA are encouraged to read the relevant section of the syllabus and collaborate with more experienced members of staff from some of the more traditional Centres for tips on conducting the SBA. Teachers at a given Centre are encouraged to work together in planning for and selecting practical activities. Where possible, it may also be useful for teachers from the science department to engage in small-scale moderation exercises at their schools so as to evaluate mark schemes and the suitability of practical activities. This should also help to improve the consistency with which mark schemes are used.

A significant amount of time is spent doing laboratory practical exercises on “separation of mixtures” with some Centres doing as much as five different activities. This tends to leave very little time for conducting exercises on some of the more difficult concepts and limits the possibility of covering the remaining aspects of the syllabus through practical work. Some essential activities continue to be neglected or treated in a somewhat trivial manner, requiring very little critical thinking on the part of the students. These include making deductions from qualitative analysis, writing balanced molecular and ionic equations and activities related to electrolysis, heating substances, organic chemistry and redox reactions.

In a few cases, the practical activities done are not based on the chemistry syllabus. For example in number of instances, students were asked to plan and design activities to show that light or some other variable is necessary for photosynthesis and to make detailed drawings of the procedure for conducting an experiment.

One other disturbing trend is that some teachers are only correcting the practical exercises done for the SBA and leaving the others unmarked. In a few instances, enough care was not given to correcting students’ work, as information that was incorrect was marked correct by teachers.

Some of the specific problems encountered at moderation are outlined below.

#### 1. Assessment of Planning and Design Skill:

- a. The unsuitability of some activities for assessing Planning and Design as well as uncertainty about what is expected by “treatment of results” are the most common problems associated with the assessment of this skill. Teachers should note the specific description of the learning outcomes being tested by this skill as stated in the syllabus (Appendix 2 point 3). Standard activities that require the straight recall or reproduction of information that is available in any chemistry text book are not suitable for assessing planning and design. A sample of such unsuitable activities selected from the candidates’ books is listed here.
  - i. Design an activity to test the hardness of water.
  - ii. Plan and design an activity to show the conditions necessary for rusting
  - iii. Plan and design an activity to prepare magnesium sulphate
  - iv. Plan and design an activity to show that the rate of reaction of calcium carbonate with dilute hydrochloric acid is dependent on surface area.
  - v. Plan an activity to determine the heat of combustion of ethanol



Suitable PD activities should pose a problem for students to solve using concepts from the syllabus being tested. The use of the concepts should be in some sort of “novel” context. As such, these activities should not be a repeat of activities done previously or readily available from a text but should require the application of knowledge. Some of the concepts tested by the activities in (i) to (v) above can be made into more appropriate PD activities as outlined below. These examples are also taken from samples of work submitted.

- i. Design a suitable activity to compare the hardness of water from two water sites.
  - ii. Plan and design an activity to determine whether the temperature of salt water affects the rate at which iron rusts.
  - iii. Crushed celery was placed in a sealed bag containing  $H_2O_2$  and left in a closed cupboard along with a similar bag containing only  $H_2O_2$ . After few hours, the first bag became much more distended than the second bag.
  - iv. Alcohols are useful fuels whose energy values are linked to the molecular weight. Design an experiment that would allow you to establish the relationship between molecular weight and heat of combustion for the alcohols ethanol, propanol and butanol.
  - v. “Blast Off”, “Super” and “Everlasting” are three different brands of baking powder. Martha insists on using Blast Off because she claims it is most effective. Plan and design an experiment to determine if Martha’s belief is true.
- b. In a number of cases, candidates lost marks for the PD activities because they presented actual results of data, suggesting that the activities were carried out. Teachers are reminded that PD activities are not to be conducted. The “Expected Results” should indicate the data **to be collected**. For example, the activity comparing the two brands of baking powder in (v) above, might require the collection of carbon dioxide gas in a syringe. In the “Expected Results” students could therefore present a table with Type of Baking Powder and Volume of Carbon Dioxide as the headings. However, no figures should be recorded in the Table.
- c. The “Treatment of Results” should be linked to the aim which should be linked to the hypothesis of the experiment. Using the same example of the baking powder, students might be expected to state that one brand of baking powder would produce a larger volume of carbon dioxide in a fixed time period than the others.
- d. At least four PD laboratory exercises should be done over the two year period. In many instances students did fewer, resulting in reduction of their marks for PD.
- e. Exercises used to assess the PD should not be used to assess any other skill.

## 2. Assessing the Analysis and Interpretation Skill

Assessment of this skill is affected by:

- confusion of criteria suitable for ORR with those suitable for AI
- inadequate number of criteria for assessing AI in a particular practical; in some cases, one or two questions were used to assess AI which did not prove to be suitably challenging for the students
- using questions to assess AI which bear no relation to the data collected
- selecting inappropriate activities for assessing AI.

The result is that AI is not being properly assessed and candidates' grades do not accurately reflect their conceptual understanding based on the general quality revealed in the laboratory activities presented.

- i. Equations and discussions and explanations should be assessed as A/I and not ORR. Teachers should pay closer attention to the writing of equations and are encouraged to correct inaccurate equations in students' books. State symbols are required for ionic equations.
- ii. The actual plotting of the graph should be assessed under ORR but calculations and interpretation of data using the graph should be treated as A/I.
- iii. For qualitative analysis, marks awarded for inference should be linked to the observations made. Also qualitative analysis exercises that require students to conduct tests on known reagents are not suitable for assessing A/I. Rather, students should be given unknowns when testing for A/I. In conducting qualitative analyses, students should be encouraged to complete their results in tabular form.
- iv. Attempts should be made to include at least one activity that requires calculations (with several steps), such as enthalpy changes, concentration, the mass of product obtained during electrolysis for assessment of AI. Calculation of concentration from volumetric analysis should be done from first principles and should not involve using:  $M_aV_a = M_bV_b$ .
- v. Other activities suitable for assessing AI include reactions of acids with various substances that require inferences to be deduced, energetics, rates of reaction which requires explanation for the shape of various parts of the graph and deductions from the graph.
- vi. Definitions and drawing of models of crystal structure and bonding diagrams are not suitable AI activities
- vii. Greater attention should be given to writing the correct formulae and equations. In many instances these were marked correct when there were errors in the candidates' work.

### 3. Table of Contents

- i. This continues to be a sore point in many books presented for moderation. All activities should be dated and pages numbered.
- ii. Activities in the laboratory books should have the same titles or numbers as those in the teachers' mark scheme.
- iii. The activities being used to compute the students' SBA scores for the various skills should be clearly indicated in the students' notebooks and mark scheme.

### 4. Absence of or Inappropriate Mark Schemes

- i. Moderation is made difficult if mark schemes are inappropriate or unclear. Incomplete or unsatisfactory mark schemes will undoubtedly work to the students' disadvantage, as an alternative mark scheme has to be used. As indicated in last year's school report, some teachers are allocating very few marks for the AI activities. In many instances the total possible score for AI is 4 or 5 marks. Ideally, the mark for each skill should be at least 10. Careful selection of activities to facilitate more discussion of the data or response to questions should reduce this tendency.
- ii. This year saw an increase in the number of Centres that did not send any mark schemes for the sample of books submitted. Where this happens candidates may be penalized as mark schemes have to be created in order to moderate the books. Where a teacher is teaching in two Centres and submits two sets of books but intends the mark scheme to be used for both sets of books, this should be clearly indicated on the moderation sheet.
- iii. In a few instances teachers submitted general mark schemes for all the skills. This practice should be discontinued and teachers should submit specific mark schemes for each activity.

5. Re-sit Candidates / Extenuating Circumstances

Teachers are again reminded to pay attention to the syllabus guidelines (page7) for re-sit candidates. If books of re-sit candidates are submitted for moderation then these should be clearly identified. Where circumstances such as illness or absence of staff have resulted in some adjustments to the required number of activities and the times where assessment takes place, this should be outlined in writing to the Registrar so that candidates are not penalized unnecessarily.

**C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE EXAMINATION  
MAY/JUNE 2007**

**CHEMISTRY**

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**CHEMISTRY**  
**GENERAL PROFICIENCY EXAMINATION**  
**MAY/JUNE 2007**

**The Structure Of The Examination**

The examination consisted of three written papers. The weightings of these papers were as follows: Paper 01 (25%), Paper 02 (30%), Paper 03 (25%), Paper 04, the School-Based Assessment (SBA), contributed 20%.

Paper 01 consisted of 60 compulsory multiple choice items based on the specific objectives in Sections A and B of the syllabus. The items were assessed under the profile, Knowledge and Comprehension (KC).

Paper 02, a structured essay paper, consisted of five compulsory questions based on the objectives in Sections A and B of the Syllabus. Question 1 was a data analysis question. Candidates were assessed under the profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 04 involved the continuous assessment of candidates by teachers over a two-year period. Samples of candidates' laboratory books were externally moderated by CXC.

**GENERAL COMMENTS**

A total of 10,471 candidates were entered for the examination representing a 4.2 % increase over the 2006 examination candidate population. Candidates' performance on Paper 01 was similar to that of 2006.

While there was a general improvement in the overall performance of candidates, especially with respect to questions based on organic chemistry, there are some fundamental areas that need to be addressed. These include failure of candidates to read questions carefully. Very often candidates were asked to give ionic equations and instead gave balanced molecular equations. Also, candidates when asked to describe expected observations (for example, a gas evolved, vigorous effervescence, a coloured precipitate), instead identified the actual substances. Writing of the partial structures (or repeating unit) of polymers continues to pose great difficulty for candidates. Also, in Paper 03 many of the questions were answered very superficially, especially questions relating to the impact of pollutants on the environment, giving the impression that many of the topics were not adequately covered by the candidates.

**DETAILED COMMENTS**

**Paper 01 – Multiple Choice**

Performance on this paper continues to be generally good. A number of candidates experienced difficulties with items based on the following syllabus objectives:

- A. 5.2 - distinguish among solutions, suspensions and colloids
- A. 6.1 – trends in the reactivity of Group 2 elements
- B1. 2.1 – recognizing addition reactions of alkenes
- B1. 2.7- identification of the combustion products of ethanol
- B 1.4.3 – the linkages present in named condensation polymers
- B2. 3.1 – catalyst used in the industrial preparation of ammonia

## Paper 02 – Structured Essay

NOTE: THESE COMMENTS SHOULD BE READ IN CONJUNCTION WITH THE QUESTION PAPER IN ORDER TO DERIVE THEIR FULL BENEFIT.

### Question 1.

Part (a)

Candidates were expected to complete the data required in Table 1 to show the titration values based on a series of burette readings given in Figure 1. They were also required to carry out a series of simple calculations, based on the titration readings and other given information to determine the mass of sodium hydroxide in 250 cm<sup>3</sup> solution.

Part (a) (i) of the question was generally well answered with most candidates scoring full marks for correctly reading the burette. A few candidates, however, incorrectly read the burette scale “bottom up “ rather than “top down” For example, a correct burette reading of “1.3” was given as “2.7”. Also, some candidates incorrectly summed the initial and final burette readings instead of subtracting them in order to obtain the volume of acid used in the titration.

In (a) (ii), most candidates were able to write the balanced equation for the reaction occurring during the titration. Common errors included writing NaOH as Na<sub>2</sub>OH and NaOh. HCl was also frequently written as HCL. This error should be brought to the attention of students in the classroom since it is a perennial problem.

In (a) (iii), most candidates were able to correctly calculate the number of moles of hydrochloric acid used in the titration based on the concentration of the standard solution (0.050 mol dm<sup>-3</sup>).

In (a) (iv), candidates were wrongly applying the formula: number of moles = concentration x volume to obtain the number of moles of sodium hydroxide in 25 cm<sup>3</sup> of solution. They failed to take into consideration the balanced equation for the reaction (a) (ii) between NaOH and HCl and the corresponding mole ratios (1:1).

In (a) (v), many candidates failed to use their answer in (a) (iv) to calculate the number of moles of NaOH in 250 cm<sup>3</sup> of solution. Instead, they incorrectly based their calculation on 1000 cm<sup>3</sup> = 0.05 moles (the given concentration of hydrochloric acid).

In (a) (vi), some candidates had difficulty calculating the mass of sodium hydroxide in 250 cm<sup>3</sup> of solution which could be simply obtained by multiplying the answer in (a) (v) by 40 (moles x molar mass).

Part (b)

This part of the question required candidates to make appropriate deductions based on a series of tests and the corresponding observations. All of these tests would have been carried out in their laboratory exercises as part of their tests for various cations and anions. The performance was generally poor.

Test 1

Most incorrectly identified the brown gas evolved which turned blue litmus red as bromine or Fe<sup>3+</sup> rather than as nitrogen dioxide. Of those who identified the gas as nitrogen dioxide, some of them incorrectly represented it as NO<sup>2</sup> or NO<sup>3</sup>. Also, many incorrectly represented the formula for nitrate as NO<sub>3</sub><sup>-</sup> or NO<sub>3</sub><sup>2-</sup>.

The test for oxygen was generally well known but many represented the formula for oxygen as O<sub>2</sub><sup>-</sup> or O<sub>2</sub><sup>2-</sup> indicating the serious misconception that oxygen ions were being tested for, rather than gaseous oxygen (molecular form). This misconception should be corrected in the classroom.

### Tests 2 and 3

The responses indicated that candidates did not know of the distinguishing feature of the aqueous sodium hydroxide and the aqueous ammonia test in determining the presence of certain cations.

Also, many candidates have the propensity for incorrectly writing the chemical symbol for the neutral atom rather than the intended ions in solution, for example, writing Pb when  $\text{Pb}^{2+}$  is intended.

### Test 4

Many did not recognize aqueous potassium iodide as the confirmatory test for  $\text{Pb}^{2+}$  ions and did not use their inference in Test 3 to guide them along. Also, the writing of the ionic equation posed a challenge to many. Some wrote an electrode half equation for the ionic equation ( $\text{Pb}^{2+} + 2\text{e}^- = \text{Pb}$ ).

### Test 5

Many candidates were unable to identify Q as lead nitrate. While some correctly did, their deductions from tests 1 – 4 were not in keeping with such a deduction. Also, many had problems writing the formula of lead nitrate.

### Part (c)

This part of the question required candidates to plan and design an experiment to obtain “solid sea salt” from a bottle of sea water containing sand. Specifically they were required to:

- List the apparatus to be used;
- Outline the steps of the procedure to be employed;
- List the main observations expected at each step of the separation procedure;
- Test for the presence of  $\text{Cl}^-$  ions in the extracted sea salt.

In (c) (i), candidates were expected to list the apparatus that could be used to bring about the desired separation. In many cases the listed apparatus bear no relation to the procedure the candidates outlined in (b). The responses were wide and varied and included the use of cloth, sieves, strainers, pots and pans, light bulbs, furnaces, ovens. The expected response was for appropriate laboratory apparatus which could be used to first separate the sand from the sea water (filtration apparatus), followed by concentration/crystallization (evaporation to dryness) of the filtrate.

In (c) (ii), an outline of an appropriate procedure in recovering “solid sea salt” from the sandy sea water was required. The majority of responses were in keeping with a methodology involving, as a first step, filtration followed by concentrating/evaporating the filtrate and recovering the crystals/residue. However, a significant number of candidates incorrectly used a separating funnel instead of a filter funnel to separate the sand from the sea water. Also, some attempted the process of separation by using distillation prior to filtration. This of course would lead to contamination of the sand and salt. Other methods of separation included centrifugation followed by decantation.

In (c) (iii), candidates were required to list the main observations at each stage of the separation procedure they described in (c) (ii). The typical responses were expected to include sand on the filter paper during the filtration stage and a white solid (salt) formed in the evaporating basin during the concentration step. A number of candidates stated the process (filtration, evaporation) rather than the observations and as a consequence lost valuable marks. Candidates are advised to carefully read the question before writing their responses.

In (c) (iv), candidates had surprisingly great difficulty describing a possible test for chloride ions in the solid sea salt. Many incorrectly suggested the use of  $\text{AgNO}_3/\text{HCl}$  instead of the expected  $\text{AgNO}_3/\text{HNO}_3$ . The use of HCl would lead to the introduction of chloride ions into the sample and hence lead to an incorrect deduction. Many

other incorrect tests included electrolysis of the sodium chloride, heating the sea salt to liberate chlorine gas and testing for the bleaching of litmus, and the flame test with the sea salt giving a green flame.

### **Question 2.**

Candidates were required to:

- Define oxidation and reduction;
- Recognize standard tests for oxidizing/reducing agents;
- Distinguish between oxidizing and reducing agents;
- Predict chemical reactions based on the position of an element in the electrochemical series;
- Write balanced ionic equations to illustrate oxidation and reduction;
- Suggest suitable household chemicals to remove a layer of carbonate coating based on their knowledge of the reactions of carbonates.

#### Part (a)

The candidates' responses clearly indicated a serious misconception between a reducing/oxidizing agent and the substance which is oxidized /reduced in the course of a reaction. This was reflected in the fact that whilst a number of candidates recognized that in Experiment I, Solution A was acting as a reducing agent whereas in Experiment 2, Solution A was acting as an oxidizing agent, very few were able to explain this in terms of the observations given: namely, the reduction of chromium ions from + 6 to +3 (orange to green) and the oxidation of iron from +2 to +3 (from pale green to pale yellow).

Common misconceptions included oxidation as electron gain and reduction as electron loss. Also, many candidates lost marks for simply stating that there is electron exchange without specifically referring to the species involved.

#### Part (b)

Candidates still have difficulty writing ionic equations as represented by the reaction between Cu and aqueous silver nitrate. Many did not include state symbols. Others included all the species involved in the reaction including spectator ions. Other common errors included writing the formula for silver ions as  $\text{Ag}^{2+}$  rather than  $\text{Ag}^{1+}$ , and representing the symbol for silver as Au.

Most candidates were able to correctly account for the blue colour of the solution observed in Experiment 4 in terms of the presence of  $\text{Cu}^{2+}$  ions. However, many very carelessly referred to simply the presence of copper rather than to  $\text{Cu}^{2+}$  ions.

#### Part (c)

The majority of candidates correctly stated that no reaction would occur when a strip of copper metal is immersed in an aqueous solution of iron (II) nitrate. However, many of these candidates were not able to fully account for this in terms of the relative positions of Cu and Fe in the reactivity series.

Many simply referred to Cu with no reference to Fe. Also, some candidates apparently misconstrued the term "electrochemical series" and as such referred to the preferential discharge of ions relative to  $\text{H}^+$  ions during electrolysis.



Part (d)

Most candidates recognized the need for a mild acid cleaning agent (such as vinegar) to remove the carbonate coating on a copper ornament. However, few were able to score full marks for writing the corresponding ionic equation. This problem is inherent throughout the examination and clearly indicates that students need to be exposed to more practice in writing ionic equations in the classroom.

**Question 3.**

Candidates were required to:

- Deduce mass number, atomic number, number of protons, number of neutrons, electronic configuration and group number based on given information;
- Predict the likelihood of an atom forming an ionic or a covalent bond based on atomic structure;
- Use dot cross diagrams to represent bonding in ionic compounds;
- Explain metallic bonding;
- Relate the structure of graphite to its properties;
- Distinguish between ionic and molecular solids.

Part (a)

This was generally well done indicating that candidates had a fair grasp of the arrangement of electrons in the various energy levels, atomic number, group number and period number. However, there were some candidates who were unable to determine group number and period number based on the electronic configuration. Also, there was some apparent confusion of mass number with proton number.

Part (b)

Most candidates correctly predicted the formation of an ionic bond between Elements A and B. However, several were unable to make the connection between the number of electrons in the valence shell and whether the element is a metal or nonmetal. As such, many were unable to give an appropriate explanation for the formation of an ionic bond between A and B. A common misconception was that A and B became noble gases upon gain or loss of electrons.

The drawing of dot cross diagrams to illustrate the bonding between A and B (ionic bonding) was a challenge to many candidates. Even though candidates correctly identified ionic bond formation in b (i), the dot-cross diagrams instead reflected covalent bonding/electron pair sharing. Diagrams at the best of times were drawn carelessly indicating either candidates did not have experience drawing dot cross diagrams or that the concept of complete electron transfer in ionic bonding is not well grasped.

Although candidates were not required to identify the elements, those who identified B as fluorine incorrectly wrote Fl as the symbol rather than F.

Part (c)

Many candidates correctly identified the bonding in A as metallic bonding. However, their description of the bonding clearly indicates a lack of understanding of metallic bonding. Terms such as floating cations or positive atoms were used to describe the cations in the crystal lattice. Many also referred to mobile electrons without reference to the cations.

Part (d)

This proved to be the most difficult part of the question for candidates. Many attempted to describe the bonding in graphite with no reference to the weak forces of attraction (Van der Waals forces) between layers.

Those who attempted to describe such forces of attraction between layers often referred to them as weak covalent bonds. Teachers need to stress the difference between the bonding within layers, as distinct from the forces of attraction between layers. Thus, although candidates knew that graphite acts as a lubricant they were not able to explain this property in terms of the weak forces between the layers in the graphite structure.

**Question 4.**

Candidates were required to:

- Use data on the combustion of a hydrocarbon, X, in order to deduce its molecular formula, the homologous series to which it belongs, its name as well as its fully displayed structure;
- Deduce the homologous series, name and fully displayed structure of a hydrocarbon, Y, of formula  $C_5H_{10}$ ;
- State a test (reagents and observations) that could be used to distinguish between hydrocarbons X and Y;
- State the reagent and reaction conditions necessary to convert Y (an alkene) into X (an alkane).

Generally the question was poorly answered with a high percentage of candidates failing to gain any KC or UK marks. In spite of this there were a number of excellent responses, with candidates gaining full marks.

Part (a)

Many candidates were unable to use the data given (moles, volumes of gases at r.t.p.) to determine the formula of the hydrocarbon ( $C_5H_{12}$ ). Most were only able to calculate the number of moles of  $CO_2$  produced from the given number of moles of hydrocarbon but were unable to use the mole ratio approach to carry the calculation forward to the end. Many candidates incorporated oxygen into their final formula, apparently because combustion data was given, in spite being told compound X is a hydrocarbon. Thus, formulae such as  $C_5H_{11}OH$  were quite common.

In a number of cases the correct formula was stated without any calculations given. Such candidates were not credited with the full marks. To obtain full marks candidates were required to show evidence as to how they arrived at their answers.

Part (b)

This part of the question required candidates to link their answers to the formula of the hydrocarbon they derived in Part (a). In spite of this, many candidates gave responses to (b) (i), (ii), (iii), which bore no relationship to their answers to (a). In fact, a number of candidates had correct responses to (b) (i), (ii), (alkane, pentane) whilst identifying X as  $C_2H_5OH$  or as  $C_5H_{11}OH$ .

Part (c)

Most candidates were able to correctly deduce the homologous series, the name and the fully displayed structure of the compound corresponding to the given hydrocarbon, Y, of formula  $C_5H_{10}$ . Common errors included:

- Using the wrong prefix for the name of the hydrocarbon. Hexene and propene were often given instead of pentene;

- Drawing structures with pentavalent carbons instead of tetravalent carbons.

Part (d)

Most candidates correctly identified a suitable reagent (bromine, acidified potassium manganate (VII)) that could be used to distinguish between Y (an alkene) and X (an alkane). However, many failed to clearly state the expected observations when BOTH X and Y are treated with the named reagent. Most focused on what is observed when the alkene is treated with the reagent with no reference as to what would be observed when the alkane is treated with the reagent.

An area of concern is the number of candidates who used combustion information (number of moles of CO<sub>2</sub> and H<sub>2</sub>O formed) as a means of distinguishing X from Y. What is expected is simple test tube reactions.

Part (e)

This part of the question proved challenging for many candidates. Many confused reagent with reaction condition as well as hydrogenation with hydration. As such, many gave H<sub>2</sub>O as the reagent in the presence of acid rather than H<sub>2</sub>/Pt, Ni.

**Question 5.**

Candidates were required to:

- Define the terms amphoteric oxide and acidic anhydride;
- Describe specific chemical tests which could be used to determine whether a compound is an amphoteric oxide or an acidic anhydride;
- Write equations for the reaction between SO<sub>2</sub> (an acidic oxide) and water;
- Suggest with reasons a suitable substance which could be used to remove acidic gases from factory effluents.

Part (a)

The responses clearly indicate that candidates did not have a clear understanding of the meaning of the terms amphoteric oxide and acidic anhydride. Instead of defining amphoteric oxide as the oxide of an element which reacts with both an acid and an alkali/base, many incorrectly conceived of it as a **mixture of two oxides** which dissolves in water to give an alkaline or acidic solution.

Similarly, instead of defining an acidic anhydride as the oxide of a nonmetal which dissolves in water to give an acidic solution, it was frequently defined as an acid without water/water of crystallization.

Part (b)

Generally, there was a positive correlation between the responses of candidates to Part (a) and Part (b), in that those who correctly responded to Part (a) were also able to describe a test, the results of which could be used to determine whether a substance (for example, zinc oxide) is an amphoteric oxide or an acidic anhydride. However, most candidates limited their responses to simply stating that the substance (the zinc oxide) should be reacted with both an acid and a base (in the case of the amphoteric oxide) or dissolved in water (in the case of the acidic anhydride) without describing the RESULTING observations of the corresponding tests. As a result they failed to mention how the results of the experiments could be used to determine whether the substance is an amphoteric oxide or an acidic anhydride. For example, in the case of the acidic anhydride, most candidates simply stated it should be dissolved in water without proceeding to say that the resulting solution should be tested with litmus paper (or any other suitable method for testing acidity), and that the moist blue litmus would change from blue to red if the substance is an acidic anhydride. Such candidates failed to secure maximum marks for this part of the question.

Part (c)

Many candidates were surprisingly confused by the (IV) in the term sulphur (IV) oxide. As a consequence, such candidates incorrectly wrote  $\text{SO}_4$  and  $\text{S}_2\text{O}_4$  as the formula for sulphur (IV) oxide rather than  $\text{SO}_2$ . Teachers should be encouraged to use such terminology in their regular classes to describe substances with variable oxidation states, so it will eventually become part of students' vocabulary.

Candidates who wrote the correct formula for sulphur (IV) oxide were able to generate the correct balanced equation for its reaction with water.

Part (d)

Most candidates were able to correctly suggest the use of a basic oxide/hydroxide as a suitable substance for use in removing acidic gases from factory effluents. However, the majority could not give a corresponding balanced equation for the expected reaction.

Most candidates gained full marks for their responses to Part (d) for indicating that the recommended substance should be used in the powdered form since it provided a larger surface area, which in turn would result in more efficient reaction with the acidic gases emitted.

A common misconception which emerged from the candidates' responses is that the powdered form of the substance allows for more rapid escape (diffusion) of the acidic gases into the atmosphere. This misconception needs to be corrected in the classroom.

### Paper 03 – Extended Essay

#### SECTION A

##### Question 1.

This question was slightly less popular than Question 2, the alternate question in Section A. Candidates were required to:

- Define the terms acid salts and normal salts;
- Write equations to illustrate the formation of acid salts and normal salts using phosphoric acid and aqueous sodium hydroxide;
- Explain the chemical principle involved in the treatment of excess stomach acid.

Part (a)

Most candidates were able to correctly define acid salts as those formed from acids by replacing only some of the ionizable hydrogens, whereas in normal salts all of the ionizable hydrogens are replaced during salt formation. However, candidates had problems representing this knowledge in terms of balanced chemical equations for the reaction between phosphoric acid and sodium hydroxide. The normal salt was typically represented as  $\text{NaPO}_4$  rather than by  $\text{Na}_3\text{PO}_4$ .

In (b) (iii), most candidates were familiar with the use of antacids and their mode of action. A few incorrectly referred to the use of strong alkalis such as sodium hydroxide and also reference was made to milk. However, many had difficulty representing the mode of action in terms of an ionic equation. Most candidates used molecular equations to represent the neutralization reaction.

Part (b)

Candidates had difficulty with calculating the heat of neutralization for the reaction between sodium hydroxide and hydrochloric acid based on the given information, in spite of the fact that the formula to be used was given (heat evolved = mass (g) x specific heat capacity x change in temperature). Candidates were able to calculate the number of moles of the acid and base used, but were not able to relate this to the number of moles of water formed, and hence calculate the molar heat of neutralization. Also, most candidates neglected to include the sign (-) associated with  $\Delta H$ , indicating that the reaction is exothermic. As such, many drew the energy profile diagrams as representing an endothermic reaction rather than an exothermic reaction. Many candidates failed to take into consideration the fact that there was a temperature rise (8.9 °C) upon adding the acid to the base indicating that the reaction is exothermic.

**Question 2.**

Candidates were required to:

- Write a balanced equation for the reaction between zinc and sulphuric acid;
- Calculate the volume of hydrogen liberated at r.t.p. when 6.5 g of Zn reacts with excess sulphuric acid;
- Predict the effect of using  $2.0 \text{ mol dm}^{-3}$ , instead of  $1 \text{ mol dm}^{-3}$ , on the expected shape of the graph when compared to that given for Experiment II in Figure 1;
- Discuss the effect of temperature and concentration on the slopes of the graphs for Experiments I, II and III. (Figure 1);
- Explain how a catalyst works;
- Draw labelled energy diagrams to illustrate the effect of a catalyst on the rate of a reaction.

Part (a)

Most candidates were able to write the balanced equation for the reaction between zinc and aqueous sulphuric acid. However, many had difficulty using the information in this balanced equation (1 mole zinc would liberate 1 mole of hydrogen) to calculate the volume of hydrogen that would be liberated at r.t.p. when 6.5 g zinc (0.1 moles) reacted with excess  $1 \text{ mol dm}^{-3}$  sulphuric acid. Students should be given more practice in calculations involving the mole concept.

Part (b)

Although candidates were asked to make a sketch of the graph of Figure 1 in their answer booklets, many sketched only the axes without including the shapes of the curves for Experiments I and II. As such, the graphs they sketched for Experiment III could not be evaluated relative to those for Experiments I and II, and hence such candidates could not be credited. It was expected that candidates would include all three curves for Experiments I, II and III on one graph, and that the curve for Experiment III would reflect a steeper initial slope when compared to the curves for Experiments I and II. However, in all three cases the maximum volume of hydrogen liberated would be the same.

In (b) (ii), candidates were expected to discuss the effects of temperature and concentration on the rates of production of hydrogen and specifically relate these to the slopes of the graphs for Experiments I, II and III. The responses were, in general, very poor and lacking in details. Most candidates simply stated that both an increase in temperature and concentration would result in an increase in reaction rate and hence an increase in rate of production of hydrogen. It was expected that candidates would have made reference to the increase in kinetic energy of the particles with increasing temperature resulting in increasing collision frequency and relate this to

the slopes of the graphs. A similar reference to increase in collision frequency with increasing concentration was expected.

Part (c)

The precautions stated in most cases bore no relation to the experiment under investigation. Most candidates simply referred to safety measures in the laboratory (protective eye gear, spills). Very few took into consideration that the objective of the experiments was to measure the rate of evolution of hydrogen. Thus, precautions such as ensuring that no gas escapes, the temperature of the gas collected is kept constant, all the zinc has reacted were expected.

Part (d)

Most candidates were familiar with the fact that catalysts increase the rate of reactions by lowering the activation energy. However, some candidates had difficulty illustrating this in terms of a fully labelled energy profile diagram. A common error was the wrong labelling of the activation energy for the enthalpy of the reaction.

## SECTION B

### Question 3.

This question was the more popular of the two questions in Section B and tested candidates'

- Knowledge and application of the reactions of alkenes and alcohols;
- Knowledge of addition and condensation polymerization;
- Ability to write balanced equations;
- Ability to write partial structures/repeating units of polymer formed from addition and condensation reactions.

Part 1 (a) (i)

Many candidates correctly stated that bromine (dissolved in an appropriate solvent) was the reagent required to convert compound A (an alkene) to its corresponding dibromoalkane. However, a number of candidates unnecessarily lost marks for stating "bromide", "Br", "bromium", as the required reagent.

Part (a) (ii)

Most candidates were able to recall  $H_2/Pt$ , Pd or Ni as the reagent required for the conversion of A (an alkene) to C (an alkane). However, some candidates confused **hydrogenation** with **hydration** and gave  $H_2O/Pt$ , Pd or Ni as the reagent.

Part (b) (i)

Candidates were required to describe, as well as to explain, what will be observed when compound D (an alcohol) reacts with acidified potassium chromate (VI). Most candidates limited their answers to **"the solution will turn from orange to green"** or **"the alcohol will be oxidized"**. Only a few gave a change in oxidation number of chromium (from +6 to +3) to account for the colour change.

Part (b) (ii)

Candidates were also required to DESCRIBE WHAT WILL BE OBSERVED when Compound D (an alcohol) reacts with sodium metal. Most candidates identified the gas as "hydrogen is evolved" rather than **describe the observation** as "vigorous effervescence, colourless gas evolved".

Most candidates had difficulties writing the balanced equation for the reaction. Most used ethanol rather than Compound D as the starting material. Teachers, as a strategy in the classroom, should encourage students to practise writing equations for reactions involving functional groups using varying structures. The principle of the reaction needs to be stressed.

Part (c)

This was fairly well answered indicating that candidates were quite familiar with the characteristics of saturated compounds and compounds which undergo addition and condensation polymerization reactions. In a few cases candidates confused the double bond ( $C = C$ ) with the equal sign.

Part (d)

This part of the question posed the greatest challenge to candidates. Candidates simply could not extrapolate their basic knowledge of writing the partial structures (or repeating units) of polymers of simple structures like ethene to a compound such as A, although the principle is the same. The same comments apply to writing the partial structure of the condensation polymer formed from Compound F. Teachers are encouraged to urge students to practise writing repeating units of addition and condensation polymers using various compounds, pointing out the principles in the process.

#### **Question 4.**

This question was the less popular question in Section B. In particular candidates were required to:

- Write chemical equations to represent the major steps involved in the manufacture of sulphuric acid by the Contact Process starting with sulphur. Reaction conditions were also required;
- Suggest how such an exothermic reaction can be used to make the manufacturing process more economical;
- Explain why sulphur trioxide is dissolved in conc. sulphuric acid rather than directly in water in the manufacturing process;
- Name two factors that should be taken into consideration in siting of a sulphuric acid plant;
- Explain why sulphur burns in air to form a gaseous oxide whereas sodium, an element in the same period, forms a solid oxide;
- To illustrate by means of a diagram the role of sulphur in the vulcanization of natural rubber;
- Determine whether sulphur dioxide and sulphuric acid are acting as oxidizing/reducing agents in a given set of reactions.

Part (a)

This part of the question was fairly well answered and reflected that the candidates had a good grasp of the main steps involved in the manufacture of sulphuric acid. However, a number of candidates lost marks quite easily for:

- Not correctly balancing rather simple equations;
- Simply describing in words (without equations) the steps involved;
- Stating vanadium as the catalyst rather than vanadium (V) oxide;

- Vaguely stating high temperatures/pressures as the reaction conditions required;
- Wrongly stating that the catalyst is required in the step involving the formation of oleum;
- Wrongly stating that sulphur trioxide is dissolved in conc.sulphuric acid rather than in water because it is insoluble in water.

Also, many candidates were not able to apply their knowledge of exothermic reactions to suggest that the heat evolved in the process could be used economically to heat the incoming gases (the concept of industrial ecology).

The response to the factors that need to be taken into consideration in the siting of a sulphuric acid plant was generally well answered. However, in a number of cases candidates incorrectly focused on health and safety issues in the plant itself. Others misconstrued the word “plant” as meaning a tree and as such referred to the amount of soil around the tree as one of the factors that should be taken into consideration.

Part (b)

Most candidates recognized sodium as a metal and sulphur as a nonmetal. However, they were not able to further develop this point to account for the fact that the oxide of sodium is a solid (an ionic compound, giant lattice structure, with strong forces of attraction between ions) whereas sulphur dioxide is a gas (simple covalent molecule, weak intermolecular forces of attraction).

Part (c)

This part of the question, which required a simple explanation (via an illustrative drawing with sulphur atoms forming bridges between the polymer chains – a description of this was credited in the marking) was not attempted by the majority of candidates. Some candidates who attempted it thought that vulcanization was an example of electrolysis and as such drew electrolytic cells. Others associated the term with volcanoes and drawings of erupting volcanoes were given.

Part (d)

Candidates were able to correctly identify the oxidizing agent in equation (i) as sulphuric acid and the reducing agent in equation (ii) as sulphur dioxide. However, many were unable to show how they arrived at their answers and as such failed to gain full marks. This demonstrated a lack of understanding of calculations of oxidation numbers and the significance of these in determining oxidizing and reducing agents.

## SECTION C

### **Question 5.**

This question was by far the more popular question in Section C.

Part (a)

Here candidates were required to:

- Name the main greenhouse gas;
- State two factors responsible for the increase in the concentration of the named greenhouse gas;
- Use a labelled diagram to illustrate the greenhouse effect.



Parts (a) (i), (ii)

Almost every candidate correctly stated that carbon dioxide is the main greenhouse gas (in terms of quantity rather than in terms of global warming potential) and that combustion of fossil fuel and deforestation are the two main contributing factors to its increase over the years.

Part (a) (iii)

Here the majority of candidates gave the equation for the combustion of coal to explain the increase in CO<sub>2</sub> resulting from the combustion of fossil fuel. Those who attempted to use a hydrocarbon as the source of the fossil fuel had difficulty balancing the equation.

Those candidates, who focused on deforestation as the contributing factor, indicated that photosynthesis would decrease and as a result less CO<sub>2</sub> would be removed from circulation.

Such candidates had difficulty writing a balanced equation to represent the overall process of photosynthesis.

Part (a) (iv)

Most candidates were able to adequately explain the greenhouse effect with the aid of a labelled diagram in terms of:

- Sun rays penetrating the earth's atmosphere;
- The heating of the earth's surface;
- The reflected rays (longer wavelengths) from the earth's surface being "trapped" by the clouds and reflected backwards towards earth causing an increased warming of the earth's atmosphere.

Some candidates incorrectly confused the greenhouse effect with the carbon cycle. Others assumed that it was the ozone layer that traps the outgoing radiation.

Part (b)

This part of the question, which tested the candidates' ability to analyse and synthesize, proved to be quite challenging. Few recognized that the use of electric cars could make a significant positive impact on the greenhouse effect if the source of electricity itself is not generated using fossil fuels but from some other renewable source of energy such as solar energy.

Part (c)

The majority of candidates had a fairly good grasp of the effects of CFCs on the ozone layer. Specifically, candidates were aware of the following:

- The ozone layer shields the earth from the shorter wavelength radiation(UV) from the sun;
- The shorter wavelength radiations are more damaging to human health and the environment (for example, causing skin cancer, cataract, mutation, coral reef damage, reduced food production);
- CFCs destroy the ozone layer by means of a complex series of chemical reactions;
- The phasing out of the use of CFCs (MONTREAL PROTOCOL) and replacing them with alternatives(for example, HFCs ).

However, the responses to the possible long-term consequences of the reduction of the ozone layer on the Caribbean tourism industry did not reflect a sense of critical thinking. Most tended to correlate this with global warming rather than to health effects (for example, skin cancer) and other environmental effects (for example, damage to coral reefs).

### **Question 6.**

Candidates were required to:

- Suggest how detergents work;
- Suggest reasons for the necessity to clean bathrooms more often when soaps rather than bath gels are used for bathing;
- Give an example of a reagent that could be used to remove tea stains and rust stains and explain how each works;
- State the nature and function of fabric softeners.

#### Part (a)

Here candidates were given the generalized structure of a detergent and were required to use this information to suggest how detergents function in removing dirt from fabric. The responses indicated that this topic was not fully understood or adequately covered in the classroom. Most candidates confused the role of the polar head (sulphonate group) and the non-polar hydrocarbon tail, stating in the process that it was the polar head which is attracted to the grease (grease loving). It is the long chain hydrocarbon non-polar tail that is attracted to the grease. Also, there was little or no reference to the role of the polar head being attracted to the water molecules.

#### Part (b)

Most candidates were familiar with the fact that soapless detergents do not produce scum in hard water whereas soaps do. However, most failed to identify the ions ( $\text{Ca}^{2+}$ ) responsible for hardness of water and as a result were not able to fully account for the observation. Also, most candidates incorrectly associated sud formation (lather) with scum formation. This common misconception should be corrected in the classroom.

#### Part (c)

Although most candidates were able to correctly name a reagent to remove tea stains and rust stains, the majority failed to identify these stains as acidic and basic in nature, respectively. As such they were not able to explain the mode of action of the named stain removers. Most vaguely mentioned that a neutralization reaction takes place.

#### Part (d)

This part of the question was also poorly answered giving the impression that the topic was not covered in the classroom. Most candidates were able to state the reasons why fabric softeners are used. However, they were unable to identify fabric softeners as cationic or non-ionic compounds and as such explain how fabric softeners work.

### **School-Based Assessment (SBA)**

#### **General Comments**

There has been some improvement in the standard of practical activities submitted for SBA assessment. Only five per cent of the Centres moderated were considered to have submitted laboratory exercises of a somewhat unsatisfactory standard. Teachers are once again to be commended for their efforts in ensuring minimum coverage of the syllabus, as well as undertaking at least the minimum number of activities, in spite of adverse

laboratory conditions and technical support. For those teachers having difficulty in completing the required activities, the topics listed on the moderation feedback report could be used as a guide to ensure adequate syllabus coverage for practical activities. Unfortunately though, there are some teachers that continue to “over practise”, some topics and or skills at the expense of others. For example, qualitative and volumetric analysis; separation; states of matter; acids, bases and salts are the topics which are generally “over practised” whereas topics such as reduction and oxidation, electrolysis and heating of nitrates and carbonates are generally not being adequately carried out.

Although most practical exercise were up to standard in terms of quality there were some cases where the requirements for assessment did not make sufficient demands on the students. A case in point is utilizing the construction of tables with headings to assess ORR skills but awarding as many as 10 marks alone for this activity.

Teachers are reminded that each skill is required to be assessed as least twice a year. However, students should benefit from carrying out other experiments to help develop these skills before they are actually assessed for SBA purposes. This seems to be lacking. In most cases it is not that students do not carry out the practice experiments since some were able to do as many as 35 – 40, but rather that only those exercises used for SBA assessment are being marked. **THIS IS A GROWING CONCERN SINCE THE STUDENT DOES NOT SEEM TO BENEFIT FROM THE FEEDBACK OF THE PRACTICE LABORATORY EXERCISES.**

In most cases, teacher marking was consistent but there is a disturbing trend emerging with a number of teachers awarding a mark of zero because of late submission. It is suggested that other means of punishment be utilized.

Teachers still seem unsure regarding the assessment of diagrams and graphs. Please be reminded that both are assessed as ORR skills and not AI nor MM. Students should be also reminded that in chemistry, diagrams should not be artistic representations and therefore no shading or colouring is necessary but rather only 2D representations are required and rulers should be employed when necessary.

In general the laboratory books presented were in “good condition”. However, there are some occurrences where

- 1) the books are in such an immaculate condition – this gives the idea that the laboratory exercises are just copied into the book at one time. The book should be a working documentation of exercises actually carried out at a specific time and place.
- 2) some practical exercises are done on extra sheets, for example, photocopies and graphs and in some cases these are not neatly or securely attached – this leaves the book looking extremely untidy and difficult to follow, as well as increases the probability of a lab being lost in transition.

Teachers are reminded that the assessment is to be done over a two year period and there should be a clear demarcation of Year I from Year II in the laboratory books, as well as in the marking schemes.

This year many books sent for moderation had chemical samples such as crystals and soap prepared displayed in them. Whereas this serves as evidence of having actually carried out the experiment it creates a problem since they tend to leak during shipping, obscuring words in some cases. This also presents a safety concern since there are clericals with no chemistry background handling these packages.

In cases where there are more than one chemistry teacher at a Centre, teachers are encouraged to work together as a team when planning and devising practical activities as well as constructing marking schemes. Marking schemes are extremely important in the moderation process and it is difficult to adequately moderate a sample when

- 1) the mark scheme does not correspond to the laboratory exercises shown the books

- 2) two or more teachers send one group of five samples and only one teacher sends a marking scheme which cannot be used for all the books.

The non-collaboration of teachers also creates a problem where the Centre is to be given feedback on the assessment of the individual skills. This is especially difficult when one teacher has done sufficient assessment and another from the same Centre has not.

Some of the specific problems encountered at moderation are outlined below.

### Planning & Design (PD) Skills

There are still major occurrences of “standard laboratory exercises” being utilized to assess PD skills. Teachers are encouraged to present scenarios to the student in the form of problem statements which would encourage critical thinking, and can be solved by standard chemical procedures or by employing sound chemical principles which are covered in the CSEC Chemistry syllabus.

The way in which a PD exercise is presented determines whether it is classified as “standard” or accepted as an authentic PD activity. A common PD lab which is considered standard is

*Plan and design an experiment to show that the rate of a chemical reaction is dependent on temperature.*

This standard activity can be presented in a form which makes it acceptable to be used to assess PD skills, as follows:

*A housewife observed that cow’s milk stayed fresh when placed in the refrigerator but when it was left on the kitchen counter for a morning she returned to find that the milk had curdled. Plan and design an experiment to explain these observations.*

Teachers are also reminded of the following:

- A reason or explanation is not needed in the Hypothesis;
- The main method to be used should be highlighted in the Aim;
- The procedure developed should theoretically satisfy the aim while being able to produce data which would “validate” the hypothesis;
- For data to be collected, if a table is drawn no results should be listed. Any PD exercise actually carried out cannot be assessed as PD;
- Where appropriate, controls and variables to be manipulated should be listed.

### Observation, Recording and Reporting (ORR) Skills

In some cases, for the ORR skills only the Reporting aspect was being assessed not Observation or Recording. Teachers should make an effort to assess all three aspects over the two-year period.

### Mark Schemes

As previously mentioned, mark schemes are extremely pertinent to the moderation process and in order to ensure students are not disadvantaged teachers are reminded to submit them to CXC along with the moderation package.

Teachers are also asked to take note of the following reminders:

- It should be made easy to identify which marking schemes correspond to which practical activity;
- When there is more than one teacher at the Centre the exercises assessed for SBA and hence the marking schemes should be the same. Where this is not possible, each exercise should be accompanied by an appropriate marking scheme;
- Marks should not be lumped together. Instead, each mark should be assigned to a specific content item;
- When students are expected to answer specific questions, these questions as well as their expected responses and the allocation of each mark should be included in the marking scheme;
- For qualitative exercises, assessing ORR and AI skills, the unknown(s), tests carried out, the expected observation as well as inferences should be noted in the mark scheme;
- For PD skills, the mark scheme should include the problem statement given to students as well as possible solutions, variables;
- Ensure that an adequate amount of marks are allocated for an exercise while noting that CXC does not award  $\frac{1}{2}$  marks. For example, do not allocate five marks for an exercise which has more than five tests. Scale down the total mark of the exercise, if necessary.

### Equations

The use of equations is not being emphasized by teachers especially in qualitative analysis since they are not being assessed in the mark schemes.

In some cases ionic equations are written for precipitation reactions but activities which require students to write molecular equations with state symbols are avoided, for example, reactions of metal carbonates with acid or the effect of heat on nitrates or carbonates.

The lack of emphasis on writing the correct symbols in formula is also evident, that is, using capital letters appropriately. For example in many cases the symbol for sodium chloride is being written as *NaCL* rather than *NaCl* and calcium carbonate as *CaCo<sub>3</sub>* rather than *CaCO<sub>3</sub>*, without any evidence of correction in the students' books.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE  
JANUARY 2008**

**CHEMISTRY**

**CHEMISTRY**  
**GENERAL PROFICIENCY EXAMINATIONS**

**JANUARY 2008**

**THE STRUCTURE OF THE EXAMINATION**

The examination consisted of four written papers. The weightings of these papers were as follows: Paper 01 (25 per cent), Paper 02 (30 per cent), Paper 03 (25 per cent) and Paper 042, the Alternate to School-Based Assessment (SBA), which contributed 20 per cent.

Paper 01 consisted of 60 compulsory multiple choice items based on the Specific Objectives in Sections A and B of the syllabus. The items were assessed under the profile, Knowledge and Comprehension (KC).

Paper 02, a structured essay paper, consisted of five compulsory questions based on the Objectives in Sections A and B of the Syllabus. Question 1 was a data analysis question. Candidates were assessed under the profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 042, the alternate to SBA, was the practical paper consisting of three questions. This paper was written by all those candidates who scored below 50 per cent in their previous SBA assessment (Paper 04) or by those writing this examination as a first attempt. In the case of candidates who had scored 50 per cent and above in their SBA, they were allowed to carry forward their SBA grades to this examination.

Candidates were required to answer all three questions. In Questions one and two candidates were required to carry out experiments and record their results, plot graphs, perform calculations and draw inferences as required. Candidates were assessed under the profiles, Use of Knowledge (UK) and Experimental Skills (XS).

**General Comments**

Candidates' entry was about the same as 2007, with 656 candidates entered for the examination in 2008.

Candidate's overall performance was similar to that of 2007. While performance on Paper 01 was steady, performance on Paper 02 improved, but performance on Paper 03 declined.

Of significance is the overall improved performance on Paper 042, especially on Question 1 (which tested manipulative skills, observation/reading and recording as well as plotting of graphs), and Question 3 (planning and design). However, the poor performance on the qualitative analysis exercise (Question 2) continues to be of concern. It appears that students are taught to simply learn these tests (observations and inferences) without much emphasis on actually carrying out these exercises in the laboratory. Students need to be exposed to more practical exercises in qualitative analysis.

While there was a general improvement in the overall performance of candidates, especially with respect to questions based on organic chemistry, there are still some fundamental areas that need to be addressed. These include failure of candidates to read questions carefully. Very often candidates were asked to give ionic equations and instead gave balanced molecular equations. Also, candidates when asked to describe expected observations (for example, a gas evolved, vigorous effervescence, a coloured precipitate), instead identified the actual substances. Writing of the partial structures (or repeating unit) of polymers from their monomeric units continues to pose great difficulty for candidates. The difficulty of writing of the partial structures of polyesters is a case in point.

In Paper 03 many of the questions were answered very superficially giving the impression that many of the topics were not adequately covered by the candidates. Also, candidates continue to perform very poorly in the options in Section C which are not “biology or environmentally” oriented. The poor performance on the question on dyes and fabrics (Question 5) when compared to the one on soils (Question 6) is a case in point. This may be a reflection of inadequate classroom preparation on essential topics such as cement, clays, glass and fabrics. It is critical in a rapidly emerging technological society that students be properly grounded in all these topics at the secondary school level.

More detailed comments on the specific questions are outlined below.

## **DETAILED COMMENTS**

### **Paper 01 – Multiple Choice**

Performance on Paper 01 continues to be generally good. The mean and standard deviation were comparable to those obtained in 2007. Also, the performance on the equating items was very similar.

However, a number of candidates experienced difficulties with items based on the following topics:

- The smallest particle of a chemical compound which takes part in a reaction
- Products formed from the electrolysis of dilute sulphuric acid
- Definition of a mole of atoms of an element
- The process of anodizing
- Identification of a metal which forms a carbonate stable to heat



## Paper 02

### Question 1

This question covered the Syllabus Objectives A: 3.5, 7.2, 7.3, and 7.6, B2: 7.1, 7.2, 7.3 and 7.4.

#### Part (a)

Candidates were presented relevant experimental data related to the effect of concentration on the rate of the reaction between  $\text{KIO}_3^-$  and  $\text{HSO}_3^-$  ions. Specifically candidates were required to read the times (in seconds) on five stop watches corresponding to the different concentrations of  $\text{KIO}_3$  used, present the data in a tabular format, plot a graph of  $1/t$  against  $[\text{KIO}_3]$  and explain the shape of the graph.

In general, most candidates were able to correctly manipulate the raw data in the appropriate format required to complete the table. However, some candidates had difficulty converting  $t$  into  $1/t$  as required. This created problems for such candidates when they attempted to plot the graph of  $1/t$  versus  $[\text{KIO}_3]$ . Also, many candidates did not appreciate the meaning of the number of significant figures they attached to a value and had difficulty plotting these values on the graph.

In plotting the graph, some candidates struggled to interpret the y-axis scale and lost marks in their plot. A common mistake was for candidates to attempt to plot time (rather than reciprocal time) against  $[\text{KIO}_3]$ . For example, for  $t = 40\text{s}$  some candidates plotted  $1/t = 0.40$  on the y axis.

The explanation of the shape of the graph was the most challenging part of this question for candidates. They seemed more familiar with concentration – time relationships than with reciprocal times. As a result many candidates mistook  $1/t$  for  $t$  and therefore instead of recognizing that  $1/t$  varied directly with  $[\text{KIO}_3]$  they said that  $t$  varied directly with  $[\text{KIO}_3]$ . Also, many candidates came up with the correct relationship between  $[\text{KIO}_3]$  and the rate of reaction by looking at the data in the table rather than at their own graph, which in many cases were in contradiction to their stated relationship. This again demonstrated that they could not relate the use of  $1/t$  to the rate of the reaction.

#### Part (b)

This part of the question tested the Syllabus Objectives B2: 7.1, 7.2, 7.3, and 7.4 and A: 3.5. Candidates were presented with details on various tests performed on a substance Q and the corresponding observations. They were required to make inferences based on these observations. Many candidates did not attempt this question (or parts of it). Those who did showed a lack of deductive reasoning.

None of the candidates were able to infer that a solid which is yellow when hot and white when cold is most likely zinc oxide. In addition, many did not indicate the charges on the ions and hence implied that the metals were present in solution rather than the metal ions. Also, in many cases the observed brown fumes which resulted from the addition of copper turnings followed by concentrated  $\text{H}_2\text{SO}_4$  were identified by many candidates as  $\text{Br}_2$ . Even those candidates who correctly recognized that the brown gas was  $\text{NO}_2$  could not infer that this indicated the presence of a nitrate ( $\text{NO}_3^-$ ).

The continued poor performance over the years on questions related to qualitative analysis is of grave concern. It appears that students are inclined to simply learn the tests for these cations/anions/gases from the textbooks. They would need to be exposed to more laboratory practice in carrying out such learning activities.

### Part (c)

In this part of the question the candidates were required to plan and design an investigation to find out which brand of beer had the highest percentage alcohol content. It was generally poorly done.

It was expected that candidates would have been able to link the apparatus and materials they detailed in (c)(i) to the method they proposed in (c)(ii). However, in many cases candidates simply listed apparatus and materials without giving a methodology. Thus, it was difficult in such cases to determine (and hence award marks) whether the apparatus/materials listed were appropriate to the proposed methodology. When methodologies were proposed they were often inappropriate and could not lead to the quantitative determination of the ethanol present in the beer sample.

Common but incorrect methodologies proposed included:

- formation of esters
- dehydration of plant tissues
- burning of the beer to remove the alcohol
- evaporation and measuring the residue
- the acidified dichromate test

In a number of cases where the appropriate methodology was described (fractional distillation), candidates could not correctly represent a fractionating column. Very often the condenser was left out. Also, when the condenser was included, the drawing indicated that the cooling water and the condensate would have mixed.

In Part (iii), where candidates were required to list one variable to be controlled, many incorrectly stated “the amount of alcohol placed in each flask” rather than “the volume of beer”. Such responses were not credited.

In Part (iv), candidates were required to state one precaution. The responses clearly indicate that students simply learn a set of “generic” precautions and reproduce them when required without taking into consideration the experiment under investigation. As such, the suggested precautions (or variables to be controlled) often bear no relation to the stated experiment.

In Part (v), many candidates incorrectly indicated that the beer with the smallest percentage alcohol was the strongest which was opposite to what they stated in their hypothesis.

### Question 2

This question covered the Syllabus Objectives A: 2.3, 2.5, 2.7, 2.8, 2.9 and 4.2. Specifically candidates were given the electronic configuration of two unknown elements and were required to:

- Deduce their atomic numbers
- Place them in the appropriate positions in the periodic table provided with explanation
- Classify them as metal or nonmetal with reason
- Comment on their relative reactivity with water
- Write a balance equation between one of these elements and O<sub>2</sub> and identify the type of bonding that exists in the oxide of this element

#### Part (a)

The majority of candidates were able to correctly deduce the atomic numbers (10 and 20) of X and Y, position them in the periodic table provided and classify them as metals. However, many had difficulty explaining their rationale for their placing X in Group II and Period 3, and Y in Group II and Period 4 respectively.

#### Part (b)

This required candidates to comment on the relative reactivity of Metals X and Y (same group but different periods) with cold water. This proved difficult for most students. More attention should be given to the reactivity series as well as to the variation in reactivity across the period as well as down the group.

#### Part (c)

This section also presented some challenge to the candidates. Many identified the bonding between X and oxygen to be covalent in spite of the fact that they correctly identified X as a metal.

### Question 3

This question tested the Syllabus Objectives A: 6.15, 6.20, 6.21 and 6.22. Specifically candidates were presented with two circuit diagrams and were required to:

- Identify the processes occurring in each case which will cause the bulb to light and to explain how these processes differ
- Identify a replacement for graphite which will cause the bulb not to light
- Give an example, with appropriate explanation, of a suitable replacement substance, Q, that will not cause the bulb to light as brightly as when P is used
- Identify the processes that occur at the electrode surfaces in Experiment II

Overall, the majority of candidates were able to obtain full UK marks but scored very poorly in the KC marks allocated.

Part (a)

Most candidates were able to correctly identify the processes (metallic conduction and electrolytic process) which cause the bulbs to light in both cases. However, the required explanation for the differences in these two processes proved to be challenging. It should be emphasized that in metallic conduction mobile electrons are responsible for carrying the charge, whereas in electrolysis the ions are involved.

Part (b)

Here most candidates recognized that replacement of graphite with a non-metal will cause the bulb not to light.

Part (c)

Most candidates recognized that P was a stronger electrolyte than Q and as such would cause the bulb to light brighter. However, they were not able to relate this to the relative number of ions present in solution (degree of ionization).

Part (d)

Most candidates correctly identified the cathode and anode but were unable to identify the processes (reduction and oxidation) occurring at these surfaces. Those that did had difficulty representing this in the form of ionic equations.

Question 4

This question tested the Syllabus Objectives B: 2.1, 2.2, 2.3, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10. In general candidates had great difficulty with this question. This poor performance in Organic Chemistry related questions has been occurring over the years. Greater emphasis should be placed on this section of the syllabus.

Part (a)

Many candidates did not recognize compound A ( $C_3H_6$ ) as an alkene. As such they incorrectly represented its structural formula as that of an alkane. They also wrote a substitution reaction to represent its reaction with bromine (an addition reaction was expected). Teachers are urged to ensure that students are properly grounded in this section of the syllabus.

Part (b)

Here again many candidates incorrectly represented B ( $C_3H_8$ ) as an alkene rather than as an alkane. As such, the reaction with bromine was incorrectly given as an addition rather than as a substitution reaction. Many of those who correctly recognized the reaction as a substitution reaction failed to include HBr as one of the products.

### Part (c)

Most candidates recognized C and D as an alcohol and an acid respectively. However, describing a simple test tube reaction that can be carried out in the laboratory to distinguish between these two compounds proved to be challenging. Many described reactions (such as the alcohol will undergo dehydration to form an alkene) which are not test tube reactions, and were not credited. This point should be emphasized in the classroom. In describing simple chemical tests to distinguish between compounds, tests should be described which would result in some observable difference (colour change, formation of a precipitate, gas evolved, change in pH (effect on litmus)).

With respect to Part (ii), candidates had great difficulty writing the equation for the reaction between the acid and the alcohol to form an ester. Students should be given practice exercises in writing out the full structures of the esters formed from such reactions. It should also be stressed that water is one of the products formed.

### Question 5

This question tested the Syllabus Objectives B2: 5.1, 5.2, and 5.3. In general the question was poorly answered. From the responses it appears that the objectives on alloys were not covered in the preparation for this examination.

### Part (a)

Candidates were required to list the main components of the alloys, steel and duralumin, and state how their properties differ from that of the starting materials. Many were unfamiliar with the composition of duralumin (copper and aluminum) and failed to include the components such as nickel, chromium and manganese as components of steel. Also, they were not able to contrast the properties of these alloys with that of the starting materials.

### Part (b)

Candidates were unfamiliar with the properties of lead that allow it to be used as a component in solder (low melting point) and as a protective shield against X-rays (absorbing these rays). However, many were familiar with the environmental impact of lead as a pollutant.

### Part (c)

This section was generally well answered. Candidates were able to correctly write the formulae for the oxides of sulphur, carbon and silicon and indicate their use in industry. However, many candidates were still carelessly writing the formula for CO as Co and SO<sub>2</sub> as So<sub>2</sub>. Marks were deducted for this. These errors should be pointed out in classrooms.

## **Paper 03**

### Question 1

This question tested the Syllabus Objectives A: 1.2, 4.5, 4.7 and 4.8. Specifically, candidates were required to:

Draw the lattice structure of diamond and sodium chloride  
Discuss how the melting point and conductivity of electricity are related to the structure of diamond  
Account for the differences in melting points of magnesium oxide and sodium chlorides  
Account for the electrical conducting properties of graphite  
Predict the type of lattice structure in solid air fresheners

#### Part (a)

Most candidates were able to correctly represent the lattice structures of diamond and graphite. However, very often the tetrahedral arrangements of the carbons in diamond were not properly represented. This point needs to be stressed in the classroom.

Most candidates were able to relate the high melting point of diamond to its giant covalent lattice. However, with respect to conduction of electricity, many confused graphite (a conductor) with diamond (a non-conductor) and as such incorrectly stated that it was the mobile electrons in diamond that were responsible for conduction.

#### Part (b)

Although the question stated that both sodium chloride and magnesium oxide have giant ionic lattices, many candidates attempted to account for the observed differences in melting points in terms of “intermolecular forces”, “covalent bonds”, and “van der Waals forces” rather than in terms of differences in the force of attraction (lattice energy) between the ions in the lattice structure (differences in charge and size of the ions).

With respect to conduction of electricity by graphite, most candidates correctly attributed this to the mobile electrons. However, a significant number confused the sliding of the layers (lubricating properties) as being responsible of its conducting properties.

#### Part (c)

This part of the question proved challenging to most candidates. Here candidates were expected to use their knowledge of the properties of compounds with various types of lattice structures to predict that since solid air fresheners are volatile, the forces of attraction between the particles would be expected to be very weak and hence would most likely have simple covalent structures.

#### Question 2

This question tested Syllabus Objectives A: 3.3, 6.5, 6.7, 6.10 and 6.12. Specifically, candidates were required to:

Distinguish among the terms alkali, strong alkali and weak alkali  
State the name and use of a strong alkali used as a household chemical  
Write the equation for the formation of lime from limestone  
Explain whether sodium sulphate and calcium sulphate can be prepared by observing changes in temperature during neutralization by an acid  
Calculate the percentage yield of salt formed by a neutralization method.

It was the less popular of the two questions in Section A. The performance of candidates was generally poor. Many demonstrated inadequate knowledge of scientific terms, procedures for preparing salts and the balancing of chemical equations.

#### Part (a)

Many failed to score marks in this section as they were unable to give reasons for distinguishing bases as alkali, strong alkali and weak alkali in terms of their solubility and degree of ionization. Also, many confused acids and alkalis by attempting to define alkalis in terms of  $H^+$  ions rather than in terms of  $OH^-$  ions. Typically, vinegar and ammonia were frequently and incorrectly given as examples of a strong alkali used as a household chemical.

#### Part (b)

Most candidates failed to score marks here simply because they did not know the formula for lime ( $CaO$ ). Also, many incorrectly included oxygen as one of the products formed from heating limestone ( $CaCO_3$ ).

#### Part (c)

Part (c)(i) of the question was very poorly answered. Candidates failed to distinguish between the solubility of sodium sulphate and calcium sulphate and as such concluded incorrectly that calcium sulphate rather than sodium sulphate can be prepared by a neutralization reaction. Also, many candidates were unable to write the correct formula for sodium sulphate ( $Na_2SO_4$ ).

In Part (c)(ii), most candidates recognized the reaction as exothermic and hence the point of neutralization would have corresponded to the maximum temperature rise as neutralization proceeded.

Most candidates failed to score marks in Part (c)(iii). It is evident from the responses, that students were programmed to learn a set of generic limitations associated with the conduct of basic experiments. However, in most cases the limitations given bore no relationship to the actual experiment under investigation. Teachers are urged to point out to students that precautions/variables/limitations should be related to the experiment under investigation.

In Part (c)(iv), most candidates were unable to describe the method for calculating the percentage yield of the salt produced. A common misconception was that the theoretical yield can be calculated from the mass of the substances in the reaction flask rather than from the volumes of acid and base used.

#### Question 3

This question tested the Syllabus Objectives B1: 2.7, 2.8, 3.3 and 3.4. Specifically, candidates were required to:

Show by means of chemical equations the preparation of ethanol from ethene and glucose

Draw a fully labeled diagram of the apparatus used to obtain pure ethanol from fermentation mixture of sugars

Use an ionic equation to represent the reaction which occurs when white wine reacts with acidified dichromate ions

Use an equation to illustrate the production of ethene from  $C_{14}H_{30}$  by catalytic cracking  
Specify a reagent which can be used to distinguish between ethanol and ethanoic acid in the laboratory

Part (a)

Most candidates were familiar with the methods and the corresponding equations for preparing ethanol from glucose (by fermentation) and ethene (by hydration). However, the conditions for these two reactions were often not stated or incorrectly stated in a number of cases.

Part (b)

Most candidates were able to gain marks for drawing the distillation apparatus. However, diagrams were often carelessly drawn. The water inlet/outlet to the condenser attached to the fractionating column was often represented to indicate that the water would have mixed with the distillate rather than served as a cooling agent. Correct drawing of condensers (double surface reflux verses air condensers) should be stressed in the classroom.

Part (c)

Many candidates did not recognize that (white)wine contains ethanol and as such would be oxidized by acidified dichromate as demonstrated by the latter changing from orange ( $Cr^{6+}$ ) to green ( $Cr^{3+}$ ). Many who did, incorrectly stated that it was the dichromate which was oxidized rather than the alcohol. This is a common mistake repeated year after year where candidates state that the oxidizing agent is the species which is oxidized during a redox reaction. This misconception needs to be corrected in classrooms.

Part (d)

Most candidates were familiar with the process of catalytic cracking and were able to represent this process by means of an equation using  $C_{14}H_{30}$  as an example.

Part (e)

Most candidates incorrectly gave sodium as the reagent which could be used to distinguish between ethanol and ethanoic acid in the laboratory. Hydrogen would be liberated in both cases and as such would be unsuitable. It needs to be stressed in the classroom that tests to distinguish between compounds in the laboratory refer to test tube type reactions where changes in colour/precipitate formation/gases evolved can be readily observed.

Question 4

This question tested Syllabus Objectives B2:1.1, 1.2, 1.3, 2.1, and 8.3. Specifically, candidates were required to:



Name and explain the extraction process by which W and Y can be extracted from their respective ores given their positions in the reactivity series

Write a chemical equation to represent the extraction process of W from its ore, WO.

Compare, using relevant equations, the properties of metals and nonmetals with respect to their reaction with oxygen to form acidic/basic oxides and their oxidizing/reducing powers

Suggest a reason why the oxides of nonmetals rather than metals were more likely to pollute the atmosphere

#### Part (a)

Most candidates correctly selected electrolytic reduction as the most suitable method for the extraction of W from its ore and related this to its position high up in the reactivity series. However, few were able to write a chemical equation to represent this reduction process. With respect to Y, most candidates correctly selected reduction by a reducing agent such as C or CO. However, a number incorrectly gave direct heating of the oxide as the method of reduction.

#### Part (b)

Most candidates knew that metals and nonmetals react with oxygen to form basic and acidic oxides respectively. However, the majority were not able to write appropriate chemical equations to illustrate the basic/acidic nature of these oxides. Similarly, most candidates knew that metals can act as reducing agents and non-metals as oxidizing agents. However, many could not illustrate this in terms of appropriate equations.

Candidates also had great difficulty suggesting a plausible reason as to why the oxides of nonmetals (rather than metals) are more likely to pollute the atmosphere. They failed to make the connection between the bonding in these two types of oxides (giant ionic lattice in metal oxides versus small covalent molecules with weak intermolecular forces in the case of the oxides of nonmetals), and their ability to volatilize and disperse into the atmosphere.

#### Question 5

This question tested Syllabus Objectives C 2.0, 5.7, 5.8 and 5.9. Specifically, candidates were required to:

Classify linen and polyester fibres as natural or synthetic

Draw structures to represent the monomeric units of these fibres and how they are linked to form macromolecules

Suggest observable differences that might be noticed upon exposure to sunlight and washing fabrics made from these two sets of fibres

State the general properties and the chemical principles upon which dyes work

The steps which should be taken prior to applying methylene blue dye to fabrics

This question was poorly answered. The responses lead one to conclude that this topic was not covered by the candidates in the classroom.

Part (a)

The majority of candidates were not familiar with the fact that the repeating monomeric unit in linen fibres is glucose. The few who knew this could not accurately represent the linkage of these monomeric units (three of them) to form the macromolecule present in the fibres. Candidates continue to have great difficulty representing the ester functional group.

Similarly, although most knew that an ester was the repeating unit, they were unable to illustrate the linking of this monomer to form the polyester. Practice in writing partial macromolecular structures from corresponding monomer units should be stressed in the classrooms.

Part (b)

The responses clearly indicated that candidates were totally unfamiliar with the types of fabric dyes and their mode of action. It needs to be stressed that to be effective a dye must penetrate the fabric and remain there (not readily washed out). This can occur due to a chemical affinity between the dye and the fabric (presence of acidic/basic groups) OR to the formation of insoluble coloured compounds which remain in the fabric. The importance of mordants in helping dyes adhere to fabrics also needs to be stressed.

Question 6

This question tested Syllabus Objectives C: 2.0, 5.7, 5.8 and 5.9. Specifically, candidates were required to:

- Discuss the nature and importance of humus
- Describe a laboratory method for measuring the pH of a soil sample
- Discuss an appropriate method for reducing the acidity of soil
- Design an experiment to investigate the effects of the deficiency of a named element on plant growth

Part (a)

Most candidates demonstrated a good understanding of the composition of humus and its importance in soil. However, the important role of microorganisms in soil fertility was not evident in the majority of responses.

Part (b)

In describing the laboratory procedure they would use to determine soil pH, most candidates simply stated that they would test the soil (dry?) with blue litmus paper. No indication was given that the soil sample should have been extracted with water and as such were not fully credited. It should be stressed in the classroom that the test with moist litmus paper would simply indicate whether the soil is acidic and would not give the actual pH value. The use of a pH meter (details not required) would have been more appropriate.

Most candidates were able to name a suitable substance (limestone, lime, hydrated lime, dolomite limestone) used to reduce soil acidity. However, they had great difficulty explaining, with the use of a relevant chemical equation, how the named chemical substance can bring about the reduction in pH. A simple acid base neutralization reaction  $(\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O})$  was expected.

### Part (c)

Whilst most candidates were able to name an element essential for plant growth, the majority had great difficulty designing an appropriate set of experiments to investigate the effect of the deficiency of this element. Of concern was the lack of control experiments in the candidates' designs. This aspect of planning and design needs to be emphasized in the classrooms.

## **Paper 042**

### Question 1

This question tested Syllabus Objectives A: 8.1 and 8.3. Specifically, candidates were required to calculate the heat of solution for potassium nitrate from data obtained by dissolving 5g of potassium nitrate in 50 cm<sup>3</sup> of water and measuring the observed temperature change at 1 minute intervals for 10 minutes. The data was used to plot a graph of temperature against time.

Most candidates did well on this question obtaining more than 12 of the 25 marks, with a significant number scoring more than 18 marks. This was due mainly to their performance on recording the temperature changes and plotting the graph.

### Part (a)

While a large number of candidates were able to record accurate temperature readings, a number recorded values such as 2.8 °C, instead of 28 °C. Others read the thermometer to  $\pm 0.1$  °C although it was calibrated to  $\pm 1$  °C. In completing Table 1, a number of the candidates did not calculate the value of  $\Delta T$  as required.

### Part (b)

For (b)(i) most candidates were able to accurately plot graphs using their data although some had a difficulty selecting an appropriate scale.

In (b)(ii) many candidates did not use their graphs as required to determine the maximum value for  $\Delta T$ . Instead they used their raw data from their tables to deduce this value.

Part (b)(iii) posed the greatest challenge for the candidates. Far too many candidates confused the shape of the graph with that for the energy profile diagram for an exothermic reaction and concluded incorrectly that the reaction was exothermic.

The more alert candidates correctly deduced that the reaction was endothermic due to the reduction in temperature during the reaction.

In (b)(iv), most candidates who attempted this section knew how to do the calculation but lost marks due to careless mistakes. These include:

Using the incorrect value for the molar mass of  $\text{KNO}_3$ . A number of candidates used 69 instead of 101 suggesting that an incorrect formula ( $\text{KNO}$ ) was used instead of  $\text{KNO}_3$ .

In determining the mass of the mixture to be used to calculate  $\Delta H$ , many added the mass of the water (50 g) to that of the potassium nitrate (5 g).

While almost all candidates were able to convert grams to kilograms they were unable to determine the heat produced by 1 mol of potassium nitrate given the heat produced by 5 g.

### Question 2

This question was the qualitative analysis question and tested Syllabus Objectives B: 7.1, 7.2 and 7.3. Candidates were required to perform tests on the solid sample, M, and record their observations as well as inferences based on the observations.

Overall, the question was not well done. Approximately 70 per cent of the candidates scored less than 7 out of a possible 13 marks and less than 8 per cent scored 10 or more out of 13.

### **General Comments**

Many candidates did not pay attention to critical observations. While they readily noted colour changes, they failed to record the formation of gases or precipitates.

A number of candidates incorrectly used the word “filtrate” in place of the word “precipitate”, presumably because they were asked to filter.

Far too many candidates did not differentiate between the ions and the element. For example, instead of writing  $\text{Pb}^{2+}$  or *lead ions* present many of them recorded *lead* as being present.

In (i), candidates were required to heat the sample strongly and were expected to observe a brown gas evolved. Instead many candidates focused their observations on the remaining residue and the “popping and sizzling” sound but made no mention of the obvious brown gas evolved.

In (iii) (a, b), candidates were required to add separately aqueous (a) sodium hydroxide and (b) ammonia slowly until in excess to a solution of the sample. The responses clearly indicate very poor technique. Apparently, many failed to add these reagents drop by drop with shaking. As such, many failed to recognize the solubility of the precipitate in the presence of excess of the reagent. This technique should be strongly emphasized in the laboratory.

In (iv), most candidates reported the formation of a “cloudy yellow solution” rather than a yellow precipitate. This again points to poor experimental techniques. Some candidates were also unable to write a balanced ionic equation for the reaction between  $\text{Pb}^{2+}$  and  $\text{I}^-$  ions. In general, it appears that students simply learn from their texts the tests for various cations/anions/gases. Teachers need to carry out more laboratory exercises in qualitative analysis with their students, paying special attention to the techniques.

### Question 3

In this question candidates were given an “extract” from a student’s note book which outlined the procedure used by the student to determine the volume of sodium hydroxide required to react with  $25\text{cm}^3$  of three different brands of rust remover. Based on this information, candidates were required to:

Suggest a possible hypothesis the student may have wanted to test

List the apparatus and materials required

Construct a suitable fully labeled table to show relevant experimental results the student may have gathered

List possible precautions and variables to be controlled

Discuss whether the results gathered supported or contradicted the hypothesis

This question was generally poorly answered. Candidates had great difficulty suggesting a possible hypothesis. Most instead stated an aim. Teachers are urged to have this distinction fully discussed in class, utilizing appropriate examples in order to help students to distinguish between these terms.

Candidates also had great difficulty differentiating between a “precaution” and a “variable that needs to be controlled”. Candidates were simply stating variables and precautions which had absolutely no bearing on the experiment.

With respect to the construction of a fully labeled table, many candidates failed to:

Indicate the initial and final burette readings

Record burette readings to one decimal place

Give a minimum of two titre readings for each rust remover titrated

**CARIBBEAN EXAMINATION COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION**

**MAY/JUNE 2008**

**CHEMISTRY**

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**CHEMISTRY**  
**GENERAL PROFICIENCY EXAMINATION**  
**MAY/JUNE 2008**  
**GENERAL COMMENTS**

This year marked the first sitting using the new format of the CSEC chemistry examination which now has two instead of three written papers. While there was no change to the multiple choice paper, for Paper 02, candidates were required to complete six questions, five of which were compulsory and the sixth selected from one of two questions from Section C of the syllabus. Questions 1-3 were structured items, while 4-7 were extended essay items.

The contribution of the papers to the overall examination was as follows:

Paper 01 (Multiple Choice)	- 30%
Paper 02 (Structured Essay)	- 50%
Paper 03 (School-Based Assessment)	- 20%

Some candidates did very well on the examination scoring full marks on several of the questions. However, while it is clear that a relatively small number of candidates have done fairly well on this new examination, it is also clear that many continue to perform way below the required standard. In many instances questions that require straight recall of definitions proved to be difficult for some candidates, as responses were vague or inaccurate. Much of the inaccuracy arose from the confusion of terms which sound alike or have things in common. This suggests that enough care is not given to differentiating and clarifying concepts, as candidates prepare for these examinations. Some topics, such as, writing and balancing equations, organic chemistry, and solving mole related problems continue to pose significant challenges for too many candidates.

**DETAILED COMMENTS**

**Paper 01 – Multiple Choice**

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance on this paper contained to be steady and satisfactory. The marks ranged from 0-59.

Candidates experienced difficulties with items based on the following objectives:

- A. 3.1 – the smallest part of a chemical compound that can take part in a reaction (answer being the molecule).
- B1. 1.8 – identifying that molecular formulae, empirical formulae and functional group were the same for two given compounds.

**Paper 02 – Structured Essay**

**Question 1.**

Syllabus References: A 6.6, 6.12, 3.4, 3.7, 7.2, and B2 7.1 and 7.2.

Part (a) tested candidates' knowledge of pH and its use in determining the end point of acid-base titrations. It also tested their ability to represent given data graphically and to carry out calculations involving molar concentration and number of moles present in a given volume of solution.

The majority of the candidates attempted this question and were able to score between 6-9 marks for recording the correct readings on the pH metres, plotting the graph and deducing the end point of the titration from the graph. However, most candidates were unable to provide clear descriptions of the pH scale. Their responses were either incomplete or poorly expressed. Most neglected to give a description of the scale but explained that the pH scale could be used to measure the acidity or alkalinity of a substance. Others referred to the pH scale as though it were a device or an instrument. Most candidates were able to explain the end point of the acid-base titration as the point of complete neutralization of the base or the acid. Some common incorrect responses were:

- The pH scale is a device used to measure the acidity or alkalinity of a substance.
- The pH scale measures the power of hydrogen atoms / ions in solution.
- The end point of a titration is time taken to complete a titration.
- The end point of a titration is when the titration is finished.
- The end point of a titration is when all the acid and base are used up.

The expected responses were:

- **pH Scale:** a scale ranging from 0-14 which measures the acidity or alkalinity of a substance
- **End point of a titration:** the point in a titration where all replaceable  $H^+$  ions of the acid react completely with all the  $OH^-$  ions of the base.

The vast majority of candidates were able read the pH metres and use their values to plot the graph. Many did not recognize the end point of  $15\text{cm}^3$  which gave a pH reading of seven. Rather they selected the reading of pH 10.8 which corresponded to a volume of  $20\text{ cm}^3$  of sodium hydroxide.

Plotting the graph proved to be difficult for some candidates. The main problem was the interpretation of the scale. Readings such as 2.2, 2.4 and 10.8 were often incorrectly plotted but most were able to plot values such as 15.0 and 20.0 correctly. Many graphs were untidy and very large dots or tiny indistinguishable dots were used when plotting the points. The curve was often jagged. Some candidates seemed unfamiliar with the curve associated with this type of data and attempted to draw a straight line.

Calculations were generally poorly done. Most candidates successfully calculated the number of moles of sulphuric acid used. However, the calculation of the concentration of the sodium hydroxide proved challenging. One common error was the use of the incorrect mole ratio of acid to base resulting in the incorrect number of moles of sodium hydroxide used. It was clear that in some cases candidates did not know how to proceed with the calculation. Many tried to use the molar gas constants ( $22.4\text{ dm}^3$  and  $24\text{ dm}^3$ ), Avogadro's constant and the values for the relative formula masses in the calculations, while a large number of candidates did not attempt this part of the question.

Part (b) tested candidates' knowledge of the tests for chloride, copper(II) and sulphite ions.

Candidates did very poorly on this part, with 0-1 out of a possible 6 marks being the most common scores. From the responses, it appears that candidates were unfamiliar with the tests and in most cases did not know what to infer from the results obtained. Most of those candidates who attempted this



question got one mark for correctly inferring that the blue precipitate formed in Test 3 was due to the presence of copper(II) ions.

Most were unable to write the one ionic equation required for Test 1, due mainly to incorrect formulae. Another problem was that some confused the reactions of oxidizing agents with those for reducing agents.

Part (c) required candidates to plan and design an investigation to compare the relative effects of four catalysts on the rate of decomposition of hydrogen peroxide. Most persons chose to compare the catalysts by measuring the volume of oxygen produced for a specific period of time, or comparing the rate of production of a given volume of oxygen. Some of the more common reasons why candidates failed to do well on this part of the question include:

- No means for comparing the relative effects of the catalysts
- No mention of control of the quantity of the hydrogen peroxide used
- Diagrams which were not feasible based on the experimental procedure proposed.

### Question 2.

Syllabus References: A (2.1, 2.6, 6.2, 6.4)

Candidates were expected to use a partially completed diagram of the Periodic Table showing the Group 7 elements to answer questions on the properties of the elements shown. They were also required to analyse the chemical properties of two compounds of unnamed elements (X and Y), and answer questions pertaining to the nature, bonding and relative positions of X and Y in the reactivity series.

Part (a)

Most candidates were able to correctly identify the set of elements shown in the table as belonging to Group 7 or the halogens. However, a considerable number failed to give the correct reasons for placing the elements in Group 7, as they did not refer to the number of valence electrons the elements have in common. Vague responses such as “the same number of valence electrons” or “similar chemical properties” were not awarded any marks.

Part (b)

This part of the question involved the reaction of chlorine with aqueous potassium bromide. It proved to be very challenging for many candidates. Many wrote inferences such as “chlorine will displace bromine” and failed to include **observations of the colour** of the solution or the bromine gas produced although the question specifically asked for the observations. A high proportion of the candidates did not know the correct symbols and valencies of the elements. Hence, they were unable to write a balanced equation for the displacement reaction, and some compounded the error by writing incorrect formulae such as  $KBr_2$ ,  $KCl_2$ ,  $PCI$ ,  $br_2$  and  $CL$ .

Part (c) (i)

It appeared that most candidates did not use the information provided on Elements X and Y to deduce their properties. Most seemed to assume that if X were a metal then Y had to be a non-metal or vice versa. Both elements were metals.

Part (c) (ii)

This part of the question was very poorly done. A very high percentage of candidates misinterpreted the question and described the bonding between Elements X and Y or between Element Y and another Element (metal and non-metal) rather than the bonding within Element Y as required. A number of candidates who correctly identified the bonding in Y could not give an adequate description of metallic bonding. In a number of cases, candidates mentioned “sea of electrons” without any mention of **positive ions** held together by the “sea” of delocalized mobile electrons.

Part (c) (iii)

Most candidates were able to correctly predict the bonding between X and oxygen based on their response to Part (c) (i). However, this is yet another instance in which candidates seemed to have difficulty providing comprehensive explanations of why that type of bonding should occur.

Part (c) (iv)

The ability to simultaneously compare the two sets of reactions and arrive at the correct sequence of reactivity of elements seemed lacking for many candidates and as such, most were unable to arrange the Elements, X, Y and Mg in the correct order of reactivity. Many seemed not to understand how to interpret the order of reactivity of metals based on the thermal stability of their compounds and displacement properties. Responses to this part suggested that candidates did not analyse the information presented in the table. Rather than using the principles of displacement reactions and thermal stability of compounds to arrive at an answer, some candidates attempted to identify the unknown elements and use their memory of the reactivity series to answer the question. In many cases, responses were incomplete, referring only to the displacement of metals lower down in the activity series by those higher up, without considering the thermal stability of compounds. A common misconception was that metals are more reactive than non-metals and this principle was used to order elements identified as non-metals from c (ii).

**Question 3.**

Syllabus References: B1: 1.8, 1.3, 1.6, 1.7, 1.9, 2.7

Part (a) required knowledge of structural isomerism. Candidates were asked to demonstrate their understanding of this concept by drawing two named isomers of butane and to name and draw a third.

Many candidates were unable to give a correct definition of structural isomerism. There was widespread incorrect use of basic terms resulting in vague and inaccurate definitions. For example, many referred to isomers as “elements”, or “atoms” that have different structural formulae, while others omitted the “same chemical formula” from the definition and simply described structural isomerism as related to different structures. A few candidates gave the definition in terms of the compounds having different physical properties but similar chemical properties.

Common errors in drawing the isomers of but-1-ene and but-2-ene were failure to include the hydrogen atoms in the structures drawn and to ensure the tetravalency of carbon in its compounds. While most candidates were able to draw the structures of named isomers, most were unable to draw and name a third isomer of butene. There was a tendency to rewrite but-1-ene or but-2-ene in a different spatial orientation for the third isomer. Here also candidate had too many or too few bonds linked to carbon. A wide variety of incorrect names were also given to 2-methyl propene which was

the third isomer required. Some of the more common ones were “butane”, “methyl butane”, “propene”, “1-methyl propene” and “methyl-prop-2-ene”.

Part (a) (iv) was relatively simple, requiring one physical property of butane. However, far too many candidates seemed unable to distinguish between physical and chemical properties. Many chemical properties such as “burns with a smoky flame” and “decolourizes bromine water” were given for a physical property of butane.

In Part (b) (i), a substantial number of candidates failed to provide a suitable definition for functional group. A common error was the failure to link the functional group to chemical properties. In some cases, candidates referred to groups of the periodic table when describing functional group.

In Part (b) (ii), candidates were required to complete a table to show some common reactions of ethanol. They were provided with the functional groups of the products formed and asked to deduce the products and the reagents. This part was poorly done. The responses indicated that for the most part, the candidates were unfamiliar with the reactions of ethanol and did not know the reagents for converting ethanol to alkenes, carboxylic acids and esters. While most candidates were able to draw the structure of ethene, the product formed with the carboxyl group and the ester linkage proved to be more challenging. In the case of the ester, the contribution by the acid was often omitted.

#### **Question 4.**

Syllabus References: A: 6.22, 6.23, 6.24, 6.25, 6.26 and 6.27

Candidates were tested on their knowledge of the electrolysis of molten lead bromide. They were required to draw suitable apparatus for electrolyzing molten lead bromide, calculate the mass of product formed at the cathode and list factors that affect the product of electrolysis. The final part of the question required candidates to explain the relative reactivity of calcium and barium.

Many candidates scored marks in Part (a) (i) of the question but a large number produced very poor drawings of the arrangement of equipment for the electrolysis of molten lead bromide. While candidates showed a general understanding that an inert electrode was required they were unable to identify a suitable inert electrode, such as graphite or platinum. The main errors in the diagrams included:

- Electrodes were not dipping into the electrolyte.
- The electrodes were not drawn thicker than the connecting wire so as to distinguish between them.
- The electrodes did not match with the polarity of the battery / power supply.
- In some cases the polarity was not included but the polarity of the electrode was given.
- In some cases the electrolyte was not identified by way of a line to show the level of the electrolyte.

Responses to Part (a) (ii) showed a low competency in the writing of ionic equations. The following common mistakes were seen to be prevalent.

- Charges were incorrect and in some cases missing altogether, for example, Ba, Ba<sup>+</sup>, Br<sup>2+</sup>, Br, Br<sup>2-</sup>.

- The equations were not balanced.
- In most cases, state symbols were not included or were incorrect.
- Candidates matched the ionic equations with the wrong electrode.

Many candidates scored some marks for Part (a) (iii), of the question. The majority of candidates scored marks for calculating the quantity of electricity. However, in some instances time in minutes were not converted or incorrectly converted to seconds. Some candidates wrote the incorrect units such as Joules, °C for Coulombs. The common errors were:

- The incorrect mole ratio was used. Many candidates used one Faraday to produce one mole of product (Barium).
- Limited knowledge of the products of electrolysis led to a wide variety of substances identified as the product, some with the correct formulae, and some with the incorrect formulae. The main error was with the product being identified as barium bromide. A smaller number used bromine as the product.
- A variety of incorrect formulae were used such as, BaBr, and even Ba<sub>2</sub>. This even occurred in cases where the correct equation for the discharge of Ba<sup>2+</sup> ions was given for the cathode reaction.

Responses to Part (a) (iv) showed that the question was misinterpreted by many candidates and consequently vague answers were given. In some responses the term “ion” was omitted in the statement that one factor affecting the product of electrolysis was the “position of the ion in the electrochemical series”. A large number of candidates confused electrochemical series with reactivity series. Some candidates misinterpreted this question and provided answers for factors that affect the amount of product formed instead of the nature of the product formed during electrolysis.

In the last part of Question 4, Part (b), candidates seemed to do rather poorly and as a result, lost this mark as they:

- did not provide a reasonable explanation for the reactivity of the Group II metals
- failed to link the position of the element in the group and its reactivity
- opted to use other chemical properties such as solubility.

### **Question 5.**

Syllabus References: B.1: 2.2 and 2.5; B.2: 3.1 and 4.1

In Part (a) of the question, candidates were given four organic compounds from which they were to identify one saturated and one unsaturated compound. They were also required to name and give the general formula of the homologous series to which the compounds belong.

Part (b) of the question tested knowledge of the industrial preparation of nitrogen, the nitrogen cycle and the reactions of metallic nitrates.

In Part (a), a fair amount of candidates managed to obtain at least four of the six marks. However, many responses to this question continued to reveal that candidates are not giving adequate attention

to distinguishing between chemical concepts that may sound alike or have things in common but are quite different. As such, many candidates failed to correctly identify C or D as the saturated compound and A as the unsaturated compound. In many cases,  $C_4H_8$  was described as saturated and  $C_4H_{10}$  as unsaturated. Instead of stating the name of the homologous series, for example, alkene, many candidates gave the name of the compounds, like butane.

Part (b) seemed to prove more challenging for the candidates and a fair number omitted this part. Here again there was confusion of terms, especially as they relate to the names of processes- nitrification and denitrification. Some had problems with the interpretation of the question and described the “ammonia plant” as if it were a living entity, perhaps because they were told that plants require nitrogenous compounds.

This question required candidates to explain how the conditions of temperature and pressure are important in the production of ammonia. As stated in the syllabus, “only simple treatment of the reversible reaction” is required. Candidates were not expected to explain the effect of temperature and pressure on the equilibrium position although a few did. Rather, candidates were expected to explain that the use of moderately high temperatures and pressures would increase the rate of collision of particles and favour a higher yield of ammonia. While many candidates described the effect of temperature and pressure on the rate of collision of particles, only a small number linked this to the yield of ammonia.

Part (c) was fairly well done but a wide variety of processes were used, some of the more farfetched ones seemed to be based on guessing. Correct responses for processes by which nitrogen from the atmosphere can be converted to nitrates were nitrogen fixation or the effect of lightning in thunderstorms, while the process by which nitrogen in soil nitrates can be released back into the atmosphere was denitrification. Evaporation, decomposition and filtration were some of the processes identified.

Part (d) was poorly done. Candidates were unclear about the reactions of Group 1 and Group 2 metals. Although many candidates realized that the brown gaseous product when Q was decomposed was nitrogen dioxide, they were unaware of the other products of the decomposition reaction.

### **Question 6.**

Syllabus Reference: C: 5.1, 5.2

This question tested knowledge of the chemistry of glass. The questions were fairly straightforward. However, most candidates seemed generally unprepared for this question. It was by far the less popular of the two Option C questions.

In (a) Part (i), very few candidates were able to give the benefits of adding sodium carbonate or calcium carbonate to silica in the manufacture of glass. Adding these substances to silica causes a reduction of the melting point of silica and reduction in the tendency of glass to crystallise.

In (a) Part (ii), candidates were expected to state how the basic component of glass would be modified to make lead-potassium glass and borosilicate glass. In the case of lead-potassium glass, modification to be made to the basic components of glass should be a substitution of lead oxide and potassium oxide for sodium carbonate and calcium carbonate. In the formation of borosilicate glass, however, a

substitution of boron (III) oxide was required for silica. The majority of candidates did not know this simple recall of information.

In (b) Part (i), candidates were expected deduce why it is important that glass does not crystallize as it cools. Candidates were expected to state that glass is ideal as a transparent container and as such if crystallization of glass takes place as it cools, it would obscure the view of the contents. Most candidates acquired at least one of the two marks here.

Part (b) (ii) proved to be very difficult for most candidates. Candidates were asked to relate the bonding in  $\text{SiO}_4$  to the melting and moulding of glass. The expected response was that the  $\text{SiO}_4$  bonds are not all of the same strength and as a result all bonds are NOT broken at the same temperature. Hence, the glass could gradually soften, thereby allowing time for the glass to be moulded. No candidate wrote this response in its entirety.

In (b) Parts (iii) and (iv), most candidates were able to explain why it was important to recycle glass and to give one advantage and one disadvantage of using glass in construction. Many got full marks for this part.

### **Question 7.**

Syllabus References: A: 3.5 and 6.5; B.2: 7.1.7.2 and C

This was the more popular of the two questions in Section C. The majority of candidates displayed an awareness of global concerns regarding food production. However, they did not do as well on this question as anticipated.

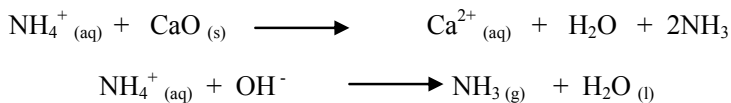
In Part (a) candidates were expected to explain that mineral balance is required for healthy plant growth and metabolic processes. Most candidates scored marks here but the responses of the weaker ones were vague, such as “mineral balance was necessary for having the right amount of growth”. Many did not give satisfactory answers for the importance of pH in plants. They were expected to state that pH influences the availability of nutrients for uptake from the soil, since some nutrients form compounds that plant roots cannot absorb. Responses from weaker candidates were not specific about the role of pH, for example, “too acidic or too alkaline conditions are bad for plants” were common responses. Only a few candidates scored the one mark in this section.

Most candidates were able to state the importance of humus for plant growth and got the two marks for indicating that humus provides organic nutrients, aerates the soil, improves crumb structure of the soil, and regulates water retention of the soil.

In Part (b), candidates were required to explain the test for ammonium ions in the soil. They had to draw on knowledge from Section B of the syllabus but many failed to give the correct test for the ammonium ion. Acceptable tests were, adding aqueous sodium hydroxide to a sample of the soil and heating it to generate ammonia. Ammonia would then be identified by the use of red litmus or hydrogen chloride gas. Many candidates described the test for ammonia instead of ammonium ion. In a few cases, candidates stated that a magnet could be used and the presence of ammonium ion would be confirmed if the soil was attracted to the magnet.

Many candidates failed to recognize that acid rain and the ammonium ion from ammonium-based fertilizers are responsible for the acidic nature of soils. Adding lime to soil would neutralize the acid. Suitable ionic equations depicting a neutralizing reaction were awarded full marks.

Part (c) of the question required the candidates to take a position on the wisdom of adding lime to soil at the same time as when adding ammonium fertilizers. A large number of candidates failed to take a position when advising the farmer and so lost one mark. Candidates were expected to state that ammonium-based fertilizers would react with lime to produce ammonia which is toxic to plants. The production of ammonia would also reduce the amount of nutrients in the ammonium fertilizers. The better candidates gave the equations such as the following.



### **Paper 03 - School-based Assessment (SBA)**

#### **General Comments**

Overall there have been noticeable improvements in the SBA assessment process. This is evident in the decline in the number of centres submitting laboratory practical exercises of unsatisfactory standard. This year, only four percent of the centres presented unsatisfactory activities. There has also been improvement in the assessment of both the Planning and design skills as well as Analysis and Interpretation skills. Teachers must be commended for making an effort to improve in the assessment process, for their efforts to ensure maximum coverage of the syllabus as well as undertaking at least the minimum number of activities.

However, there is a need to highlight some areas which will aid teachers in further improvement, as well as assist with an easier moderation process.

#### **SBA Samples**

In general the samples were presented in good condition. However, there were some cases where the following occurred:

- Some laboratory practical exercises were done on extra sheets which were not neatly or securely attached. This left the book looking extremely untidy and difficult to follow, and it increases the probability of exercises being lost in transition.
- Some books lacked a Table of Content, page numbers and dates. Teachers should emphasize to their students the importance and necessity of having an up-to-date index, numbering pages and dating exercise. Those exercise utilized for assessment should also have corresponding dates in the Mark Schemes.
- Some centres did not completely fill out the CHEM-3 form which shows the breakdown of marks for the individual skills. This hampered the moderation process.
- Again this year some books sent for moderation had chemical samples such as crystals prepared displayed in them. Whereas this serves as evidence of having actually carried out the experiment, it creates a problem since they tend to leak during shipping, obscuring words in some cases. This also presents a safety hazard.

#### **Equations**

The use of equations is still not being emphasized by teachers. This year 18 percent of the centres had equations which were used inappropriately, for example:

- Candidates wrote incorrect equations which were not corrected by the teachers.
- Many equations lacked state symbols.
- Some equations were incorrectly balanced, and were marked as correct.

The lack of emphasis on writing the correct symbols in formulae is again evident. For example, in many cases the symbol for sodium chloride was written as *NaCL* rather than *NaCl* and calcium carbonate as *CaCo<sub>3</sub>* rather than *CaCO<sub>3</sub>*, without any evidence of correction in the students' books.

### Graphs

More emphasis also needs to be placed on graph work. Twenty-five per cent of the centres submitted samples with unsatisfactory graph work. In addition, many teachers do not seem to be clear as to how and where graphs should be assessed. The plotting of graphs should be assessed under the ORR skills and not the AI skills. However, interpretations of the graphs can be assessed under the AI skills.

### General Assessment and Mark Schemes

Teachers at a given centre are yet again encouraged to work together when planning and devising practical activities, as well as constructing marking schemes. Marking schemes are extremely important in the moderation process and it is difficult to adequately moderate a sample when

- (1) the mark scheme does not correspond to the exercise shown in the books.
- (2) two or more tutors send one group of five samples and only one teacher sends a marking scheme, which cannot be used for all the books.

The non-collaboration of teachers also creates a problem where the centre is to be given feedback on the assessment of the individual skills. This is especially difficult when one teacher has done sufficient assessments and another from the same centre has not.

Mark schemes are extremely pertinent to the moderation process and in order to ensure candidates are not at a disadvantage, teachers are reminded to submit them to CXC along with the moderation package. A numbers of centres neglected to send Mark Schemes and some of those received were inappropriate and could not be used.

Teachers are again asked to take note of the following reminders:

- All laboratory exercises should be corrected even if they are not being assessed for SBA purposes. This ensures that the student is given an opportunity to practise, hence sharpening their experimental skills and learning from their mistakes.
- It should be made easy to identify the Mark Schemes corresponding to the exercise.
- When there is more than one teacher at the centre the exercise assessed for SBA and hence the Marking Schemes should be the same. Where this is not possible, each exercise should be accompanied by an appropriate Mark Scheme.
- Marks should not be lumped together. Instead, each mark should be assigned to a specific content item, for example, when more than one mark is allotted for a calculation, a breakdown of how individual or partial marks are allocated should be included in the Mark Scheme.



- When students are expected to answer specific questions these questions, as well as their expected responses and the allocation of each mark, should be included in the Mark Scheme.
- For qualitative exercise, assessing ORR and AI skills, the unknown(s), tests carried out, the expected observation, and inferences should be noted in the Mark Scheme.
- For PD skills, the Mark Scheme should include the problem statement given to students, possible solutions, variables and so on.
- Ensure that an adequate amount of marks are allocated for an exercise while noting that **CXC does not award half marks**. For example, do not allocate five marks for an exercise which has more than five tests. Scale down the total mark of the exercise if necessary.
- All marks should be converted to out of ten.
- A maximum of two skills should be assessed per activity.
- If more than one skill is assessed per activity then the marks allotted for each skill must be clearly demarcated and not lumped together as one mark.

#### Planning and Design (PD) Skills

There are still major occurrences of standard exercise being utilized to assess PD skills. Teachers are encouraged to present scenarios to the students in the form of problem statements, which can be solved by standard chemical procedures or by employing sound chemical principles, covered in the CSEC Chemistry syllabus. Students should not have to come up with their own PD exercise for each assessment.

The way in which a PD exercise is presented determines whether it may be classified as a standard laboratory exercise or accepted as an authentic PD activity. A common PD lab which is considered standard is:

*Plan and design an experiment to show that the rate of a chemical reaction is dependent on temperature.*

This standard exercise can be presented in a form which makes it acceptable to be used to assess PD skills, as follows:

*A housewife observed that cow's milk stayed fresh when placed in the refrigerator but when it was left on the kitchen counter over night she found that the milk had curdled. Plan and design an experiment to explain these observations.*

Teachers are also reminded of the following:

- A reason or explanation is not needed in the Hypothesis.
- The main method to be used should be highlighted in the Aim.
- The procedure developed should theoretically satisfy the aim while being able to produce data which would "validate" the hypothesis.
- For data to be collected, if a table is drawn no results should be listed. Any PD lab carried out can no longer be assessed as PD.
- Where appropriate, controls and variables to be manipulated should be listed.

- It is suggested that one mark is not enough for procedure. There should be at least three marks:
  - Appropriate language and tense (1 mark)
  - Feasibility (1 mark)
  - Sequence (1 mark)
- Observations and Inferences should not be marked under PD.
- Equations and tests for gases should not be assessed under PD skills.
- Background information should not be assessed under PD. Instead, a problem statement must be given to the students by the teachers.
- It is recommended that aims should not begin with 'To plan and design...'

#### Analysis and Interpretation

The Analysis and Interpretation skill continues to be one of the better assessed skills. However, to ensure continued improvement the following should be noted:

- Observations should not be assessed under AI.
- Definitions should not be assessed under AI.
- Mole calculations should be done from first principle, using the unitary method. **CXC does not accept the use of the equation  $M_1V_1=M_2V_2$ .**

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION  
MAY/JUNE 2009**

**CHEMISTRY**

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**CHEMISTRY**  
**GENERAL PROFICIENCY EXAMINATION**  
**MAY/JUNE 2009**

**GENERAL COMMENTS**

Candidates were required to write three papers – Paper 01, comprising 60 multiple choice items. Paper 02, essay-type questions and Paper 03, the School-Based Assessment.

On Paper 02, candidates were required to complete six questions, five of which were compulsory and the sixth selected from one of two questions from Section C of the syllabus. Questions 1 – 3 were structured items, while 4 – 7 were extended essay items.

The contributions of the papers to the overall examination were as follows:

Paper 01 - (Multiple Choice)	- 30%
Paper 02 - (Structured Essay)	- 50%
Paper 03 - (School-Based Assessment)	- 20%

The candidates' performance at this sitting of the examination showed some improvements over performance in previous years. The optional question on Gardening (Question 7, Paper 02 ) was generally well done by those candidates who selected it. Many candidates also performed well on Part (a) of the data analysis (Question 1, Paper 02) which tested knowledge of the mole and drawing and interpreting graphs, and on Question 4 which was based on the Periodic Table. However, several issues highlighted in previous reports continue to cause concern and it does not appear that there is any improvement in these areas. These areas include the performance on items that test organic chemistry, particularly polymers and knowledge of the definitions of key concepts in chemistry. The many vague responses reflect a superficial understanding of some very important concepts.

**DETAILED COMMENTS**

**Paper 01 – Multiple Choice**

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance on this paper continued to be steady and satisfactory. The marks ranged from 0 to 59.

The mean score earned by candidates was 60 per cent with a standard deviation of 11.

## Paper 02 – Structured Essay

NOTE: THESE COMMENTS SHOULD BE READ IN CONJUNCTION WITH THE QUESTION PAPER AND SYLLABUS IN ORDER TO DERIVE THEIR FULL BENEFIT.

### Question 1

Syllabus References: A8.1, 6.5, 6.8, 3.3; B2, 4.1, 4.2, 7.1, 7.2, 7.3

#### Part (a)

##### **Candidates' Performance**

Part (a) was fairly well done with an average mark of 9.8 (61 per cent) out of 16, with approximately 74 per cent of the responses obtaining a mark of 8 or more.

#### Parts (a)(i) a) and b)

These parts tested candidates' knowledge of the (metal) reactivity series, specifically the relative reactivity of zinc and copper.

##### **Candidates' Performance**

Most candidates were able to give two observations that would result from the reaction between aqueous copper(II) sulphate and zinc powder.

##### **Common Incorrect Responses**

- Black precipitate of copper.
- Blue precipitate of solid copper.
- There would be a colour change.

##### **Expected Responses**

- Blue colour of copper(II) sulphate fading to a lighter blue or to colourless.
- Formation of a red-brown solid (copper metal).
- Increase in temperature.

It was noted, however, that some candidates used terms like 'white solution' and 'clear solution' for colourless, and erroneously gave the appearance of the solid copper as a blue solid, particularly mistaking Cu(s) for Cu<sup>2+</sup>(aq).

#### Part (a)(i) c)

Candidates were required to distinguish between an 'exothermic reaction' and an 'endothermic reaction'.

##### **Candidates' Performance**

Many candidates had difficulty in distinguishing between these two types of reactions. Candidates were expected to give differences based on the net absorption/release of energy (heat).

### **Common Incorrect Responses**

- Endothermic reactions are slow, exothermic reactions are fast.
- Endothermic reactions are inside, exothermic reactions are outside.
- Endothermic reactions are a positive charge, exothermic reactions are a negative charge.
- Exothermic reactions give out energy while endothermic reactions require energy.

### **Expected Responses**

Endothermic reactions occur with a net absorption of energy from the environment (and this results in a decrease in the temperature) while exothermic reactions occur with a net release of energy into the environment (which results in an increase in temperature).

#### Part (a)(ii) a)

This section involved the assessment of the Use of Knowledge (UK) and Experimental Skills (XS) profiles. Candidates were required to make temperature readings from five displayed thermometer diagrams and compute the changes in temperature.

#### **Candidates' Performance**

This was generally well done, with most candidates scoring full marks.

#### Part (a)(ii) b)

This section required the candidates to plot the temperature changes against the mass of zinc added.

#### **Candidates' Performance**

Although the points were plotted correctly in most cases, several candidates had difficulty in drawing a smooth curve through the points. In some cases, candidates used a ruler to connect the points by straight lines.

#### Part (a)(ii) c)

This part required the use of the candidates' interpolating skills, to determine the temperature change for a specified mass of zinc.

#### **Candidates' Performance**

Most candidates were able to interpolate correctly and obtained the one mark available for UK.

#### Part (a)(iii)

Candidates were required to calculate the mass of zinc required to completely react with 100 cm<sup>3</sup> of 0.20 mol dm<sup>-3</sup> copper(II) sulphate.

#### **Candidates' Performance**

Many candidates failed to gain the maximum two marks available for UK, because of their inability to calculate the number of moles present in a given volume of solution of known concentration.

### Common Incorrect Responses

- Many candidates incorrectly assumed that 100 cm<sup>3</sup> of a 0.20 mol dm<sup>-3</sup> solution contained 0.20 moles, instead of  $0.2 \times 100/1000 = 0.02$  moles

### Expected Responses

A 0.20 mol dm<sup>-3</sup> solution is one that contains 0.20 moles of solute per 1 dm<sup>3</sup> (or 1000 cm<sup>3</sup>) of solution, hence:  
1000 cm<sup>3</sup> of 0.20 mol dm<sup>-3</sup> copper(II) sulphate contains 0.20 moles  
1 cm<sup>3</sup> of 0.20 mol dm<sup>-3</sup> copper(II) sulphate contains (0.20/1000) moles  
100 cm<sup>3</sup> of 0.20 mol dm<sup>-3</sup> copper(II) sulphate contains  $100 \times (0.20/1000) = 0.02$  moles.  
Cu<sup>2+</sup>(aq) and Zn(s) react in a 1:1 mole ratio, therefore 0.02 moles of zinc are required.  
Mass = number of moles x Relative Atomic Mass (RAM) = 0.02 moles x 65 g mol<sup>-1</sup> = 1.3 g

### Part (a)(iv)

Candidates were required to use the information from Part (iii), to explain why the different masses of zinc in the last two experiments gave the same change in temperature.

### Candidates' Performance

This part was generally well done. Some candidates seemed not to realize, however, that from the type of graph drawn, the horizontal portion at the end indicates the completion of the reaction.

### Common Incorrect Responses

- The small change in mass of zinc would not cause a difference in temperature.

### Expected Responses

The 100 cm<sup>3</sup> of copper(II) sulphate solution requires 1.3 g of zinc for complete reaction. Experiments 4 and 5 have masses that are in excess of this mass. After the 1.3 g of zinc have reacted, the reaction would be complete.

### Part (a)(v)

Candidates were required to account for the observation that when silver is used instead of zinc, no temperature change is observed.

### Candidates' Performance

Many candidates compared the reactivity of silver to zinc, instead of the reactivity of silver to copper, or did not give a detailed enough comparison.

### Common Incorrect Responses

- Silver is less reactive.
- Silver is less reactive than zinc.

### **Expected Responses**

Silver is below copper in the reactivity series, therefore silver would not displace copper(II) ions from solution.

#### Part (b)

In Part (b), candidates were given the results of three tests on Solid R. They were required to indicate the possible inferences from the results of the tests and to deduce the identity of Solid R. The presence of the ammonium ion and ammonia as the pungent gas which turned red litmus blue were the inferences for Test 1. Test 2 was a positive test for the chloride ion and an ionic equation was required for the formation of silver chloride from silver and chloride ions. Solid R should have been identified as ammonium chloride.

### **Candidates' Performance**

In spite of the simple and well-known tests for the ammonium and chloride ions, candidates performed poorly on the qualitative analysis question. Very few were able to score more than two (40 per cent) of the five marks for this section. The responses suggested that candidates lacked experience with these "routine" qualitative tests. Some of the responses were quite far-fetched such as  $\text{Zn}^{2+}$  and  $\text{NO}_3^-$ .

### **Common Incorrect Responses**

- Many incorrect responses were given for the formula of the ammonium ion and ammonia gas.
- Several candidates referred to ammonia as ammonium gas.
- Far too many candidates are still unable to write ionic equations as they do not know the symbols for the ions.

#### Part (c)

Part (c) tested candidates' planning and designing skills. They were required to plan a suitable method for distinguishing between vinegar and muriatic (hydrochloric) acid.

### **Candidates' Performance**

While most candidates were able to score one mark for correctly listing the materials required for the method suggested, many were unable to identify suitable methods. Many candidates focused their responses on the "cleaning abilities" of the cleaners rather than the properties of ethanoic and hydrochloric acid. Several candidates repeated the smell of the cleaners as stated in the question or outlined methods for cleaning kettles, tiles and toilets as a means of differentiating between the two acids. Full marks were awarded for feasible procedures that included all important steps that were logically organized. Candidates used a range of possible responses which were accepted. These included:

- The reaction of the vapour from the acid with ammonia to produce ammonium chloride.
- Universal indicator – comparing colours and /or pH values.
- pH meter – comparing pH values.
- Testing for chloride ions.
- Titrating – comparing the volume of acid/base used for neutralization.
- Formation of the ester in the case of the vinegar.
- Reaction with metal, metal carbonate, metal hydrogen carbonate – comparing the rate of reaction or the volume of gas evolved in a specific time.
- Electrolysis – comparing ammeter readings with each acid as the electrolyte.



As well as suggesting a suitable method, candidates were required to indicate the basis on which the two acids could be distinguished given the method selected. Those who selected suitable methods were usually awarded marks in this section.

### **Common Incorrect Responses**

- The use of litmus paper to differentiate the acids was most common. Many candidates thought that the stronger acid would turn the litmus a darker shade of red than the weak acid.
- Failure to recognize the need to carry out the same tests on both acids in order to compare results.
- Carrying out different tests on each acid.
- Some confusion concerning the correct name of the universal indicator paper. Names such as pH scale and universal litmus paper were used.

### **Question 2**

Syllabus References: A1.2, 4.6, 4.7; B1: 1.7, 1.8, 1.9, 3.1

This question tested knowledge of inorganic and organic chemistry. Most candidates did fairly well and were able to score more than 8 (53.3 per cent) of the 15 marks allotted.

For Part (a), candidates were presented with a diagram of the effect of temperature changes on ice. They were required to identify the states of matter, read from the graph the melting and boiling points, deduce what would be observed during melting and to state the processes for converting water vapour to water and solid iodine to gaseous iodine.

Part (b) tested knowledge of allotropes of carbon and Part (c), knowledge of hydrocarbons and structural isomerism.

### **Candidates' Performance**

#### **Part (a)**

Candidates did very well on this part although the weaker candidates were unable to name sublimation as the process occurring when solid iodine was converted to gaseous iodine. Almost all candidates were able to give the names of the three states of matter and to identify the temperatures which represented melting and boiling points from the diagram showing the change of state with temperature. The better candidates were able to clearly state that point C would have a mixture of both ice and water. Responses such as "the ice has melted" were not awarded any marks.

#### **Part (b)**

Far too many candidates lost marks because they were unable to give a clear definition of allotropes. Here, they confused many concepts such as isotopes and isomers with allotropes. Additionally, they described allotropes as compounds instead of elements.

The majority of candidates were able to identify graphite as the allotrope of carbon that conducts electricity but only a few were able to explain why.

### Part (c)

While many candidates listed crude oil, petroleum and natural gas as sources of hydrocarbons, which were all awarded full marks, a wide variety of incorrect responses were also given. Most candidates gave a correct definition for structural isomerism but again used terms such as atoms and elements quite loosely and incorrectly in the definition. For the most part, candidates were able to draw a four-carbon hydrocarbon. However, many were challenged to draw the corresponding isomer.

### **Common Vague or Incomplete Responses**

- Identification of the process taking place at point C, melting, instead of stating what would be observed.
- Classification of allotropes as atoms and compounds.
- Attributing the conductivity of graphite to ions present in the element or identifying it as a metal with a “sea of mobile electrons”.
- Identification of the corresponding isomer of an alkane as an alkene.
- Bending the hydrocarbon chain to form a new isomer instead of rearranging the carbon skeleton.

### **Question 3**

Syllabus References: B1: 3.2, 3.1, 2.7, 4.6, 3.8; A1: 5.4

This question was very poorly done, with an average mark of 4 (26.7 per cent) out of 15. Only 20 per cent of the candidates were able to obtain a score of 8 (53.3 per cent) or more out of the 15 marks, while 3 per cent of candidates scored between 13 and 15. Approximately two-thirds of the candidates earned less than 5 (33.3 per cent) marks or did not respond. In this question, candidates were required to identify and give uses for the lightest and heaviest fractions in the fractional distillation of crude oil; draw the structure of products when bromine and sodium reacted with a given molecule (with alcohol and alkene moieties), draw the partial structure of a polymer, draw the structure of a monomer given the polymer, and identify differences in the enzyme hydrolysis and acid hydrolysis of polyamides.

### Part (a)

In this part, candidates were required to (i) name the property of compounds upon which fractional distillation is based, (ii) name the lightest and heaviest fractions obtained from fractional distillation of crude oil, and (iii) state one use of each of the named fractions.

### **Candidates' Performance**

The majority of candidates correctly indicated that the property was the boiling point. Many did not know the names for the lightest and heaviest fractions, while most candidates were able to give a correct use of either one or both fractions.

### **Common Incorrect Responses**

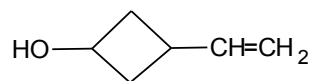
- Names of lightest fraction: liquified gas, natural gas.
- Use of lightest fraction: fuel for cars.
- Use of heaviest fraction: fuel.

### Expected Responses

- (i) The boiling point is the property of compounds upon which fractional distillation is based. Vapour pressure is also accepted.
- (ii) The names and uses of the crude oil fractions:  
Lightest fraction:  
Name – gaseous fraction/propane/methane  
Use – cooking gas/source of hydrogen  
Heaviest fraction:  
Name – bitumen  
Use – road paving

### Part (b)(i)

Candidates were required to draw the products of the reaction of a molecule bearing –OH and –CH=CH<sub>2</sub>, functionalities:



### Candidates' Performance

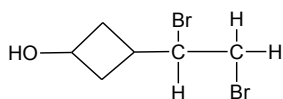
The majority of the candidates did not correctly indicate the addition of bromine across the double bond, or the reaction of sodium with the –OH group.

### Common Incorrect Responses

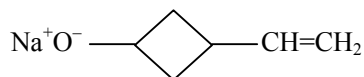
- Bromine reacting with –OH group.
- Addition of bromine, with retention of double bond.
- Addition of sodium across double bond.
- Opening of the ring on reaction with bromine.

### Expected Responses

Bromine (Br<sub>2</sub>) adds across the double bond to give:



Sodium (Na) reacts with the –OH group to liberate hydrogen gas and forms the alkoxide salt,



### Part (b)(ii)

Candidates were required to draw the partial structure (using three molecules of A) of the polymer formed from the polymerisation of A.

### Candidates' Performance

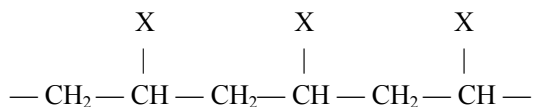
A large number of candidates produced a partially correct structure and were able to get one of the two available marks, but most had the structure incorrectly drawn.

### Common Incorrect Responses

- Linking of the rings.

### Expected Responses

The expected structure should have a 'backbone' of carbon-carbon bonds with the side groups on alternating carbon atoms:



### Part (c)

In this part, candidates were tested on their knowledge of condensation polymerisation. The structure of a polyamide, **B**, formed from the condensation polymerisation of amino acid molecules was shown, and candidates were asked to (i) identify the type of polymerisation involved, (ii) draw the monomer formed when the polyamide **B** undergoes acid hydrolysis and give one difference in the reaction conditions required for acid hydrolysis when compared to enzyme hydrolysis.

### Candidates' Performance

The majority of candidates responded correctly to Part (i). In Part (ii), a small percentage of candidates correctly drew the structure of the amino acid. Most candidates indicated that acid hydrolysis required a higher temperature than enzyme hydrolysis.

### Common Incorrect Responses

#### Part (c) (ii) (a)

- Structure of a di-acid was given.
- Structure of a diamine was given.
- Structures with incomplete carboxylic acid or amino acid end groups were given.

#### Part (ii) (b)

- "One requires a higher temperature" and not stating which one does.

### Expected Responses

- The monomer has one amino (-NH<sub>2</sub>) and one carboxylic (-COOH) end group at either end of the molecule.
- Acid hydrolysis requires a lower pH (or higher acid concentration). Enzyme hydrolysis requires a lower temperature (body temperature).

#### **Question 4**

Syllabus References: A2.8, 4.1, 4.2; B2: 2.1, 4.1

This question tested knowledge of the basis for assigning elements to groups and periods, the reduction of metal oxides by electrolytic or chemical reduction, writing ionic equations for displacement reactions and covalent bonding. Most candidates scored seven (46.7 per cent) or more marks for this question.

#### **Candidates' Performance**

##### Part (a)

For the most part, candidates were able to explain the basis for using the electron configuration to assign elements to groups and periods. Some candidates chose to write unnecessary information on periodic trends and gained no marks for their efforts. In a few cases, candidates were able to give the correct electron configuration of an element but incorrectly identified its group or period.

##### Part (b)

Most candidates correctly identified aluminium as the element whose oxide could be reduced by chemical reduction. It was expected that candidates would deduce that there were strong bonds formed between aluminium and oxygen and that electrolytic reduction was used as chemical reduction and would not be powerful enough to extract the aluminium. Although many candidates knew the difference between chemical and electrolytic reduction, they were unable to offer suitable explanations for electrolytic reduction being used to extract aluminium from its oxide and so lost two of the three marks in this section. Many associated the extraction with the position of the element in the reactivity series saying that as aluminium was high in the series, it would be extracted by electrolysis. The comparison of the two processes was missing from many of the responses. Many candidates seemed not to know that coke was a reducing agent.

In identifying elements that could participate in a displacement reaction, many candidates chose elements that were not in the table given, although the question required that elements should be selected from the table. The concept of a displacement reaction was fairly well understood. However, candidates lost marks because they were unable to write a balanced ionic equation inclusive of state symbols. No marks were awarded for selecting zinc and copper in response to Part (b)(ii) as this example was actually given on the question paper and these elements were not included in the table given.

##### Part (c)

The majority of candidates correctly identified covalent bonding as that in the compound iodine monochloride. Covalent bonding was usually well explained. However, far too many candidates lost marks because they were unable to show the correct representation of the covalent bond formed between iodine and chloride.

#### **Common Incorrect Responses**

- Identifying sodium, magnesium and potassium as examples of elements that can be extracted from their oxides by electrolytic reduction.
- Failure to show all electrons in the outer shell of the elements participating in the covalent bond.
- Failure to balance both the charge and the elements for ionic equations.
- Attributing the placement of elements to group to the valency of the element.

### **Question 5**

Syllabus References: B2: 3.1, 5.3, 7.1, 7.2 and A 3.4

Candidates were tested on their knowledge of the industrial preparation of ammonia, and the preparation and identification of ammonia in the laboratory. They were also required to write equations relating to the oxidation of nitrogen(II) oxide to nitrogen(IV) oxide and the conversion of nitrogen(IV) oxide to nitric acid.

Generally, the question was poorly done, with approximately 75 per cent of the candidates scoring between zero and five (33.3 per cent) out of the possible 15 marks, with another eight per cent not attempting the question.

#### **Part (a)**

Candidates were required to give **(i)** the name of the catalyst and the temperature used in the manufacture of ammonia **(ii)** ONE reason why the temperatures currently used in the manufacture of ammonia make the process cost effective and **(iii)** a reason for the step (labelled as D) used for the recycling of un-reacted starting material (nitrogen and hydrogen) on the flow diagram for the manufacture of ammonia.

#### **Candidates' Performance**

More than 50 per cent of the candidates scored at least one of the two marks for Section (i). Section (ii) seemed to be the most difficult for the candidates, even with those candidates who had good scores on the question. For Section (iii), most candidates were able to correctly identify the recycling step.

#### **Common Incorrect Responses**

##### **Part (a) (i)**

- Enzyme
- Iron oxide
- Al
- Fe<sup>3+</sup>
- Pt

Some candidates guessed and provided responses such as:

- 300° atmospheres
- -92 kJ mol<sup>-1</sup>

Most candidates wrote at length about the cost of equipment, with responses such as:

##### **Part (a) (ii)**

- It is cost effective because they need to get equipment that can supply the temperature necessary for the reaction to occur.
- Because the temperature is so high, the cost of materials and equipment (needed to heat and compress) to give out the heat energy is high and costly.

### Part (a) (iii)

Step D in Figure 4 was important as:

- A way of purifying the ammonia
- Gases were being recycled and condensed into a liquid
- A step used to prevent air pollution
- Liquid ammonia was being recycled

### **Expected Responses**

The correct catalyst is finely divided iron (iron was accepted) and the temperature range is 300° – 600 °C. Although the reaction is exothermic and lower temperatures would shift the equilibrium to the products (giving higher yields), lower temperatures would make the reaction rate too slow to be economical. Step D is used to recycle the unreacted starting materials (hydrogen and nitrogen), which make the process more economical.

### Part (b)

Candidates were required to (i) write a balanced equation to show the laboratory production of ammonia and (ii) describe a suitable test for identifying ammonia.

### **Candidates' Performance**

Many candidates seemed not to know the basic steps involved in the laboratory production of ammonia, even though this is a part of the qualitative analysis. Many of those who got the equation correct omitted a source of heat. In Part (ii), the majority of the candidates gave correct answers.

### **Common Incorrect Responses**

#### Part (b) (i)

- Heating ammonium hydroxide.

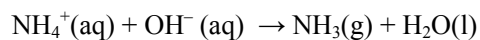
#### Part (b) (ii)

Some candidates wasted time describing the production of ammonia. Some incorrect responses were:

- Glowing splint would be re-lit.
- Used a pungent smell to identify ammonia.
- Changed blue litmus paper to red.

### **Expected Responses**

Heating of any ammonium salt with a base will produce ammonia gas. The correct ionic equation for Part (i) is,



For Part (ii), the correct responses are:

- Damp red litmus paper changes to blue in presence of ammonia.
- Dense white fumes are produced with hydrogen chloride gas.

### Part (c)

Candidates were required to (i) write balanced equations for the oxidation of nitrogen(ii) oxide to nitrogen (IV) oxide, and the oxidation of nitrogen(IV) oxide to nitric acid in the presence of water and (ii) give two uses of ammonia.

### **Candidates' Performance**

Even though the names of the reactants and products were given in each case, many candidates had difficulty with oxidation numbers, writing the correct chemical formulae, and balancing the equations in Part (i). Most candidates were aware of the industrial and home uses of ammonia, and gave correct responses to Part (ii).

### **Expected Responses**

In Part (i), the correct responses are:

- $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$
- $4\text{NO}_2(\text{g}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 4\text{HNO}_3(\text{aq})$

Candidates should be made aware of the nomenclature with and without oxidation numbers, for example, nitrogen monoxide  $\equiv$  nitric oxide, nitrogen dioxide  $\equiv$  nitrogen(IV) oxide.

Uses of ammonia include the production of fertilizers, cleaners and urea, also testing for metal ions.

### **Question 6**

Syllabus Reference: C6.2, 6.5, 6.8, 6.10

Approximately 10 per cent of the candidates chose this question. Those who did, showed some awareness of the chemistry of common materials found around the home.

### Part (a)

Candidates were expected to state what is meant by

- plasticity – the ability to be moulded
- porosity – ability to give up water without cracking
- vitrification – the process to become glossy.

They were also required to suggest some of the benefits of the plasticity and porosity of clay.

### **Candidates' Performance**

Part (a) was poorly done by many candidates. They confused the phrases “what is meant” with “suggest a reason”.



### Part (b)

Almost all of the candidates gave the component of cement as calcium carbonate, limestone, silica or klinker. They also gave correct ingredients of concrete. Section (ii) was most problematic for the majority of the candidates as they were unable to provide a suitable response for why the floor was dampened while hardening.

### Part (c)

This part of the question differentiated the stronger from the weaker candidates as the weaker candidates did not know that the dampening of clay would have the opposite effect to the dampening of concrete.

### **Expected Responses**

A suitable response for the plasticity of clay was that it allows pottery to have a variety of uses due to different shapes such as pots, jars. Porosity is important as it helps the clay object to keep its shape without cracking.

Concrete is normally dampened during hardening as:

- Water helps to form hydrates.
- These hydrates are silicates, thread-like crystals.
- The hydrates hold the components of the concrete.
- The concrete floor would crack if not dampened.

As water makes clay soft, dampening it during the drying process would retard its ability to dry and the object would lose its shape.

### **Question 7**

Syllabus References: C 6.2, 6.5, 6.8, 6.10; B2: 7.1

The average mark was 9.4 out of 15 or 62 per cent of the score. Sixty-nine per cent of the candidates scored a mark of 8 (53 per cent) or more. The majority of the candidates displayed an awareness of the inter-relationship among Chemistry, Biology, Ecology and Agricultural Science. As a result of this reinforcement, the majority of the candidates scored high marks.

### Parts (a) (i) and (ii)

Candidates were required to define 'humus' as it relates to soil, and state three reasons why humus is an important component of soil.

### **Candidates' Performance**

These parts were well done with candidates being able to correctly identify and define humus and humus content in soil as dead and decaying organic (plant and animal) matter. Popular responses were humus is the organic substances in the soil and it

- is necessary to retain moisture
- provides nutrients
- aerates the soil
- improves crumb structure
- provides a home for microorganisms.

### **Common Incorrect Responses**

- Humus is the top layer of the soil.

### **Expected Responses**

Definition: Humus is the organic matter of the soil.

Reasons for the importance of humus: more efficient use of nutrients due to water held in humus, aids in moisture retention, improves soil structure allowing diffusion of air, reduces the tendency for minerals to be flushed out to the lower levels of soil, increases soil fertility, creates an environment that supports living organisms necessary for the conversion of soil nutrients to plant food, holds the soil together and helps prevent soil erosion and allows “excess water” loss thus preventing water logging.

#### Part (b)

Candidates were required to correctly identify a test for the ammonium ion in a soil sample.

### **Candidates’ Performance**

This part was problematic for the vast majority of the candidates. *It appears as if the candidates who gave correct responses were the ones who actually carried out the test as suggested on page 60 of the syllabus.* A number of candidates did not know the formula for the ammonium ion and some referred to it as the ‘ammonia ion’.

### **Common Incorrect Responses**

- $\text{Fe}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Na}^+$  and other ions.

### **Expected Responses**

$\text{NH}_4^+$  ion.

#### Part (c)

Candidates were required to give one advantage and one disadvantage each for biological and chemical control of pests.

### **Candidates’ Performance**

Some candidates confused chemical control with the use of chemical fertilizers. Better responses for chemical control included: ‘it is fast acting and easy to use’ being an advantage, and ‘it is expensive and kills useful organisms’ as a disadvantage, and for biological control, an advantage is ‘it does not have to be reapplied’ and a disadvantage is ‘it affects the ecosystem and the biological control eventually becomes a pest’.

### **Expected Responses**

Chemical control, advantages: easy to apply, works quickly, broad spectrum of activity, can be selective, more easily available.

Chemical control, disadvantages: may be costly in the long term, pests may build resistance, toxic upon ingestion/inhalation, undesirable environmental consequences, may kill useful insects.

Biological control, advantages: once successful, does not need to be reapplied, increases diversity of the ecosystem, poses no environmental threat.

Biological control, disadvantages: takes much longer than chemicals to see a response, may upset ecological balance, may themselves become pests, migration or death of control.

#### Part (d)

Candidates were required to (i) give the meaning of hydroponics and (ii) state two advantages and two limitations of setting up a hydroponic farm.

#### **Candidates' Performance**

Many responses to Part (i) were vague as they did not associate hydroponics with a soil-less culture or an inert medium. However in Part (ii), the advantages of hydroponic farming were well stated, for example, growing of out-of-season crops, maximising use of land space, requiring a smaller labour force, greater crop yields. Some candidates had problems in identifying the limitations, and in some cases candidates misinterpreted the phrase 'cost effective' to mean expensive. Some good responses to limitations include: it is expensive to set up, it is a mono-culture, restricted to one type of crop, high technical expertise required, requires constant monitoring of the hydroponics farm, cultural acceptance of crops grown using hydroponics.

#### **Common Incorrect Responses**

- Some stated, loosely, that hydroponics is the growing of plants in water.

#### **Expected Responses**

Hydroponics is the process of growing of plants in a soil-less culture. This may include the use of water only, or an inert medium such as sand or gravel.

Advantages: no weed problems, answer to reduced arable land space, requires a small labour force for maintenance, no nutrient-deficient crops, crops available out of season.

Limitations: range of crops successfully cultivated is limited, anchorage and support of roots must be catered for, needs great care and monitoring, employees need a high level of technical knowledge, expensive to set up, societal acceptance of crops may be limited.

Perhaps, by visiting a hydroponics farm, the reinforcement of the theory would be achieved.

### **Paper 03 – School-Based Assessment (SBA)**

#### **General Comments**

This year, there has been improvement in the quality of the samples submitted for moderation. There was a noticeable increase in the number of centres where the standard of the practical exercises was at least satisfactory. Teachers must again be commended for making an effort to improve the standard of the SBA and for their efforts to ensure maximum coverage of the syllabus as well as undertaking at least the minimum number of activities.

The points highlighted here should serve to aid teachers in further improvement of the SBA as well as assist in making the moderation process more effective.

### SBA Samples

In general, the samples were presented in good condition but some emphasis should be placed on the following:

- Some books lacked a table of contents, page numbers and dates.
- Those laboratory exercises utilized for assessment should be clearly marked and identified in the candidates' books and the corresponding dates should be in the mark schemes
- The CHEM-3 form which shows the breakdown of marks for the individual skills should be completed and submitted for moderation.

### Equations

This year there was an increase in the number of centres which adequately utilized equations. However, several errors were also noted.

- In many cases, students wrote incorrect equations which were not corrected by the teachers.
- Students should be encouraged to include state symbols whenever they are writing equations.
- Some equations which were incorrectly balanced were given as accurate by the teachers.

Greater emphasis should be placed on writing the correct chemical symbols. The most common error is with the use of capital letters. For example, in many cases the symbol for sodium chloride is being written as *NaCL* or *NACl* rather than *NaCl* and calcium carbonate as *CaCo<sub>3</sub>* rather than *CaCO<sub>3</sub>*, and these were not corrected in the candidates' books.

### Graphs

More emphasis also needs to be placed on graph work. Approximately 25 per cent of the centres submitted samples with unsatisfactory emphasis on graph work. In assessing graphs, the plotting of graphs should be assessed under the ORR skills and not the A/I skills. However, interpolation of the graphs can be assessed under the A/I skills.

### Mark Schemes

It should be noted that a small percentage of the centres moderated (6 per cent) did not submit mark schemes. Additionally approximately 50 per cent of those submitted were inappropriate for at least one of the skills moderated. Teachers are encouraged, once again, to work together when planning and devising practical activities as well as constructing mark schemes. In a few instances, it was evident that two or more teachers submitted one group of five samples and only one teacher sent a mark scheme. In such cases, it was not possible to use the mark scheme submitted to moderate all the samples. Teachers are encouraged to co-ordinate common activities and mark schemes since one sample is required from a centre.

With respect to mark schemes:

- They should be specific for different laboratory exercises. In many cases teachers submitted one mark scheme to cover all the AI skills. Where this may be possible for PD skills, activities used to assess AI skills are too varied. This leads to an extremely vague and in most cases unusable mark scheme.
- The mark scheme should correspond to the laboratory exercises shown in the books. A common system should be used to identify the exercises in the books submitted with the appropriate mark schemes.
- Marks should not be lumped together. Instead, each mark should be assigned to a specific content item; for example, when more than one mark is allotted for a calculation, a breakdown of how individual or partial marks are allocated should be included in the mark scheme. If more than one skill is assessed per activity then the marks allotted for each skill must be clearly demarcated.

- When students are expected to answer specific questions these questions, as well as their expected responses and the allocation of each mark, should be included in the mark scheme.
- For qualitative laboratory exercises, assessing ORR and AI skills, the unknown(s), tests carried out, the expected observation, as well as inferences, should be noted in the mark scheme.
- For PD skills, the mark scheme should include relevant details, for example, the problem statement given to students as well as possible solutions and variables.
- Ensure that an adequate number of marks are allocated for an exercise while noting that **CXC does not award half marks**. For example, do not allocate five marks for an exercise which has more than five tests. Scale down the total mark of the exercises if necessary.
- All marks should be converted to a mark out of 10.
- A maximum of two skills should be assessed per activity.

### Planning and Design (PD) Skills

PD skills remain the most challenging of the skills to assess. In this regard, some extensive comments on PD activities are included which hopefully will assist in improving the assessment of this skill.

Some areas where improvement is necessary include:

- The problem statements
- Stating the hypothesis
- Recording of data to be collected
- Writing of the treatment of results
- Use of appropriate tense

Below are some very specific comments:

- Scenarios
  - Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise. These should also be included in the teacher's mark scheme.
  - It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PDs) be found.
  - It is not recommended that students be left to generate the problems/scenarios on their own. However, in circumstances where this is done, these problems/scenarios should be vetted by the teacher to make sure that they are testable and chemistry-based.
- Hypothesis
  - The hypothesis should be testable. Consider the following scenario

*Scenario: Four bottles which had lost their labels are now labelled A, B, C and D. It is suspected that they are a sulphate, chloride, carbonate and a hydroxide. Plan and design an experiment to determine the identity of these solutions.*

A non-testable hypothesis would be: *the identification of 4 solutions that have lost their labels.*

A testable hypothesis would be: The solutions are A- sulphate, B – carbonate, C – chloride and D – hydroxide.

- As much as possible, the manipulated variable should be included in the hypothesis.
- The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used in the experiment should be outlined in the hypothesis.
- Aim
  - The aim must relate to the hypothesis as well as the problem statement.
  - Students should be encouraged to specify the method or technique to be employed in the experiment. It should be the bridge between the method and the hypothesis.
- Procedure
  - Special attention must be placed on the tense used in the procedure. Students should write the procedure in the present or future tense. Any other tense is unacceptable.
- Expected Results / Data to be Collected
  - This particular area is not well understood and hence it is recommended that the term “data to be collected” be used rather than “expected results”.
  - In this section the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis should be recorded.
  - The data to be collected may be presented in tabular form or as a description of specific data including units where appropriate.
  - Some examples:
    - When doing a titration the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to use it as data collected.
    - If chromatography is used, then the data collected should include the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin.  $R_f$  values should never be used as data to be collected since these are also calculated.
- Treatment / Interpretation of Results / Data
  - It is recommended that the term “results” be replaced by “data” in the heading in an attempt to make it clear that this section looks at how the data collected will be used at proving or disproving the hypothesis.
  - This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

- Some examples:
  - In a scenario where students are trying to find out which brand of vinegar is more concentrated the Interpretation of Data could be: *If Brand Y vinegar uses the least volume (Data to be collected) to neutralize  $x \text{ cm}^3$  of base then Brand Y is the most concentrated vinegar (stated in the aim), and therefore the hypothesis is supported.*
  - In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *if both brands of ink contain the same number of components with the same colour and are the same distance from the origin (data to be collected), then both brands of ink contain the same dye (stated in the aim) and therefore the hypothesis is supported.*
- Limitations / Precautions / Assumptions
  - It is recommended that teachers assist the students in distinguishing between these terms. While they can be related, the way that they are stated can make a significant difference.
- Sources of error
  - This section should not be present in a PD lab since it refers to a lab that has been carried out.

In addition, the points listed below are worth repeating even though they have been stated in past reports.

#### Planning and Design (PD)

- All PD activities should be based on chemical concepts. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition, or any other non-chemistry discipline are not suitable. An example of an inappropriate example is: Plan and design an experiment to prove that *Women are smarter than men or Secondary school students are smarter than drop-outs.*
- It is recommended that activities that involve live specimens, for example, frogs or slugs should not be considered for Planning and Design.
- Students should undertake at least four PD activities over the two year period. When this is not done the students are at a disadvantage.
- Observations, calculations or diagrams should not be included in a mark scheme used to assess PD skills.
- Plan and design activities which have been carried out cannot be assessed for PD skills.
- Standard practical exercises which can be obtained from a chemistry text are inappropriate for PD activities. Some examples include:
  - *Plan and design an experiment to determine the effect of concentration on the rate of a reaction.*
  - *Plan and design an experiment to determine the products of electrolysis of  $\text{H}_2\text{SO}_4$  using inert electrodes.*
  - *Plan and design an experiment to determine the conditions of rusting.*

### Analysis and Interpretation (AI)

The Analysis and Interpretation (AI) skill continues to be one of the better-assessed skills. However, to ensure continued improvement the following points should be noted.

- Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should **not** be assessed under A/I.
- Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.

Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that the students understand what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again **CXC does not accept the use of the equation  $M_1V_1 = M_2V_2$ .**



**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE CARIBBEAN SECONDARY  
EDUCATION CERTIFICATE**

**JANUARY 2010**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

This year, the number of candidates registering for the examination in January increased by 45 per cent when compared to January of 2009. However, the number who actually wrote all the required papers increased by 33 per cent (from 425 to 565).

A slight improvement was noted on the candidates' performance at this sitting of the examination compared with 2009. On Paper 2, candidates did fairly well on Questions 1, 2 and 4 but performed unsatisfactorily on the other questions. Several issues highlighted in previous reports continue to cause concern as the weaknesses identified still persist. One example is the performance on the questions that test organic chemistry. For Paper 2, a significant percentage of the candidates did not attempt Question 3 and those who attempted it did poorly.

A number of candidates seemed not to have been adequately prepared for Section C of the syllabus. The few students who wrote Question 6 which tested knowledge of clay and cement performed unsatisfactorily. Several responses to questions were vague, missing reference to key concepts for definitions and lacking depth where explanation was required. In many instances, the responses were superficial which may have been due to the fact that enough care was not given to differentiating and clarifying concepts as candidates prepared for these examinations.

Candidates wrote the Alternative Paper to the School Based Assessment (SBA) for the first time. The performance on the data analysis question was commendable but improvement is needed in the areas of qualitative analysis, and planning and designing.

## DETAILED COMMENTS

### Question 1

Syllabus References: A: 5.4, 3.3, 3.4, 6.10; B2: 7.1, 7.2

#### **Part (a)**

In this section, candidates were required to:

- (i) explain how a salt is formed
- (ii) distinguish between anhydrous and hydrated salts
- (iii) write a balanced equation for the reaction of dilute sulphuric acid and copper(II) oxide
- (iv) calculate the mass of anhydrous copper(II) sulphate that would be formed from a given mass of copper(II) oxide when reacted with a given volume of dilute sulphuric acid of known concentration

- (v) plot a graph of mass of anhydrous salt produced against mass of copper(II) oxide used
- (vi) use the graph to determine the mass of copper(II) sulphate that would be produced from a given mass of copper(II) oxide, and (vii) explain why there is no change in the mass of salt produced for two experiments (where the former was the limiting amount).

### Candidates' Performance

The average mark for this question was 8.5 out of 25 or 34 per cent. The majority of candidates earned marks for explaining how a salt is formed, but many candidates did not mention 'water of crystallization' in their responses in explaining the difference between a hydrated salt and an anhydrous salt. Many candidates earned the 2 marks for the equation for the reaction between sulphuric acid and copper(II) oxide. Many candidates were able to correctly calculate the mass of anhydrous copper(II) sulphate from the given mass of copper(II) oxide, calculating the correct number of moles of copper(II) oxide, stating the correct mole ratio and relating it to the mass of product. The majority of candidates obtained the maximum 3 marks for the graph, and were able to correctly read off (interpolate) the mass of anhydrous copper sulphate produced from a given mass of copper(II) oxide. Though the responses were somewhat varied in explaining why the mass of copper sulphate had reached a maximum after a while, many candidates realized that sulphuric acid was the limiting reagent and that addition of more copper(II) oxide would cause no further reaction.

### Common Incorrect Responses

- 1(a)(ii) Hydrated salts have water and anhydrous salts do not.
- 1(a)(vii) No more copper(II) oxide will dissolve.

### Expected Responses

- Hydrated salts contain water of crystallization and anhydrous salts do not.

### Part (b)

Part (b) tested candidates' knowledge of the identification of cations using qualitative analysis. An aqueous solution of Substance X (containing iron(II) and ammonium ions) was reacted with aqueous sodium hydroxide, dropwise and then in excess. Either the observation or the inference was given for each test, and the candidates were required to fill in the corresponding inference (with supporting equation(s)) or observations, respectively.

### Candidates' Performance

The majority of the candidates correctly indicated that red litmus changed to blue in the presence of an alkaline gas. Very few earned the 2 marks for the equation showing the reaction of ammonia and hydrogen chloride gases to form ammonium chloride.

**Part (c)**

In Part (c), candidates were required to describe an appropriate method that could be used to produce a pure solid sample of silver chloride starting with a solution of silver nitrate. The hint was given that all silver salts are decomposed by light.

**Candidates' Performance**

Some candidates failed to give the name of a soluble source of chloride ions, but a large number gave hydrochloric acid, which is a very good choice. Even though the hint was given that silver salts are decomposed by light, the majority of candidates did not state that light was to be excluded from the product, or that diminished light was to be used.

**Common Incorrect Responses**

- The salt should be placed in light to decompose.

**Expected Responses**

Candidates should indicate a soluble source of chloride, filtering the insoluble silver salt, washing impurities from the product and doing the preparation in reduced light, or in the absence of light.

**Question 2**

Syllabus References: A: 4.1, 4.2, 4.3, 4.5, 4.6, 4.7, 4.8

This structured question addressed the topic of structure and bonding. In Part (a), candidates were expected to complete a table by identifying the structure of one form of carbon, labelled V, based on the given appearance, melting point and electrical conductivity as well as to identify the electrical conductivity of another form of carbon, labelled Q, based on the appearance, melting point and structure given. Candidates were also expected to state the term used to describe different forms of an element.

In Part (b) (i), candidates were required to identify the forms of carbon from the information given in Part (a). In Part (b) (ii), candidates were given a partially drawn structure of Q and asked to complete the diagram showing the bonding within and between the layers. In Part (b) (iii), they were expected to state the use and the associated property of the two forms of carbon and in Part (b) (iv), they were required to explain why an ionic solid conducts electricity when molten but not when solid.

**Candidates' Performance**

This question was relatively well done; almost half of the candidates scored 8 or more out of the 15 available marks.

### Expected/Common Incorrect Responses

In Part (a), most candidates were able to identify correctly the structure of V as giant covalent and that Q was an electrical conductor. However, it is clear that many candidates were confused by the terms ‘allotrope’ and ‘isotope’.

Part (b) (ii) and (iv) seemed to be more challenging to candidates. Many could not complete the partial structure of graphite and those that were able to did not differentiate the covalent bonds from the intermolecular forces. When asked to explain why an ionic solid conducts electricity when molten but not when solid, many candidates incorrectly responded in terms of mobile electrons rather than mobile ions.

Part (c) was generally well done although some candidates seemed not to realize that both Cl and I have 7 electrons in their valence shell.

### Question 3

Syllabus References: B1: 4.1, 4.2, 4.3, 4.4, 2.8, 3.8

Candidates were required to define polymerization, identify the type of polymerization reaction from given equations, name polymers from given structures and give one use of each. Candidates were also required to write the equation for the reaction of magnesium with ethanoic acid and state whether the reaction would go at room temperature.

### **Part (a)**

In this part, candidates were required to define the term ‘polymer’.

### **Candidates’ Performance**

The majority of candidates were able to give a definition which included ‘monomer’ and also indicated that a polymer is a long chain molecule.

### **Common Incorrect Responses**

The following response is **not accurate** enough, that is, it should reflect that a polymer is a long chained molecule:

- A polymer is made from the joining of more than one monomer.

### **Expected Response**

A polymer is made from the joining of large number of (many) monomers to form a long chain.

**Part (b)**

Two polymerization equations were given depicting the addition polymerization of ethene and the condensation polymerization of a di-acid and a di-alcohol. Candidates were required to identify the equation which depicted 'addition polymerization', name the polymers in the two equations and give one use of each of the polymers in these equations.

**Candidates' Performance**

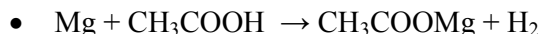
Most candidates were able to identify correctly equation (1) as the addition polymerization reaction but had difficulty naming the polymers (polyethene and polyester) in Equations 1 and 2, respectively. The majority of candidates was able to give one use of the two polymers - polyethene used in making plastics was a common response, as well as polyester used in making clothing/fabric.

**Part (c)**

Candidates were required to write a balanced chemical equation for the reaction between ethanoic acid and magnesium metal, and to indicate whether the reaction would proceed at room temperature.

**Candidates' Performance**

Most candidates gave an equation showing the production of a salt and hydrogen gas but some candidates had magnesium as a univalent metal ion. Many gave unbalanced equations. Many correctly indicated that the reaction would proceed at room temperature.

**Common Incorrect Responses****Expected Responses**

The correct name of the polymer in Equation 1 is polyethene, but polythene and polyethylene are also acceptable. The polymer in Equation 2 is a polyester. The uses for polythene include: plastic bags, containers for cleaning agents, mixing bowls. The uses for polyesters include: clothing, ropes, car bodies, and roofing sheets when polyesters are reinforced.

The correct equation is:  $\text{Mg(s)} + 2 \text{CH}_3\text{COOH(aq)} \rightarrow \text{Mg(CH}_3\text{COO)}_2 + \text{H}_2\text{O(l)}$

**Part (d)**

Candidates were required to (i) circle the peptide bond (link) on a figure showing the partial structure of a protein molecule containing three amino acid units, (ii) draw the fully displayed structure of one of the amino acid molecules that would be produced upon hydrolysis, and (iii) state two conditions under which proteins can be hydrolysed.

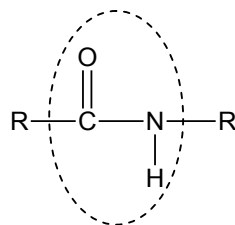
### Candidates' Performance

A number of candidates had difficulty in correctly identifying the peptide (amide) link, arbitrarily encircling different segments of the structure.

### Common Incorrect Responses

- A number of candidates incorrectly chose the C-N single bond, for example, between the amino acid and the carboxyl group as the peptide linkage.

### Expected Responses



The amide link is encircled in the structure:

### Question 4

Syllabus References: A: 6.17, 6.18, 6.19, 6.20, 6.21, 6.23; B1: 1.1, 1.2, 1.4, 1.5, 1.6

This question was mixed with parts coming from the sub-topics of conduction of electricity by electrolytes, and isomerism in alkanes and alkenes. Some candidates wrote their responses in the body of the question although the instructions clearly indicated that they should use the blank pages reserved for Question 4. (Candidates should be reminded at the examination centres to refrain from writing in the body of the question.)

### Part (a)

In this part of the question, candidates were asked to indicate whether a bulb would glow when a switch is closed to complete a circuit after a substance was placed in contact with two electrodes. The investigation was carried out on two pairs of substances.

### Part (a) (i)

Candidates were asked to state whether the bulb would glow for **solid lead bromide** and **molten lead bromide**.

### Candidates' Performance

Generally, candidates performed below the required standard with 28 per cent of candidates scoring 8 or more of the possible 15 marks for the question.

### Common Incorrect Responses

- Some candidates correctly stated that molten lead bromide would cause the bulb to glow, but incorrectly gave the reason as the presence of mobile electrons.

### Expected Responses

The cations and anions are mobile in the molten lead bromide and are therefore able to carry the electric charge.

#### Part (a) (ii)

Candidates were asked to state whether the bulb would glow brighter for solutions of **1 mol dm<sup>-3</sup> hydrochloric acid** or **1 mol dm<sup>-3</sup> ethanoic acid**.

#### Candidates' Performance

Many candidates gained the mark for correctly stating that hydrochloric acid would cause the bulb to glow brighter while some had difficulty giving an explanation. Many stated that HCl is completely ionized in dilute solution. The weaker candidates mixed up Pair 1 and Pair 2.

#### Common Incorrect Responses

- Ethanoic acid would cause the bulb to glow brighter.

### Expected Responses

Hydrochloric acid is the stronger electrolyte and is completely ionized; therefore, more ions are available in solution to carry the electric charge.

#### Part (a) (iii)

Candidates were asked to write a balanced equation for the reaction occurring at the cathode for either of the solutions, **1 mol dm<sup>-3</sup> hydrochloric acid** or **1 mol dm<sup>-3</sup> ethanoic acid**.

#### Candidates' Performance

Performance on this section was generally weak, and candidates had great difficulty in writing the correct ionic (cathodic) equation.

#### Common Incorrect Response

A number of candidates incorrectly wrote the equation as:  $\text{H}^+ + \text{e}^- \rightarrow \text{H}$

#### Expected Response

- $2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightarrow \text{H}_2(\text{g})$



**Part (b)**

Four fully displayed structures of hydrocarbons with four carbon atoms were given, and candidates were required to (i) write the name for one structure (2-methyl propene), (ii) state which of the structures are isomers, (iii) state, with reason, which two hydrocarbons belong to the same homologous series, and (iv) write the name of the homologous series.

**Candidates' Performance**

Generally, candidates performed well on this part of the question which was very encouraging, bearing in mind that the performance in organic chemistry is usually weak. Overall, candidates did not give three isomers, **a**, **b** and **c** but gave only two. They recognized that **a** and **b** belonged to the same homologous series because of the presence of a C=C double bond. Some stated that **a** and **b** belonged to the alkene group and have the same general formula.

**Common Incorrect Responses**

- butene, but-2-ene, methyl prop-2-ene
- alkene general formula -  $C_4H_8$

**Expected Responses**

- (i) 2-methyl propene, methyl propene
- (ii) **a**: 2-methyl propene, **b**: but-2-ene and **c**: cyclobutane are all isomers of  $C_4H_8$ .
- (iii) **a**: 2-methyl propene and **b**: but-2-ene belong to the **alkene** homologous series, both having a carbon-carbon double bond (C=C).
- (iv) the general formula for the alkene homologous series is  $C_nH_{2n}$ .

Question 5

Syllabus References: B2: 1.3, 3.1, 7.2

This compulsory question was an extended response based on the inorganic section of the syllabus.

In Part (a) of this question, candidates were asked to suggest how they could use a lighted splint and a piece of moist litmus to distinguish among three gases,  $Cl_2$ ,  $H_2$  and  $N_2$ .

In Part (b), candidates were asked to explain what occurs at the anode and cathode in the electrolysis of brine and to write an ionic equation for the reaction at the anode. They were also required to suggest why brine was used instead of dilute sodium chloride for the industrial preparation of  $Cl_2$  and write an ionic equation that will justify their suggestion.

### Candidates' Performance

This question was very poorly done. Candidates seem to need adequate exposure to test gases in the laboratory. Less than 15 per cent of the candidates scored more than 8 out of 15.

### Expected/Common Incorrect Responses

#### Part (a)

Candidates were expected to recognize that  $\text{H}_2$  will react with the lighted splint giving a 'pop' whereas,  $\text{Cl}_2$  will bleach the litmus paper but  $\text{N}_2$  will not react with any of the two. Most candidates knew that  $\text{H}_2$  would react with the splint and that  $\text{Cl}_2$  will react with litmus but not many indicated that  $\text{H}_2$  will give a pop or that the paper would be bleached by the  $\text{Cl}_2$ . Very few candidates knew that  $\text{N}_2$  would not react with the splint or the litmus.

#### Part (b)

Many candidates appeared unfamiliar with the industrial preparation of  $\text{Cl}_2$ . While some candidates recognized that  $\text{Cl}^-$  ions would migrate to the anode, many referred to them as chlorine ions rather than chloride ions. Some candidates confused the reactions occurring at the anode and cathode. Some even wrote that the chemical symbol for brine was Br.

The equation proved difficult for most. One common error was the placement of the electrons in the equations, for example  $2\text{Cl}^- + 2\text{e}^- \rightarrow \text{Cl}_2(\text{g})$  was written instead of  $2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2(\text{g})$ .

In Part (iii), candidates were expected to recognize that with dilute NaCl the  $\text{OH}^-$  ions would be discharged in preference producing  $\text{O}_2$  at the anode instead of  $\text{Cl}_2$ . Very few candidates made this assertion. In response to the question why brine is used instead of NaCl, the following common misconceptions arose:

- With brine the reaction will go faster.
- Brine is a stronger/better/purer electrolyte.
- Since brine is more concentrated, more  $\text{Cl}_2$  will be produced than with dilute NaCl.

### Question 6

Syllabus References: C2: 5.3, 5.4, 5.6, 5.7, 5.8

This question was an optional question which related to Section C2 of the syllabus: The Chemistry of Some Materials Found in and Around the Home.

In Part (a), candidates were required to identify the chemical components of clay, suggest a possible source of 'glass' in fired clay and relate the use of clay in pottery for making items of different shapes to one of its properties.

In Part (b), candidates were asked to give an explanation for a mason advising his client to keep a freshly completed concrete floor moist.

In Part (c), candidates were asked to identify one example each of a plant and animal fibre that could be used to make fabric, state the chemical composition of plant and animal fibres and to suggest two chemical tests to distinguish between them.

### Candidates' Performance

Less than 15 per cent of the candidates attempted this option. The entire question was poorly done indicating a lack of preparedness for this topic. The majority of the candidates who attempted it scored less than 2 out of 15; no one scored more than 8 out of 15.

### Expected/Common Incorrect Responses

In Part (a), candidates were expected to know that the components of clay were silica and metal silicates. However, most confused chemical composition with the physical attributes such as particle size and water retention. Very few candidates were able to link the glassy look of clay to the melting of the sand or silica. Many of those who attempted this question referred to the practice of adding a chemical glaze. When asked to relate the use of clay in pottery for making items of different shapes to one of its properties, instead of using the term plasticity - its ability to be moulded - some candidates used terms such as flexibility or malleability. The majority seemed to confuse properties with uses and gave responses such as flower pots.

Candidates were not successful at earning marks in Part (b) of the question. It was expected that candidates would have mentioned that cement can harden in both water and air and that water is needed for crystal formation which continues long after the initial setting. Candidates however, concentrated on the process without using the composition of cement in these explanations. For example, one common **incorrect** answer was that the water filled the air spaces which, if left, would cause the cement to crack.

In Part (c), most candidates were able to give correctly an example of an animal fibre and a plant fibre. However, many did not know that the chemical composition of animal fibres was protein and plant fibre was cellulose. Candidates also did not demonstrate ample knowledge of chemical tests that could be used to distinguish between an animal fibre and a plant fibre. Some common **incorrect** and vague answers were:

- Iodine test for starch
- Use different chemicals on the fibres
- Heat or burn them
- Use DNA testing

### Question 7

Syllabus References: C 6.1, 6.3, 6.4, 6.7, 6.10; B2: 6.2

This question was also an optional question and related to Section C2 of the syllabus: The Chemistry of Some Materials Found in and Around the Home.

In Part (a), candidates were asked to name two elements essential for plant growth as well as to identify the deficiencies associated with the named elements.

In Part (b), candidates were presented with a diagram of an incomplete nitrogen cycle which they were asked to complete.

In Part (c), candidates were asked to suggest one way in which lime can cause nitrogen to be lost from the soil and to write a representative ionic equation.

In Part (d), candidates were asked to identify two advantages and a possible limitation of using hydroponics as an alternative method of growing crops.

### **Candidates' Performance**

This question was poorly done by the candidates who attempted it. More than 85 per cent of the candidates scored less than 7 out of 15 indicating a lack of preparedness for this option as well.

### **Expected/Common Incorrect Responses**

#### **Part (a)**

Most students were able to identify at least two elements that were essential for plant growth. However, there were a few candidates who incorrectly listed sunlight, carbon dioxide and water as elements. Identifying specific deficiencies presented the greatest challenges in this section; for the most part, candidates just noted poor plant growth.

#### **Part (b)**

It appeared as if many candidates were not familiar with the terms associated with the nitrogen cycle, for instance, in many cases instead of writing nitrogen fixation some wrote 'nitrifying' or 'nitronifying'. However, most candidates were able to identify correctly that nitric acid is converted into nitrates.

#### **Part (c)**

Some candidates believed that 'lime' referred to the citrus fruit containing ascorbic acid hence being acidic in nature rather than alkaline. Some candidates listed the effect that lime would change the overall pH of the soil and noted that it will kill the nitrogen-fixing bacteria in the soil.

Not many candidates identified that nitrogen is removed from soil in the form of ammonia as a result of the lime reacting with the ammonium ions in the soil. As a result, they were unable to write the associated ionic equation ( $\text{OH}^- + \text{NH}_4^+ \rightarrow \text{NH}_3 + \text{H}_2\text{O}$ ).

#### **Part (d)**

Most candidates were able to identify the advantages and at least one limitation associated with the use of hydroponics, although some thought that too much water would damage the plants. Some correct responses for the limitations are:

- It is expensive.
- There is a need for highly skilled employees.
- Precise measurements are needed for chemicals etc.

### Paper 03/2 – Alternative to SBA

Syllabus References: A 3.3, 3.4, 3.7 and B2: 7.1, 7.3

#### Question 1

In this question, candidates were required to determine the optimum mole ratio in which the hypochlorite ions react with thiosulphate ions in the presence of a base when the temperature produced from reacting different volumes of hypochlorite ions with thiosulphate ions was measured. The question carried 26 marks and the majority of the candidates scored more than 16 marks.

#### **Part (a)**

Candidates were required to:

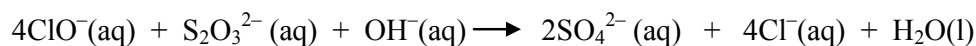
- complete a data table based on three sets of thermometer readings
- plot a graph of change in temperature against experiment number and determine the maximum change in temperature ( $\Delta T$ )
- calculate the number of moles of hypochlorite and thiosulphate ions when  $\Delta T$  is at its maximum and hence use the mole ratio to balance the equation for the reaction.

#### **Candidates' Performance**

Candidates did very well on completing the data table, plotting the graph, deducing the maximum change in temperature from the graph and determining the volume ratio of Solution 1: Solution 2 when  $\Delta T$  was at its maximum. However, a large number of candidates were unable to calculate the number of moles of  $\text{ClO}^-$  in Solution 1 and  $\text{S}_2\text{O}_3^{2-}$  in Solution 2. Many candidates used the total volume of solution provided instead of the volume ratio at the maximum temperature change to calculate the number of moles.

#### **Expected Response**

Candidates were expected to use 4:1 for the ratio of  $\text{ClO}^-$  in Solution 1:  $\text{S}_2\text{O}_3^{2-}$  in Solution 2. The correct balanced equation was



**Parts (b) and (c)**

Candidates were required to state two precautions to be taken during the reaction between hypochlorite ions and thiosulphate ions and one possible source of error.

**Candidates' Performance**

A number of students were unable to identify two precautions. Many used incorrect experimental procedures as precautions. Likewise, they were unable to state sources of error.

**Expected Response**

Experimental precautions should include any action that could cause danger or affect the quality of the data collected. Hence, possible precautions include avoiding contact between bleach and skin as bleach is corrosive and ensuring that the thermometer bulb is totally immersed in the solution when recording temperature.

**Common Incorrect Response**

Some common incorrect precautions included:

- Making sure that the measurements are correct.
- Not contaminating the solution.
- Always reading the burette below the meniscus.
- Working in an enclosed area.

Some common incorrect sources of error were:

- Taking the wrong measurement.
- Losing some of the liquid.

Question 2**General Comments**

This was the qualitative analysis question and tested Syllabus Objectives B7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when an unknown solid Y was subjected to a series of tests.

**Candidates' Performance**

Overall, the question was not well done. The average score for this question was 22 per cent. Many candidates seemed to be unfamiliar with the reactions and were unable to deduce the observations that matched the inferences recorded. Many terms such as residue, precipitate, solution and filtrate were incorrectly used.

**Expected Response**

Candidates were expected to record the presence of a white precipitate, soluble in excess sodium and ammonium hydroxide for Tests (a) (i) and (iii) respectively, while there should be no visible change for Test (a) (ii). Test (b) which confirmed the presence of chloride ions should first yield a colourless filtrate for Part (i) and a white precipitate soluble in aqueous ammonia for Part (ii).

**Common Incorrect Response**

Many candidates recorded coloured precipitates indicative of the presence of iron and copper ions.

**Question 3**

This question tested the planning and design skill. Candidates were required to plan and design an experiment to determine whether tap water could be made harder by adding various metal nitrates. Most of the candidates who attempted this question scored less than 5 marks. It appeared that candidates did not understand the concept 'hard water'. Many candidates tested the effect of the ions on water hardness by adding them all to the same volume of water instead of to separate quantities of water. Some also thought that it was the nitrate ion rather than the cations that made the water hard.

**Candidates' Performance**

Most candidates were able to obtain at least one mark for stating the apparatus needed which was dependent on the method that they selected. Candidates lost marks if they failed to include essential apparatus based on their method.

Many candidates did not include a control in their plan. This was important given the stated hypothesis. Candidates were able to gain marks for stating the variables to be controlled but most did not give the specific data to be collected to test the hypothesis.

In the discussion of the results, candidates lost marks for not discussing how the data to be collected would be used to evaluate the hypothesis.

**Expected Response**

A response for the method and the discussion of results which was awarded full marks is given here.

**Procedure**

- Fill each of six boiling tubes with 5 cm<sup>3</sup> of water.
- To one boiling tube, place a block of soap and shake for five seconds. Measure the height of the lather formed and record that value.

- To the other five boiling tubes, add one of the nitrates to each (in equal volumes) and a block of soap.
- Cover each one with a rubber bung, shake each for five seconds and record the height of the lather produced.

**Variables to be Controlled**

- The temperature (should remain at room temperature)
- The size of the block of soap
- The volume of water and nitrates used

**Discussion of Results as they Relate to Hypothesis**

When the heights of the lather in the boiling tubes with the nitrates are compared with that in plain water, if more lather is produced, the water got softer. If less lather is produced, the water gets harder. If the same amount of lather is produced, the water did not get harder or softer.



**CARIBBEAN EXAMINATIONS COUNCIL  
HEADQUARTERS**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION**

**MAY/JUNE 2010**

**CHEMISTRY  
GENERAL PROFICIENCY**

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## GENERAL COMMENTS

This year marked the first sitting of the CSEC Chemistry examination with the new format for Paper 02. Paper 02 now has six compulsory questions instead of five (Question 1 – Question 5) and one optional question (Question 6 or Question 7). Questions 1 - 3 were structured items and 4 - 6 were extended essays. Question 6 was based on Section C of the syllabus – Chemistry Involved in Cooking. There was no change to Paper 01.

Several candidates did very well on the examination scoring full marks on several of the questions. However, while it is clear that a relatively small number of candidates have done fairly well on this examination, it is also clear that too many continue to perform way below the required standard. In many instances, questions that require straight recall of definitions proved to be difficult for students as responses were vague or inaccurate. Much of the inaccuracy arose from the confusion of terms which sound alike or have things in common. This suggests that enough care is not given to differentiating and clarifying concepts as candidates prepare for these examinations. Some topics such as writing and balancing equations, organic chemistry, and solving mole-related problems continue to pose significant challenges for several candidates.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance on this paper continues to be steady and satisfactory. The marks ranged from 0 - 60.

The mean score was 57.5 per cent and the standard deviation was 11.14.

The candidates experienced the most challenge with the item based on the following objective:

- A. 6.26 – the approximate value of the Faraday constant.

The best performances were on:

- A 1.2 – the differences between the three states of matter in terms of energy and management of particles.
- A 2.8 – the classification of elements in the periodic table based on atomic numbers, atomic structure and oxidation state.

### Paper 02 – Structured Essay

#### Question 1

Syllabus References: A: 3.4, 7.2, 7.3, 7.4, 8.2; B2: 7.1, 7.2, 7.3

#### **Part (a)**

In this part of the question, candidates were required to (i) identify the labels on an energy profile diagram which showed a catalyzed and an uncatalyzed pathway of an exothermic reaction, (ii) plot a graph of the volume of oxygen (at RTP) against time using the given data for the decomposition of hydrogen peroxide, (iii) write a balanced equation to show the catalytic decomposition of hydrogen peroxide, (iv) compare the candidate's graph with one that was already plotted, and account for the differences between the two (v) read the volume of oxygen at a given time, and calculate the number of moles of oxygen in the volume, making use of the molar volume at RTP.

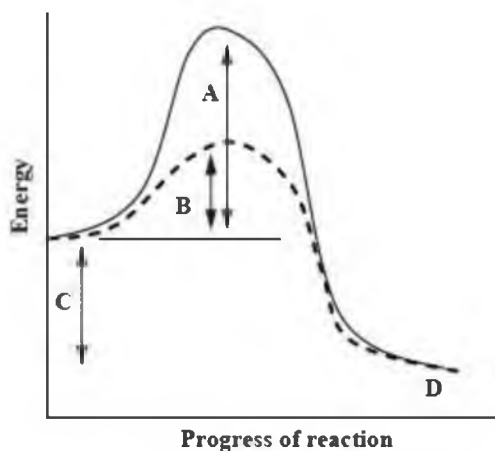
### Candidates' Performance

Many candidates identified the 'product' on the figure of the reaction profile, but did not distinguish between the activation energy of the catalyzed and uncatalyzed pathways, and did not identify the difference between the energy of the reactant and the product as the 'enthalpy change' of the reaction. Some candidates wrote 'enthalpy' instead of 'enthalpy change'. Many candidates gave the correct equation for the catalytic decomposition of hydrogen peroxide going to water and oxygen gas, but some incorrectly had the manganese dioxide taking part in the reaction and undergoing a chemical change. Most candidates scored the maximum 3 XS marks for correctly plotting the six points on the graph. The majority of the candidates correctly indicated that Jonathan's experiment produced more oxygen, and at a faster rate, than Karen's experiment. However, most did not link the higher rate of production of oxygen gas to the higher concentration of hydrogen peroxide used in Jonathan's experiment. The vast majority of candidates correctly read the volume of oxygen at 45 seconds in Karen's experiment as 8 cm<sup>3</sup>.

### Part (a) (i)

#### Expected Responses

The correct labels for the energy profile diagram are listed below the diagram.

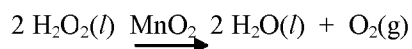


- A: Uncatalyzed activation energy
- B: Catalyzed activation energy
- C: Enthalpy change
- D: Products

### Part (a) (ii)

#### Expected Responses

The balanced equation for the catalytic decomposition of hydrogen peroxide, using manganese dioxide, MnO<sub>2</sub>, as catalyst is:



A catalyst, in this case manganese dioxide, remains chemically unchanged at the end of a reaction. The formula of the catalyst should be written over the arrow to recognize its presence during the reaction.

### Part (a) (iii)

#### Candidates' Performance

Common errors in plotting points on the graph included:

- Plotting the points in ink
- Using a pencil with a blunt point
- Not encircling or intersecting points clearly

### Part (iv)

#### Candidates' Performance

This part of the question proved to be the most challenging for the candidates. A large number of candidates were not able to interpret the difference between the slopes of the TWO plots, and did not relate the increased slope in Jonathan's plot to the increase in concentration of hydrogen peroxide.

#### Common Incorrect Responses

Many candidates referred to an increase in the "amount" instead of an increase in the "concentration" of hydrogen peroxide, and did not link the increase in rate of reaction to the increase in the number of collisions between reactant molecules. Some of the incorrect responses included:

- Jonathan's experiment was performed with a catalyst and Karen's experiment was not.

#### Expected Responses

The slope of Jonathan's graph is steeper (greater) than Karen's, or, Jonathan's reaction is faster than Karen's. More oxygen is produced for Jonathan's reaction. The faster rate of reaction in Jonathan's experiment is due to the increased concentration of hydrogen peroxide.

### Part (a) (v) (b)

#### Candidates' Performance

Many candidates did not recognize that the question was making reference to the volume of oxygen ( $8 \text{ cm}^3$ ) that was read from Karen's graph, while a number of candidates had difficulty converting from  $\text{cm}^3$  to  $\text{dm}^3$  or *vice versa*. TWO common errors, when calculating the number of moles of oxygen, was using the relative atomic mass (R.A.M) of oxygen and/or using the concentration of the  $0.04 \text{ mol dm}^{-3}$ .

#### Expected Responses

The correct volume of oxygen gas from the graph is  $8 \text{ cm}^3$ , and the molar volume of a gas at RTP was given as  $24 \text{ dm}^3$ . The correct calculation of the number of moles of oxygen, requires either the conversion of the volume of oxygen to  $\text{dm}^3$ , or the molar volume to  $\text{cm}^3$ .

$$1000 \text{ cm}^3 = 1 \text{ dm}^3$$

Therefore,  $1 \text{ cm}^3 = (1/1000) = 0.001 \text{ dm}^3$

Therefore,  $8 \text{ cm}^3 = 8 \times (1/1000) \text{ dm}^3 = 8 \times 0.001 = 0.008 \text{ dm}^3$

Since,  $24 \text{ dm}^3$  contain 1 mole of oxygen gas at RTP

Then,  $1 \text{ dm}^3$  would contain  $(1/24)$  moles of oxygen

Therefore,  $0.008 \text{ dm}^3$  would contain  $0.008 \times (1/24)$  moles =  $0.00033$  moles =  $3.3 \times 10^{-4}$  moles

## Part (b)

Candidates were tested on qualitative analysis in this part of the question.

### Candidates' Performance

This part was very poorly done, and probably reflects the under-preparation of the candidates, or the candidates' unfamiliarity with the required range of tests in qualitative analysis.

TEST 1: The majority of candidates did not identify the brown gas as nitrogen dioxide. The given observation was "brown gas which turns moist blue litmus red".

### Common Incorrect Responses

- $\text{NO}_2^-$  ions, NO ions
- Bromine gas
- Nitrogen gas

### Expected Responses

The award of the 1 UK mark required one correct inference which could be one of the following:

- Acidic gas
- Nitrate ( $\text{NO}_3^-$ ) present
- Nitrogen dioxide gas,  $\text{NO}_2(\text{g})$

TEST 2: The majority of candidates were not able to recognize that a precipitate of silver iodide would be formed by the addition of a solution containing silver ions to a solution that contains iodide ions. The given test "acidified silver nitrate is added to a solution of X, and aqueous ammonia is added until in excess".

### Common Incorrect Responses

- White precipitate, insoluble in excess
- White precipitate, soluble in excess

### Expected Responses

The award of the 2 XS marks required candidates to state that the observation would be "a yellow precipitate, insoluble in excess aqueous ammonia".

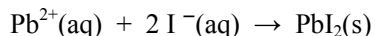
TEST 3: The test and observation were "aqueous lead nitrate is added to a solution of X" and "a bright yellow precipitate forms", respectively. An ionic equation was required for the 2 UK marks. Many candidates wrote some compound with both lead and iodide present but very few candidates had the correct, balanced, ionic equation.

### Common Incorrect Responses

- $\text{Pb}^+ + \text{I} \rightarrow \text{PbI}$
- $\text{Pb}^{2+} + \text{I} \rightarrow \text{PbI}_2$

### Expected Responses

The correct balanced equation is:



### Part (c)

This part tested the candidates' ability to plan and design an experiment to compare the effects of the catalysts, manganese (IV) oxide and catalase, on the rate of decomposition of hydrogen peroxide. Candidates were required to draw a clearly labelled diagram of a suitable experimental arrangement and state two variables that should be controlled during the experiment.

#### Candidates' Performance

In general, diagrams were poorly drawn, which could be due to insufficient practice at drawing pieces of chemical apparatus and a 'set-up'. There was a general lack of an appreciation of metal oxides as being solids. The majority of candidates did not include catalase in the experimental set-up. Many candidates gave precautions or named responding variables, instead of the TWO variables to be controlled.

#### Common Incorrect Responses

Manganese (IV) oxide was represented as a liquid or a solution, which was being added from a burette or a pipette, into a solution of hydrogen peroxide.

#### Expected Responses

Suitable diagrams should allow for the generation and measurement of the volume of oxygen gas. The effect of the two different catalysts could be compared if

- (i) the time is noted for a fixed volume of oxygen to be collected, and the shorter time would reflect the faster rate and hence the more effective catalyst, or
- (ii) the volume of oxygen collected in a given time is noted, and the larger volume would reflect the more effective catalyst.

In both cases, the controlled variables would be temperature, concentration of hydrogen peroxide, volume of hydrogen peroxide. In (i) volume would be controlled, and in (ii) time would be controlled.

N.B. Both volume and time cannot be controlled simultaneously.

### Question 2

Syllabus References: A: 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 4.1, 4.2, 4.3; B2: 4.1)

This question tested candidates' understanding of periodicity, reactions of metals, isotopes and radioisotopes, radioactivity and chemical bonding. All candidates attempted this question. The mode was 6 and the mean score was 5.5 out of 15, with 32 per cent of the candidates scoring 8 or more.

#### Part (a) (i)

#### Candidates' Performance

In this part, two incorrect statements were given and candidates were required to give the corrected version with reason(s). Most candidates were able to give the answer in terms of electronic configuration (EC) of the elements. However, some categorized the elements into two separate groups such as metals and non-metals. Some wrote the incorrect EC for the elements or omitted the EC of some and so could not be awarded the mark. It was noticed that many candidates used the incorrect terms, for example, 'atoms' or 'elements' in place of 'electrons' in the outer shell.

### Expected Responses

Correct statement: The elements sodium to chlorine are in the same period of the periodic table, **OR**, the elements sodium to chlorine are not in the same group of the periodic table.

Reason: Elements in the same period have the same number of occupied energy levels (shells), **OR**, they have different numbers of electrons in their outer shells.

### Part (a) (ii)

#### Candidates' Performance

This part was poorly done. Many candidates wrote that Mg was lower than Cu in the reactivity series or that copper was more reactive than Mg. Many did not state that metals were reducing agents and so answered in terms of which metal was a better oxidizing agent. Mg was compared to Zn instead of Mg to Cu as required. Very few candidates spoke of the electropositivity of Mg. Many also conceived the reactivity series to be the same as the periodic table.

#### Common Incorrect Responses

Most candidates simply changed around the names of the metals and gave this **incorrect** response:

- Of the elements magnesium and copper, copper will more readily **oxidize** an aqueous solution of zinc ions than magnesium would.

### Expected Responses

Correct statement: Of the elements magnesium and copper, magnesium will more readily **reduce** an aqueous solution of zinc ions than copper.

Reason: Magnesium and copper are metals or reducing agents. Magnesium, being more electropositive, is the stronger reducing agent.

### Part (b) (i)

#### Candidates' Performance

Candidates should be encouraged to read the questions carefully as this question specifically stated that the products of the reaction were a hydroxide and hydrogen gas, yet many wrote the products to be the oxide and hydrogen. Some displayed a lack of understanding of when to use atoms or ions although they were told to write a chemical equation and not an ionic equation. Some wrote the hydrogen molecule as H and some did not balance the equation. State symbols were often missing.

#### Common Incorrect Response

- $P + H_2O \rightarrow POH + H$

### Expected Response

The correct equation for the reaction of the group one element P is

- $2P(s) + H_2O(l) \rightarrow 2POH(aq) + H_2(g)$

### **Part (b) (ii)**

#### **Candidates' Performance**

Many candidates did not notice that P and Q were isotopes. Instead they spoke of P and Q as being metals in the same group, even though the question stated that P and Q had the same electronic configuration (2, 8, 1). Some candidates spoke of P and Q as having the same valence shell, which is simply another way of saying they are in the same group. Many candidates failed to make the connection between isotopes having the same chemical properties and so would have the same products in their reaction with water. Some used the words 'allotropes', 'isomers' or 'isotropes' instead of isotopes.

#### **Expected Responses**

P and Q are isotopes. Isotopes have the same chemical properties.

### **Part (b) (iii)**

#### **Candidates' Performance**

Many candidates simply stated that 'radioactive' meant 'unstable nuclei' not adding that these must split to emit  $\alpha$ ,  $\beta$  or  $\gamma$  radiation. Some stated that radioactive meant reactive or unstable which is an inadequate answer.

#### **Expected Response**

Radioactive substances spontaneously emit small particles in order to become stable.

### **Part (b) (iv)**

#### **Candidates' Performance**

A wide range of responses was given and most candidates were able to correctly state two uses of radioactive materials. The most popular responses included cancer treatment, tracers, blood flow and photosynthesis research.

#### **Common Incorrect Responses**

- Used in the sterilization of food
- Used for x-rays
- Used in photocopying machines
- Used in fertilizers

### **Part (c)**

#### **Candidates' Performance**

Many candidates seemed to confuse 'ionic bonding' and 'covalent bonding'. Some candidates drew two diagrams depicting both ionic and covalent bonding. Some candidates started off with a diagram that correctly depicted the electron transfer then incorrectly showed sharing of electrons in the product. Many candidates drew the incorrect ion for Q. Others drew only one atom of Q, instead of two atoms of Q, donating one electron to the oxygen. Too many candidates incorrectly gave the electronic configuration of oxygen as 2,8,6 instead of 2,6. Many did not draw proper arrows depicting electron transfer and omitted the charges on the ions.



### Question 3

Syllabus References: B1: 1.3, 1.6, 1.7, 1.8, 1.9, 2.7,

This question was not well done. The mean mark was 4.4 out of 15 with 0, 1 and 2 being the most frequent scores. Only 21 per cent of the candidates scored 8 or more. This question tested candidates' ability to recall scientific definitions, make two-dimensional representation of organic molecules, and identify the conditions (or reagents) in THREE organic reactions of ethanol.

#### **Part (a) (i)**

Candidates were required to define 'structural isomerism'.

#### **Candidates' Performance**

This part was generally well done. While most candidates understood that it involved 'same structural formula' and 'different molecular formula', many were unable to state what possessed these characteristics, and cited 'elements', 'atoms' and 'substances' in the definition. Frequently, candidates equated 'similar' with 'same'.

#### **Expected Responses**

Compounds which have the same molecular formula, but have different arrangement of atoms are said to display 'structural isomerism'.

#### **Parts (a) (ii) and (iii)**

In Part (ii), candidates were required to draw fully displayed structures of but-1-ene and but-2-ene, two isomers of butene, and draw and name one other structural isomer of  $C_4H_8$  in Part (iii).

#### **Candidates' Performance**

While some candidates were able to draw the correct structures, this presented a challenge to most candidates. Some candidates did not associate the prefix in **but**-1-ene with FOUR carbon atoms, and **incorrectly** drew structures with three or five carbons. Many of the incorrectly drawn structures had carbon atoms with five bonds instead of four bonds.

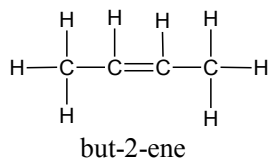
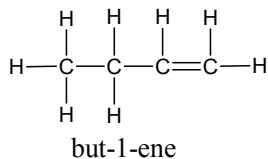
#### **Common Incorrect Responses**

A common **incorrect** name for the other structural isomer of  $C_4H_8$  was **but-3-ene**, where candidates changed the backbone of the molecule from  $C=C-C-C$  to  $C-C-C=C$ , not realizing that it resulted in the same molecular structure of but-1-ene.

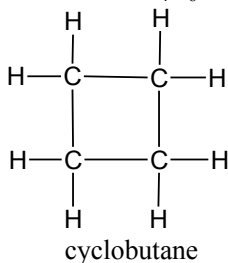
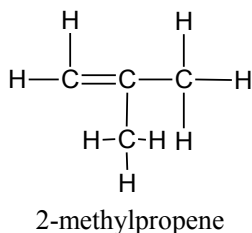
Some of the candidates, who were able to draw the correct structure of the other structural isomer, 2-methylpropene, gave **incorrect** names which included:

- methylpropane
- methylbutane
- 1-methylpropene

### Expected Responses



There are TWO other possible structural isomers of  $\text{C}_4\text{H}_8$ :



### Part (a) (iv)

#### Candidates' Performance

This part was generally well done, but some candidates confused 'chemical property' with 'physical property'.

#### Common Incorrect Responses

- Burns with a sooty flame
- Liquid at room temperature
- High melting point, high boiling point
- Unsaturated
- Has double bonds

### Expected Responses

Any one of the following physical properties was awarded the 1 KC mark – colourless gas, odourless gas, gas at room temperature, low melting point, low boiling point, soluble in non-polar solvents.

### Part (b) (i)

Candidates were required to state what is meant by a 'functional group'.

#### Candidates' Performance

Many candidates were able to give a correct statement. However, the word 'group' caused some candidates to give responses which related to groups of the periodic table, and homologous groups.

#### Common Incorrect Responses

- Members of the same homologous series
- Functional group is alkanes, alkenes etc

### Expected Responses

A 'functional group' is an atom or group of atoms in an organic compound whose reactions determine its overall chemical properties.

### Part (b) (ii)

Candidates were required to give (a) the reagents and conditions, and (b) the fully displayed structures of the product for reactions of the conversion of ethanol to ethene, ethanoic acid and an ethyl ester.

#### Students' Performance

This part of the question was poorly done. In Section (a), many candidates had the correct reagents and conditions (conc.  $\text{H}_2\text{SO}_4$ ,  $170\text{ }^\circ\text{C}$ ; or conc.  $\text{H}_3\text{PO}_4$ ) for the dehydration of ethanol to form ethene, and the majority of candidates gained the mark for the structure of ethane.

The oxidation of ethanol to ethanoic acid, posed a challenge for most candidates. Some candidates, recognized that this was an oxidation reaction, and simply wrote '[O]' instead of acidified potassium permanganate (VII) or acidified potassium dichromate (VI).

The conversion of ethanol to an ethyl ester was also challenging for the majority of the candidates. Some candidates had one of the reagents (conc.  $\text{H}_2\text{SO}_4$ ) but did not have a carboxylic acid. In most cases, the partially displayed structure was written.

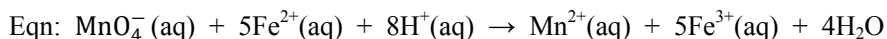
#### Question 4

Syllabus References: A: 6.8, 6.13, 6.14, 6.15, 6.16; B1: 3.4

This question tested candidates' understanding of redox (reduction-oxidation) reactions and the fermentation process.

### Part (a) (i)

Candidates were required to identify both the reducing and oxidizing agents in a given equation, and explain their choices.



#### Candidates' Performance

While many candidates were able to describe what happens during reduction and oxidation, some were unable to identify correctly the reducing and oxidizing agents.

#### Common Incorrect Responses

- $\text{MnO}_4^-$  was the reducing/oxidizing agent because there was an increase from a negative charge to a positive charge ( $\text{Mn}^{2+}$ ).
- $\text{Fe}^{2+}$  was a metal and hence was a reducing agent.
- $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$ : The increase in oxidation number resulted from electron gain.
- $\text{Fe}^{2+}$  was a reducing agent or an oxidizing agent.
- $\text{H}^+$  was the oxidizing/reducing agent.

#### Expected Responses

$\text{Fe}^{2+} (\text{aq})$  is the reducing agent – The oxidation number on Fe increases from 2+ to 3+. It undergoes electron loss.

$\text{MnO}_4^- (\text{aq})$  is the oxidizing agent – The oxidation number on Mn decreases from 7+ to 2+. It undergoes electron gain.

### Parts (a) (ii) and (iii)

Candidates were required to write a balanced equation for the reaction of iron (II) oxide with dilute sulphuric acid, state whether the reaction was acid-base or redox, and explain their choice.

### Candidates' Performance

Many candidates were unable to write the correct formula for iron (II) oxide as FeO. Several, incorrectly, had hydrogen gas as a reaction product. Still, many candidates correctly stated that the reaction was acid-base, since an acid and a base reacted to produce a salt and water. Some candidates stated that since the reaction was not redox, then it was acid-base. They were awarded the marks.

### Common Incorrect Responses

Incorrect formulae for iron (II) oxide, such as Fe<sub>2</sub>O, FeO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub> and IO, were given instead of FeO. The lack of understanding of redox chemistry, contributed to candidates calculating wrong oxidation states and so incorrectly inferred that the reaction was redox.

### Expected Responses

Correct equation:  $\text{FeO(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{FeSO}_4\text{(aq)} + \text{H}_2\text{O}$

The reaction is acid-base. A basic oxide (base) and an acid reacted to produce salt and water.

### Parts (b) (i), (ii) and (iii)

Candidates were required to state what was meant by 'fermentation' as it relates to the manufacture of rum, write an equation for the fermentation process, and give with reason, one material that could be used to produce wine by fermentation.

### Candidates' Performance

The majority of candidates indicated that the anaerobic respiration of yeast was essential, and that the products were ethanol and carbon dioxide. However, many candidates did not mention the importance of sugars as the starting material, and they were penalized for this omission.

The equation for fermentation, reflected unfamiliarity with the formulae of glucose and ethanol, and sometimes water was incorrectly included as either reactant or product. Several candidates had the correct reactants and products, but the equation was unbalanced.

The majority of candidates gave a correct material, usually a fruit source, for wine making although many did not indicate that the sugar content was the important factor for fermentation.

### Common Incorrect Responses

Most of the incorrect responses for a material for making wine included the use of a flavouring agent (for example, pimento, and hibiscus) instead of a fruit source with high sugar content.

### Expected Responses

Fermentation is the conversion of sugars (in molasses) into smaller molecules like ethanol and carbon dioxide, by the anaerobic respiration of yeast.

Equation:  $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2 \text{C}_2\text{H}_5\text{OH} + 2 \text{CO}_2$  (An enzyme is placed over the arrow)

Any suitable fruit source that has reasonably high sugar content, for example, bananas, grapes, cherries may be used.

### Question 5

Syllabus References: B2: 2.2, 5.1, 5.2, 8.1

The question tested candidates' knowledge of the extraction of iron from its ore using a blast furnace, the uses of iron and its alloys and the function and importance of iron in blood. Ninety-five per cent of the candidates attempted this question. The mean mark obtained for this question was 5.2 (out of 15).

#### **Part (a)**

##### **Candidates' Performance**

Approximately 60 per cent of the candidates were unable to give a correct formula for the iron ore –  $\text{Fe}_2\text{O}_3$ . Many candidates knew the name of the ore but were unable to write its formula.

##### **Common Incorrect Responses**

$\text{FeO}$ ,  $\text{Fe}_3\text{O}_2$  and  $\text{FeO}_2$

##### **Expected Responses**

Hematite,  $\text{Fe}_2\text{O}_3$ ; magnetite,  $\text{Fe}_3\text{O}_4$ ; siderite,  $\text{FeCO}_3$  or  $\text{Fe}_2\text{S}_3$  (1 KC mark)

#### **Part (b)**

##### **Candidates' Performance**

Most candidates who attempted this question, omitted Part (b) and many of those who described the process did not give the correct balanced equations. In addition, many candidates erroneously wrote carbon dioxide reacting *with oxygen* (instead of carbon) to give carbon monoxide. Some of the better responses included the formation of slag (but were not awarded any marks). Some candidates used the process of electrolysis for the extraction of iron from its ore but only a few explained the process properly. Consequently, they gained very little marks because they failed to state the types of electrodes used as well as the correct electrolyte. The relevant equation(s) for this process proved to be challenging for the candidates.

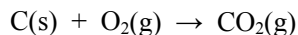
##### **Common Incorrect Responses**

- Carbon dioxide reacts with oxygen to give carbon monoxide.

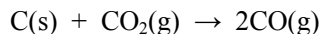
### Expected Responses

The three steps are:

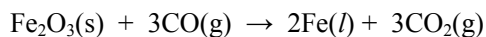
- Coke is burned in air to produce carbon dioxide.



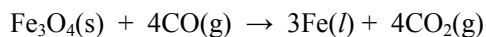
- Carbon dioxide is reduced by coke to form more carbon monoxide.



- Carbon monoxide reduces the iron ore, forming iron and carbon dioxide.



Or



### Part (c)

#### Candidates' performance

Most candidates gained at least one KC mark for stating that iron rusts. However, some candidates confused the terms “corrosive” and “corrosion”.

#### Common Incorrect Responses

A few candidates incorrectly noted that stainless steel is a better conductor of heat than iron (a common misconception), and that it is not as easily stained as the name suggested.

### Expected Responses

Stainless steel

- is more rust resistant
- is stronger
- is more attractive
- reduces the transfer of iron to our bodies.

### Part (d)

Nearly all the candidates who attempted this question gave a correct use of iron and were awarded the allotted 1KC mark.

### Part (e)

The majority of candidates who attempted this question gained the 1 mark for correctly stating the name of the iron compound found in the blood, but spelling of the word **haemoglobin** was challenging for many. While some candidates received the 2 marks for correctly stating the effect of a lack of iron in the blood, most obtained at least 1 mark.

### **Expected Responses**

The lack of iron may cause:

- Less oxygen to be transported
- Tiredness or fatigue
- Anaemia

### Question 6

Syllabus References: C1: 1.1, 1.2, 1.5, 1.6, 1.7, 1.9

This question tested candidates' knowledge of the chemistry of cooking, more specifically, the effect of heat on egg whites, the tenderizing of meat by enzymes and the pressure cooker, and the effect of heat on vitamin C. Ninety-six per cent of the candidates attempted this question. The modal score for this question was 8, and a mean score of 8.4, out of a maximum 15 marks. Sixty per cent of the candidates had a score of 8 or higher.

### **Part (a)**

#### **Candidates' Performance**

The majority of candidates were able to give two reasons for cooking food before consumption.

#### **Expected Responses**

- Destroys harmful organisms
- Improves digestibility
- Improves appearance
- Improves flavour

### **Part (b) (i)**

#### **Candidates' Performance**

The majority of candidates were able to describe the changes that occurred when egg white is heated.

#### **Common Incorrect Responses**

Some candidates described the whole, cooked egg as a yellow ball surrounded by a white layer, instead of describing the whites. This type of response was awarded no credit. Other incorrect responses described the cooked egg white as:

- Cloudy
- Milky
- Gel-like
- Plastic-like

#### **Expected Responses**

Egg white changes from clear to an opaque, white solid.

**Part (b) (ii)**

**Candidates' Performance**

Many candidates were able to state correctly that heat caused egg white to undergo denaturation or coagulation or loss of solubility.

**Common Incorrect Responses**

- Heat destroyed the protein.
- Heat killed the protein.

**Part (c) (i)**

**Candidates' Performance**

Most candidates were able to infer correctly that cooking meat would take longer if neither the pineapple nor a pressure cooker were used.

**Part (c) (ii)**

**Candidates' Performance**

Most candidates were unable to explain the principles involved in the functioning of the pressure cooker. Some candidates did not understand the meaning of 'principles' and gave instructions on how to use a pressure cooker.

**Common Incorrect Responses**

- Air (gas) is prevented from escaping.
- The seal prevents the escape of pressure.
- Heating the closed container creates a pressure.
- There is an increase in atmospheric pressure.
- The heat is locked in.
- There is a build-up of heat.
- The steam passes through the meat.

**Expected Responses**

The **steam** is trapped and prevented from escaping. This causes an **increase** in pressure inside the pressure cooker, which causes an increase in boiling point of the water, which allows the food to be cooked in a shorter time.

**Part (c) (iii)**

**Candidates' Performance**

Most candidates were able to state TWO benefits of using a pressure cooker. These include, reducing cooking time, saving energy, and tenderizing foods faster.

**Part (c) (iv)**

**Candidates' Performance**

Candidates performed poorly on this part of the question. Only a small number of candidates correctly identified the enzyme in pineapple as bromelin. Fewer still were able to correctly explain that this enzyme



hydrolyses the amide bonds in protein – stating instead that ‘*it increased the rate of the reaction*’ or ‘*it loosens the bonds in collagen*’. Very few candidates were able to correctly state that, in a pressure cooker, the heat causes the insoluble collagen in the connective tissue to be converted into soluble gelatin thereby softening the texture of the meat. The responses which suggest that the use of the pineapple is a chemical reaction while the use of the pressure cooker is a physical or mechanical reaction received no credit.

### **Common Incorrect Responses**

- Pineapple adds flavour.
- The enzyme *bromelin* was incorrectly referred to as *papain*, *pepsin*, *pectin*, *bromine*.

### **Expected Responses**

Enzymes in the pineapple break the longer meat fibres into smaller ones, making the fibre more soluble. Pressure cookers tenderize meat by converting the insoluble collagen in the meat to soluble gelatine.

### **Part (c) (v)**

#### **Students’ Performance**

Most candidates were able to obtain one mark for stating that heat causes the oxidation or decomposition or destruction of vitamin C. Very few candidates were able to obtain the second mark for stating that the rate of oxidation or destruction of vitamin C increased with increasing temperature.

### **Common Incorrect Responses**

Heat kills vitamin C.

## **Paper 03/1 - School-based Assessment (SBA)**

### **GENERAL COMMENTS**

There were some centres which showed improvement in many areas. However, there were still a few centres which presented significant problems for moderation. The main problems were:

1. Inadequate marking schemes were submitted.
2. Laboratory exercises tested objectives from other disciplines such as Biology and Integrated Science. This occurred in the assessment of the PD skill.
3. AI skills were assessed as ORR skills and ORR skills as AI.
4. The marking of laboratory notebooks was incomplete.
5. One activity was assessed for more than 2 skills.
6. The mark schemes were not synchronized with all the laboratory notebooks from a centre, especially in centres where there is more than one teacher. Teachers are encouraged to collaborate and use common mark schemes.

### **Mark Schemes**

There were a few schools with very good and detailed mark schemes, but more than 50 per cent of those submitted were inappropriate for at least one of the skills moderated.

### Planning and Design Skills

Of the centres assessed for this skill, 64 per cent of them were good or very good, while 36 per cent were unsatisfactory.

### Analysis & Interpretation Skills

Of the centres assessed for this skill, 81 per cent of them were good or very good, while 19 per cent were unsatisfactory.

### Use of Equations

Of the centres assessed, 78 per cent presented samples where equations were used satisfactorily.

### Emphasis on Graph Work

Of the centres assessed, 72 per cent placed satisfactory emphasis on the use of graphs, that is, at least three or more graphs were used over the two years.

### Standard of Practical

Of the centres assessed, 100 per cent of the presented samples were of a satisfactory standard. However, teachers are still having difficulty assessing PD according to CXC standard.

### Reminders

1. CXC does not award  $\frac{1}{2}$  marks.
2. A minimum of 2 laboratory assignments should be assessed for each skill per year.
3. All laboratory assignments should be numbered, dated and listed in the Table of Content.
4. All laboratory assignments, whether being assessed for SBA or not, should be corrected so that students can benefit from the corrections.
5. Skills assessed for various laboratory assignments in the students' books should match those highlighted in the mark schemes.
6. Mark schemes should be explicit and unambiguous, that is, marks should not be lumped, but each should be assigned to a specific content area.
7. In qualitative analysis, the mark schemes should include the names of the unknowns as well as the expected observations and inferences.

## **Paper 03/2 - Alternative to SBA**

### Question 1

The highest mark awarded for this question was 17 out of a maximum of 23.

The marks awarded for experimental skills were higher than those testing the use of knowledge.

For the experimental skills, only one candidate earned the full four marks for Part (a).

The candidates did not seem to fully understand the question, and the relative atomic masses given were frequently used in the calculation of the mass of the salt required.

In completing Table 1, most candidates recorded the correct burette readings. A few added the initial and final burette readings to obtain the volume of Solution X used. Many of them used the volume of Solution Y (25 cm<sup>3</sup>) stated in the question as their calculated volume of Solution X.

For use of knowledge, Part (iii) (b) produced the best answer, while one candidate answered Part (f) correctly.

### Question 2

This question was very poorly done. The majority of the candidates appeared not to have been exposed to basic chemical tests. This was reflected in the marks which varied from zero to three. It was also evident that some candidates had difficulty differentiating between observations and inferences.

In Question 2 (a) (iii), only one candidate was awarded the full two marks for stating that barium sulphate was formed. In cases where candidates inferred that a carbonate, sulphate or sulphate could have been formed from the first test and the sulphate compound was confirmed in the second test, they were credited.

In Question 2 (b) (ii), many candidates did not attempt the ionic equation, and if they did, many of these equations were not balanced.

### Question 3

Overall, the performance on this question was poor. Many candidates did not include a combustion reaction in their design. Candidates placed the fuels in a water bath or simply heated them. They showed understanding that a temperature change is involved, but were describing procedures which seem quite impractical, such as measuring the temperature of the burning fuel or of burning wood soaked in the fuel.

Unsuitable procedures, or procedures not clearly described led to many incorrect answers in Parts (c) and (d).

Candidates seemed not to understand Part (e). This was reflected in the poor discussion which lacked reference to the results from the experiment as described.

Candidates had little difficulty providing the apparatus and materials needed for the procedure described.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION**

**JANUARY 2011**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The candidates' overall performance on this sitting of the examination was not markedly different from previous performances although there were differences in how the candidates responded to questions on some topics. There were some common areas on both Papers 1 and 2 that posed challenges for the candidates. In addition, there seemed to be several gaps in the candidates' understanding of concepts that led to poor answers.

### Some Areas of Concern

- **Weakness in discriminating among concepts**
  - Many candidates confused concepts that sound alike or have different meanings but are related in some way. These included pairs such as addition and condensation polymerization, basic and acidic; saturated and unsaturated groups such as ionic molecular and atomic. Many candidates also loosely referred to activation energy as energy level. Teachers can help students to overcome this hurdle by engaging in teaching for conceptual understanding. Time should be spent helping students to have deep and enduring understanding rather than simply calling to memory how the concepts are defined. Time should be spent helping students to connect ideas so as to help them discriminate better. Teachers should also encourage the correct use of terms during classroom conversation. Many candidates lost KC marks for careless or incorrect use of these terms.
  - Many candidates gave the wrong catalyst for the Contact process and gave instead other catalysts such as nickel and iron which are used in other industrial processes.
- **Unfamiliarity with concepts**
  - Candidates seemed unfamiliar with some concepts that are usually encountered in practical lessons. These include diffusion, sublimation and precipitation.
- **Difficulty thinking in hypothetical terms**
  - Many candidates are unable to think in terms of "a metal M with a valency of 2". They have to work in concrete terms, and often spend time trying to identify the metal M. This is not generally required in these cases and candidates are advised to use their examination time more wisely. Students seem to need additional practice in this level of thinking which will only take place if teachers provide these opportunities in routine classroom assessment.

In this regard, use should be made of past examination questions to provide students with ample practice.

- **Writing and balancing equations**
  - This skill seems to be on the decline once more. Far too many incorrectly written formulae were presented in the scripts.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. The performance on this paper continued to be steady and is comparable with the performance in 2010.

The mean score earned by candidates was 52 per cent with a standard deviation of 10.

### Paper 02 – Structured/Extended Response Questions

#### Question 1

Syllabus References: A: 3.3, 3.4, 3.7, 6.7, 6.8, 6.9, 6.10, 6.12

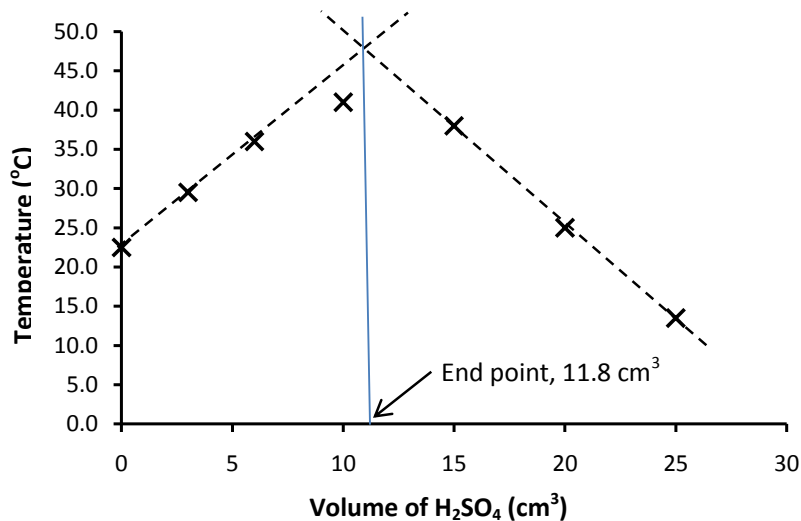
In Part (a), candidates were required to differentiate between a ‘strong acid’ and a ‘weak acid’; determine the end-point in an acid-base titration by the graphical interpolation method from temperature readings obtained when different volumes of dilute sulphuric acid were added to 25 cm<sup>3</sup> samples of 2 mol dm<sup>-3</sup> NaOH; write a balanced equation for the reaction; calculate the number of moles of NaOH used, and calculate the concentration of the sulphuric acid.

The average mark for this question was 8.5 out of 25. Most candidates correctly stated that a strong acid is completely ionized while a weak acid is only partially ionized. Many suggested that potassium hydroxide (a strong base) could be substituted for sodium hydroxide, while many gave incorrect suggestions such as magnesium hydroxide, aluminium hydroxide and calcium hydroxide. The majority of candidates gained the three marks for Experimental Skills (XS) for plotting all seven points correctly on the graph, but many had difficulty in drawing the ‘two lines of best fit’ through the ‘increasing’ and ‘decreasing’ points.

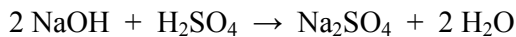
Candidates were required to draw the two lines of best fit through the points and determine, by interpolation, the end point of the acid base reaction. This was the most challenging part of this question and many candidates lost marks for drawing the lines of best fit. Some candidates did not draw the lines intersecting, suggesting that they were unfamiliar with this

procedure for determining end point. A number of candidates failed to balance the common equation between sodium hydroxide and sulphuric acid and so lost marks in this section. Many candidates also had difficulty doing the calculations in (vii) and (iii).

The expected responses for Part (a) are as follows:



Balanced Equation for the reaction:



Number of moles of NaOH used in the reaction:

1000 cm<sup>3</sup> of 2 mol dm<sup>-3</sup> NaOH contain 2 moles

Therefore, 1 cm<sup>3</sup> of 2 mol dm<sup>-3</sup> NaOH contains (2/1000) moles

Therefore, 25 cm<sup>3</sup> of 2 mol dm<sup>-3</sup> NaOH contain (2/1000) x 25 = 0.050 moles.

Calculation of the concentration of H<sub>2</sub>SO<sub>4</sub> in mol dm<sup>-3</sup>:

From the equation, 2 moles of NaOH require 1 mole of H<sub>2</sub>SO<sub>4</sub>

1 mole of NaOH requires (1/2) mole of H<sub>2</sub>SO<sub>4</sub>

0.050 moles of NaOH require (1/2) x 0.050 = 0.025 moles of H<sub>2</sub>SO<sub>4</sub>

These 0.025 moles of H<sub>2</sub>SO<sub>4</sub> are contained in the volume of acid at the end-point (11.8 cm<sup>3</sup>).

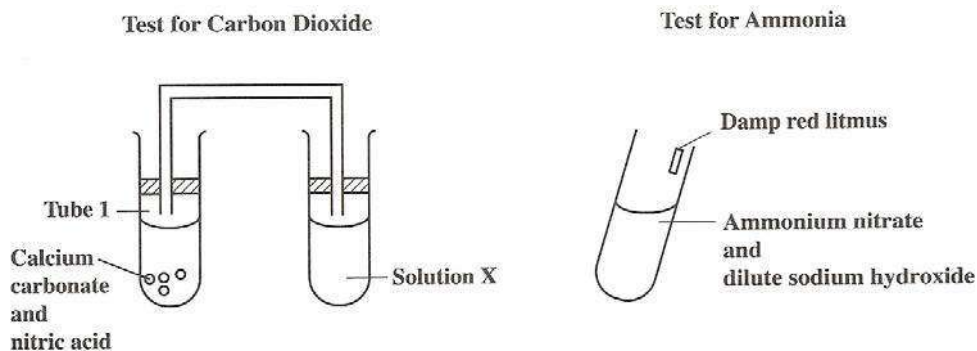
Therefore, 11.8 cm<sup>3</sup> of H<sub>2</sub>SO<sub>4</sub> contained 0.025 moles of H<sub>2</sub>SO<sub>4</sub>

1 cm<sup>3</sup> of H<sub>2</sub>SO<sub>4</sub> contained (0.025/11.8) moles of H<sub>2</sub>SO<sub>4</sub>

1000 cm<sup>3</sup> of H<sub>2</sub>SO<sub>4</sub> contained (0.025/11.8) x 1000 = 2.1 moles of H<sub>2</sub>SO<sub>4</sub>

Therefore, the concentration of H<sub>2</sub>SO<sub>4</sub> = 2.1 mol dm<sup>-3</sup>.

Part (b) tested candidates' knowledge of laboratory experiments used to identify two gases — carbon dioxide and ammonia — as shown in the following figure.



Candidates were required to (i) identify Solution X; (ii) identify ONE flaw in each set-up; (iii) write a balanced equation for the reaction occurring in Tube 1, and (iv) explain why nitric acid is used instead of sulphuric acid in Tube 1 to obtain a positive test result.

For Part (b) (i), the majority of candidates correctly identified Solution X as Lime Water,  $\text{Ca(OH)}_2(\text{aq})$ .

One striking **incorrect** response was 'calcium nitrate', which would have been the solution in the other test tube after the reaction was complete.

For Part (b) (ii), many candidates were able to identify two flaws in the set-up for both tests, stating correctly that the delivery tube should be inserted under the surface of Solution X so that the gas would bubble into the solution, and that heat should be applied to the test tube in the test for ammonia gas. Some candidates stated that the litmus paper should not be so 'deep' inside the test tube, so as to avoid splashing of the sodium hydroxide solution onto the litmus paper. Some candidates also stated that there should be a hole in the bung above Solution X so as to prevent pressure build-up and explosion of the test tube. These responses were awarded full marks.

For Part (b) (iii), many candidates recognized that the product of the reaction in Tube 1 was calcium nitrate, but had difficulty writing the formula for calcium nitrate or the correct balanced equation.

A number of candidates gave the incorrect formula of calcium nitrate as  $\text{Ca(NO}_3)$ . The expected response is  $\text{CaCO}_3(\text{s}) + 2 \text{HNO}_3(\text{aq}) \rightarrow \text{Ca(NO}_3)_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

Candidates were not penalized if the state symbols were omitted.

In Part (b) (iv), candidates' performance indicated that the majority of them were unaware that insoluble calcium sulphate would be formed in sulphuric acid. Some candidates stated that an insoluble salt would be formed but did not explain how the insoluble salt would affect the production of carbon dioxide. This is one example of the need for teachers to help students understand rather than recall a process.



If sulphuric acid is used, insoluble calcium sulphate would form around (on the surface of) the calcium carbonate granules, slowing down and eventually stopping the generation of carbon dioxide. Enough carbon dioxide would not be generated to produce a positive test result.

### Question 2

Syllabus Objectives A: 1.1, 1.2, 8.1, 8.2, 8.3

Part (a) tested knowledge of diffusion of solids in liquids and the effect of heat on the rate of diffusion of solids in liquids.

Candidates were required to state the colour of the potassium permanganate and to explain that after 24 hours the colour would spread throughout the water to make a homogeneous mixture. Beaker B, which was heated to 50 °C, would become purple before Beaker A as the higher temperature would increase the internal consistency of the particles causing them to diffuse faster.

Most candidates knew the colour of the potassium permanganate but many lost marks as they did not describe the changes that would take place in the beakers over time. Responses were somewhat superficial such as “the solution turned purple” with little appreciation shown for the fact that this was a gradual process and that it did not take place suddenly. While most candidates scored marks for correctly stating that the contents of Beaker B would become purple before the contents of Beaker A, many again lost marks for the superficial responses given for the reasons for the differences. A common example was “The heat causes the permanganate to dissolve faster”. Candidates were required to explain that the higher temperature resulted in internal energy of the particles and that it was as a result of the increased internal energy that the particles were able to diffuse faster in Beaker B.

Part (b) tested candidates’ knowledge of energy changes. Candidates were required to draw the energy profile diagram for the heat change when 8 grams of ammonium nitrate was dissolved in water and to calculate the heat of solution of ammonium nitrate.

The energy profile diagram expected for ammonium nitrate was that of an endothermic reaction. Candidates were required to use the formula  $Q = mC\Delta T$  to calculate the heat change for 8 grams of ammonium nitrate and hence the heat change for one mole.

Far too many candidates identified the heat change as exothermic instead of endothermic. Generally, the energy profile drawings were poor. Those candidates who managed to score marks got the relative positions of the reactants and products and/or the activation energy correct. The majority of the candidates were unable to label the axes for the energy profile diagram. Most referred to the x-axis as “time” instead of “reaction pathway”.

In calculating the heat change for the reaction, the major challenge seemed to be determining the correct mass to be used. Some candidates used the mass of the ammonium nitrate while some added the 8 grams of the potassium nitrate to the mass of the water. The correct mass

to be used for this calculation, in which 50 cm<sup>3</sup> of water was used to make the solution, was 50 grams. The majority of candidates were able to convert the mass in grams to kilograms.

Very few candidates stated the correct assumption for the calculation and stated instead an assumption that related to the conduct of the experiment that no heat was lost to the environment. While this may have been relevant for the conduct of the experiment, the more appropriate assumption for the calculation was that the heat capacity of the solution was the same as that of water or that the density of the solution was the same as that of water.

### Question 3

Syllabus References: B1: 2.2, 2.3, 2.4, 2.5, 2.6

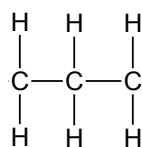
Candidates were tested on the nomenclature and structure of an alkane and an alkene, the reaction of alkenes with bromine, the identification of homologous series from structures, and the solubility of compounds in water, based on their structures.

The average mark on this question was 6.5 out of 15, with approximately 40 per cent of candidates scoring 8 marks or more. This shows an improvement, when compared to previous examinations, on questions on organic chemistry.

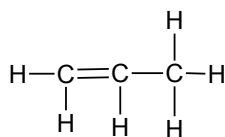
In Part (a), candidates were given the molecular formulae of two hydrocarbons, propane (C<sub>3</sub>H<sub>8</sub>) and propene (C<sub>3</sub>H<sub>6</sub>), and were required to give the fully displayed structures and names.

Many candidates were able to deduce the names of both hydrocarbons, and the structure of propane, but had difficulty with the structure of propene, and so, were able to obtain three of the four marks for Use of Knowledge.

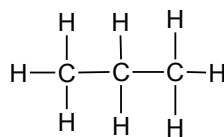
Many candidates had the following incorrect structure for propene:



The correct structures and names are as shown below:



(A) propene



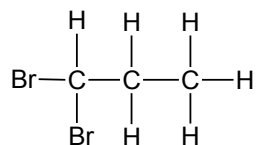
(B) propane

For Part (b), candidates were required to indicate which of the hydrocarbons — propane or propene — would react with bromine by (i) stating the observation for the reaction, (ii)

writing a chemical equation for the reaction, and (iii) drawing the *fully displayed* structure and giving the name of the product of the reaction.

The responses indicated that the majority of candidates were aware of the colour of bromine, but unfamiliar with the reaction of alkenes with bromine.

A number of candidates gave the incorrect structure of the reaction product as

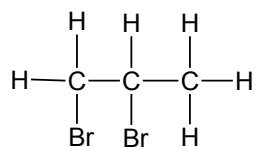


which does not account for the addition of bromine *across* the double bond of the alkene.

For Part (b) (i), the response which was expected is that the red-brown colour of the bromine would disappear, or the solution would be decolourized, or the solution would change from red-brown to colourless.

The correct equation for Part (b) (ii) is  $\text{C}_3\text{H}_6 + \text{Br}_2 \rightarrow \text{C}_3\text{H}_6\text{Br}_2$

For Part (b) (iii), since bromine ( $\text{Br}_2$ ) adds across the double bond,



the correct structure of the product is 1,2 dibromopropane.

In Part (c), candidates were given the structures of propanol (an alcohol), methyl propanoate (an ester) and butanoic acid (a carboxylic acid), and were required to (i) write the names of the homologous series to which each belonged, and (ii) indicate, with reason, which *two* are soluble in water.

The majority of candidates were able to identify at least one of the three homologous series correctly, while less than 20 per cent correctly identified all three. Some candidates gave the names of the three compounds instead of the homologous series. The majority of candidates recognized that the presence of polar groups (e.g. OH) on a molecule would aid the solubility in water, a polar solvent.

Some candidates were unable to distinguish between the ester and the carboxylic acid and wrote 'acid' instead of carboxylic acid.

Candidates also incorrectly referred to the OH group as a hydroxide ion ( $\text{OH}^-$ ).

Compounds	Homologous Series
Propanol	Alcohols
Methyl propanoate	Esters
Butanoic acid	Carboxylic acids

#### Question 4

Syllabus References: A: 5.5, 6.1, 6.2, 6.3, 6.4; B2: 4.1, 4.2

Candidates were tested on their knowledge of the ‘clarifying’ and ‘crystallization’ steps in the manufacture of cane sugar, the variation of atomic radii and reactivity in Group II elements, the relative reactivity of the halogens, and the acidic/basic properties of the oxides of non-metals/metals.

This question was poorly done, with an average mark of 4 out of 15; 13 per cent of the candidates scored 8 marks or more.

In Part (a), candidates were required to outline what happens in the ‘clarifying’ and ‘crystallization’ steps in the extraction of sucrose from the juice of sugar-cane. The majority of candidates did not appreciate the *clarifying* step. Many candidates had a better understanding of what happens during *crystallization*, in general, but not specifically to the process as it relates to the production of sugar.

Candidates incorrectly outlined clarifying as washing and filtering to remove dirt and indicated that clarifying is where the impurities of sugarcane juice are removed. They also inaccurately stated that juice is heated and left to crystallize.

Candidates were expected to state that during *clarifying* the sugarcane juice is neutralized by the addition of calcium hydroxide and heated. Insoluble impurities are precipitated in the form of insoluble calcium salts. In *crystallization*, pure sugar crystals are added (a process known as seeding) to the thick, supersaturated syrup to cause the formation of crystals.

In Part (b) (i), candidates were required to give a reason for the increase in atomic radius (i.e. the size of the atom) as Group II is descended, from magnesium to barium.

Many candidates recognized that an increase in the number of electron shells (energy levels) occurred as the group is descended, but failed to state that shielding of valence electrons from the nucleus, by the electrons in the filled inner shells, would result in an increase in atomic radius.

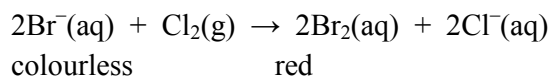
For Part (b) (ii), candidates were required to explain the higher reactivity of barium, when compared to magnesium, towards water, using the table of ionization energies that was given.

Most candidates correctly indicated that the higher reactivity of barium was due to its lower ionization energy (as seen in the table), but failed to state that the lower ionization energy is as a result of the valence electrons being more easily lost, hence the higher reactivity.

For Part (c), candidates were required to indicate whether (i) chlorine gas and (ii) iodine crystals would react with an aqueous solution of sodium bromide.

This part of the question was fairly well done. Most candidates correctly indicated that a reaction would take place with chlorine gas, but there would be *no reaction* with iodine.

The correct equation, showing the oxidation of bromide ( $\text{Br}^-$ ) to bromine ( $\text{Br}_2$ ) by chlorine gas ( $\text{Cl}_2(\text{g})$ ) is:



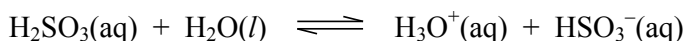
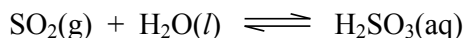
Part (d) required candidates to distinguish between two aqueous solutions — one of sulphur dioxide and one of sodium oxide. Specifically, they were asked to describe a test that could be used to identify the solution formed with sulphur dioxide, and to write a balanced equation to support the test.

Part (d) was fairly well done, with most candidates recognizing that sulphur dioxide is an acidic gas. Candidates gave a variety of correct responses (apparently from their practical experience), including:

- Heat the solution and test the gas with damp blue litmus paper.
- Test the solution with blue litmus paper.
- The solution would be red/orange with universal indicator.

Sulphur dioxide is an acidic gas which dissolves in water to give an acidic solution. A simple test is to test the solution with blue litmus paper, which would change to red.

Acceptable equations were:



### Question 5

Syllabus objectives: A: 4.7; B2: 1.2, 1.3, 3.1

Part (a) tested candidates' knowledge of the Contact Process. Candidates were required to

- describe the processes involved in the first two stages of the process,
- identify the conditions for the production of sulphur trioxide and
- explain the use of sulphuric acid as a solvent for sulphur trioxide instead of water.

Candidates were able to give a description of the two steps involved in going from sulphur to sulphur trioxide as well as the relevant chemical equations. In Step 1, it was expected that candidates would state that sulphur was burnt or heated in air. For Step 2, the required response was that the sulphur dioxide from step 1 was “burnt in excess oxygen” to make

sulphur trioxide. Again, responses that were not specific — such as sulphur “reacted” or “combined” with the air — were not awarded full marks.

While most candidates found little difficulty with the equations for Step 1, the equation for step 2 was generally incorrect. Very few candidates knew all the conditions for Step 2: viz. – 1–2 atm., 450 °C and  $V_2O_5$  catalyst. Many got at least one mark for this section.

Very few candidates knew that the reaction for  $SO_3$  with water was highly exothermic and that a highly corrosive mist would form as a result and hence, conc. sulphuric and not water was used to dissolve the sulphur trioxide.

The writing of the ionic equation for the reaction of carbonate with an acid was poorly done. Many candidates seemed unable to write the equation in terms of  $H^+$  ions only and had to write the equation using the formula of a hypothetical acid such as HX and sodium carbonate.

Part (b) tested candidates’ knowledge of the structure and subsequent properties of diamond and graphite.

This question posed unexpected difficulties for many candidates as they knew the general structure of diamond and graphite but were unable to explain how the structure of diamond made it strong and therefore suitable for cutting whereas the structure of graphite was layered and flaky and hence not suitable for cutting. Candidates were required to refer to the tetrahedral structure of diamond with its strong covalent bonds contributing to its hardness while the weak inter-layer bonds of graphite leads to it being flaky or soft and therefore not suitable for cutting. For the most part, candidates described the structure – loosely in terms of strong bonds for carbon and often incorrectly as weak bonds in graphite.

### Question 6

Syllabus Objectives: C1 1.3, 1.4, 1.9, 1.10

In Parts (a) and (b), candidates were tested on their knowledge of the constituents of flour and the action of yeast in bread making. They were also required to compare the actions of baking powder and yeast in making dough rise.

While many candidates seemed to have a general knowledge of the process of bread making, it was clear from the responses that very little attention was being given to the chemistry of the steps in bread making. This limited interpretation of the requirements for responses saw many candidates writing a lot of information on the actual process of bread making but being awarded little marks as they did not include the chemical principles for carrying out the steps.

Additionally, the candidates knew very little of the chemical equations required for the reactions and many were unable to balance the equations. There were many careless mistakes with representing the correct formula of some important compounds involved in the process such as glucose and maltose. It was also clear from the responses that students need

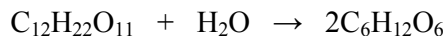
additional help in providing answers to questions that require comparing processes. The tendency was to describe and not to compare the actions of yeast and baking powder.

Many candidates were unable to name one other major component of flour and many identified “wheat” and “gluten” as other major components of flour. While gluten is produced when flour undergoes some amount of mixing with water, gluten is not considered a major component of flour. The correct responses for that section were proteins, fat or moisture.

Candidates lost marks for not identifying the fact that both baking powder and yeast produce carbon dioxide when they are used as raising agents but the process by which the CO<sub>2</sub> is produced is different for the two substances. Whereas the yeast produces the carbon dioxide as a result of the actions of an enzyme, the production of CO<sub>2</sub> from baking powder is based on an acid-base reaction.

Many candidates were unable to provide a clear explanation of how the yeast caused the dough to rise during baking. The responses to this section were particularly poor. The expected response was that the carbon dioxide when produced was trapped in the dough but the gas expanded on heating, pushing up the dough in a bid to escape thus causing the dough to rise. Many referred to the fact that CO<sub>2</sub> aerated the dough — a common phrase found in many texts — but the response required more than this description. There should have been an explanation of the phenomenon.

The two equations required were



Part (c) of the question tested candidates’ knowledge of the action of hydrogen carbonate and heat on the concentration of acids.

A fair number of candidates were able to apply their knowledge of acid/baser reactions to answer this part of the question. However, they did not provide a suitable explanation of how heat affected the vitamin C content and hence the acidity during stewing. Many referred to the heat as “denaturing the enzyme” — another common phrase found in many texts referring to the action of heat on enzymes. Candidates seemed to confuse enzymes with vitamin C.

The expected response was that while sodium hydrogen carbonate, the chemical in baking soda, would reduce the acidity of in tamarind juice, the heat would destroy the vitamin C in cooking and hence, there would be no need to add the HCO<sub>3</sub> in that case.

**Paper 03/2 – Alternative to SBA**

Syllabus References: A 1.2, 3.3, 6.0, 8.3, B2. 7.1, 7.2, 7.3

Question 1

This question tested candidates' knowledge of the solubility of sulphates and the experimental details required for the preparation of an insoluble salt. It also tested their ability to calculate percentage yield and their understanding of the method of determining the melting point of a solid. The maximum mark available was 26. Almost all of the candidates were able to gain at least five of the marks.

Part (a) required candidates to

- (i) describe a test to distinguish between sodium sulphate and lead(II) sulphate
- (ii) prepare a dry sample of lead(II) sulphate
- (iii) calculate the theoretical yield of lead(II) sulphate to be obtained from a given mass of lead(II) nitrate and sulphuric acid.

Many candidates did not recognize that the difference between the two salts related to their solubility in water. As a result many of them attempted chemical tests such as the addition of hydrochloric acid, aqueous sodium hydroxide or aqueous potassium iodide in order to test for the presence of  $\text{Pb}^{2+}$  ions in solution. This lack of knowledge was also evident in their preparation of the salt where they tried to crystallize the salt from an aqueous solution. Even those candidates who recognized that lead(II) sulphate was insoluble lost a mark for not first preparing an aqueous solution of lead(II) nitrate from the solid that they were given. A surprisingly large number of candidates seemed to think that filtration required only filter paper and left out the funnel when listing their apparatus.

A large percentage of the candidate population could not write the simple equation for the reaction between lead(II) nitrate and sulphuric acid. Many candidates thought that the products of the reaction included water, nitrogen(IV) oxide and hydrogen gas. Others could not write the formula for nitric acid. In the calculation of the theoretical yield of the lead(II) nitrate, most candidates showed an aptitude for calculating molar mass and the number of moles of a substance. Unfortunately, many tended to divide the mass of lead(II) nitrate given by the molar mass of lead(II) sulphate in order to get the number of moles of lead(II) sulphate. Calculations were not clearly set out and oftentimes no reference was made of the mole ratio between the nitrate and the sulphate.

In order to distinguish between sodium sulphate and lead(II) sulphate it was expected that water would be added to separate samples of the salt, so that the one that dissolved would be sodium sulphate and the insoluble one would be identified as lead(II) sulphate.

When preparing lead(II) sulphate, four steps were required:

- addition of distilled water to the lead(II) nitrate to form a solution



- mixing the solution of lead(II) nitrate with the sulphuric acid provided
- filtering off the insoluble lead(II) sulphate
- washing the residue with distilled water and drying in an oven

In the calculation of the theoretical yield of lead(II) sulphate from 3.31 g of lead(II) nitrate, candidates were required to calculate the number of moles of lead(II) nitrate, that is,  $3.31/331$ , use the 1:1 mole ratio between it and lead(II) sulphate to determine that the number of moles of lead(II) sulphate that were produced was therefore 0.01 and hence multiply this number by the molar mass of lead(II) sulphate which is 303 to obtain a mass of 3.03g. The percentage yield was then  $2.25 / 3.03 \times 100$ .

Part (b) required candidates to

- draw a diagram of the arrangement of the apparatus for determining the melting point of stearic acid
- use the data provided from such an experiment to plot a graph that would allow them to determine its melting point
- account for the shape of the graph with increasing temperature in terms of change in state of the stearic acid.

The diagram for determining the melting point of stearic acid should have been labelled and should have included a source of heat, a water bath and a container with stearic acid which had a thermometer immersed in the acid. The container should have been in the water bath.

The melting point of the acid, from the graph, was 55 °C.

There were three distinct regions to the graph. The first upward slope was the result of increasing temperature causing an increase in the internal energy of the particles so that the particles began to move away from each other. At the level section of the graph the solid was being converted to liquid. The increase in temperature did not cause the temperature of the particles to rise because the energy was being used to break the bonds and convert the solid to the liquid. Once melting was completed, the temperature of the liquid began rising again as the particles continued to increase their movement.

### Question 2

This was a simple qualitative analysis question that tested Syllabus Objectives B2. 7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when an unknown solid, Y, was added to water, the mixture was filtered and tests were performed on the filtrate and residue. A maximum of 10 marks were awarded for this question.

Responses to the question were better than in previous examinations, although overall the question was poorly done. Some candidates excelled getting eight and nine marks out of the allotted ten marks. A large number of candidates chose to omit the question. The majority of those who answered the question seemed unfamiliar with the bright yellow colour of the lead(II) iodide precipitate and with the solubility of the copper(II) hydroxide precipitate in excess aqueous sodium hydroxide and ammonia. The blue colour of copper(II) hydroxide and

the white precipitate that carbon dioxide produced with lime water were, however, very well known. Unfortunately, too many candidates still refer to lime water turning cloudy/milky in the presence of carbon dioxide. Too many candidates still write observations that give either a colour without a state or a precipitate without a colour.

Candidates were expected to record the presence of a white precipitate, soluble in excess sodium hydroxide, in Test (ii). A yellow precipitate should have been observed in the reaction with potassium iodide while there should have been no visible reaction with silver nitrate. In Test (v), it was expected that candidates would record effervescence and a white precipitate when the gas was bubbled through lime water. A blue precipitate that was insoluble in excess sodium hydroxide but which dissolved in excess ammonia giving a deep blue solution were the expected observations for Tests (vi) and (vii) respectively.

### Question 3

This question tested the planning and design skill as related to Syllabus Objective A 8.3. Candidates were required to plan and design an experiment to determine whether methylated spirit and kerosene produced the same amount of energy on combustion. The question was poorly done. Most of the candidates who attempted the question scored less than 5 of the 12 marks awarded. Candidates were given adequate guidance in the stimulus material at the beginning of the question. Despite this, many candidates did not appear to have read the data carefully and proposed improbable procedures.

A creditable number of candidates scored at least one mark for the procedure. Only a few, however, realized that the measurements that had to be taken should form part of the procedure. Some candidates used a procedure that did not allow them to collect data that could be subjected to mathematical treatment. For example, the fuels were allowed to heat a fixed volume of water for a specific length of time and the temperature of the water was taken after the time period. The fuel that heated the water to the higher temperature was said to have the higher heat of combustion.

The diagram of the apparatus to be used in the experiment was fairly well done by most candidates. Some candidates tried to heat the liquids whose heat of combustion was to be measured directly indicating clearly that they had not read the information at the beginning of the question where it was stated that “the heat of combustion can be readily determined from experimental data obtained from the heating of water by the fuels”. Other candidates lost a mark for not immersing the bulb of the thermometers in the water. Still others did not give diagrams of assembled apparatus.

Some candidates misunderstood what was required in Part (c) as data to be collected. A common error was to give temperature change as the answer instead of the initial and final temperature of the water. Similarly, mass of fuel burnt was given instead of the initial and final mass of the burners containing the fuel. Some confusion also existed between the data to be collected and the variables in the experiment. Calculation of  $E_H = mC\Delta T$  was well known.

Not quite as familiar was the calculation for  $\Delta H$  in which  $E_H$  was divided by the number of moles.

Most candidates were able to identify sources of error in the experiment.

A possible response that would be awarded full marks is given below.

### **Procedure**

- Measure out 100 cm<sup>3</sup> of water and place it in a beaker.
- Place the beaker on a tripod and measure and record the temperature of the water.
- Weigh a spirit burner filled with methylated spirit.
- Place the burner under the water and light it. Allow it to heat the water for 10 minutes.
- Extinguish the burner, record the temperature of the water and reweigh the burner.
- Repeat the experiment using a burner filled with kerosene.

### **Diagram**

The diagram should include

- a container of water on a tripod
- thermometer immersed in the water
- spirit burner containing fuel under the water

### **Data to be collected**

- initial and final temperature of water
- volume/mass of water
- initial and final mass of burner

### **Calculation of Heat of Combustion**

$$E_H = mC\Delta T$$

$$\Delta H = E_H/\text{no. of moles of fuel used}$$

### **Sources of error**

- heat loss to the environment
- loss of mass of fuel through wick of burner before it is reweighed

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION**

**MAY/JUNE 2011**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The overall performance of candidates in the 2011 examination was not markedly different from previous sittings. Candidates performed best on Questions 1 and 2. Although performance on some topics such as organic chemistry continues to be poor, there were no questions on which some candidates did not obtain full marks. From year to year, the report on performance in the CSEC examination highlights the areas that candidates seem to find difficult as well as the kinds of errors that they make. Yet, these weaknesses persist. This report again serves to highlight the strengths and weaknesses in candidates' performance in the examination. Teachers and students are encouraged to use the information presented here to self-assess and so better prepare for the examination.

### Factors Contributing to Poor Performance

#### Weakness in discriminating among concepts

- Far too many candidates continue to confuse related concepts, terms that may sound alike or those that may have a different meaning from everyday common usage. These include concepts such as corrode and corrosive; corrosion and rust; metals, non-metals and their ions such as iodine and iodide; glowing and lighted splint and cathode and anode. In a number of instances, terms were used rather loosely, completely distorting the overall meaning of the idea being communicated. This was very evident when definitions of electrolysis and anaerobic fermentation were given. The point made in previous reports is worth repeating here. Teachers should engage students in developing a deep and enduring understanding of concepts by using strategies that help students to connect ideas and understand principles. Classroom conversations on concepts should be encouraged and the correct use of terms during classroom conversation be the norm. Many candidates lost Knowledge and Comprehension (KC) marks for careless or incorrect use of these terms.
- The language of chemistry also posed problems for some candidates. Far too many candidates confused calcium hydroxide with calcium carbonate. Many showed limited appreciation for the balancing of ionic equations where both the charge and the number of ions need to be balanced. Candidates wrote terms such as 'kill' or 'destroy' when referring to the denaturing of protein molecules.

#### Misunderstanding of concepts linked to practical procedures

- Candidates seemed unfamiliar with some concepts that are usually encountered in practical lessons. The poor performance on Question 5, for example, was linked to limited understanding of what is required in stating a chemical test and what is meant by the term 'observation'.
- Many questions involved a fair knowledge of practical procedures. It was evident from some of the responses that many candidates did not make the connections between what was being asked and the practical activities that they ought to have encountered while preparing for the examination. For example, in Question 1, the reaction between Solution S and excess sodium hydroxide was described as producing "a solution that was soluble in excess".

#### Difficulty thinking in hypothetical terms

- This was most evident in the responses to Question 5. Many candidates were unable to predict the correct order of the three metals, copper, iron and Metal X. In a number of instances, candidates attempted to identify Metal X. Candidates seem to need additional practice in this level of thinking which will only take place if teachers provide these opportunities in routine classroom assessment. In this regard, use should be made of past examination questions to provide candidates with ample practice.

### Writing and balancing equations and interpreting chemical reactions

- It was clear that many candidates have not learnt the correct valencies of common elements and radicals. As a result, formulae were incorrectly written in equations resulting in marks being lost. This was one of the main reasons for the poor performance on Questions 4 and 5.
- Candidates' inability to interpret what is taking place in a chemical reaction was most evident in Question 6. It is possible that the poor performance on Part (c) of Question 6 was also linked to their confusion of iodine and iodide, mentioned earlier in this report.

### Reading and Plotting Graphs

- Many candidates need practice with reading the scales of graphs and plotting points accurately.
- The drawing of the line of best fit is also a skill that many candidates have not mastered.

The following sections give details of the performance on specific questions. This section should be read with the actual question paper as reference.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the Knowledge and Comprehension profile. Performance on this paper continues to be steady and satisfactory. The marks ranged from 0 to 60.

The mean score was 55.2 per cent and the standard deviation was 11.23.

Candidates experienced the most challenges with items based on the following objectives:

- A.1.1 – Particulate nature of matter
- A2.8 – Arrangement in periods and groups
- A.6.2 – Ease of ionization (strength of oxidizing power)
- A.6.17 – The differences between oxidizing and reducing agents
- B1.1.9 – Structural isomerism for alkanes and alkenes up to four atoms
- B2.4.1 – Reactivity of metals
- B2.4.2 – Order of reactivity

### Paper 02 – Structured Essay

#### Question 1

Syllabus References: A: 6.18, 6.20, 6.22, 6.25, 6.27, 6.24; B2 7.1, 7.2, 7.3

#### **Part (a) (i) and (ii)**

This section was based on an experiment on electrolysis in which current was made to pass through an electrolyte of aqueous copper sulphate using copper electrodes. The mass of copper produced during the experiment was determined by weighing the cathode at specific intervals and subtracting the original mass of the cathode from the mass obtained at these intervals. An incomplete table of the results was included for candidates to complete based on the data presented. Parts (i) and (ii) tested candidates knowledge and comprehension of electrolysis. This question recorded the best overall performance among candidates. Yet, there are still many areas of weakness that were identified.

### Candidates' Performance

Several definitions given indicated candidates' misunderstanding of the purpose and principles of electrolysis. Many candidates lost marks because they failed to include two key components — the fact that electrolysis is a chemical process in which the decomposition of the electrolyte takes place and secondly that it is the passage of an electric current through the electrolyte that does this. The following definition given serves to highlight some of the confusion surrounding the purpose of electrolysis as well as how concepts are used incorrectly. "Electrolysis is the process whereby substances are placed, then electrodes to see how the flow of electrons go towards the correct electrode."

Here the notion of electrolysis resulting in decomposition of the electrolyte is missing and 'electrons' instead of 'ions' are migrating to the electrodes. This is an example of the incorrect use of two concepts having to do with charged particles.

Many candidates confused the cathode and the anode. It was evident that they did not make the associations between cathode with cations and anode with anions. Those associations would help candidates to relate the charge of the electrodes to the charge on the ions that migrate to them. This poor understanding might have caused many candidates to write that "the anode attracts positive ions" and "the cathode attracts negative ions" and also that "the cathode is positively charged and the anode negatively charged". Inappropriate terms were also used in describing what happens at the electrodes. For example, some candidates wrote "the cathode collects positive ions and the anode collects negative ions". The use of the word "collect" in this sense is of course misleading as the ions migrate to the respective electrodes. Most candidates were able to score at least one mark for Part (i).

### Expected Response

The expected response was that electrolysis is the process by which electrolytes are decomposed by an electric current. Candidates who wrote statements such as *Electrolysis is the process where an electrical current is passed through a compound causing it to split* were also awarded full marks.

Most candidates scored at least one mark for Part (ii). The more popular responses included the charge of the electrode, whether oxidation or reduction occurs there and the type of ions migrating to the electrode during electrolysis.

### Part (a) (iii)

#### Candidates' Performance

Candidates were required to draw a diagram of the circuit used to carry out the investigation and to label the cathode and electrolyte.

While many candidates were able to score at least two marks for this diagram, there were a few who seemingly had no recollection of how to represent the cell or the electrodes. The most common error was to reverse the conventions used to represent the positive and negative terminals of the cell in the circuit diagram. Hence, the cathode was labelled as being connected to the positive terminal and the anode to the negative terminal.

Most candidates correctly identified the electrolyte and represented the electrodes as dipping into the electrolyte. In some cases, candidates labelled the switch as the cathode or the electrolyte and there were a few diagrams where the cell was not included at all.

### Expected Response

Full marks were awarded for diagrams in which the electrodes were dipping into the electrolyte and correct labelling of the cathode (connected to the negative terminal of the cell) and the electrolytes.

### Part (a) (iv–x)

In this section of the question, candidates were required to complete the table to show the missing values for the mass of the cathode and the mass of copper deposited, plot a graph of mass of copper versus time, and use the graph to predict the mass of copper that would be deposited at 28 minutes. They were also required to calculate the mass of copper that would be deposited during the reaction.

### Candidates' Performance

Most candidates managed to score the five marks for completing the table and used the data from the table to accurately plot the five points on the graph. The two points which posed difficulty for candidates were the points at 15 and 25 minutes as these fell between the small squares on the graph paper. Some candidates were very careless in plotting those points and so lost a mark. Many candidates were unable to extrapolate from the graph the mass of copper to be deposited at 28 minutes as they did not have 30 cm rulers to draw the line to get the reading. Some candidates attempted to draw the straight line graph by free hand and still others seemed to estimate what point the line would cross at 28 minutes. Consequently, many candidates gave incorrect values for the mass of copper to be deposited after 28 minutes (Part vi).

The main flaws with the ionic equation for the reaction were

- (a) omission of or incorrect state symbols
- (b) subtraction of  $2e^-$  from the  $Cu^{2+}$  ions instead of adding them to produce copper metal.

Most candidates were able to calculate the quantity of electricity passed during the reaction. The main error here was that a few candidates failed to convert minutes to seconds and a few did not know the correct units for the quantity of electricity.

Part (ix) posed the greatest challenge for candidates. Many of them lost one or both marks here. Many candidates tried to use various algorithms for doing the calculation and got stuck as they selected the wrong ones or ended up doing calculations that were not required. Here as well, there was indiscriminate use of units. In a number of instances, candidates failed to take the number of Faradays required to deposit one mole of copper into consideration when solving the problem.

Most candidates knew to use the formula mass of copper to multiply the number of moles from Part (ix) to get the mass of copper.

### Expected Response

The procedure given below is only one way of approaching the problem.

$$\text{Quantity of electricity} = 0.2 \times 20 \times 60 = 240 \text{ C}$$

$$\text{No. Moles Copper} = 240 / (2 \times 96000) = 1.23 \times 10^{-3}$$

$$\text{Mass of copper} = 64 \times 1.23 \times 10^{-3} = 0.079 \text{ g}$$

### Parts (a) (xi) and (xii)

### Candidates' Performance

These two sections seemed to have been the most difficult sections in Part (a). Candidates were required to suggest a possible reason for the difference between the theoretical yield as obtained from the calculations and the actual mass of copper as obtained from the experimental data.



Many incorrect responses were given. Among the more popular ones were:

- The presence of impurities
- Experimental error

A fair number of candidates were familiar with the electrolysis of aqueous copper sulphate solution using different electrodes and were able to obtain a mark. However, vague responses such as “graphite is inert and would not take part in the reaction” were not awarded any marks.

### **Expected Response**

Responses such as *the electrodes were not properly dried* or *there were fluctuations in the current passing through the electrolyte* were awarded the mark for Part (xi).

Differences in the reaction at the anode when the copper anode was replaced with graphite electrodes included:

- Oxygen would be produced instead of the formation of copper ions.
- $\text{OH}^-$  ions would be discharged.
- No change in the mass of the anode would occur.

### **Part (b)**

This section was based on the qualitative analysis and required knowledge of the test for the nitrate and zinc ions.

### **Candidates' Performance**

The responses to this section were disappointing as these very common tests were seemingly unfamiliar to many candidates. Far too many candidates lost marks as they were unable to suggest correct observations for the inferences that an acidic gas and the nitrate ions were present.

### **Common Incorrect Responses**

- Gas produced which turned red litmus blue (for the presence of the acidic gas)
- White precipitate insoluble in excess (for the presence of the  $\text{Zn}^{2+}$  ion)

### **Expected Responses**

The correct responses were:

- Gas produced which turned blue litmus red
- Brown gas produced
- A white precipitate soluble in excess NaOH

### Question 2

This question tested syllabus objectives A: 4.1, 4.3, 4.5, 4.7, 5.3

Candidates did fairly well on this question.

### Part (a)

This section of the question tested knowledge of the structures and conductivity of three solids: iodine, zinc and diamond. The majority of candidates scored between four and six marks on this section. Only the very weak candidates failed to obtain any marks. Although the question indicated the terms to be used for describing the bonding in the substances, some candidates ignored the categories given and wrote terms such as 'large covalent' and 'covalent' in describing the structures. These categories were not awarded any marks. A number of candidates classified zinc as ionic instead of metallic.

The correct responses were:

Iodine	simple molecular	does not conduct in the solid state
Zinc	metallic	conducts in solid state
Diamond	giant covalent	does not conduct

### Part (b)

Part (b) was based on a comparison of the solubility curves for magnesium chloride and potassium nitrate. Most candidates correctly interpreted the solubility curves and identified magnesium chloride as the more soluble of the two solids at 15°C. While most candidates knew how to determine the mass of potassium nitrate that would be deposited after cooling from 80°C to 20°C, far too many candidates lost marks because they read the graphs incorrectly.

The correct readings from the graph were 14.4 g for the solubility at 80°C and 7.6 g for the solubility at 20°C. The correct answer for the mass of potassium nitrate was therefore 6.8 g, obtained by simple subtraction of the solubility at 20°C from the solubility at 80°C.

The temperature at which the two salts had equal solubility was the temperature at which the two solubility curves intersected. The correct reading was 56.5°C.

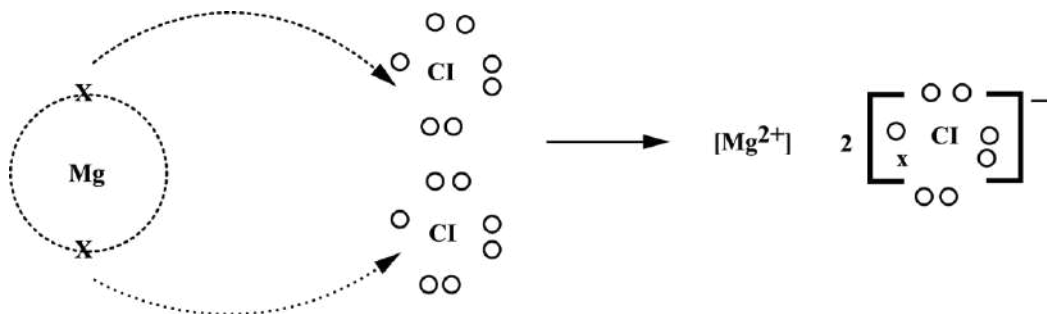
### Part (c)

This section required a diagram to show the bonding between magnesium and chlorine. Candidates were expected to deduce that the bonding between magnesium and chlorine was ionic. They were not provided with the atomic numbers of magnesium and chlorine as these are among the first 20 elements of the Periodic Table and candidates are expected to be familiar with them.

The main incorrect responses were:

- Treating magnesium as having a valency of 1 instead of 2
- Treating chlorine as having a valency of 2 instead of 1
- Representing the bonding diagram as covalent instead of ionic bonding
- Failure to show the charged ions formed after magnesium donates the valence electrons to chlorine

The correct dot cross diagram to show the bonding between magnesium and chlorine is given below.



**Part (d)**

Candidates were asked to use their knowledge of bonding to predict the bonding likely to be present in solid air fresheners and to explain their reasoning.

Most candidates lost marks here. Whereas many candidates correctly identified the bonding as simple molecular, the majority of candidates could not provide a suitable explanation for this. A number of candidates incorrectly identified the bonding as ionic or giant covalent.

**Expected Responses**

The correct classification was simple molecular. The required explanation included a mark for

- showing understanding that the bonds between the particles were relatively weak
- recognition that the weak bonds would result in the particles escaping and diffusing into the surrounding atmosphere at room temperature.

Hence, responses such as the ones below were awarded full marks.

*Simple molecular. This allows them to diffuse easily into the air by breaking the weak bonds found in a simple molecular structure, for example, Iodine.*

*As simple molecular because bonds can be easily broken to release scent. Giant covalent and ionic lattice are strong bonds and cannot be easily broken as that of simple molecular.*

However, responses such as the one below was only awarded two of the three marks as it did not adequately convey the second bulleted point above.

*I would classify them as simple molecular as the molecules are moulded into solid and are held by weak bonds like Van der Waals' bonds which are easily broken.*

Question 3

Syllabus References: B1: 3.4, 3.5, 3.6, 4.2, 4.3, 4.7

Candidates were tested on anaerobic fermentation, alkaline hydrolysis of esters, saponification and synthetic detergents, and addition and condensation polymerization.

### **Part (a) (i)**

In this part, candidates were required to define *anaerobic fermentation*.

#### **Candidates' Performance**

Less than 50 per cent of the candidates gave the correct definition of *anaerobic fermentation*.

#### **Common Incorrect Responses**

- When yeasts respire anaerobically
- Respiring without the use of oxygen
- The production of wine/ethanol using yeast

#### **Expected Response**

Anaerobic fermentation is the conversion of sugars to smaller molecules like ethanol and carbon dioxide. It takes place in the absence of oxygen.

### **Part (a) (ii)**

In this part, candidates were required to give one reason why high temperatures are not suitable for anaerobic fermentation.

#### **Candidates' Performance**

Many candidates were unaware that it was the enzymes in the yeast cells that were responsible for converting the sugars to ethanol and carbon dioxide, or that the enzymes were proteins and therefore would be denatured at elevated temperatures, and lose their function. Some candidates gave partially correct responses stating that enzymes operate at an optimum temperature but did not mention what would happen if the optimum temperature was exceeded.

#### **Common Incorrect Responses**

- High temperatures can kill the yeast.
- High temperatures can kill the enzymes.

#### **Expected Response**

Temperatures in excess of 40°C will denature the enzymes (proteins) in the yeast, which makes them inactive.

### **Part (b)**

Candidates were required to draw the *fully displayed* structures of the products of the alkaline hydrolysis of ethylpropanoate. Esters are formed from the condensation reaction between a *carboxylic acid* and an *alcohol*, with the elimination of a molecule of water. Hydrolysis is the reverse of this process, where the ester produces the carboxylic acid and the alcohol.

#### **Candidates' Performance**

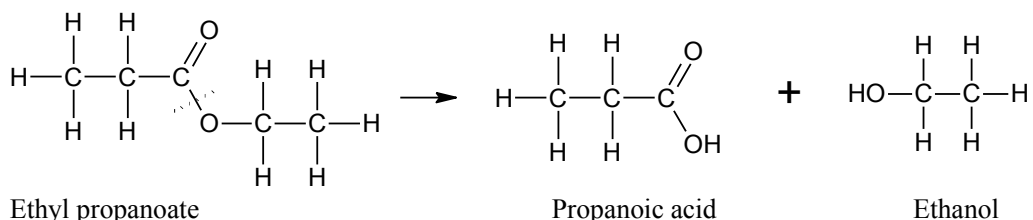
Less than 50 per cent of the candidates gave the correct structures for propanoic acid and ethanol.

#### **Common Incorrect Responses**

- Drawing structures for an acid and water instead of acid and alcohol
- Drawing condensed structures instead of fully displayed structures
- Not drawing all the hydrogen atoms on the functional groups
- Drawing HO instead of OH as the functional group of alcohols
- Drawing a carbon atom with five or six bonds around it, instead of four

### Expected Responses

The hydrolysis reaction is shown below, where the single bond between the carbon and the oxygen is broken as shown and the elements of water are added, the OH onto the carbon and the H onto the oxygen.



### Part (c)

In this part, candidates were required to name one by-product of the saponification of fats and oils, and to state one disadvantage of synthetic cleaning agents over soaps.

### Candidates' Performance

The majority of candidates did not appear to understand the meaning of the term 'by-product', giving answers which indicated that they thought that by-product meant what the soaps/detergents could be used to make. Very few candidates gave the correct by-product or were able to give an advantage.

### Common Incorrect Responses

Some incorrect responses showed some confusion, or were vague. Some examples are:

- Scum was formed by the detergent.
- The detergent was difficult to lather.
- Detergents 'pollute the environment'.
- Detergents were 'biodegradable'.

Incorrect by-products:

- Water
- Scum

### Expected Responses

The by-product is glycerol and two disadvantages are that synthetic cleaning agents can cause excessive foaming and they are not biodegradable. This means that they will stay in the environment for a very long time.

### Part (d) (i)

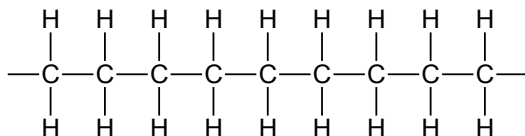
Candidates were provided with the fully displayed structure of propene, and were required to draw the partial structure of the polymer formed from propene, using three units of the monomer to demonstrate the answer.

### Candidates' Performance

It was evident that some candidates did not read this question properly as they either used the incorrect monomer in their diagrams or used the incorrect number of repeat units (2 or 4 instead of 3).

### Common Incorrect Responses

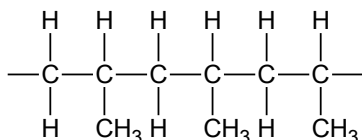
In one common incorrect response, candidates had the three carbon atoms of propene connected in a line.



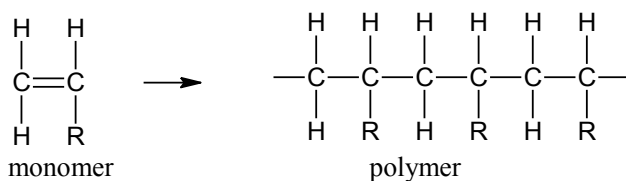
The above structure is that of polyethene.

### Expected Responses

The correct partial structure of the polymer is:



For alkene type monomers, the carbon atom bearing the R-group is referred to as the *head* and the other carbon atom (the one bearing the two hydrogen atoms) as the *tail*. In the polymer chain the monomers are joined in a *head-to-tail* fashion so that the structure is as shown below. In propene and polypropene the R-group is CH<sub>3</sub>.



### Part (d) (ii)

In Part (d) (ii), candidates were required to state the name of the type of polymerization that 3-aminopropanoic acid would undergo, and give the general name of the polymer.

### Candidates' Performance

The majority of candidates correctly stated that the type of polymerization is *condensation polymerization*, but did not give the correct *general name* for the type of polymer. Some candidates assumed that the question was referring to the propene monomer and gave answers which were propene related. Some candidates assumed that since 3-aminopropanoic acid is an amino acid then the polymer formed would be a protein. Proteins are formed from the condensation of several *naturally occurring* amino acids.

### Common Incorrect Responses

The most common incorrect response for the type of polymerization was:

- Addition polymerization

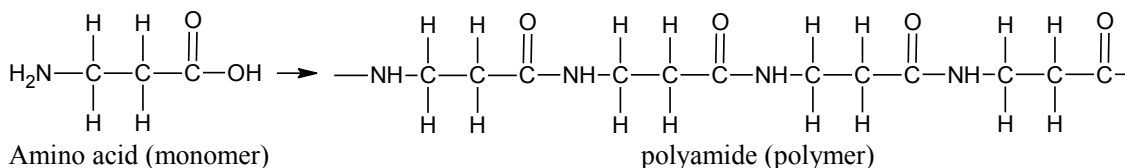
Common incorrect responses for the type of polymer formed were:

- Polypropene
- Polyamine
- Protein
- Polypeptide

### Expected Responses

The type of polymerization reaction that 3-aminopropanoic acid undergoes is condensation polymerization, and the general name for the type of polymer is polyamide. The reaction is between the amino group of one monomer and the carboxylic acid group of another monomer, a molecule of water is eliminated and an *amide* bond/link is formed, hence the name *polyamide*.

The structure of the polyamide polymer was not required but it is shown here in an attempt to clarify the answer. The monomer and the partial structure of the polymer are shown below.



### Part (d) (iii)

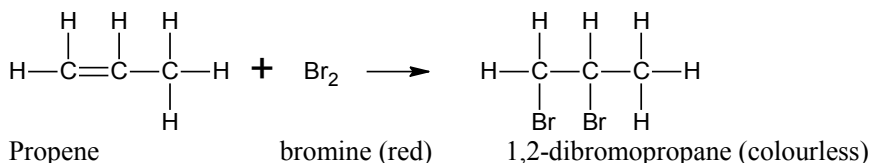
In this part, candidates were required to outline a chemical test that can be used to distinguish between propene and its polymer.

### Candidates' Performance

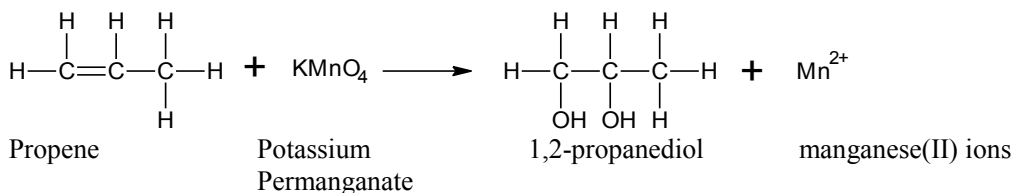
Many candidates correctly stated that propene would react with bromine (in an addition reaction) and would therefore decolourize a reddish solution of bromine dissolved in an organic solvent, or bromine in water. Some candidates also correctly stated that propene would decolourize a purple solution of acidified potassium permanganate (KMnO<sub>4</sub>). Many candidates gained one mark for giving a correct reagent, but failed to get the other mark by *not* stating how the reagent is used to distinguish between propene and its polymer.

### Expected Responses

Alkenes react with bromine, which is red in colour, to give the colourless 1,2-addition product, where the two bromine atoms are added on either side of the double bond, as shown in the following equation:



In general, alkenes react with purple acidified potassium permanganate solution to give the 1,2-dialcohol and the almost colourless  $\text{Mn}^{2+}(\text{aq})$  ion. 1,2-propanediol, which is also colourless, is the product in this case.



Many candidates did not attempt Parts (d) (i)–(iii).

### Question 4

Syllabus References: A 8.2, 8.3, 6.8, 6.10; B2: 6.1, 6.2

#### Part (a) (i)

This section tested knowledge of the reactions of acids with carbonates and metals and required the writing of equations to describe these reactions. In addition, it tested knowledge of the chemical tests for carbon dioxide and hydrogen gas.

#### Candidates' Performance

Given the familiar chemicals used in this question, it was very disappointing to read some of the responses obtained. Many candidates demonstrated very little knowledge of these reactions and were careless in their answers. It was clear that they knew that acids react (a) with carbonates to produce a salt, carbon dioxide and water and (b) with active metals to produce hydrogen gas and a salt. The question specifically asked for the 'expected observations' for the reactions and 'a chemical test' to identify any gas that would be evolved. Marks were lost in this section because of three main reasons.

- Many candidates missed the word 'observation' and stated instead the expected products of the reactions.
- In describing the test for the gases, either the incorrect reagents / conditions were used or there was no description of what results would be obtained for a positive test.
- Incorrect chemical formulae were used.

Many candidates were more familiar with the reaction between potassium carbonate and dilute nitric acid and hence more errors occurred in the attempt to construct the equation for the reaction between zinc and dilute nitric acid.



### Common Incorrect Responses

- Test for hydrogen with a glowing splint instead of a lighted splint
- Giving the correct test reagents for the gas but not stating the results
- Formula for lime water given as  $\text{CaCO}_3$  instead of  $\text{Ca(OH)}_2$
- Formula for zinc nitrate given as  $\text{ZnNO}_3$  instead of  $\text{Zn(NO}_3)_2$
- The litmus test given as the confirmatory test for carbon dioxide
- Recording the observation as “hydrogen gas evolved or carbon dioxide evolved” instead of vigorous effervescence or bubbles formed and zinc metal/potassium carbonate disappears

### Expected Responses

Acceptable observations for both reactions were *rapid effervescence of a colourless gas*.

The test for carbon dioxide involves passing the gas through lime water. A white precipitate confirms the gas. The test for hydrogen involves testing the gas with a lighted splint. Hydrogen will put out the splint with a ‘pop’.

### Part (a) (ii)

This part of the question tested knowledge of the preparation of a soluble salt such as potassium or zinc nitrate.

### Candidates’ Performance

Many candidates scored at least one mark for this question as they included the process of crystallization of the filtrate in their response. However, the procedures recorded indicated that many candidates did not have a clear understanding of how to prepare soluble salts.

### Common Incorrect Responses

- The salt was treated as an insoluble salt and ionic precipitation used as the method for preparing it.
- ‘Solutions’ were filtered to obtain a filtrate.
- Filtrates were evaporated to dryness instead of concentrating the filtrate and allowing the crystals to form.

### Expected Responses

The correct procedure for preparing a solid sample of the salt is as follows:

- Add excess solid (metal or carbonate) to the acid.
- Filter the mixture to remove the excess metal or carbonate.
- Heat the filtrate to evaporate most of the liquid and allow crystals to form.
- Filter to remove crystals and dry.

### Part (b)

This question tested knowledge of the factors that cause rusting.

### Candidates' Performance

Rusting was generally well understood but the uncertainty about the conditions for rusting led to incorrect answers. Some responses were ambiguous. An example of this was “no corrosion is expected in A and B but a small amount will be visible”. This response was not awarded any marks. Other candidates referred to the rate of rusting instead of whether or not rusting would take place.

### Expected Responses

The correct responses were that there would be no rust formed in A and B as in the case of A no oxygen is present and in the case of B, no water is present. Rust would be formed in C as both water and oxygen would be present.

### Question 5

Syllabus References: B2: 5.1, 4.1, 4.2, 5.2: A: 3.3

In this question, candidates were required to (a) determine the relative reactivity of an unknown Metal X, when compared to iron and copper, (b) explain the properties and uses of alloys (c) use the mole concept in a calculation.

### Part (a)

In this part of the question, two experiments were described.

Experiment 1: A piece of Metal X, when placed in a blue solution of copper(II) sulphate, became copper plated, and the solution gradually became colourless.

Experiment 2: There was no visible change when a piece of Metal X was placed in a solution of iron(II) sulphate.

### Part (a) (i)

Candidates were required to place the three metals (X, iron and copper) in order of their appearance in the reactivity series, starting with the most reactive.

### Candidates' Performance

Many candidates had two of the metals in the correct order, but less than 50 per cent of them had all three metals in the correct order.

### Expected Responses

The correct order with the most reactive metal placed first is: Iron > Metal X > Copper.

Metal X displaced copper metal from a solution of copper(II) ions, therefore Metal X is more reactive than copper (that is, Metal X > Copper). Metal X does not displace iron metal from a solution of iron(II) ions, so metal X is less reactive than iron (that is, Metal X < Iron, or, Iron > Metal X). Putting both pieces of information together gives: Iron > Metal X > Copper.

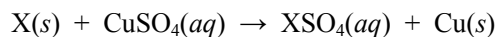
### Part (a) (ii)

In Part (a) (ii), candidates were required to write an ionic equation, *including state symbols*, for the reaction between Metal X and copper(II) sulphate.

### Candidates' Performance

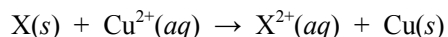
Most candidates attempted to write the full equation instead of the ionic equation. In many cases, where the ionic equation was given the state symbols were absent.

### Common Incorrect Response



### Expected Response

The ionic equation for the reaction between Metal X and copper(II) sulphate is



### Part (b) (i)

In this part, candidates were required to define an alloy.

### Candidates' Performance

Many candidates correctly indicated that an alloy is a mixture of metals. However, many of them stated that an alloy consisted of one or two metals.

### Common Incorrect Responses

- An alloy is a mixture of two metals or non-metals.
- Some candidates confused alloys with isomers, allotropes and isotopes.

### Expected Response

An alloy is a mixture of two or more metals.

### Part (b) (ii)

In this part, candidates were required to give the name of the alloy of copper and aluminium.

### Candidates' Performance

The majority of candidates came up with one of the names of the several alloys of copper and aluminium.

### Common Incorrect Responses

Many candidates did not give the correct spelling of the alloy.

### Expected Responses

The alloys are Duralumin, Dyraluminium, Duraluminum, Dural.

### Part (b) (iii)

Candidates were required to state two properties of the alloy, named in Part (b) (ii), that make it a good choice for use in the aircraft industry.

### Candidates' Performance

A number of candidates incorrectly stated that the alloy is less corrosive, when they meant to say that the alloy is more resistant to corrosion. Some candidates also stated that the alloy is resistant to rusting, again, meaning resistant to corrosion. (Iron rusts, and so *rust* or *rusting* should be reserved for use *only* when referring to iron or alloys of iron).

### Common Incorrect Responses

Many candidates gave responses that were not relevant to the aircraft industry: shiny, malleable, good electrical conductivity.

### Expected Responses

The two important properties of aluminium are that it is resistant to corrosion and it has a low density (that is, light).

### Part (b) (iv)

In this part, candidates were required to list two other uses of this alloy.

### Candidates' Performance

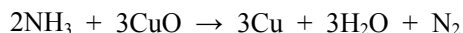
Most candidates were able to get the two marks. The marks were awarded for any reasonable suggestions for using the alloy.

### Expected Responses

Uses for the alloy include saucepans, window frames, drink cans.

### Part (c)

This part required candidates to do a mole concept calculation based on the given equation:



They were required to calculate the mass of copper produced when 0.12 dm<sup>3</sup> of nitrogen is produced at temperature and pressure.

### Candidates' Performance

Many candidates had difficulty with the mole ratio, probably because both of the materials that are relevant to the calculation appear on the same side of the equation. Some candidates incorrectly used a mole ratio of 2:3, which is for ammonia and copper. Some candidates used the mole ratio of 1:3 between N<sub>2</sub> and Cu.

### Expected Responses

The steps in the calculation are outlined below, one mark is awarded for each step.

$$\text{Number of moles of nitrogen} = \frac{0.12 \text{ dm}^3}{24 \text{ dm}^3 \text{ mol}^{-1}}$$

The mole ratio is 1 N<sub>2</sub> : 3 Cu

$$\text{Number of moles of copper} = \frac{0.12 \text{ dm}^3}{24 \text{ dm}^3 \text{ mol}^{-1}} \times 3$$

$$\text{Mass of copper} = \left( \frac{0.12 \text{ dm}^3}{24 \text{ dm}^3 \text{ mol}^{-1}} \times 3 \right) \times 64 \text{ g mol}^{-1} = 0.96 \text{ g}$$

### Question 6

Syllabus References: C1: 1.2, 1.6, 1.8, 1.9

In this question, candidates were examined on the denaturing of proteins by heat, the action of commercial and natural tenderizers on meat, the effect of heat on the Vitamin C content of a sample of orange juice, and the reducing properties of Vitamin C.

#### **Candidates' Performance**

In general, candidates performed poorly on this question, with an average mark of 4.3 out of 15. Fourteen per cent of candidates scored eight marks or more on this question. The mode was three marks.

#### **Part (a)**

In this part, candidates were required to give the reason(s) why protein powders, used as diet supplements, were mixed with cold or lukewarm water instead of boiling water.

#### **Candidates' Performance**

The majority of candidates got one of the two marks by indicating that the proteins would be denatured by the boiling water, but failed to state that denaturing would make the protein insoluble.

#### **Common Incorrect Responses**

- Hot water will damage or kill the protein.
- Heat would denature the enzyme.
- Protein would lose its nutritive value.
- The protein would no longer be able to carry out its function.

#### **Expected Responses**

Hot water will cause the proteins to be denatured which makes them insoluble.

#### **Part (b) (i)**

In this part, candidates were required to explain how natural or commercial tenderizers work when used to tenderize meat.

#### **Candidates' Performance**

Many candidates were able to get only one of the three marks.

#### **Common Incorrect Responses**

A number of candidates misunderstood the question and referred to the tenderizing of meat on the *commercial scale*, using instruments like the pressure cooker, the meat mallet and the meat grinder. Some incorrect responses were:

- Commercial tenderizers like the pressure cooker cook the meat at high temperatures.
- Beat the meat with a hammer to break up the strands.

### **Expected Responses**

Tenderizers contain enzymes. These enzymes hydrolyze the amide linkages between the amino acids of the protein, breaking the long strands into smaller ones.

#### **Part (b) (ii)**

In this part, candidates were required to list one advantage and one disadvantage of using commercial tenderizers over natural tenderizers.

#### **Candidates' Performance**

A number of candidates obtained one of the two marks by correctly stating that commercial tenderizers work faster than natural tenderizers. The majority of candidates were unable to state a disadvantage of commercial tenderizers.

#### **Common Incorrect Responses**

- Advantage – Natural tenderizers get the meat very soft.
- Disadvantage – Commercial tenderizers do not soften the meat as well as natural tenderizers.
- Disadvantage – Commercial tenderizers do not soften the meat completely.
- Disadvantage – Commercial tenderizers are more expensive.

### **Expected Responses**

Advantages – Commercial tenderizers usually work faster than natural tenderizers. They are always readily available, because they are not seasonal.

Disadvantages – There are health related concerns with using substances which are 'foreign' to the human body. Commercial tenderizers can affect the taste of food, possibly giving 'off' flavours.

#### **Part (b) (iii)**

In this part of the question, candidates were required to suggest why baking soda,  $\text{NaHCO}_3$ , can be used to tenderize meat.

#### **Candidates' Performance**

This part was very poorly done: the majority of candidates were unable to give the reason why baking soda can be used to tenderize meat. They stated that the baking soda tenderized the meat (repeating the question) but did not explain the process.

#### **Common Incorrect Responses**

- It is an acid and breaks the links between proteins.
- It softens the meat.
- It also breaks down protein.
- The hydrogen present assists the hydrolysis of proteins.

### **Expected Responses**

Baking soda,  $\text{NaHCO}_3$ , is basic. Therefore, it furnishes hydroxide ions when it comes in contact with water. These hydroxide ions are able to attack and break the amide link in the proteins. This process is known as *base hydrolysis*.

### **Part (c)**

In this part, two identical samples, A and B, of orange juice were analysed for their Vitamin C content, after Sample B was boiled and allowed to cool. Both samples were titrated with an iodine solution using starch as indicator. Candidates were required to (i) state the colour change at the end-point of the titration in both cases, (ii) state, with explanation, which sample would require the larger volume of iodine solution, and (iii) explain with reference to the oxidation number of iodine, whether Vitamin C is acting as an oxidizing agent or a reducing agent.

#### **Part (c) (i)**

##### **Candidates' Performance**

The majority of candidates correctly indicated that the colour change at the end point of the titration would be blue-black. (In titrations of this type, when the reagent that is reacting with the iodine is used up, the further addition of iodine will result in the excess iodine reacting with the starch indicator to give the blue-black starch-iodine complex).

##### **Common Incorrect Response**

- Turned dark

##### **Expected Response**

The colour at the end point is blue-black.

#### **Part (c) (ii)**

##### **Candidates' Performance**

A number of candidates realized that boiling Sample B would cause the amount of Vitamin C in the sample to be reduced, and so would require less iodine solution to obtain the end point. Most candidates were not able to explain how the heat affected the amount of Vitamin C.

##### **Common Incorrect Responses**

- Sample B would need more iodine because it was boiled.
- Heat increased the rate of reaction in Sample B so that more iodine would be used.

##### **Expected Responses**

Sample A would require the larger volume of iodine solution, because heating Sample B increases the rate of oxidation of Vitamin C by oxygen from the atmosphere. This increased rate of oxidation results in a decrease in the amount of Vitamin C in Sample B.

#### **Part (c) (iii)**

##### **Candidates' Performance**

A number of candidates correctly stated that Vitamin C is acting as a reducing agent, but did not give the correct explanation in terms of the change in the oxidation number of iodine.

### Common Incorrect Responses

- Iodine was reduced.
- Vitamin C is an oxidizing agent.
- The oxidation number of iodine decreased so the vitamin C is acting as an oxidizing agent.
- The oxidation number of iodine increased so the vitamin C is acting as a reducing agent.

### Expected Responses

Vitamin C is a reducing agent since it causes the oxidation number (O.N.) of iodine to decrease; that is, the O.N. of iodine decreases from ZERO in  $I_2$  to  $-1$  in  $I^-$ .

## Paper 031 – School Based Assessment (SBA)

### Planning & Designing Skill

Generally, the standard of the laboratory activities assessed for the skill of Planning and Design (PD) has declined slightly. Some suggested areas of possible improvement include:

- Better problem statements (which should be included in the mark schemes)
- Better stated hypotheses
- More appropriate recording of data to be collected
- Writing of the treatment of results
- Use of appropriate tense

The following are areas where some improvement is still needed:

#### Scenarios

- Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise, this should also be included in the teachers' mark scheme.
- It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PDs) be found.
- It is not recommended that students be left to generate the problems/scenarios on their own; however, in circumstances where this is done these problems/scenarios should be first vetted by the teacher to make sure that they are testable and chemistry based.

#### Hypothesis

- The hypothesis should be testable. Consider the following scenario:  
Scenario: Four bottles which had lost their labels are now labelled A, B, C and D. It is suspected that they are a sulfate, chloride, carbonate and a hydroxide. Plan and design an experiment to determine the identity of these solutions.  
A non-testable hypothesis would be: "the identification of four solutions that have lost their labels"  
A testable hypothesis would be: *The solutions are A — sulfate, B — carbonate, C — chloride and D — hydroxide.*
- As much as possible, the manipulated variable should be included in the hypothesis.
- The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used in the experiment should be outlined in the hypothesis.

#### Aim

- Students should be encouraged to specify the method or technique to be employed in the experiment.
- The aim must relate to the hypothesis as well as the problem statement.



### Procedure

- Special attention must be placed on the tense used in the procedure. Students should be taught to write the procedure in the present or future tense, any other tense is unacceptable.

### Expected Results/Data to be Collected

- This particular area is not well understood and hence it is recommended that the term 'data to be collected' be used rather than 'expected results'.
- In this section the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis will be recorded.
- The data to be collected may be presented in tabular form or as a description of specific data including units where appropriate.

### Some examples:

- When doing a titration, the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to be used as data collected.
- If chromatography is used, then the data collected should include the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin.  $R_f$  values should never be used as data to be collected since this is also calculated.

### Treatment/Interpretation of Results/Data

- It is recommended that the term 'results' be replaced by 'data' in the heading in an attempt to make it clear that this section looks at how the data collected will be used at proving or disproving the hypothesis.
- This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

### Some examples:

- In a scenario where students are trying to find out which brand of vinegar is more concentrated, the Interpretation of Data could be: *If Brand Y vinegar uses the least volume (Data to be collected) to neutralize  $x \text{ cm}^3$  of base then Brand Y is the most concentrated vinegar (stated in the aim), and therefore the hypothesis is supported.*
- In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *if both brands of ink contain the same number of components with the same colour and are the same distance from the origin (Data to be collected), then both brands of ink contain the same dye (stated in the aim) and therefore the hypothesis is supported.*

### Limitations/Precautions/Assumptions

- It is recommended that teachers assist students in distinguishing between these terms. While they can be related, the way that they are stated can make a significant difference.

### Sources of error

- This section should not be present in a PD laboratory activity since it refers to an activity that has been carried out.

### Other Comments

Teachers are encouraged to observe the following:

- All PD activities should be based on chemical concepts. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition or any other non-chemistry discipline will not be accepted.
- Students should undertake at least four PD activities over the two-year period. When this is not done students are at a disadvantage.
- Observations, calculations or diagrams should not be included in a mark scheme used to assess PD skills
- PD activities which have been carried out cannot be assessed for PD skills.
- Standard practical exercises which can be obtained from a chemistry text are inappropriate for PD activities.

Some examples include:

- *Plan and design an experiment to determine the effect of concentration on the rate of a reaction.*
- *Plan and design an experiment to determine the products of electrolysis of  $H_2SO_4$  using inert electrodes.*
- *Plan and design an experiment to determine the conditions of rusting.*

### Analysis and Interpretation

The Analysis and Interpretation (AI) skill continues to be one of the better assessed skills. However, to ensure continued improvement here are a few points to note:

- Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should not be assessed under AI.
- Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.
- Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that students understand what is required of them. In addition, calculations involving moles and volumes should be done from first principles using the unitary method. *CXC does not accept the use of the equation  $M_1V_1=M_2V_2$ .*

Create more explicit mark schemes:

- In the case of volumetric analysis, the concentration of reagents used should be provided in the mark scheme.
- In the case of qualitative analysis, the name of the unknown or the ions expected should also be included in the mark scheme.

### **Paper 032 – Alternative to SBA**

Syllabus References: A: 3.1, 3.3, 5.3, 8.1, 8.3; B2: 1.1, 4.1, 4.2, 7.1, 7.2, 7.3

#### Question 1

This question tested candidates' knowledge of energetics. Candidates were required to determine the heat change that occurs when solid  $KNO_3$  is dissolved in water. Few candidates were able to gain 16 or more of the 26 marks that were available.

Part (a) required candidates to:

- (i) State an apparatus suitable for measuring the  $50\text{ cm}^3$  of water.
- (ii) Read and record temperature readings from the thermometers given.
- (iii) Calculate the temperature changes that occurred.

Many candidates were unable to state suitable apparatus for measuring an accurate volume of solution. The most common responses were beakers and measuring cups. Appropriate answers were measuring cylinder, burette or pipette. The majority of candidates was able to record accurately the temperature readings, but although an example of calculating the temperature difference was given, many candidates did not follow the instruction and hence did not calculate the temperature change accurately.

Part (b) required candidates to:

- (i) Plot a graph of temperature against time.
- (ii) Calculate the maximum change in temperature and indicate on the graph how the answer was obtained.
- (iii) Determine whether the reaction was exothermic or endothermic with a given reason.
- (iv) Calculate the moles of  $\text{KNO}_3$  used, the heat change and the molar heat change.

Although the majority of candidates received full marks for the plotting of the graph, there were a few who only plotted the temperatures that they recorded. There were very few candidates who were able to indicate the maximum and minimum points on the graph. In addition, some candidates were unable to differentiate between exothermic and endothermic reactions and in many cases the definitions and explanations did not correspond.

Some candidates could not calculate the relative molecular mass of  $\text{KNO}_3$  and others were unable to determine the number of moles present. When calculating the heat change some candidates did not use the correct mass of solvent, in many cases they used the mass of the  $\text{KNO}_3$  or the combined masses of the  $\text{KNO}_3$  and the solvent. The correct calculation is:

$$\begin{aligned} Q &= m \times c \times \Delta T \\ &= 50\text{g} \times 4.2 \text{ Jg}^{-1}\text{°C}^{-1} \times 8.2 \text{ °C} = 1722 \text{ J} \end{aligned}$$

Many candidates were also unable to accurately calculate the heat change that occurred when 1 mole of  $\text{KNO}_3$  dissolved in the water. It must also be noted that candidates were unable to handle the units, many of them gave answers without units.

In Part (c), candidates were required to describe how they would prepare a saturated solution at 25 °C, however, it seems that most candidates misinterpreted the question and attempted to prepare a sample of  $\text{KNO}_3$ . The correct procedure is as follows:

1. Heat water to a temperature above 25 °C.
2. Add, with stirring, an excess amount of solid  $\text{KNO}_3$ .
3. Cool the solution down to 25 °C.
4. Filter the solution from the crystal.

## Question 2

This qualitative analysis item tested Syllabus Objectives B2-7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid R as well as its aqueous solution. A maximum of 10 marks were awarded for this question.

This question was poorly done. More than 70 per cent of the candidates scored five marks or less in this question and more candidates were awarded no marks for this question than on any other. Many candidates

seemed unfamiliar with making observations. Most of them rewrote the test or the inferences rather than the expected observations.

### Question 3

This question tested candidates' planning and designing skill. It was related to Syllabus Objectives B2-1.1, 4.1 and 4.2. Candidates were required to plan and design an experiment to determine which of metals A or B. is more reactive. The hypothesis, "Metal A is more reactive towards acids than Metal B", was provided. The question was poorly done. More than 75 per cent of the candidates who attempted the question scored a mark of five or less out of 12.

Most candidates recognized that the two metals had to be reacted with an acid but did not time the metal to be dissolved completely or measure the volume of gas collected within a given time. In addition, some candidates tried to identify the metal, while others did not know what an acid was. This was exemplified by the use of other chemicals such as sodium hydroxide and ethanol. There were some procedures given that did not relate to the hypothesis at all but candidates were able to capture the marks awarded for apparatus since that related to their procedure.

Candidates were not able to extract from their procedure the variables to control and those who did used vague terms such as the 'amount' of acid or metal rather than 'volume' of acid or 'mass' of metal. Identifying the data to be collected also proved difficult for most candidates and in many cases, they did not know how to use the data they wanted to collect to show if the hypothesis was valid or invalid.

Very few candidates were able to identify a possible source of error and although this was dependent on the chosen procedure. It should be noted that sources of errors should be factors over which the candidate has no control and which can affect the results, such as, the reaction time for starting and stopping a stop watch, and not inaccurate measurements which can be easily avoided by the candidate, such as, reading a burette incorrectly.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
SECONDARY EDUCATION CERTIFICATE EXAMINATION**

**JANUARY 2012**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

Overall, candidates' performance in this sitting of the examination declined compared with performance in 2011. There were some common areas on both Papers 01 and 02 that were challenging for the candidates. Additionally, gaps were apparent in candidates' understanding of concepts and this was evident in poor responses in several cases.

Candidates exhibited strengths in:

- reading scales of the instruments drawn
- plotting of points accurately, given axes.

However, they demonstrated weaknesses in the following areas:

- Depth in Responses Provided

Vague and incomplete responses were significant contributory factors to candidates' overall poor performance on the written papers. Candidates tended to be superficial— giving only parts of the required responses – they failed to provide adequate explanations or evidence for proposed claims. This led to very few cases in which full marks were awarded for questions or sections of questions.

- Writing and Balancing Equations

The ability to write balanced equations based on interpretation of reactions described as well as to recall common reactions was tested in several questions. The responses in this area were generally weak. The main deficiencies identified were:

- omission of or incorrect state symbols in ionic equations
  - wrong products for reactions that ought to be known based on the syllabus requirements
  - failure to balance equations, including balancing charge for ionic equations
  - writing chemical formulae.
- Defining and Discriminating among Concepts

Critical information was often omitted from definitions of concepts.

The point made in a previous report is worth repeating here. Candidates confuse concepts and principles that seem to be related in some way and fail to make distinctions regarding why some reactions take place while others do not. For example, candidates know the group trends in terms of reactivity for the groups. However, they fail to discriminate between how metals versus non-metals react. This was clearly seen in response to Question 4.

- Unfamiliarity with Procedures

It was evident that there was limited recollection and understanding of some common practical procedures such as testing for gases, identifying reducing and oxidizing agents, and determining the heat of solution. In many instances, essential steps were omitted or predicted results were incorrect.

Generally, it appears that candidates need more practice in writing ionic and molecular equations. This is likely to be more meaningful if the equations are linked to actual observations of chemical reactions where the association can be made between the observations, the use of the symbolic language of chemistry and the activities at the molecular level. Candidates are also encouraged to provide more specific and detailed explanations which show a deeper understanding of the processes occurring at the molecular level.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. Performance on this paper continued to be consistent with the performance of the last two years. The mean score earned by candidates was 52 per cent, with a standard deviation of 11.

### Paper 02 – Structured/Extended Response Questions

#### Question 1

Syllabus References: A: 6.14, 6.15, 6.16, 6.17, 8.1, 8.2, 8.3

The mean score for this question was 7 out of 25.

In Part (a), candidates were required to define *heat of neutralization* and to use titration data to construct a graph and determine the heat of neutralization. Candidates failed to include critical components in the definition such as *the reaction between an acid and a base* and *the production of 1 mole of water*, which resulted in several of them obtaining only one of the two marks for definition. Many candidates did not know the definition and attempted to describe the reaction for determining the heat of neutralization. A few candidates described heat of neutralization in terms of a temperature change instead of the heat produced for the reaction. Such responses included ‘the temperature change during a neutralization reaction or the heat taken to neutralize a solution’. Neither of these responses was awarded a mark.

Responses such as *the heat of neutralization is the energy change per mole of water during the neutralization reaction between an acid and a base* were awarded full marks as they reflected an understanding of a neutralization reaction and associated the heat change with the number of moles of water produced.

The majority of candidates was able to plot the graph using the given data but some failed to interpret the scale correctly and lost marks. Part (a) (ii) required the use of the graph to determine the end point of the reaction. Most candidates knew that the end point should be determined from the intersection of the ascending and descending lines on the graph. A few candidates plotted the points but failed to draw the lines and so failed to earn the mark for Part (a) (ii). For the most part, those who drew straight lines drew the best straight lines. A few candidates drew curves which ought not to have been the case for a graph showing heat of neutralization.

The calculation in Parts (a) (iii) and (iv) were fairly well done and candidates were able to obtain some of the marks for this section. The weaknesses in the responses to Parts (a) (iii) and (a) (iv) were:

- including the term ‘neutralization’ in the definition for heat of neutralization without explaining that this refers to a reaction between an acid and a base
- failing to add the mass of the acid and base
- failing to convert the mass from grams to kilograms.

### Calculation of Heat Change at the Point of Neutralization

$$\begin{aligned} \text{Volume of Acid from graph} &= 12 \text{ cm}^3 \\ \text{Total volume of liquid: } &12 \text{ cm}^3 + 25 \text{ cm}^3 = 37 \text{ cm}^3 \\ \text{Mass} &= 37 \text{ g} = 0.037 \text{ kg} \\ \Delta H &= 0.037 \times 4.2 \times 18 \\ &= 2.8 \text{ kJ} \end{aligned}$$

Part (b) tested candidates' knowledge of the laboratory experiment to determine the heat of solution of potassium nitrate and their ability to draw a suitable energy profile diagram.

In Parts (b) (i) and b (ii), very few candidates provided a suitable definition of the heat of solution. Many candidates used some concepts incorrectly or did not complete the responses. Many of them knew that making a solution involves the solute dissolving in the solvent. However, the majority of them failed to include the amount of solute (1 mole) in the definition. Hence, vague responses such as "the heat produced when a substance is allowed to dissolve in water or heat taken in by a solution" were awarded no marks. Neither of these addressed the amount of solute or formation of a solution from a solute and a solvent.

However, responses such as *energy change in which 1 g of solute dissolves in a particular volume of solvent to form a solution* were awarded one mark while *the heat of solution is the energy change when 1 mole of solute completely dissolves in a particular volume of solvent* was awarded two marks. Almost all the candidates were able to read the scales in Figure 2.

In Part (b) (iii), weak experimental skills and lack of procedural knowledge for determining the heat of solution were evident in candidates' responses. Given that the required procedure involved measuring temperature change, it was important that candidates included the use of insulated containers, measured the amount of water and the  $\text{KNO}_3$ , recorded the temperature of the water before mixing with the  $\text{KNO}_3$ , and recorded the final temperature given that the reaction was endothermic. It was also important that the correct sequence of steps was carried out for the reaction. Some of the more common incorrect steps are noted here.

- Omitting to weigh potassium nitrate and measure the volume of water
- Carrying out the experiment in a beaker instead of an insulated container
- Measuring the initial temperature as that after the solute was added to the solvent instead of the temperature of the water before adding the salt
- Describing the procedure for a titration to find heat of solution
- Suggesting that the 'highest temperature' instead of the *final temperature* should be measured although the reaction was endothermic
- Failing to identify the reaction as endothermic. This also led to incorrect energy profile diagrams in Part (iv).

A *good* response by a candidate which was awarded full marks is indicated below.

1. Weigh the amount of solid needed (8 g  $\text{KNO}_3$ ) using an electric balance.
2. Measure 50  $\text{cm}^3$  of water using a measuring cylinder.
3. Empty water in a polystyrene cup, insert a thermometer and record the reading when the temperature is constant.



4. Mix the 8 g of  $\text{KNO}_3$  in the water and stir vigorously using the thermometer.
5. Record the final temperature when the reading is constant.

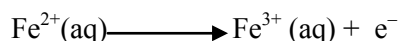
In Part (b) (iv), many candidates either failed to recognize the reaction as endothermic or did not recall the energy profile diagram for an endothermic reaction. Hence, some candidates drew the energy profile diagram for an exothermic reaction. A fair number of candidates were either unprepared for this part of the question or misinterpreted the question and drew the apparatus for conducting the reaction. In most instances, candidates lost marks for incorrectly labelling the axes as 'temperature' and 'time' instead of *energy* and *reaction pathway*.

Marks were awarded for a diagram with the correct shape for an endothermic reaction, correct labelling of the axes and correct identification of the heat of reaction or the activation energy. Both axes had to be correctly labelled in order to be awarded full marks.

Part (c) tested candidates' ability to identify reducing and oxidizing agents based on observed experimental data and to write balanced half equations to show oxidation of iron(II) nitrate. Overall, the performance of candidates on this section of the paper was poor. The majority exhibited significant challenges in writing balanced chemical equations, in particular, those that represent redox reactions. In most cases, their equations were incorrect as charges and/or atoms were not balanced. This section also drew on candidates' familiarity with practical procedures, such as conducting tests using specific oxidizing and reducing agents (Syllabus Objectives A:6.16 and 6.17). The responses suggested that there was a general lack of knowledge in this area which may be due to limited exposure to practical work.

Very few candidates were able to describe the expected observation for Experiment 3. This reaction was confused with the reaction between  $\text{Pb}^{2+}$  ions and aqueous potassium iodide. Hence, many candidates reported a yellow precipitate as the expected result. This response was not awarded any marks. Based on Table 2, the colour changes indicated that iron(II) nitrate was oxidized and potassium manganate(VII) reduced. Hence X was both an oxidizing and a reducing agent.

The correct half equation for the reaction with aqueous iron(II) nitrate required inclusion of state symbols. Teachers and candidates are reminded that state symbols are always required for ionic equations. The correct equation for Part (c) (i) is given below.



The correct response for Part (c) (iii) was a *brown precipitate*. Marks were also awarded for 'brown solution'.

Some common *errors* and *incorrect* responses are noted below:

- Confusion of what happens to the oxidizing and reducing agents versus the oxidized and reduced species in a redox reaction. Several candidates reported that  $\text{Fe}^{2+}$  was reduced to  $\text{Fe}^{3+}$ .
- Failure to explain why oxidation or reduction occurred in the case of  $\text{Fe}^{2+}$  and  $\text{MnO}_4^-$  respectively. Although some candidates were able to correctly identify  $\text{Fe}^{2+}$  as being oxidized and  $\text{MnO}_4^-$  as being reduced, they were unable to explain why this was so using oxidation numbers.
- There was an unawareness that some substances can function both as oxidizing and reducing agents.
- The  $e^-$  in the half equation was either missing or misplaced in many cases.
- There seemed to be greater familiarity with the reactions of potassium permanganate as an oxidizing agent than with  $\text{Fe}^{2+}$  as a reducing agent.

## Question 2

Syllabus References: A: 3.2, 3.3, 3.4, 4.5, 4.7, 7.1, 7.2, 7.3

Parts (a) to (c) tested candidates' knowledge of factors that affect the rate of reaction of hydrochloric acid on calcium carbonate. They were also required to interpret graphical data to calculate the mass of calcium carbonate used in the reaction. Part (d) tested candidates' knowledge of conductivity of ionic crystals.

The average mark on this question was 6 out of 15, with candidates scoring the complete range of marks, 0 to 15.

For Parts (a) and (b), almost all candidates were able to write the correct equation for the reaction between calcium carbonate and dilute hydrochloric acid. A few candidates had problems balancing equations even though this reaction has been tested on several occasions.

Most candidates correctly interpreted Figure 3 and gave the total volume of gas as  $20 \text{ cm}^3$ . There were a few instances where candidates were unable to interpret the graph and added the volume of gas produced at 1, 2, 3, 4, 5 and 6 minutes to obtain the total volume of gas produced.

The calculation of the number of moles of gas at STP as well as the mass of limestone proved relatively simple for the more able candidates. The weaker candidates tended to multiply the volume of gas by 22, 400 instead of dividing to obtain the number of moles of gas.

Generally, for Part (c), candidates were able to explain the rate of reaction and to identify two factors that affect the rate of reaction. However, factors were suggested which would not be relevant for this specific reaction (acid + carbonate), such as light, pressure and catalyst.

Almost all candidates correctly inferred that increasing the temperature would increase the rate of reaction. However, here again, the explanations for the increase in rate were vague and incomplete. These included responses such as "particles move faster at a higher temperature" or "particles have more energy".

The correct response required an explanation in terms of the effect of an increase in kinetic energy. As such an expected response was

*Increase in temperature causes particles to move faster resulting in more collisions of particles with minimum energy to react.*

Part (d) required the conditions for conduction in ionic compounds and the reasons for these. These were not fully understood by the majority of candidates. Many had the general understanding that charged particles are necessary for conducting electric current but there was not enough discrimination in terms of which particles are responsible for conduction in ionic compounds versus metals and the reason why conduction is not possible in ionic crystals even though ions are present. This was evident in *incorrect* responses such as:

- *Calcium carbonate will not conduct electricity in the solid state as it is not a metal and only graphite and metals conduct in the solid state.*
- *It will not conduct because no free or mobile electrons are present.*
- *It will not conduct because ionic compounds only conduct when liquid or molten.*

The *correct* response was:

*The ions of solid calcium carbonate are fixed within the lattice and there are no mobile ions to carry the current.*

### Question 3

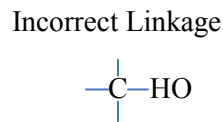
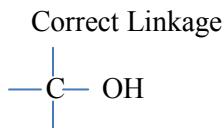
Syllabus References: B1: 3.1, 3.2, 3.5, 4.4, 4.5, 4.6, 4.7

Candidates were tested on the fractional distillation of crude oil, nomenclature and structure of esters and the structure and properties of polymers. The average mark on this question was 4 out of 15, with a significant number of candidates unable to score 8 or more marks. Too many candidates continue to perform poorly on organic chemistry.

For Parts (a) and (b), most candidates were able to obtain some of the marks for naming two sources of hydrocarbons. The most common responses were *petroleum and crude oil*. Only a few candidates named *peat, natural gas* and *coal* as other sources.

Most candidates were able to give the name of a fraction from the distillation of crude oil and give one use for one fraction. Some candidates lost marks for stating names of fractions such as 'kerosene' instead of giving its use.

In Part (c), the majority of candidates were unable to identify Compound X as *ethyl ethanoate* although many knew that it was an ester. Drawing the correct structures for the hydrolysis products of the ester was also challenging for many candidates. They named a range of organic products and many did not attempt to draw the compounds. Many candidates are still not paying attention to important details, for example, the valences of oxygen and carbon, when they draw the structures of organic compounds. A common error made with the structural formula of hydroxyl compounds such as alcohols and acids is that candidates link the -OH group to the carbon via the hydrogen instead of via the oxygen.



The correct products for Part (c) (ii) were *ethanoic acid and ethanol*.

For Part (d), a fair number of candidates were able to draw the structure of the polymer. However, the problems traditionally identified with polymer chemistry over the years continued to be evident in candidates' responses this year. These include the incorrect link between the monomers and failure to draw the ends of the polymer to correctly represent continuity. Several candidates were unable to give a suitable test to differentiate the monomer from the polymer.

The polymer required was starch and the structure is given below.



The expected observations for mixing the monomer and polymer with water is that the monomer will dissolve to give a colourless solution while the polymer is insoluble, forming a white suspension.

Candidates performed poorly on Part (e) as they *gave examples* of the polymer instead of *stating the type* of the polymer. The most common incorrect response was 'protein'. The correct response was *polyamide*. Polypeptide was also accepted. Most candidates were able to give a correct use of the polymer.

#### Question 4

Syllabus References: A: 2.8, 6.2, 6.3, 6.4, 6.15, 6.16; B2: 7.2

Candidates were tested on their knowledge of the periodic table and properties of elements from Groups 1, 2 and 7.

Performance on this question was also poor with a significant number of candidates scoring less than 5 of the 15 marks. This poor performance was primarily due to candidates' inability to write ionic and molecular equations and their seeming unfamiliarity with the reactions of the elements in Groups 1, 2 and 7.

The writing of the electron configuration in Part (a) was very well done by most candidates. However, some of the reasons for placing sodium in Period 3 were vague, for example, "It is placed in Period 3 because of the number of shells". A better response would be *It is placed in Period 3 because there are three shells*.

The reaction of sodium with water was fairly well known. Most candidates knew that hydrogen gas was a product of the reaction but the majority of them could not write the equation. A few candidates identified the gas as oxygen instead of hydrogen. Generally, those candidates who identified the gas as hydrogen were able to correctly test for the gas. The most common error with this test was the use of a 'glowing splint' instead of a *lighted splint*.

Generally, the reactivity of elements down the group was well known. Most candidates correctly predicted that the reactivity of Element X would be greater than that of potassium and sodium.

Part (a) (iii) was misunderstood or ignored by a number of candidates. The question tested knowledge on the chemical properties of the oxides of metals and non-metals. Specifically, it required a simple laboratory test to differentiate a solution of the oxide of Element Y (a metal) from that of a solution of the

oxide of sulphur. It was expected that the difference in pH would be used to make this distinction. Only the more able candidates got this correct. The solution of the metal oxide is basic while that formed when the oxide of sulphur is dissolved in water is acidic. A wide range of incorrect responses were submitted.

Part (b) (i) tested candidates' knowledge of the reactions of chlorine as an oxidizing agent. An ionic reaction was required for its reaction with aqueous iron(II) ions.

Perhaps because the previous part of the question tested group trends of metals, some candidates explained the reaction of chlorine and iron(II) sulphate in terms of chlorine's relative reactivity with respect to iron and overlooked the fact that chlorine was reacting in its capacity as an oxidizing agent. Candidates were confused about some concepts and this was evident in their failure to select the relevant concepts to answer questions.

Several candidates knew that iron(II) ions were oxidized while chlorine gas was reduced. However, many of them still confused oxidation and reduction. Some candidates were able to write the molecular equation but the majority of candidates was unable to write the ionic equations. Many of them seemed not to understand what were the species taking part in the reaction. The distinction between chlorine gas, chlorine atoms and chloride ions is still not clear and so various forms of chlorine were indiscriminately used in writing the equation. The balancing of charges was not well done even when the atoms were balanced. Candidates need help in understanding how to deduce state symbols for reactions, even in cases where reactions are unfamiliar.

The correct ionic equation for the reaction was



Part (b) (ii) tested candidates' knowledge of the group trends with respect to the relative oxidizing power of iodine and chlorine. Most candidates clearly knew that the reactivity of the halogens decrease down the group. However, here again, there was evidence that candidates were not discriminating between the reactivity of the elements in Group 7 and the reactivity of metals in the activity series. Hence, many candidates explained the difference in reactivity with iron(II) ions as "chlorine being higher than iron in the activity series and so it was able to displace iron". In doing so, they totally missed the point that chlorine and iodine are not metals. This speaks to a tendency to apply the principle of more active metals being able to displace less active metals from solution to the reactions of the halogens. While it is true that chlorine will displace iodine from a solution of the iodide, this is because chlorine is a stronger oxidizing agent and not because it is a more active metal. The relative oxidizing powers of iodine and chlorine were rarely considered in the responses to this question.

The expected response for this question was:

*As the group is ascended, the oxidizing power of the halogens increases. Iodine is not a strong enough oxidizing agent to oxidize iron(II) ions.*

### Question 5

Syllabus objectives: B2: 1.1, 1.2, 2.1, 2.2, 4.2

Part (a) tested candidates' knowledge of the extraction of iron from its ore, using the blast furnace. Part (b) tested their knowledge of the activity series of metals and the reaction of heat on the hydroxides and nitrates of metals high up in the series. Candidates performed poorly on this question. A significant number of them did not attempt this question or did not earn any marks.

Most candidates who attempted Part (a) managed to get a mark for stating the three substances put into the blast furnace – the *ore*, *coke* and *limestone*. However, many candidates who attempted to write the formula for the iron ore did so incorrectly.

Surprisingly, many candidates failed to recall the reactions taking place in the blast furnace that lead to the production of iron. Generally, candidates were able to explain that the coke was first converted to carbon monoxide and were able to write this equation. However, they could not explain why carbon monoxide was used as the reducing agent instead of coke. The most common error was the use of carbon dioxide to reduce the iron instead of carbon monoxide.

In Part (b), the equation for the action of heat on the hydroxide of M was better known than that for the action of heat on its nitrate. The most common errors were to give M a valency of 1 rather than 2 so that the formulae of the hydroxide and nitrates were given as MOH and MNO<sub>3</sub> respectively, to produce hydrogen when the hydroxide was heated and to produce nitrogen dioxide when the nitrate was heated.

In Part (b) (ii), most candidates recognized that metal M could be extracted by electrolysis of the molten ore. Candidates were not complete in their explanations for why this was so and gave vague responses such as “metal is very reactive”. The required answer was:

*M is more reactive than aluminium, since it can displace it from its aqueous solution and therefore it forms stable ores that require a strong method of reduction.*

In Part (c), many candidates gave physical rather than chemical properties of M. Most often quoted were the high melting point of M and its ability to conduct electricity.

### Question 6

Syllabus Objectives: C1 1.2, 1.3, 1.4

Parts (a) and (b) tested candidates' knowledge of the role of water, leavening agent and heat in making dough and required knowledge of equations for the actions of baking powder and yeast in making dough raie.

While many candidates seemed to have a general knowledge of the process of bread making, they incorporated limited reference of chemical concepts in their responses.

Most candidates described the role of water as ‘making it sticky or soft’. Only a few candidates used the terms *elasticity* or *viscosity*. With respect to the role of the leavening agent, candidates failed to mention aeration and generally, the responses did not relate the raising of the dough to the movement of the carbon dioxide. Candidates lost marks for not differentiating between the two processes for producing carbon dioxide from yeast and baking powder.

The majority of candidates mentioned the role that heat plays in cooking the dough and giving it the brown colour. However, hardly anyone associated the heat with the conversion of water to water vapour or to the expansion of carbon dioxide.

The ability to represent the various steps associated with making dough using chemical equations posed significant challenges for candidates. These equations were generally unknown. In most cases, chemical formulae were incorrectly written.

A good response for Part (a) should have addressed the following:

#### Role of Water

- Hydration of the protein to form a gluten – a viscoelastic complex
- Provision of moisture necessary for the fermentation of yeast
- Aeration of the dough during baking

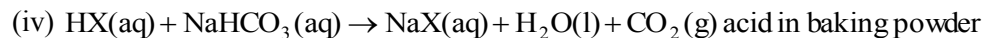
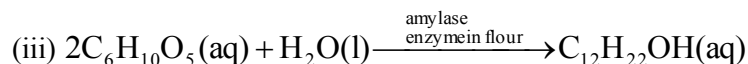
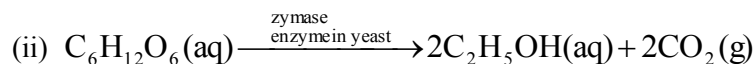
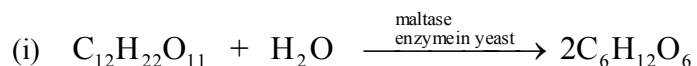
#### Role of Leavening Agents

- The CO<sub>2</sub> produced on fermentation of the yeast aerates the dough causing it to rise.
- The CO<sub>2</sub> produced from the reaction between NaHCO<sub>3</sub> and an acid aerates the dough causing it to rise.

#### Role of Heat (any two of the following points)

- Heat fixes the colour, taste and shape of the dough.
- Heat causes expansion of the CO<sub>2</sub> during baking which causes the dough to rise.
- Heat serves to destroy the yeast and prevents further fermentation.
- Heat serves to convert the water to water vapour which expands on heating due to its gaseous state. This further increases the volume of the dough.

For Part (b), any two of equations (i)–(iii) and equation (iv) were required.



Part (c), tested candidates' knowledge of the hydrolysis of starch and the effect of iodine on the products of hydrolysis.

Many candidates recognized that the lack of the blue-black colour with iodine was due to the absence of starch but most of them failed to provide a suitable explanation for what might have happened to the starch. Only a few candidates mentioned the possibility that starch may have been hydrolyzed and deduced that the end product would be glucose. Some candidates mentioned that sucrose and other

substances may be present. Some of them reported that starch was broken down to sucrose instead of glucose.

The expected response was that *moisture from the air would hydrolyse the starch at high temperatures to produce glucose. Hence, the resultant products would have a negative test with iodine.*

### Paper 03/2 – Alternative to SBA

#### Question 1

Syllabus References: A: 3.3, 3.4, 3.6, 3.7, 6.12, 6.25

This question tested candidates' knowledge of standard solutions, volumetric analysis and electroplating. The maximum mark available was 26. Most candidates were able to score at least 8 out of 26.

Part (a) required candidates to

- (i) describe the preparation of a standard solution of aqueous sodium hydroxide containing X grams in 250 cm<sup>3</sup>
- (ii) read the volume of acid used from the burettes, complete the table of results and determine the average volume of acid used for the titration
- (iii) identify a suitable indicator for the titration of NaOH and H<sub>2</sub>SO<sub>4</sub> and explain how the endpoint can be determined
- (iv) write a balanced equation for the reaction between NaOH and H<sub>2</sub>SO<sub>4</sub>
- (v) calculate the mass of NaOH that was used to make 250 cm<sup>3</sup> of the standard solution.

It appeared as if many candidates had never prepared or were never exposed to a standard solution. In most cases candidates described a titration. Three simple steps were required to prepare a standard solution of aqueous NaOH containing X grams in a 250 cm<sup>3</sup> solution:

- Weigh out the X g of the NaOH pellets.
- Transfer all to a clean 250 cm<sup>3</sup> volumetric flask.
- Make the solution up to the mark.

Although most candidates were able to read the burettes accurately, a few read it backwards. In addition, the majority of candidates was able to correctly identify and utilize the best two readings to calculate the average volume of H<sub>2</sub>SO<sub>4</sub> used. They were also able to identify suitable indicators but were vague about the colour change that would occur. It was expected that candidates would have stated the initial and final colours but most of them identified the final colour. Writing the balanced chemical equation for the reaction of the NaOH with the H<sub>2</sub>SO<sub>4</sub> presented a challenge for a few candidates; the most common mistake was writing the formula for sodium sulphate as NaSO<sub>4</sub> instead of Na<sub>2</sub>SO<sub>4</sub>. For the most part, the calculations were well done, with the majority of candidates able to calculate the relative formula mass of the NaOH.



Part (b) focused on the concept of copper plating and required candidates to

- (i) identify suitable materials needed for the electrodes as well as the electrolyte
- (ii) draw a diagram to show the arrangement of the apparatus needed
- (iii) state the type of reaction which occurs at the anode
- (iv) write balanced equations for the reactions at the electrodes.

For the most part, candidates seemed familiar with copper plating. Some of them, however, did not know what the anode should be; the most common *incorrect* answer was graphite. In addition, those who gave the incorrect electrode thought it was H<sub>2</sub>SO<sub>4</sub>. Although most candidates recognized that oxidation occurs at the anode, a few of them misinterpreted the question and stated that electrolysis occurs at the anode. It was expected that the equation at the anode and cathode would have been written as

$\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$  and  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$  respectively  
but most candidates neglected to include the state symbols.

### Question 2

Syllabus References: B2: 7.1, 7.2, 7.3

This was a qualitative analysis question in which candidates were required to deduce the observations that would be made when various tests were performed on an unknown solution Z. A maximum of 10 marks were awarded for this question and it was fairly well done. It should be noted however, that candidates should be aware of when there is a need to test any possible gases evolved as well as when it is more appropriate to state *no precipitate formed* rather than simply stating ‘no changes’ or ‘no reaction’. Also, most candidates were not aware that when copper turnings, followed by concentrated H<sub>2</sub>SO<sub>4</sub>, is added to a solution with nitrate ions that, in addition to the brown gas evolved which turns blue litmus red, the resulting solution will be blue in colour.

### Question 3

Syllabus References: A: 6.10, 6.8

For this question, candidates were required to plan and design an experiment to make lead chloride crystals from samples of lead nitrate and sodium chloride crystals. This question was poorly done. It was expected that candidates would recognize that the following steps were required for the procedure:

- Make separate solutions of both lead nitrate and sodium chloride.
- Mix both solutions together.
- Filter the resulting solution.
- Wash residue with cold water.

Instead, many candidates mixed both salts then tried to dissolve the mixture in water or dissolved one salt then tried to add the other one to it. Some candidates even thought that after mixing the crystals, they could heat the mixture until it melts forming lead chloride on cooling. Other common mistakes were neglecting to wash the residue and evaporating the solution rather than filtering it.

However, many candidates were able to gain marks for listing the pieces of apparatus necessary. This was due mainly to the fact that the apparatus was only dependent on the procedure the candidate proposed.

In Part (c), candidates were required to state one safety precaution and one experimental precaution that should be taken into consideration. The safety precaution proved much less challenging than the experimental precaution. Expected responses were as follows:

- Safety – wearing gloves etc.
- Experimental – excess sodium chloride could be used or ensure that the crystals are washed.

Part (d) required candidates to discuss two possible reasons why the yield is unlikely to be 100 per cent in preparing a sample of lead chloride. This part of the question was most challenging for candidates. The main points raised by candidates were the possibility of contamination of the lead chloride, difficulty in drying the sample, hence having a yield of more than 100 per cent and difficulty in transferring all the solid material. The point that there was a possibility of the filter paper tearing was also mentioned but it was not awarded any marks as this was considered to be due to poor experimental procedure.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**MAY/JUNE 2012**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The overall performance of candidates in the 2012 examination was slightly below that of previous sittings. Candidates performed best on Questions 4 and 6. The topic Pollution and the Environment was tested for the first time. There were no questions on which some candidates did not obtain full marks. From year to year, the report on performance in the CSEC examination highlights the areas that candidates seem to find difficult as well as the kinds of errors that they make. Yet, these weaknesses persist. Again, this report highlights the strengths and weaknesses in candidates' performance in the examination. Teachers and students are encouraged to use the information presented here to self-assess and so better prepare for the examination.

### Areas of Strength

Candidates performed fairly well in the following areas:

- Plotting points on a graph
- Factors that affect the rate of chemical reaction
- Redox processes that take place at the electrodes
- Some definitions, for example, oxidation and reduction and hard water
- Calculation of the quantity of electricity that passes through an electrolytic cell given current and time
- Homologous series for hydrocarbons
- Organization of elements in the Periodic Table
- Factors that cause corrosion
- Properties of water
- Strategies that can be used for preserving the environment

### Areas of Weakness

Candidates performed poorly on the following topics:

- Electrochemistry
- Qualitative analysis

### Factors Contributing to Poor Performance

- Writing and balancing equations and use of the correct mole ratio
  - Candidates were required to write chemical equations in all questions except Question 6. The major weakness was the incorrect formulae used throughout which stemmed from incorrect valencies. As a result, formulae were incorrectly written in equations resulting in marks being lost.
  - Candidates' failure to use the correct mole ratio when solving problems for Questions 1 and 2 also led to the loss of marks.
- Superficial rather than critical level of understanding of concepts
  - This was evident in the inability of candidates to provide the right reason for the claims made. For example, candidates lost marks because they could not provide a correct reason for the differences and similarities in the two graphs for the marble chips and powdered calcium carbonate in Question 1. Candidates seemed not to know how to select the required content to answer questions from their knowledge

base. Perhaps candidates need to be provided with more practice to answer questions that require analysis and explanations so as to improve their critical thinking skills.

- The tendency to be superficial in responses was also noted in the types of errors that candidates made. It was clear that many had an idea of the area but lacked the specific knowledge to provide complete or correct responses. For example, in Question 2, many candidates mixed up the changes required for the anode and the cathode in order to obtain pure copper from impure copper although they were credited marks for the changes required for the electrode. This weakness was also evident in the diagrams drawn for Question 1, and the general formulae for alkenes and alkanes in Question 3. The recommendation made in previous reports is worth repeating here. Teachers should engage students in developing deep and enduring understanding of concepts by using strategies that help students to connect ideas and understand principles. Classroom conversations on concepts should be encouraged and the correct use of terms during classroom conversations should be the norm. In addition, it is important that students be provided with visual images to represent concepts, for example, general formulae, dot-cross diagrams and arrangements of apparatus for experimental procedures.
- There is also a tendency to use terms loosely. For example, candidates referred to the corrosion of aluminium as rust, iron(III) ions as iron, and electrochemical series as reactivity series.
- Limited Understanding of Practical Procedures
  - It appeared that candidates were unfamiliar with conducting qualitative analysis and performed unsatisfactorily on Question 1.
  - Other practical procedures required in parts of Questions 2, 3 and 4 also proved to be challenging and too many candidates lost marks for these areas.

## DETAILED COMMENTS

### Paper 01 — Multiple Choice

This paper tested Sections A and B of the syllabus in the Knowledge and Comprehension profile dimension. Performance on this paper continues to be steady and satisfactory. The marks ranged from 0 to 60. The mean score was 51.5 per cent and the standard deviation was 11.39.

Candidates experienced the most challenges with items based on the following objectives:

- A.1.2 – Differences among the three states of matter
- A2.5 – Notation representing mass number, atomic number, oxidation number
- A.5.3 – Solubility of solids in water
- A.6.10 – Salt preparation based on solubility of salt
- B1.2.7 – Reaction of ethanol
- B2.1.2 – Reactions of metallic carbonates
- B2.4.2 – Order of reactivity

## Paper 02 – Structured Essays

### Question 1

Syllabus References: A: 7.1, 7.7, 7.3, 7.4; B2 7.1, 7.2, 7.3

Part (a) (i) tested candidates' knowledge of experimental procedure for collecting and measuring the volume of gas generated during a chemical reaction. Candidates were required to draw a suitable diagram for the reaction between dilute nitric acid and calcium carbonate, and for measuring the volume of gas (carbon dioxide) generated.

Most candidates attempted this section, but many diagrams were poorly drawn. This was mainly due to the following flaws:

- The experimental apparatus was not airtight making it impossible to collect the gas.
- The delivery tube did not extend into the reaction flask to allow for efficient collection of the gas.
- Many candidates drew diagrams of the distillation apparatus.
- There was no evidence of how the volume of gas could be measured.

Candidates were expected to draw a diagram showing a delivery tube above the reaction mixture in an airtight container and connected to a graduated gas syringe to measure the volume of gas to be collected.

In Part (a) (ii), candidates were required to plot the points obtained for the reaction of marble chips and dilute acid, using the same axes as for the powdered calcium carbonate which was already drawn. Candidates generally performed well, in that a significant number plotted six points accurately and most were able to get at least two of the three marks for this section.

The points that most candidates found difficult to plot were those for 30, 70 and 90 s. In some cases, the plotting of points, although accurate, were not done neatly. For example, large dots and asterisks were sometimes used. In a few cases, candidates drew the best-fit curve without plotting all points although this was not what the question required.

Part (a) (iii) tested candidates' ability to compare the two graphs for the reaction of marble chips and powdered calcium carbonate with dilute acid (in terms of steepness of the curves and the total volume of gas) and to account for the similarities and differences.

Most candidates were able to earn at least one mark here as they were able to identify similarities and/or differences in the two graphs. They were able to determine the steepness of the curves, relating this to the rate of the reaction and correctly identified the graph with the steeper slope as having the faster rate. However, many candidates were unable to provide correct responses for the similarities and differences.

In many responses, candidates gave the impression that powdered calcium carbonate and marble chips were different compounds. In looking at similarities, some candidates mentioned that both reactions had the 'same end point' rather than stating that *the same volume of gas was produced at the end of each reaction*.

The expected similarity in the two graphs was *the total volume of carbon dioxide produced was the same for powdered calcium carbonate and marble chips*. The expected reason was *the mass of calcium carbonate used was the same for both reactions*.

The expected difference was *the graph for the reaction with powdered calcium carbonate had a steeper slope than that for marble chips at the start of the reaction*. The reason being that *the rate of reaction for powdered calcium carbonate was faster and/or the total surface area of the powdered calcium carbonate was greater than that of marble chips*.

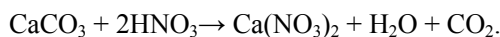
For Parts (a) (iv)–(v), candidates were required to write a balanced equation for the reaction between calcium carbonate and nitric acid and to calculate the theoretical yield of carbon dioxide from 1.8 g of calcium carbonate at RTP.

Most candidates were able to write the required equation but far too many were unable to write the correct formula for calcium nitrate and so did not produce a balanced equation. Candidates performed the calculation fairly well and were able to calculate correctly the molar mass provided they had the correct formula. However, they lost marks for failure to relate the number of moles of carbon dioxide to the number of moles of calcium carbonate.

### Common Errors and Incorrect Responses

- Formula for calcium nitrate was commonly written as 'CaNO<sub>3</sub>'.
- Molar mass of calcium carbonate calculated as 68 by adding the atomic masses of calcium, carbon and oxygen without regard to the number of each element (40 + 12 + 16) or 84 — by using the incorrect formula (CaCO<sub>2</sub>) for calcium carbonate.
- In a few cases, hydrogen gas was indicated as a product.
- Some candidates used the mole ratio between CaCO<sub>3</sub> and HNO<sub>3</sub> in their calculations instead of CaCO<sub>3</sub> and CO<sub>2</sub>.
- They also wrongly found use for Avogadro's constant.
- Many incorrect statements were used in the calculations. For example, candidates inferred that the gas formed was calcium carbonate.

The expected balanced chemical equation for Part (a) (iv) was



The expected calculation for Part (a)(v) was

Number of moles of CaCO<sub>3</sub> used was 1.8/100 = 0.018 moles  
From equation: 1 mole CaCO<sub>3</sub> produced 1 mole CO<sub>2</sub>  
Therefore: 0.018 moles CaCO<sub>3</sub> will produce 0.018 moles CO<sub>2</sub> gas  
1 mole of a gas occupies 24 000 cm<sup>3</sup>  
Therefore, 0.018 moles of CO<sub>2</sub> formed will occupy 0.018 x 24 000 cm<sup>3</sup> = 432 cm<sup>3</sup>.

In Parts (a) (vi)–(vii), candidates were required to provide an explanation for the difference in the theoretical yield of 432 cm<sup>3</sup> and the actual yield of 370 cm<sup>3</sup>, and to state two factors other than particle size that could affect the rate of reaction between the calcium carbonate and dilute acid.

Very few candidates were able to provide a suitable explanation for the difference between the theoretical and actual yields of carbon dioxide. Candidates were not awarded marks for sources of error that could have been due to faulty technique over which there was control. Most candidates were able to state one other factor that would affect the rate of reaction.

Most candidates identified temperature as another factor that could affect the rate of reaction.

### Common Incorrect Responses

Common incorrect responses that were not awarded marks were:

- parallax errors
- failure to measure the gas accurately
- time and pressure.

In Part (vii), candidates were not credited for mentioning surface area as the question informed them that the investigation dealt with particle size. Many candidates suggested light — even though the reaction is not a photochemical reaction — and pressure — even though neither of the reactants was in the gaseous state.

Candidates were expected to state factors such as temperature and concentration of the nitric acid.

Part (b) tested candidates' knowledge of the tests for common cations and anions. The cation was iron(III) ions and the anion, the chloride ion. Candidates were required to deduce the correct observations and inferences based on either the stated observation or inference given.

Candidates performed poorly on this part, with most of them scoring three or fewer marks from the total of eight.

### Common Incorrect Responses

- Test (i) — candidates inferred the presence of  $\text{Fe}^{2+}$ , Pb and Br instead of  $\text{Fe}^{3+}$ .
- Test (ii) — candidates indicated the formation of a white precipitate and disintegration of magnesium.
- Test (d) (iii) — candidates had difficulty writing a balanced ionic equation. Their attempts revealed incorrect state symbols and incorrect placement of charges.
- Test (iv) — the candidates inferred the presence of halide ions and some recognized the absence of only one of the possible three anions that were absent.
- Test (v) — candidates suggested yellow precipitate which was insoluble in excess aqueous ammonia and white fumes.

### Question 2

Syllabus References: A: 6.14, 6.15, 6.18, 6.24, 6.25, 6.27, 6.28

This question was based on a diagram depicting the electrolysis of aqueous copper(II) sulfate, using platinum electrodes. Candidates performed below a satisfactory level on this question.

In Part (a), candidates were required to determine the oxidation state of sulfur in  $\text{CuSO}_4$ . Many candidates were able to correctly deduce the oxidation state of sulfur in the compound as +6. However, a considerable number gave -1, 16, +4, -2 and -8.

For Part (b) candidates were told that hydroxide ions were discharged in preference to sulfate ions at the anode for this electrolytic experiment. They were expected to state a reason for this.

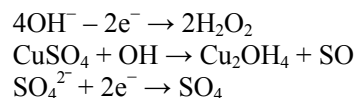
Many candidates were able to state correctly that the hydroxide ions are lower in the electrochemical series than sulfate ions. Some candidates, however, incorrectly suggested that the hydroxide ions are higher than the sulfate ions in the electrochemical series.

Part (c) required candidates to write a balanced equation for the reaction occurring at the anode of the electrolytic cell.



Although some candidates were able to write the correct half equation for the discharge of the hydroxide ion at the anode, it seemed as though many candidates were unfamiliar with the ionic half equation required or even the use of ionic half equations as electrodes of electrolytic cells.

### Common Incorrect Responses



In Part (d), candidates were required to state whether the reaction at the anode was an oxidation or a reduction and to give an explanation for their responses.

This section proved to be quite challenging for many candidates. The major challenges were as follows:

- There was confusion as to whether oxidation or reduction involved loss or gain of electrons.
- Candidates did not associate oxidation with the reaction at the anode.
- The reaction was described as *reduction* but the explanation given was loss of *electrons*.
- Some explanations involved an increase in oxidation state but there was no supporting evidence from the calculation of the oxidation states.

The expected response was *oxidation* at the anode due to loss of *electrons*.

In Part (e), candidates were required to state two changes that would occur in the electrolyte used. Some candidates stated the changes that would take place at the electrodes instead of in the electrolyte. Many candidates were able to state at least one of the changes expected.

The expected responses were:

- The colour of the electrolyte faded.
- The electrolyte became more acidic.
- Copper particles were dislodged from the electrode and were deposited in the electrolyte.

Part (f) required candidates to calculate the mass of the copper that would be deposited at the cathode with the passage of 5 amperes of current through the electrolyte for half an hour. Many candidates were able to earn at least one of the four UK marks awarded; however, several candidates failed to use

- the correct half equations for the reaction at the cathode
- an ionic half equation
- seconds when calculating quantity of electricity
- the mole ratio to relate the number of moles of electrons to the number of moles of copper produced.

The expected response was

Ionic equation	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$
Quantity of electricity	$5 \times (30 \times 60) = 9000 \text{ C}$
No. of Faradays	$9000 \text{ C} / 96500 \text{ C} = 0.093 \text{ F}$
No. moles copper formed	$0.093 / 2 = 0.047 \text{ moles}$
Mass copper formed	$0.047 \times 64 = 2.98 \text{ g}$

Part (g) required candidates to state how the apparatus depicted in Figure 3 should be modified at the anode, cathode and electrolyte, so as to obtain pure copper from impure copper.

Although many candidates were able to earn at least one of the three marks, too many candidates failed to earn maximum marks here. Some did not distinguish between pure copper and impure copper and stated that 'copper' would be at the anode and cathode.

The expected response was

At anode: impure copper

At cathode: pure copper

Electrolyte: no modification required

### Question 3

Syllabus Reference: B1:

This question tested candidates' knowledge of chemistry of alkanes and alkenes, and the reaction of alcohols and acids to produce esters.

Part (a) (i) was very well done and most candidates correctly identified A as belonging to the alkenes and B to the *alkanes*. The more common errors were:

- Incorrect spelling of alkane and alkene
- Stating the specific names of the compounds (propene and butane) instead of stating the names of the homologous series
- Mixing up the series names and classifying A as alkane and B as alkene

In Part (a) (ii), candidates were required to give the general formulae for alkanes and alkenes. Surprisingly, this proved to be difficult for many candidates. The common errors were:

The variable n was represented as indices such as  $C^nH^{2n}$  instead of  $C_nH_{2n}$

Incorrect inclusion of plus signs in the general formulae such as  $C_n + H_{2n}$  and  $C_n + H_{2n+2}$

Stating the chemical formula instead of the general formula

For Part (a) (iii), candidates were required to state one condition for the chlorination of B and to draw fully displayed structures for the products of the chlorination of A and B.

Most candidates correctly identified light as the necessary condition of the chlorination of the alkane. Common incorrect responses were heat, temperature, pressure, darkness, dim light and catalyst.

For Part (iii) b), common incorrect responses included:

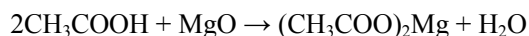
- An increase in the carbon skeleton
- Chlorine instead of a carbon skeleton
- Products having branched carbon skeletons
- Products containing double bonds
- Bromine instead of chlorine being the atom added or substituted
- Chlorine atoms added to Carbons 1 and 3 instead of Carbons 1 and 2 for the reaction of A

For Part (b), the correct response for the role of potassium was *oxidizing agent*. However, many candidates incorrectly indicated that the dichromate was acting as a catalyst in the reaction.

In response to providing a chemical equation for Part (b) (ii), the following incorrect responses were noted:

- Candidates had problems writing the correct formula for ethanoic acid, magnesium oxide (represented as  $\text{MgO}_2$ ) and magnesium ethanoate.
- In a few instances, hydrogen and oxygen were included as products in the reaction instead of water.
- Equations were unbalanced.
- Potassium dichromate was included as a reactant.
- Hydrogen represented as h instead of H.

The expected equation was



The gas formed when Compound E (carboxylic acid) reacts with calcium carbonate is carbon dioxide. In Part (b) (iii), candidates were required to give a test for carbon dioxide and were expected to give the limewater test. This test gives a white precipitate when carbon dioxide is bubbled through calcium hydroxide solution (limewater).

#### **Common Incorrect Responses**

- The wrong tests were given. These included tests for hydrogen gas, with litmus paper, and breathalyzer tests.
- Lime water was incorrectly identified as lime soda, soda lime, lime juice, calcium carbonate and sodium hydroxide.
- Physical tests were used instead of chemical tests.

In Part (b) (iv), candidates were required to name the homologous series to which J belongs. The correct homologous series is Esters. A significant number of candidates identified the series as 'organic acids', 'carboxylic acids'. Less common responses included 'ester linkage', 'polyester', 'esterfication', 'amides' and 'amines'.

#### Question 4

Syllabus References: A: 2.7, 2.8, 4.1, 4.2, 4.5, 6.1, 6.3

Candidates were tested on the uses of radioisotopes, the arrangement of elements in the periodic table, ionic bonding and predicting properties of unknown elements based on their electronic configuration. Candidates were provided with four unknown elements, P, Q, R and S, and their electronic configurations:

P: 2, 7    Q: 2, 8, 2    R: 2, 8, 6    S: 2, 8, 8, 2

In Part (a), candidates were required to state two other uses of radioisotopes (apart from Uranium-235 which is used for energy generation) and explain the importance of each.

It appeared that some candidates failed to read the question since they wrote the importance of energy generation, which was already given in the question. Additionally, many candidates were unable to explain the importance of either one or both of their chosen uses. However, many candidates had information on a number of current uses of radioisotopes.

The expected response included

- Carbon-14 dating — a method of finding out the age of once-living, archaeological specimens that are no more than 50 000 years old.

- Tracers — substances containing very small quantities of radioisotopes to allow for easy detection and measurements often used to study chemical changes within living organisms.
- Radiotherapy — used to treat cancer cells because it destroys cancer cells more rapidly than normal cells.
- Pacemakers — some artificial pacemakers are powered by the energy produced by radioactive decay.

In Part (b) (i), candidates were required to outline the criteria for placing elements in the Periodic Table, and state the appropriate group and period for each of the unidentified elements, P, Q, R and S.

Many candidates wrote much more than what was required, and included in their answers criteria based on atomic number, metallic and non-metallic properties, etc. The majority of candidates were able to list the correct group and period for the four unknown elements.

The number of *valence electrons* (that is, electrons in the outer shell) determines the group number, and the number of *shells* determines the *period* number. Hence the correct placements were:

Element	Group	Period
P	7	2
Q	2	3
R	6	3
S	2	4

In Part (b) (ii), candidates were required to deduce whether the compound formed between P and Q was ion or covalent, use *dot-cross* diagrams to show the bonding in the compound, and write its formula.

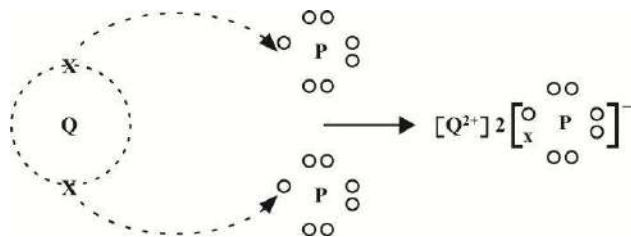
Many candidates correctly deduced that the bonding was ionic. [This is strictly true for the metals in Groups 1 and 2 combining with the non-metals in Groups 6 (16) and 7 (17)]. Many candidates showed the transfer of both valence electrons from one atom of Q to two atoms of P, that is, one electron to each P atom. However, some candidates did not show the electron configuration or the charge of the ions that were formed after the transfer of electrons. Many candidates correctly indicated that the formula for the compound formed between Q and P was  $QP_2$ .

### Common Incorrect Responses

- Incorrectly showing Q and P sharing electrons in covalent bonding
- Showing both electrons of Q being transferred from one atom of P
- Giving the incorrect charge on the cation of Q as  $Q^+$  instead of  $Q^{2+}$

Candidates were expected to state that the bonding between Q and P is ionic.

The ionic bonding diagram should show both valence electrons from Q being transferred to the valence shells on two atoms of P, resulting in a  $Q^{2+}$  cation and two  $P^-$  anions.



The compound formed between Q and P must be neutral and so two  $P^-$  anions are required to balance out the  $2+$  charge on  $Q^{2+}$ , i.e.  $(+2) + (2 \times -1) = (+2) + (-2) = 0$ . The correct formula is therefore  $QP_2$ .

In Part (b) (iii), candidates were asked to compare the reactivity of elements Q and S with dilute hydrochloric acid, and write a balanced equation for one of the reactions.

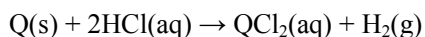
A number of candidates identified element Q as magnesium and element S as calcium and then made use of the reactivity series to state that calcium was more reactive to magnesium, rather than comparing the reactivity based on trends in Group 2. Many candidates correctly stated that reactivity increased down the group, and so element S would be more reactive. However, some did not state which of the elements was lower in the group.

### **Common Incorrect Responses**

- Q is more reactive than S.
- $Q + 2HCl \rightarrow QCl + H_2$ .
- A number of candidates had water as a product of the reaction.

Candidates were expected to state that Q and S are in the same group and that element S is lower down in the group and is therefore more electropositive and more reactive; hence, element S would react more vigorously with dilute hydrochloric acid.

The correct equation (using either Q or S) is:



### Question 5

Syllabus References: B2: 1.1, 4.1, 6.1, 8.1; A: 6.8

This question tested candidates' knowledge of corrosion of metals, with specific reference to aluminium and iron.

In Part (a), candidates were required to state the property of metals that is responsible for corrosion and describe the process of corrosion.

Many candidates correctly stated that oxygen (from the air) and water (moisture, rain) were necessary for corrosion to take place, but could not identify the property of the metal that is responsible for corrosion.

### **Expected Responses**

Metals corrode because they are reducing agents, and they react readily with other elements such as oxygen and sulfur in the presence of moisture to form oxides and sulfides, respectively. (Note: since metals are reducing agents, they will react with oxidizing agents). Two common oxidizing agents are oxygen (from the atmosphere) and sulfur (from natural deposits).

For Part (b), candidates were required to write three relevant chemical equations for the corrosion of iron.

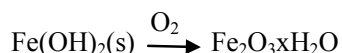
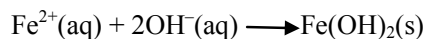
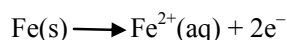
### **Candidates' Performance**

The majority of candidates were unable to write three correct equations.

### Common Incorrect Responses

- $\text{Fe} + \text{H}_2\text{O} \rightarrow \text{FeO}$
- $\text{Fe} + \text{O}_2 \rightarrow \text{FeO}$
- $\text{Fe(s)} + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$
- $\text{Fe}^{2+} + \text{O}_2 \rightarrow \text{FeO}$

The equations were expected to show the oxidation of elemental iron (oxidation state = 0) to the +2 state in iron(II) hydroxide ( $\text{Fe(OH)}_2$ ), and then further oxidation to the +3 state in hydrated iron(III) oxide ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ).



In Part (c), candidates were required to explain why the corrosion of aluminium is beneficial while the corrosion of iron is not. Many candidates stated that the corrosion of aluminium is beneficial since it formed a protective layer, but did not indicate what the protective layer was.

Many candidates referred to aluminium oxide as rust. They discussed corrosion in general but did not discuss the specific cases of iron and aluminium, which were required.

### The expected responses were:

*Aluminium* — Aluminium reacts with oxygen from the air to form aluminium oxide ( $\text{Al}_2\text{O}_3$ ). This aluminium oxide layer sticks to the surface of the metal, and is impervious to water. This prevents water from attacking the metal below the oxide surface layer. Hence, corrosion of aluminium protects it from further corrosion, and makes it very stable.

*Iron* — Corrosion of iron leads to the formation of a *flaky* layer of rust. Once this flaky layer of rust forms, it does not adhere to the metal surface but it easily falls off and exposes fresh surfaces of the iron for further rusting. This corrosion of iron causes a continuous eroding of the metal surface, which leads to weakening of the metal, and could cause structural damage.

For Part (d), candidates were required to explain why it is not advisable to prepare acidic foods in aluminium pots.

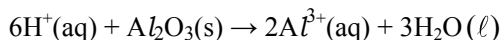
The majority of candidates indicated that the acid in the foods would react with the aluminium metal, but many did not realize that the acid would have to first react with the oxide layer in order to expose the metal. The majority of candidates indicated that the product(s) of the reaction would be harmful or poisonous.

### Common Incorrect Responses

Aluminium would react vigorously with the acid in the food.

Aluminium would react with the acid producing hydrogen, which would then explode and cause harm.

Candidates were expected to state that the acid in the food will react with the aluminium oxide layer:



to form aluminium salt(s) and water. The removal of the protective oxide layer exposes the reactive aluminium metal which will continuously react with the acid in the food, and cause degradation/corrosion of the aluminium metal. This causes aluminium ions to enter the food and eventually the body. Aluminium ions have been linked to diseases such as Alzheimer's.

### Question 6

Syllabus References: C2: 3.8, 3.9, 3.10, 3.12

This question tested candidates' knowledge of the properties of water and how they relate to the functions of water in maintaining life. The average mark on the question was 6.6 out of 15 or 44 per cent. Thirty-five per cent of candidates were able to score 8 or more of the 15 marks.

Candidates performed poorly on this Part (a). Many of them were unable to correctly identify the properties of water but some could state functions that are related to maintaining life. A misconception of many candidates is that oxygen in the water molecule is the oxygen that is available to aquatic organisms.

### **Common Incorrect Responses**

- Water is necessary for drinking.
- Water is necessary to bathe, cook and clean.
- Water evaporates, condenses as clouds and falls as rain in the hydrological cycle which is important to life.
- Rainfall cools the earth.
- Water is made up of hydrogen and oxygen, and the oxygen is used in respiration in living things.
- Water is clear/transparent.

The expected responses were:

Water is a solvent which dissolves substances essential for metabolic processes in living things. The high specific heat capacity of water helps living things to maintain a constant body temperature when ambient temperatures rise.

Water is not very volatile (has a high heat of vaporization) so that evaporation causes cooling of the living thing.

Water's density decreases on freezing so that bodies of water freeze at the top allowing life to continue underneath the ice.

The following points were also credited:

- Water keeps the body hydrated/prevents dehydration.
- Water provides a habitat for aquatic organisms.

Part (b)(i), tested candidates' ability to define the term *hard water*. Candidates performed poorly on this part of the question. A very large number of them defined *hard water* as ice.

### Common Incorrect Responses

- Hard water contains dissolved impurities/minerals/ions.
- Hard water contains dissolved calcium and/or magnesium.

The expected responses were:

- Hard water is water which contains dissolved calcium and/or magnesium salts/ions.
- Hard water is water which contains  $\text{Ca}^{2+}$  or  $\text{Mg}^{2+}$  ions.
- Hard water is water which lathers with difficulty.

Part (b)(ii) tested candidates' knowledge of methods used to soften hard water and their ability to write an equation to represent the process.

Candidates who defined hard water as 'ice' and then stated that 'hard water is softened by heating' were not credited. Many candidates could not write a balanced equation for the softening of water by heating or adding sodium carbonate.

### Common Incorrect Responses

- Water is softened by chlorine/bleach.
- Water is softened by adding lime/calcium carbonate.
- Water can be softened by adding acid:  
 $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
- Water is softened in the purification process: passed through a sand filter, put in a settling chamber.

The expected responses were:

- Hard water can be softened by heating/boiling.  
 $\text{Ca}(\text{HCO}_3)_2(\text{aq}) \rightarrow \text{CaCO}(\text{s}) + \text{CO}_2(\text{g})$
- Hard water can be softened by adding sodium carbonate/washing soda.  
 $\text{CaSO}_4(\text{aq}) + \text{Na}_2\text{CO}_3(\text{s}) \rightarrow \text{CaCO}_3(\text{s}) + \text{Na}_2\text{SO}_4(\text{aq})$
- Hard water can be softened by using ion exchange resin.  
 $\text{Ca}^{2+}(\text{aq}) + 2\text{Na}-\text{X}(\text{s}) \rightarrow \text{Ca}-\text{X}(\text{s}) + 2\text{Na}^+(\text{aq})$

Part (c) tested candidates' knowledge of methods that individuals and communities can use to manage and maintain the environment. Most candidates were able to correctly state methods which could be used to manage and maintain the environment.

### Common Incorrect Responses

- Pass laws to prohibit...
- Build water treatment plants

The expected responses were:

- Conserve resources by
  - reducing the amount of solid waste produced
  - reusing articles such as glass bottles and plastic containers
  - recycling substances such as aluminium, iron, glass and paper



- Conserve water by
  - turning off the tap/shower when not using
  - fixing leaks
  - using a cup of water to brush teeth
  - using a bucket to wash the car
  - using wash water to water plants
- Conserve energy by
  - turning off lights when not in the room.
  - reducing energy consumption by carpooling/walking instead of using a car to go to a nearby destination.
  - using alternative sources of energy, for example, solar power.
- Properly dispose of garbage in sealed bags/covered bins/sanitary landfills/do not litter.

Also credited were:

- Organize clean-up days/keep waterways clear of garbage.
- Plant trees.
- Do not burn garbage.

### **Paper 032 – Alternative to School-Based Assessment (SBA)**

Syllabus References: A: 1.1, 1.2, 5.2, 5.3

#### Question 1

This question tested candidates' knowledge of states of matter, in particular, the cooling curve as well as separation of mixtures by filtration and calculation of percentage composition by mass. The maximum marks available were 26 and the majority of candidates gained 15 or more.

Part (a) required candidates to

- (i) read and record temperature readings from the thermometers given
- (ii) plot the temperature readings against time on the axes provided and draw a smooth curve through the points
- (iii) interpolate from the graph the temperature at a given time
- (iv) deduce the physical state of the substance at a given time
- (v) compare the arrangement of particles at two different stages of cooling.

Most candidates read all the thermometers correctly although a few of them were challenged in cases where the thermometer readings were not whole numbers. The graph was generally well done but some candidates had difficulty using the scale provided and some used rulers to join the points rather than drawing a smooth curve. Many candidates could not interpolate the temperature readings of the graph at a given time but this may have been due to their inability to utilize the scale effectively. It appears that the concept of the melting point was not fully understood in that some candidates did not recognize that the constant temperature was indeed the melting point.

Candidates were asked to indicate the physical state of the substance while in the plateau region of the curve. Very few recognized that it would be a mixture of both solid and liquid, most candidates said one or the other and a few used terms such as 'semi-solid'.

Determining and comparing the arrangement of the particles at two different time intervals of cooling proved difficult and most responses were very vague. It was evident that not many candidates were able to identify that the substance was transitioning from liquid to solid. Some candidates incorrectly described arrangements which suggest that the substance was transitioning from a solid to a liquid and in a few cases, the arrangement for gases was described.

In Part (b), candidates were presented with a known mass of a mixture of sand and copper(II) sulfate to which they would add water, filter and evaporate the filtrate to dryness. At the end of the experiment they were required to identify what they would observe in the beaker and on the filter paper; read the balances and determine the mass of the residue and the resulting mass from evaporation; calculate the percentage of mass of each component of the mixture and give a reason why the sum of the percentage masses was different from 100 per cent.

When asked to describe what can be observed in the beaker at the end of the experiment, some candidates described the contents of the beaker at the beginning of the experiment. A typical answer would have been *a blue solution of copper sulfate with sand at the bottom* rather than just a blue solution. However, the majority of the candidates did recognize that sand would be in the filter paper.

Again, the reading of the scale on the balance presented some difficulty. Each interval on the scale represented 0.2 grams. The correct answer would have been *6.3 grams* but instead, responses like 6.15 and 6.25 grams were given for the mass of the residue. In addition, a large number of candidates did not recognize that they were required to subtract the mass of the watch glass in order to calculate the mass of the residue. Similar mistakes were made when asked to calculate the mass of solid.

In calculating the percentage mass of the sand and copper(II) sulfate in the mixture, the most common error seen was that candidates did not use the original mass of the mixture that was given before the experiment started. Several candidates incorrectly used the sum of the mass of the residue and solid calculated. Very few of them were able to suggest why the percentage masses of the two components determined from the experiment did not add to 100 per cent. Rather than suggest that some of the copper sulfate may have been lost in the sand or some of the solid was lost during transfer, some candidates suggested that the mass of the watch glass was subtracted.

## Question 2

Syllabus References: B2: 7.1, 7.2, 7.3.

This question focused on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid, R, as well as its aqueous solution. Overall, this question was poorly done with more than 50 per cent of the candidates scoring three or fewer of the ten marks.

The majority of candidates seemed not to be familiar with qualitative analysis — the tests as well as making observations. For example, when given that the addition of sodium hydroxide dropwise, then in excess, implied that  $\text{Zn}^{2+}$ ,  $\text{Al}^{3+}$  or  $\text{Pb}^{2+}$  ions were present, some candidates simply stated that a precipitate was formed without indicating that it was soluble in excess, identifying the colour, or stating that a white solution was formed. In addition, when told that the addition of dilute nitric acid to the residue followed by testing the gas with filter paper dipped in acidified potassium dichromate led to the deduction that sulfur dioxide gas was given off, it was apparent that some candidates did not know that they were expected to observe when a gas was given off. The correct response would have been a *pungent or choking smell* or an *irritating odour*, however, effervescence was accepted.

### Question 3

Syllabus References: A 5.1, 5.4

This question tested candidates' planning and designing skill. Candidates were asked to plan and design an experiment which could be used to determine whether water-soluble, black ink from two different manufacturers consist of the same components. They were required to suggest a hypothesis, procedure, apparatus and materials, data to be collected, variables to control, as well as to discuss the results as it related to the hypothesis. Candidates performed unsatisfactorily with the majority earning six or fewer of the 12 marks.

The language of a hypothesis is important. Most candidates wrote aims or questions for hypotheses. It was expected that some of the candidates would recognize that the procedure should be based on chromatography. Some candidates did but other popular methods were based on dissolving the inks, titration and distillation. However, candidates who suggested chromatography as the method of choice had difficulty describing the process. Some suggested placing the ink in the beaker but the common mistake was allowing the dot of ink to be immersed in the solvent. Although it was expected that candidates would use either filter paper or chromatography paper, many different types of paper were suggested, such as litmus, cobalt, carbon, calligraphy and tissue paper. In the procedure, candidates earned marks for placing the spot on the paper above the solvent level, allowing time for separation and for being able to make a comparison between the two inks. Some candidates also had difficulty determining the apparatus they would need to carry out their procedure.

For the data to be collected, marks were awarded for the number of spots, the colour of the spots and the distance they travelled. Most candidates stated two of the three points; the one most commonly neglected was the number of spots. Regardless of the procedure given, the amount of ink used was the most popular answer for the variable to control.

For the discussion, again, only the colours and distance travelled were mentioned and the number of spots was omitted. Also, candidates were expected to use diagrams to illustrate their discussion but in many cases the diagrams did not complement the discussion but were used independently.

## **Paper 031 – School Based Assessment (SBA)**

### Planning and Designing (PD) Skill

Generally, the standard of the laboratory exercises assessed for the Planning and Designing (PD) skill has declined this year as there was a 10 per cent increase in exercises with unsatisfactory PD skills. This was due mainly to the noticeable increase in the number of standard practical exercises presented this year. Standard practical exercises are those which can be obtained from a chemistry text, and are therefore deemed inappropriate for PD activities, for example:

Plan and design an experiment to determine

- the effect of concentration on the rate of a reaction
- the products of electrolysis of  $\text{H}_2\text{SO}_4$  using inert electrodes
- the conditions for rusting.

Various formats have been used for the presentation of PD skills, some of which make it very difficult to moderate. Below is a suggested format which may be useful to both teachers and students:

- Scenarios
  - Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise. These should also be included in the teachers' mark scheme.
  - It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PD's) be found.
  - It is not recommended that students be left to generate the problems/scenarios of their own; however, in circumstances where this is done these problems/scenarios should be vetted by the teacher to make sure that they are testable and chemistry based.
- Hypothesis
  - The hypothesis should be testable.
  - As much as possible the manipulated variable should be included in the hypothesis.
  - The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used on the experiment should be outlined in the hypothesis.
  - The language of the hypothesis is also important. It should be stated like an aim.
- Aim
  - Students should be encouraged to specify the method or technique to be employed in the experiment.
  - The aim must relate to the hypothesis as well as the problem statement.
- Apparatus/Materials
  - Traditionally, most teachers require that the apparatus and materials be placed before the procedure in keeping with the format used for the laboratory exercises. Please note that PD skills in this section may also be written and accepted after the procedure as it is a good practice to identify from the procedure the list of apparatus and materials required. This is better done while planning the experiment rather than writing a procedure to fit the apparatus and materials.
  - Students should also be encouraged to pay special attention to this section since a mark is deducted for every piece of essential apparatus omitted as determined by the suggested procedure.
- Procedure
  - Special attention must be given to the tense used in the procedure. Students should be taught to write the procedure in the present or future tense; any other tense is unacceptable.
  - As mentioned before, this section may also be placed before the apparatus and materials section.

- Variables
  - It is recommended that the variables; manipulated, control and responding, be placed immediately after the procedure. Students should be encouraged to list these variables separately as this is an exercise in critical analysis.
- Data to be collected
  - Some students refer to this section as ‘Expected Results’. It is recommended that the term *Data to be Collected* be used rather than ‘Expected Results’.
  - In this section, the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis should be recorded. Please note that actual values should not be recorded in the tables.
  - The data to be collected may be presented in tabular form or as a description of specific data including units, where appropriate.
- Some examples
  - When doing a titration, the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to be used as data collected.
  - If chromatography is used, then the data collected should include the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin.  $R_f$  values should never be used as data to be collected since this is also calculated.
- Treatment/Interpretation of Data
  - Again it is recommended that the term *data* be used rather than ‘results’ in the heading in an attempt to make it clear that this section looks at how the data collected will be used to prove or disprove the hypothesis.
  - This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

Some examples:

- In a scenario where students are trying to find out which brand of vinegar is more concentrated, the Interpretation of Data could be: *If Brand Y vinegar uses the least volume (Data to be collected) to neutralize  $X \text{ cm}^3$  of base then Brand Y is the most concentrated vinegar (stated in aim), and therefore the hypothesis is supported.*
- In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *If both brands of ink contain the same number of components with the same colour and are the same distance from the origin (Data to be Collected), then both brands of ink contain the same dye (stated in the aim) and therefore the hypothesis is supported.*

- Limitations/Precautions/Assumptions
  - It is recommended that teachers assist students in distinguishing between these terms. While they can be related, the way that they are stated can make a significant difference.

Please note that *Sources of Error* should not be presented in a PD lab since it refers to a lab that has been carried out.

In addition, teachers should also be aware of the following:

- All PD activities should be based on chemical concepts. Although scenarios may involve Biology, Physics, Food & Nutrition, the focus of the activity must involve chemical concepts related to the Chemistry syllabus.
- Students should undertake at least four PD activities over the two-year period. When this is not done, students are at a disadvantage.
- Some PD exercises submitted for SBA were assessed for other skills as well. This suggests that the exercise was carried out and so cannot be moderated for PD skills. This places the students at a serious disadvantage.
- While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does indeed suit all the PD activities submitted. If not, each PD activity should have a separate mark scheme.

To assist in improving the standard of PD exercises, some ideas for possible PD activities adapted from Jacques (2006) are suggested below.

1. Comparison of homemade vinegar against store-bought vinegar.
2. Best solvent to remove ink stain from a shirt.
3. Comparison of the heat content of alcohols (how the number of carbon atoms in the alcohol affect the heat of combustion)
4. Which water source is best for rusting
5. Vitamin C content in different brands of Vitamin C tablets or fruit juices
6. Electroplating a coin: which would deposit greater amount of metal for a given quantity of electricity — univalent or divalent metal ion. Please note that items like leather belts or sandals should not be used here.
7. Acidity in green-skinned fruits compared to ripened fruits
8. Comparison of different brands of baking powder
9. Comparison to determine if different brands of black marker contain the same ink
10. Comparison of a recently discovered fuel with gasoline (existing fuels)
11. Comparison of hardness of water using soap
12. Comparison of melting point of pure and impure substances, for example, pure stearic acid and stearic acid with a small amount of glucose added
13. Eating peanuts from Brand A makes one thirstier than eating peanuts from Brand B

*Please find below more detailed information as examples for number 4 and number 11.*

4. – *Scenario:*

*Mrs Jones and Mrs Thompson both bought steel burglar bars for their homes. Mrs Jones lives near the beach while Mrs Thompson lives inland. Three years later Mrs Jones's bars have more rust than Mrs Thompson's. Mrs Jones believes that the rust is due to the exposure of the burglar bars to water from the sea. Plan and design an experiment to determine whether sea water accelerates rusting in steel.*

*Hypothesis:*

*Iron rusts faster when exposed to salt water than fresh water.*

*Aim:*

*To investigate the effect of salt water as opposed to fresh water on iron by measuring the mass of iron produced.*

*Variables:*

*Manipulated – types of water*

*Controlled – volumes of water used and the time exposed to air*

*Responding – mass of rust*

11. – Scenario

*Debbie went in Dominica and while washing clothes she realized that she used less soap than when washing in Barbados. Plan and design an experiment to explain this observation.*

*Possible hypotheses:*

- 1. The water in Dominica is softer than the water in Barbados*
- 2. The water in Barbados contains more calcium and magnesium ions than the water in Dominica.*

*Possible Aim:*

*To determine which water contains more calcium and magnesium by ionic precipitation*

*Variables:*

*Manipulated – types of water*

*Controlled – type of detergent, volume of water*

*Responding – the mass of precipitate formed*

Analysis and Interpretation (AI) Skill

The Analysis and Interpretation skill continues to be one of the better assessed skills. In general, the qualitative analysis and calculations were well done. However, to ensure continued improvement here are some points to note:

- Observations, definitions, background information, plotting of graphs, and questions which are not directly related to the specific practical should not be assessed under AI.
- Emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.
- Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that they understand what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again, *the use of the equation  $M_1V_1=M_2V_2$  is not accepted.*
- Teachers should emphasize writing correct (conventional) formulae, for example, sodium chloride as NaCl and not NaCL and Mg not mg for magnesium.
- Students should be required to complete their table of contents.
- Teachers are encouraged to provide students with more guidance in the discussion section of the laboratory report. Perhaps teachers can ask specific questions which will assist students in this section. These questions should be included in the mark scheme to guide the moderation process.

- Create more explicit mark schemes:
  - In the case of volumetric analysis, the concentration of reagents being used should be provided in the mark scheme.
  - In the case of qualitative analysis, the name of the unknown or the ions expected should also be included in the mark scheme.
  - If there is more than one teacher at a school/centre, then teachers should collaborate and submit one common mark scheme.
  - When interpolation from a graph is marked for AI skill, the mark scheme needs to be more explicit to guide the moderation process.



**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2013**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

Overall, candidates' performance in this sitting of the examination improved compared with performance in 2012.

This report provides feedback on the strengths and weaknesses reflected in candidate performance indicates the expected responses, and notes the common errors made by candidates. As such, it should be of value to both students and teachers for self-assessment and planning. It is anticipated that if these comments are noted and the recommendations integrated into teaching and learning on a wide scale, then this should lead to an improvement in overall performance on the examination.

Candidates demonstrated general knowledge of some of the specific and important concepts relating to the following areas:

- Reading scales from diagrams of instruments
- Calculating number of moles given mass
- Calculating gas volumes at RTP
- Calculations that involve equations with 1:1 mole ratio
- Drawing bonding diagrams for ionic compounds
- Calculation of the quantity of electricity that passes through an electrolytic cell given current and time
- Drawing structural formulae and naming alkanes and alkenes
- Writing some equations, for example, combustion of hydrocarbons and reaction of metals and acids except for organic acids
- Uses of polymers
- Understanding of the carbon cycle
- Principles underlying reactivity series of metals
- Physical properties of metals
- Strategies that can be used for preserving the environment

Candidates seemed to have challenges in the following areas:

- Redox reactions
  - differentiating between oxidizing and reducing agents
  - interpreting
- Recalling specific details, such as, conditions and reactants for several chemical reactions outlined in the syllabus, definitions of concepts
- Differentiating between the principles of metallic and ionic bonding
- Qualitative analysis for the identification of cations and anions
- Polymers

Poor performance was noted in:

- Writing and balancing equations and use of the correct mole ratio
  - Incorrect formulae which resulted from incorrect valencies were used throughout. Consequently, formulae were incorrectly written in equations and marks were lost.
  - Writing ionic equations to show reactions at the electrode - the weaknesses here relate to the wrong formulae for ions and the adding and subtracting of electrons to show the discharge of ions.
  - Incorrect formulae were used for salts of organic acids.
- Definitions of key concepts – Evidently, conceptual understanding was lacking.
  - This was most noticeable in the definitions for *rate of reaction* and *polymer*.

- Weak explanations for various phenomena
  - Candidates provided poor explanations for some of the claims they made. For example, in Question 1 of Paper 02, many candidates were able to compare the volumes of gases obtained for Experiments 2, 3 and 4. However, they were not able to explain the reasons for these differences.
  - Many of the types of errors mentioned in previous reports were evident in the responses. Candidates have a general idea of some topics but lack the specific knowledge to show depth of understanding. For example, there was the tendency to attribute conduction of electricity to the movement of electrons regardless of whether this was in reference to a metal or an electrolyte. There were many instances of descriptions of circuits that had the ammeter, instead of the electrodes, submerged in the electrolyte. It seems that the recommendation made in previous reports is worth repeating here. Teachers should engage students in developing deep and enduring understanding of concepts by using strategies that help students to connect ideas and understand principles. Classroom conversations on concepts should be encouraged and the correct use of chemical terms during classroom conversation should be the norm. In addition, it is important that students be provided with visual images of concepts such as general formulae, dot-cross diagrams and arrangements of apparatus for experimental procedures. Finally, strong emphasis should be placed on students writing clear and accurate accounts of phenomena using chemical terms correctly. Teacher feedback to students should help them to understand the gaps between what they have written or said and the required standard.
  
- Limited understanding of practical procedures
  - It appeared that candidates were unfamiliar with testing for strong and weak electrolytes.
  - They also lacked knowledge of the solubility of salts.

## DETAILED COMMENTS

### UNIT 1

#### Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. Performance on this paper declined slightly compared with the performance in 2012 and 2011. The mean score earned by candidates was 50 per cent, with a standard deviation of 10.

#### Paper 02 – Structured/Extended Response Questions

##### Question 1

Syllabus References: A: 7.1, 7.7, 7.3, 7.4; B2 7.1, 7.2, 7.3

Parts (a) to (e) tested knowledge of factors that affect the rate of a chemical reaction; use of oxidation numbers to explain oxidizing agents and relative reactivity of zinc and magnesium with dilute acid. Candidates were required to calculate the volume of gas produced at RTP when a given mass of zinc reacted with dilute hydrochloric acid.

##### **Performance of Candidates**

In Parts (a) and (b), most candidates gave incorrect or incomplete definitions of the *rate of reaction*. Generally, they failed to include key components such as the *change in concentration of the reactants or products with time*. Most candidates gave responses such as – ‘how long the reaction would take to

occur' or 'the time taken for the reaction to take place'. Many repeated the term 'rate' in their response. Most candidates scored all three marks for completing Table 1 using the data in Figure 1.

A correct response for Part (a) was *the change in concentration of product or reactant per unit time*. The correct readings from Part (b) were 171 cm<sup>3</sup>, 187 cm<sup>3</sup> and 46 cm<sup>3</sup>.

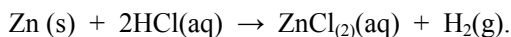
In Parts (c) (i) to (iii), candidates were required to write a balanced equation for the reaction between zinc and dilute hydrochloric acid, deduce the oxidizing agent for the reaction based on oxidation number and determine the volume of gas produced at RTP from reacting 1 g of zinc with excess dilute acid.

Candidates performed fairly well on the writing of the equation and calculation of the volume of hydrogen gas produced. However, many of them lost marks because they were unable to deduce the oxidizing agent and they confused *oxidizing agents* and *reducing agents*. Many candidates were not sure how a change in oxidation number during a reaction could be used to determine the oxidizing agent and so gave incorrect responses.

Some common **incorrect** responses noted were:

- Formula of zinc chloride as ZnCl instead of ZnCl<sub>2</sub>.
- Zinc is the oxidizing agent.
- Hydrogen is the oxidizing agent.

The expected equation for Part (c) (i) was



The oxidizing agent was HCl or H<sup>+</sup> as the oxidation number changed from +1 (in H<sup>+</sup>) to 0 (in H<sub>2</sub>). This decrease in oxidation number indicates that the H<sup>+</sup> was reduced and hence was the oxidizing agent.

One correct approach to calculating the volume of hydrogen is as follows:

$$\begin{aligned} \text{No. of moles Zn} &= 1/65 \\ \text{Mole ratio Zn:H}_2 &= 1:1 \\ \text{No. of moles H}_2 &= 1/65 \\ \text{Volume H}_2 &= \text{No. of moles} \times \text{Volume of 1 mole} \\ &= 1/65 \times 24 \\ &= 0.37 \text{ dm}^3 \end{aligned}$$

In Part (d), candidates were required to compare the volume of gas obtained for Experiments 2, 3 and 4 with that obtained in Experiment 1 and provide explanations for the differences. Candidates performed well on comparing the volumes of gas. However, for the most part, they did not provide satisfactory explanations for the differences in volume. Vague responses which failed to get to the reason for the changes were given - these were not discussed in terms of the reactions at the molecular level. There was also the tendency to repeat the information provided in Table 1 as the explanation for Experiment 1, for example, 'because the powder was used instead of granules'.

Some common errors and **incorrect** responses noted were:

- 'The volume for Experiment 2 was greater because the concentration was greater causing a faster reaction.' This response was considered to be inadequate as it did not address why increasing the concentration resulted in a higher volume of gas.

- ‘The volume of gas for Experiment 3 was greater than Experiment 1 as they used powdered zinc instead of granules which meant that the volume was higher’. This is repetition of the information in Table 1.

The expected responses were:

- *The volume of gas in Experiment 2 was greater than that in Experiment 1 because there are more reactant species in a higher concentration of HCl.*
- *The volume of gas in Experiment 3 was greater than that in Experiment 1 because zinc powder has a greater surface area than zinc granules.*
- *The volume of gas in Experiment 4 was less than that in Experiment 1 since at a lower temperature, collisions are less frequent and less energetic.*

In Part (e), most candidates correctly deduced that using magnesium granules would result in a faster rate of reaction than zinc granules. However, many sketched the graph representing the rate of reaction with magnesium on separate axes to that in Figure 2, contrary to the instructions provided. This made it difficult to compare the steepness of the slopes of the two graphs and hence determine whether candidates understood this concept. Many candidates lost this mark. Candidates are advised to read each question carefully.

Part (f) tested the planning and design skill. Candidates were required to plan and design an experiment to differentiate between a *strong electrolyte* and a *weak electrolyte*.

Candidates performed poorly in this section with the majority earning three or less of the total six marks. Many candidates earned no marks in this section. Candidates seemed to have limited knowledge of electrolysis and limited exposure to laboratory techniques.

The following comments relate to some common errors:

- Many of the circuits described had the ammeter or conductivity metres, instead of the electrodes, dipping into the electrolyte.
- Candidates did not know that barium sulfate was an insoluble salt and was therefore not suitable for use in differentiating a strong from a weak electrolyte.
- Sodium chloride was taken to be a solution and so there was no step included for dissolving it in water. Candidates are reminded that unless otherwise stated, substances that appear in questions should be interpreted as existing in their normal states at room temperature.
- Several **inappropriate** instruments were recorded for measuring the electrolytes required, for example, the burette, pipette and volumetric flasks.
- Many terms were used loosely or confused. These included terms such as electrolyte, electrodes, conductance, strong and weak electrolytes.
- Most candidates earned no marks for Part (ii) as they were not explicit about how the readings could be related to the nature of the electrolyte.

The following comments outline what was expected in response to Part (f):

- *Indication that the materials were prepared for the experiment. Hence, the solid substances used should be put in solution and transferred to beakers for use.*
- *Indication of how the apparatus was set up for conducting the test. There should be evidence that candidates understood that a complete circuit should include an ammeter or conductivity meter included to measure the current. Electrodes should be dipped into the liquids placed in the beaker.*
- *It should be evident that readings would be recorded to supply data for solving the problem.*

- *There should be scope for comparing the conductance of substances in order to differentiate the strong and weak electrolytes.*

Part (f) (ii) required candidates to link the expected observations to the possible deductions. Hence, if the readings on the ammeter or conductivity meter were high then this would signify a strong electrolyte. If the conductance or ammeter readings were low, this would suggest a weak electrolyte.

### Question 2

Syllabus References: A1.2, 4.1, 4.2, 4.3, 4.8, 5.4

The question tested candidates' knowledge of the separation of mixtures of solids, based on the strengths of the different inter-particle forces.

In Part (a) (i), candidates were asked to state the name of the process used to separate a mixture of solid sodium chloride and iodine based on the diagram of an experimental set-up of the process that was provided.

### **Performance of Candidates**

For Part (a)(i), most candidates correctly identified the process as *sublimation*.

Some common **incorrect** responses were *evaporation and crystallization*.

In Part (a) (ii), candidates were required to describe the observations that would be made when the mixture of sodium chloride and iodine was heated. Very few candidates provided the correct observations. Some candidates incorrectly stated that the water would evaporate leaving the NaCl and I<sub>2</sub> crystals.

The expected response is given below:

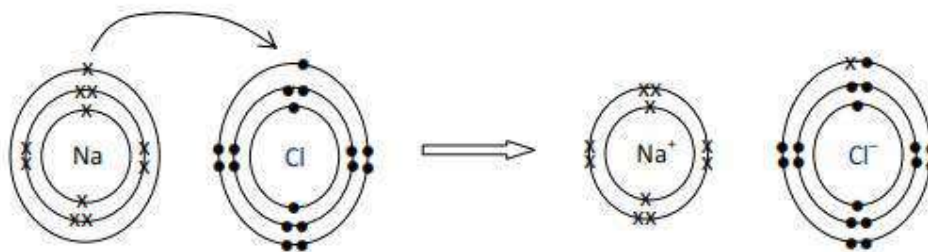
*The dark crystals of iodine would have sublimed. Eventually, all the iodine would leave the mixture and be collected on the base of the top beaker, leaving the sodium chloride in the bottom beaker. The observations would be:*

1. *Purple gas generated from the bottom beaker.*
2. *Dark-purple solid formed on the outside of the top beaker.*
3. *White solid remained in the bottom beaker.*

Candidates should have a clear understanding of the meaning of *observations* which include colour changes and change of state or phase.

In Part (a) (iii), candidates were required to show the bonding in NaCl using dot-cross diagrams. Candidates performed well on this part. The majority of them correctly indicated the transfer of the single valence electron from the sodium atom to the valence shell of chlorine. Some candidates lost marks for not showing the charge on the ions. A few candidates showed bonding of a covalent type, and so were not awarded any marks.

The following diagram was expected:



This diagram shows the transfer of the single valence electron from the sodium atom, to the valence shell of the chlorine atom. The result is a  $\text{Na}^+$  ion and a  $\text{Cl}^-$  ion. These oppositely charged ions then experience a strong attraction for each other. This attraction is known as *ionic bonding*.

In Part (a) (iv), candidates were asked to explain why gentle heating is suitable for separating  $\text{I}_2$  from a mixture of  $\text{I}_2$  and  $\text{NaCl}$ .

The majority of candidates realized that  $\text{NaCl}$  is an ionic compound and has strong interparticle forces. However, many candidates incorrectly assumed that there was a bond between  $\text{NaCl}$  and  $\text{I}_2$ , and that this bond was being broken under gentle heating.

Many candidates incorrectly focused their responses on the interaction between  $\text{NaCl}$  and  $\text{I}_2$ , rather than the weak intermolecular forces between the  $\text{I}_2$  molecules. Candidates were expected to state that *NaCl has strong forces of attraction between its particles, that is, the  $\text{Na}^+$  and  $\text{Cl}^-$  ions are linked by ionic bonds. This makes NaCl stable to gentle heating OR gentle heating will not break these strong ionic bonds. Iodine is a molecular solid with weak intermolecular forces, and gentle heating is sufficient to break these weak forces, separating the  $\text{I}_2$  molecules in the solid.*

In Part (b), candidates were required to state whether the same technique could be used for separating a mixture of iron filings and sodium chloride, and then explain their answer with reference to the bonding in Fe. Many candidates did not make reference to the bonding in iron. Some went on to describe a different method of separation, and were not credited any marks.

Some common **incorrect** responses noted were:

- Using a magnet to remove the iron
- Dissolving the  $\text{NaCl}$  in water and filtering off the iron

The response expected was that *iron has metallic bonding and strong electrostatic attraction. These result in iron having a high melting point. Therefore, gentle heating will not be sufficient to break the bonds either in  $\text{NaCl}$  or Fe.*

### Question 3

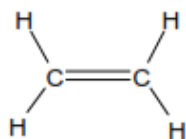
Syllabus References: B1: 2.1, 2.2, 2.3, 2.6, 2.8, 4.3, 4.5

Candidates were tested on their ability to generate names and structures from formulae; to write equations for combustion of a simple hydrocarbon and the reaction of a metal with carboxylic acid; and to predict solubility based on structure and polymerization.

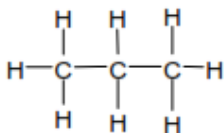
In Part (a) (i), candidates were given the formulae of two hydrocarbons (A,  $\text{C}_2\text{H}_4$  and B,  $\text{C}_3\text{H}_8$ ) and were required to draw the *fully displayed* structures and state the names.

Most candidates were able to deduce the correct structures and names.

The correct structures and names of the two hydrocarbons are:



A (C<sub>2</sub>H<sub>4</sub>), ethene

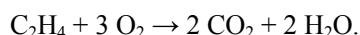


B (C<sub>3</sub>H<sub>8</sub>), propane

In Parts (a) (ii) and (iii), candidates were required to state whether Compound A burns with a sooty flame or a clean, blue flame, and to write a balanced chemical equation for the reaction.

Approximately half of the candidates stated correctly that Compound A burns with a sooty flame. Since A, ethene, is an alkene, it is expected that the flame would be sooty. Less than 50 per cent of the candidates wrote the correct *balanced* equation for the combustion of ethene.

Too many candidates seemed not to know the basics of writing and balancing chemical equations. The equation for the combustion of ethane is

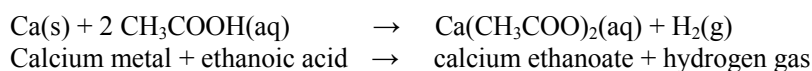


In Part (b), candidates were provided with the fully displayed structures of ethanoic acid (C) and methyl ethanoate (D), and were required to explain why C is soluble in water and D is not. Candidates were asked to write the balanced chemical equation for the reaction of Compound C (ethanoic acid) with calcium metal.

Many candidates identified the OH functional group in the ethanoic acid as being responsible for its solubility but some incorrectly referred to the OH functional group as the 'OH<sup>-</sup> ion'. The majority of candidates gave an incorrect chemical equation, and seemed very unfamiliar with the topic.

The expected response was that:

*Compound C has a polar hydroxyl (OH) group which is attracted to polar water molecules. Hence, Compound C is soluble in water. Compound D is non-polar and would not be attracted to water molecules. Hence, D is insoluble in water. The chemical equation for the reaction of calcium metal with ethanoic acid is:*



In Part (c), candidates were asked to define a polymer, state the type of polymerization that occurs when propene (E, C<sub>3</sub>H<sub>6</sub>) is heated under pressure, the name of the product, and one use of the product.

Although more than 50 per cent of the candidates were unable to correctly define a polymer, more than 60 per cent correctly stated that reaction was *addition polymerization*. The most common **incorrect** response for the type of polymerization was 'condensation polymerization'.

The expected responses were:

*A polymer is a long, chain-like molecule formed from many small molecules called monomers.*

*Propene polymerizes by addition polymerization.*

*The name of the polymer is polypropene (polypropylene).*

*Uses include hard plastics for car accessories, toys, domestic wares, shoe heels, crates and carpets.*



#### Question 4

Syllabus references: A. 6.20; 6.23, 6.24, 6.25, 6.27

This question tested candidates' knowledge of electrolysis. Less than 40 per cent of the candidates scored seven or more marks on this question.

Here again, it was clear that candidates confused terms and used them loosely. *Ions* and *electrons* were used interchangeably. There was little evidence that candidates had adequate conceptual understanding of the nature of ionic bonding and what causes ionic compounds to show electrolytic conductivity. Reasons for the conductivity of the different substances were vague.

Most candidates scored the two marks for the diagram. However, many of them found it challenging to write equations for reactions at the electrodes. Calculations were done fairly well and most candidates were able to score at least one mark in this section for calculating the amount of electricity passing through the electrolyte.

Part (a) required candidates to explain the difference in conductivity between magnesium and magnesium iodide. In Part (b), candidates were required to draw a labelled diagram of the apparatus used in the electrolysis of molten magnesium iodide and to write suitable equations to show the reactions at the anode and cathode.

The following comments relate to the main **incorrect** responses:

- Conduction in the electrolyte was attributed to movement of electrons instead of ions.
- Incomplete responses were given for the conduction in Mg. For example, a common response was 'magnesium will conduct electricity because it is a metal and metals conduct electricity'. While this is true, it is not enough to answer the question as it does not show adequate understanding of the activities at the microscopic level. Generally, explanations in chemistry require this level of understanding to be shown.
- Incorrect labelling of the anode and cathode based on the symbol used for the power supply
- Incorrect ionic equations
- Electrons added to the wrong side of the equation, for example,  $I^{-}(aq) + 2e^{-} \rightarrow I_2(g)$ 
  - Incorrect state symbols
  - Writing the equation for the discharge of magnesium ions at the anode instead of at the cathode

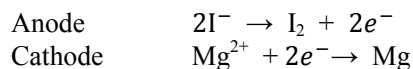
The expected response for Part (a) should show understanding that

- the electrons were responsible for conducting the current in magnesium
- the bonding in magnesium iodide is ionic but the ions are strongly held in the crystal lattice of the solid and therefore unable to conduct the electricity
- in the molten state, the electrons were free to move.

A good response was *magnesium metal conducts electricity due to the presence of mobile electrons in its lattice metal structure (metallic bonding). The electrons are free to move throughout the structure and hence they are able to conduct, that is, carry a charge. Magnesium iodide is an ionic structure and does not possess free electrons. In the molten state due to the presence of mobile ions, magnesium permits conduction.*

For Part (b), it was expected that the diagram should show a complete circuit with the anode labelled as the positive electrode and the cathode the negative electrode.

The reactions at the anode and cathode were as follows:



In Part (c), candidates were required to calculate the mass of product that would be formed when a current of 5 A was passed through the electrolyte for a total of ten minutes.

The main errors were:

- Failure to equate  $2F$  with the deposit of 1 mole of Mg
- Use of incorrect statements – showing indiscriminate use of units and terms
- Calculating the mass of magnesium iodide instead of magnesium

The expected response was as follows:

$$\begin{aligned} \text{Quantity of electricity} &= 5 \times (10 \times 60) = 3000 \text{ C} \\ \text{Number of faradays passed} &= 3000/96500 = 0.031 \\ 2 \text{ faradays deposit 1 mole Mg} \\ \text{Moles of Mg deposited} &= 0.031/2 = 0.0155 \text{ moles} \\ \text{Mass of Mg deposited} &= 0.0155 \times 24 = 0.372 \text{ g} \end{aligned}$$

### Question 5

Syllabus References: B2: 8.1, 8.2, 8.3, 6.2, 5.2, 1.1, 1.2, 4.1, 4.2

This question tested candidates' knowledge of the carbon cycle and, some reactions of Group II metals and their compounds.

In Part (a) (i), candidates were required to outline how two processes, X ( $\text{CO}_2$  in atmosphere  $\rightarrow$  Ocean) and Y ( $\text{CO}_2$  in atmosphere  $\rightarrow$  plants) move carbon through the cycle.

The majority of candidates did not associate process X with the dissolving of  $\text{CO}_2$  in ocean water or in rain water. Some candidates wrote that  $\text{CO}_2$  moves into the ocean (at process X) but did not state by what process.

The following responses were expected:

- Process X –  $\text{CO}_2$  dissolves in water, for example, rain water, and enters the ocean as carbonates.
- Process Y –  $\text{CO}_2$  is removed from the atmosphere by photosynthesis in plants.

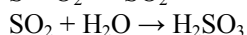
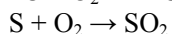
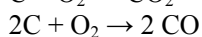
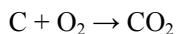
In Part (a) (ii), candidates were asked to describe the process occurring at Z (Fossil fuels  $\rightarrow$   $\text{CO}_2$  in atmosphere), explain one harmful effect that could occur as a result of the process and write one supporting, balanced equation.

The majority of candidates correctly identified the process Z as burning/combustion of fossil fuels and gave a relevant equation.

The responses expected were:

*Harmful effects due to (i) extensive burning which results in production of large quantities of carbon dioxide, a green-house gas, and contributes to global warming, (ii) formation of carbon monoxide (CO), a toxic gas; in limited supply of oxygen, CO combines with haemoglobin in the body thus reducing oxygen supply, which can lead to death; (iii) burning of leaded fuels releasing toxic lead compounds into the environment which can lead to lead poisoning; (iv) formation of acid rain resulting from the sulfur contained in some fuels. Burning releases sulfur dioxide, SO<sub>2</sub>, which forms acid rain which is known to damage buildings, artefacts.*

Relevant equations include:



Part (b) was based on information provided in a table.

In Part (b) (i) a), candidates were required to write a suitable equation for the action of heat on the carbonate of R.

Based on the formula of the oxide of R, (RO), it can be deduced that the metal R is in Group II and the formula of its carbonate is RCO<sub>3</sub>. A small number of candidates was able to show the correct formula of the carbonate, and fewer could give the equation for its decomposition upon heating. Some candidates incorrectly wrote the formula of the carbonate as R<sub>2</sub>CO<sub>3</sub>.

The correct equation for the decomposition of the carbonate of R is: RCO<sub>3</sub>(s) → RO(s) + CO<sub>2</sub>(g).

In Part (b) (i) b), candidates were required to write a suitable equation for the reaction between M and aqueous aluminium ions. Very few candidates gave the correct equation for this reaction. From the formula of the oxide (MO), it can be deduced that the ion of M is divalent, that is, M<sup>2+</sup>. The correct ionic equation is: 3 M(s) + 2 Al<sup>3+</sup>(aq) → 3 M<sup>2+</sup>(aq) + 2 Al(s).

In Parts (b) (ii) and (iii), candidates were required to explain why M is more reactive than R with dilute acid, and to state one physical property and one chemical property that both M and R are likely to share.

Many candidates were able to associate the higher reactivity of M with its higher position in the activity series.

*Candidates were expected to state that M is above aluminium and R is below aluminium in the activity series. Therefore M is higher up than R, and metals higher up in the series are more reactive than those lower down.*

Any appropriate, common physical and chemical properties is acceptable, for example, *physical* – conduct electricity, good conductors of heat; *chemical* – form basic oxides, react with acid to give salt and hydrogen.

### Question 6

Syllabus References: C 2.3, C2.3.5, C2.3.6, C2.3.7

In Part (a), candidates were required to identify sources of chlorofluorocarbons and phosphates – two known pollutants and explain how the environment is affected by each.

Candidates performed fairly well on this section and were able to identify sources for the two pollutants. However, the explanations of how they affected the environment tended to be incomplete. In their explanations, they were required to say what each pollutant did to the environment and how the damage was done in each case. In many cases, candidates lost marks for the second part of the response. A common incorrect response was that CFCs lead to global warming.

The expected responses were that

- CFCs are found in aerosols, refrigerants.  
Phosphates are found in detergents, fertilizers.
- CFCs produce chlorine radicals which attack the ozone layer and break it down.  
Phosphates cause algae blooms in ponds and rivers which use up the oxygen causing eutrophication.

In Part (b), candidates were required to discuss the advantages and disadvantages of using incinerators, landfills and recycling as methods of solid waste disposal.

Many candidates performed well on this item as they were able to find a wide range of advantages and disadvantages for each method. However, the level of discussion was weak and candidates tended to list points without showing how the points related to each other. Candidates' writing skills and ability to express themselves with clarity and precision were the main factors that reduced the overall quality of the responses.

Some of the advantages for using the three methods are as follows:

<b>Landfill</b>	<b>Recycling</b>	<b>Incinerator</b>
<ul style="list-style-type: none"> <li>• Relatively cheap</li> <li>• Large quantities of waste can be disposed of</li> <li>• Can be used for methane production</li> </ul>	<ul style="list-style-type: none"> <li>• Allows for conservation of natural resources</li> <li>• Tends to be energy efficient</li> <li>• Uses less space than landfills</li> </ul>	<ul style="list-style-type: none"> <li>• Reduces the volume of solid waste</li> <li>• Heat produced can be used to produce electricity</li> <li>• Destroys pathogens</li> </ul>

Some of the disadvantages for using the three methods are as follows:

<b>Landfill</b>	<b>Recycling</b>	<b>Incinerator</b>
<ul style="list-style-type: none"> <li>• Tend to use up too much land</li> <li>• High start-up cost for equipment and excavation</li> <li>• If improperly used can lead to water pollution or explosions from methane</li> </ul>	<ul style="list-style-type: none"> <li>• Separation and purification is difficult</li> <li>• In many cases, products are considered of low grade</li> <li>• Lack of public acceptance of products</li> </ul>	<ul style="list-style-type: none"> <li>• Set up and maintenance tend to be expensive</li> <li>• Can cause air pollution</li> </ul>

**Paper 032 – Alternative to SBA**Question 1

Syllabus References: A: 3.3, 8.1, 8.3

This question mainly tested candidates' knowledge of electrochemistry. The maximum mark available was 26. Most candidates were able to score at least 12 out of 26.

Candidates were provided with information regarding the materials, reagents and the procedure required to determine the heat of neutralization for the reaction of hydrochloric acid with sodium hydroxide.

Part (a) required candidates to read a balance and a thermometer and report the information in a table. Most candidates achieved this and earned at least five of the six marks available for this task.

In Parts (b) to (d), candidates were required to write the chemical equation for the reaction and calculate the mass of solution and the temperature change that occurred based on their readings; calculate the heat change for the reaction and the moles of water that were produced during the reaction; and indicate whether the reaction was exothermic or endothermic.

Although most candidates accurately wrote the equation to represent the reaction between NaOH and HCl, a few used capital and lower case letters incorrectly when writing the formulae. For example, NAOH or NaoH was noted for sodium hydroxide and HCL or Hcl for hydrochloric acid.

The calculation of the mass of the solution and temperature change presented little difficulty for candidates. There were a few candidates who calculated temperature change by subtracting the final temperature from the initial temperature to determine whether the reaction was endothermic or exothermic. The practice is incorrect and candidates should be discouraged from doing so.

Since the required equation was given, calculating the heat change for the reaction presented little difficulty for candidates. However, calculating the moles of water produced in the reaction, a basic mole calculation, proved challenging for far too many candidates. Likewise calculating the heat of neutralization was also challenging. In addition, many candidates neglected to include units in the calculation. Candidates should always be encouraged to work with units during a calculation and to state the final unit at the end.

Too many candidates noted that the reaction was endothermic rather than exothermic. This indicated that there are some misconceptions in this area. Candidates should be able to recognize that the rise in temperature measured is due to the reaction releasing heat and not taking in heat; hence, it was exothermic and not endothermic.

In Parts (e) and (f), candidates were required to indicate possible precautions and sources of errors associated with the experiment.

The two most common answers given in this section were associated with parallax and laboratory safety. In some cases, candidates in trying to describe how they could avoid parallax error, noted that the instruments should be read at 90° rather than at eye level. Although candidates were credited for such answers, it was expected that they would have included some of the possible precautions and sources of error outlined below.

Precautions:

- Pouring liquid down the sides of the stirring rod
- Stirring gently to avoid splashing
- Covering the cup as quickly as possible after mixing

Sources of error:

- Some heat produced could have been absorbed by the container.
- Some heat could have been lost to the room/surroundings.
- Measuring using a measuring cylinder is not as precise as using a pipette.

Candidates were not credited for answers such as choosing apparatus that was not broken, human error, incorrect measurement or wrong temperature reading.

Part (g) tested candidates' ability to determine how a change from a styrofoam cup to a beaker would affect the results. It required the candidates to have a clear understanding of the energy changes that take place in a chemical reaction. Not many candidates demonstrated that they had this understanding. Some candidates recognized that the beaker is a better conductor of heat than the styrofoam cup but could not relate that knowledge to the impact it would have on the experimental heat of neutralization. It was expected that candidates would be able to deduce that since the beaker is a better conductor of heat then more of the heat produced in the experiment would escape to the room before it is measured. Hence, the temperature reading taken would be lower than expected. This lower temperature reading would result in a lower calculated heat of neutralization.

In Part (h), candidates were asked to calculate the mass of solid that would be needed to make up a particular volume of solution of known concentration. Many candidates should have been familiar with this type of calculation but far too many were still having challenges. In some of the scripts, it was evident that candidates were not employing the unitary method. Hence, when the answer was incorrect it was difficult to award partial marks since their reasoning lacked clarity and was difficult to follow.

In Part (i), candidates were asked to adapt a metal stirrer in order to make it more suitable for use in the experiment. Candidates provided a variety of answers. Some of them simply replaced the stirrer with one of plastic or glass rather than adapt the metal stirrer. Several focused on the heat that could be possibly transferred into the solution from the person holding the metal stirrer and not on the heat that could be possibly absorbed from the metal stirrer itself. Hence, the answers spoke to wrapping plastic, cloth or rubber on the handle of the stirrer rather than on the entire stirrer. Marks were awarded only for adaptations that utilized insulating and water-proofing material.

## Question 2

Syllabus References: B2: 7.1, 7.2, 7.3

This question was based on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid mixture. The majority of candidates earned less than five of the maximum ten marks. This suggests that the candidates had limited knowledge of this area. For example, when told that a few drops of KI solution was added (suggesting that an oxidizing agent was possible), instead of noting that a brown precipitate would be observed many candidates recorded 'a yellow solution or a brown solution'.

### Question 3

Syllabus References: B2: 1.2

Candidates were required to plan and design an experiment specifically using the action of heat to distinguish among anhydrous calcium nitrate, anhydrous calcium carbonate and calcium hydroxide which were placed in unlabelled containers. Again, this question was poorly done with the majority of candidates earning less than five out of ten marks.

In many cases, the list of apparatus was incomplete. Most candidates stated that they would need a Bunsen burner and a test tube but made no reference to a test tube holder, for example. The procedures which candidates proposed were varied. It was expected that they would place a small amount of each solid in separate test tubes, heat each separately, record the observations and test the gases produced.

Although candidates were instructed that they must use the action of heat to distinguish the three compounds, some candidates used no heat at all in their procedure. Several of them proposed a procedure based on solubility instead. Many of those who suggested the use of heat either recommended using a water bath or dissolving the salts in water or HCl first before heating.

When asked to state one precaution that should be taken in conducting the experiment, some candidates correctly expressed that they should point the test tubes away from their faces or mentioned one of many safety precautions. Some precautions, however, were not precise; for example, they suggested that one should avoid contaminating the sample or should stand away from the Bunsen flame. A suggestion such as 'making sure that the apparatus was clean' was not awarded any marks.

Many candidates thought that heating a hydroxide would form hydrogen gas and oxygen gas instead of the oxide and steam. The test for CO<sub>2</sub> was well known as well as the colour of NO<sub>2</sub> gas. However, some candidates suggested inferences rather than the observations which were required. For the discussion section, many candidates linked the observations and the inference for the gas to deduce a possible identity for the compound.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**MAY/JUNE 2013**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The overall performance of the candidates on this sitting of the examination was not markedly different from previous sittings. The report on performance in the CSEC examination highlights the common areas which the candidates seem to find difficult as well as the nature of the errors that they make. It is hoped that students and teachers will use this information to conduct self-assessment, identify strengths and weaknesses and so better prepare for future examinations.

Most candidates demonstrated adequate knowledge of the important concepts in the following areas:

- Plotting graphs and reading values from graphs
- Factors that affect the rate of reactions
- Properties of alloys
- Factors affecting the discharge of ions at the electrodes
- Understanding of global warming

### **Some of the factors contributing to the unsatisfactory performance of candidates include:**

- A tendency for responses to be superficial
  - Many candidates lost marks because they wrote in general or vague terms. Their language of chemistry is not very well developed. One consequence was the tendency to use related terms interchangeably although the terms have significant differences in meaning. For example, candidates often interchanged ‘*dilute*’ and ‘*weak*’ when referring to acids.
  - Too many candidates tended to pay little attention to correct explanations for known phenomena. For example, there is general knowledge that catalysts will increase the rate of a reaction but the reason for this is not fully appreciated. As a consequence, candidates did not discriminate well especially in the multiple-choice questions. In response to Question 5 on Paper 02, many candidates stated, generally, that the reason for the discharge of the hydrogen was “the position of the ions in the electrochemical series”, but did not give the relative positions of the ions in the series.
  - Teachers are encouraged to insist on greater accuracy in students’ oral and written responses.
- Limited understanding of concepts
  - Many candidates gave inadequate or inappropriate answers because they did not understand terms used in the questions or they used concepts loosely when writing their responses. Candidates showed limited understanding of terms such as *precipitate* (Question 1), *discharge* (Question 2), and *physical properties* (Question 5). *Reactivity series* was confused with *electrochemical series* and the terms *react*, *reactive* and *un-reactive* were often used without explanation of the nature of the reactions being described.
  - Several candidates had challenges with calculations of problems involving the mole where a stepwise approach to problem solving was not given in the question.
  - Candidates often used incorrect units and statements in calculations, thus demonstrating weak conceptual understanding.
  - Many candidates seemed not to understand the principles governing separation of mixtures.
  - Several candidates confused the element with its ion, for example, referring to the ion as Pb instead of Pb<sup>2+</sup>

- Interpreting questions
  - It appeared that candidates were not sure what was required by instructions such as *compare* and *explain*.
  - Many candidates did not understand what types of reactions could readily be conducted in a laboratory.
- Writing and balancing equations and interpreting chemical reactions
  - Many candidates still struggled with writing ionic equations, mainly because they did not learn the valencies of common elements and radicals and so could not write the correct charges of the ions.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. The performance of this paper improved slightly compared with 2012. The mean score earned by candidates increased from 50 per cent to 55 per cent, with a standard deviation of 11.

### Paper 02 – Structured and Extended Response Questions

#### Question 1

Syllabus References: A: 3.3, 3.4, 4.8, 5.4, 6.10, B2: 7.1, 7.2, 7.3

Part (a) (i) – (v) was based on an experiment to determine the effect of temperature on the solubility of potassium iodide. Candidates were required to calculate from the given data, the mass of potassium iodide (KI) that dissolved in 100 cm<sup>3</sup> of water at different temperatures, and plot the graph of mass of salt dissolved, against temperature. Using the graph, they were then required to determine the solubility of KI at various temperatures and calculate its concentration at 30 °C.

Most candidates were able to score the first 6 marks on the paper by correctly completing the table, plotting the points, drawing the best straight line to complete the graph and determining the solubility of the KI at 70 °C from the graph. Parts (iv) and (v) were more challenging as many candidates did not know how to determine the mass of solid that would be formed when the temperature was cooled from 70 °C to 30 °C. The better candidates scored full marks on these sections. For Part (v), candidates knew how to find the molar mass of KI and calculated the number of moles of KI produced at 30 °C. However, many did not know how to continue from there to calculate the molar concentration. Too many candidates used an incorrect reading from the graphs for the mass of salt at 30 °C and so lost marks.

The expected responses were:

- (ii) The masses for the corresponding temperatures were:
- |       |       |       |       |
|-------|-------|-------|-------|
| 20 °C | 40 °C | 60 °C | 80 °C |
| 162g  | 196 g | 230 g | 264 g |
- (iii) The solubility at 70 °C from the graph was 247 g/100 cm<sup>3</sup>.
- (iv) The mass of KI that would precipitate out when the solution was cooled from 70 °C to 30 °C was determined by subtracting the solubility at 30 °C from the solubility at 70 °C. These values were obtained from the graph.

$$\text{Mass of salt precipitated} = 247 - 180 = 67 \text{ g/cm}^3.$$

- (v) R.M.M.  $KI = 39 + 127 = 166$   
No. moles  $KI = 180 / 166$  moles  
At  $30^{\circ}C$ ,  $100\text{ cm}^3$  contains  $180 / 166$  moles  
 $1000\text{ cm}^3$  contains  $(180 / 166) \times (1000 / 100) = 10.8$  mol

Part (b) tested candidates' knowledge of why potassium iodide was very soluble in water but only sparingly soluble in ethanol.

Many candidates performed poorly on this question, as it appeared that they did not interpret the question correctly. They did not take into account that the question compared the solubility of KI in water and in ethanol. There was also evidence that some concepts were not clearly understood and there was a tendency to provide explanations at a superficial level; for example, there was widespread use of informal language and clichés such as *like dissolves like* and *water is a universal solvent*. The more common incorrect responses resulted from the following:

- Several candidates took the extreme positions that water was *polar* and ethanol was therefore *non-polar*. This statement is incorrect as ethanol is a polar solvent but not as polar as water.
- KI was described as *polar* instead of *ionic*.
- The difference was ascribed to differences in reactivity and ethanol was described as being *less reactive* than water.

Consequently, there were responses such as:

*Water is a polar solvent. Ethanol is not polar so it does not fully dissociate the potassium iodide. It is not a good solvent.*

*The statement is true because potassium iodide is an ionic compound and one property of ionic compounds is that it is soluble in water but insoluble in organic compounds such as ethanol.*

Both statements are only partially correct. The question required an explanation, which means that candidates were required to give reasons. These reasons should therefore indicate why ethanol, being polar, would not completely dissolve potassium iodide.

The expected response was

*Potassium iodide is an ionic solid and dissolves in water, a polar solvent. It is only partially soluble in ethanol because although ethanol is polar, it is not as polar as water.*

Part (c) tested candidates' knowledge of how to separate two soluble salts, sodium sulfate and sodium chloride, in the solid state.

Candidates performed poorly due to careless reading of the question and limited knowledge regarding solubility of common salts. Responses also showed that candidates were familiar with techniques for separating mixtures but were not able to apply the principles to this unfamiliar context.

### **Common Incorrect Responses**

It did not appear that the majority of the candidates considered that the two solids were ionic compounds that were both soluble when they attempted to answer this question. A wide range of suggestions was made for the separation. Some of the more common ones were fractional distillation and sublimation.

More than a third of the candidates assumed that sodium sulfate was insoluble and suggested *filtering the mixture after dissolving the sodium chloride in water*. Many overlooked that a mixture was given and treated the two solids as separate. Still others assumed that the mixture was a liquid although the question stated that the mixture was a solid. In responding to this section, many candidates used the term *precipitate* incorrectly. Assuming that the sodium sulfate was insoluble, they described the sodium sulfate as forming a *precipitate* and the sodium chloride as going into solution after water was added. This is an incorrect use of the term *precipitate* which refers to a solid coming out of solution. In this case, had the sodium sulfate really been an insoluble salt, that would not have been the case as it was a solid present from the start that did not dissolve on mixing with water.

### Expected response

The easiest approach to separating the mixture would be to first make a solution by mixing with water as both solids were soluble and then precipitating out one of the salts leaving the other in solution. The new mixture could be filtered and filtrate crystallized to give the salt. Hence, barium nitrate could be added to remove the sulfate and leave sodium chloride in solution. Instead, silver nitrate could be added to remove the chloride. Following filtration, the filtrate could then be crystallized to obtain the solid.

Part (d) of the question tested knowledge of two common chemical tests on an unknown solid for which the observations were recorded.

This was also another task on which candidates performed unsatisfactorily. These common tests were clearly not familiar to a wide cross-section of candidates, indicating that limited practical work was done in this area.

### Common Incorrect Responses

- The brown gas was described as *bromine* and *iron*.
- The equation of the formation of the yellow precipitate was given as  $\text{Pb}^{2+} + \text{I}^- \rightarrow \text{PbI}_2$ .
- No interpretation was given for the change on the blue litmus.
- Lead or Pb was present instead of  $\text{Pb}^{2+}$  or lead ions.

### Expected response

Test (i) – Nitrogen dioxide produced or nitrate ion present; Acidic gas is present.

Test (ii) – Yellow precipitate is lead iodide or lead ions are present.

### Question 2

Syllabus References: A: 4.1, 4.2, 4.3, 4.8, 6.1, 6.2, 6.4

This question tested candidates' knowledge of trends down Group 2 and Group 7, and across the period. The question also tested candidates' knowledge of bonding in and general properties of covalent compounds.

The following table was given:

Na	Mg		Al	Si	P	S	Cl	Ar
	X						Y	

Candidates were NOT required to identify X and Y.

In Part (a) (i), candidates were required to compare the ease of ionization of two elements, X and Mg, and to provide a suitable explanation for their answer.

The majority of candidates correctly stated that X is more easily ionized than Mg. However, many were unable to give the correct explanation, and only rephrased the answer to the previous part of the question, stating that as the group is descended the ionization energy decreases.

### **Common Incorrect Responses**

Many candidates simply stated that ionization energy decreases down the group. This is an observed trend and NOT an explanation. Other incorrect responses included:

- X is lower down in the periodic table.
- X is lower in a group.
- Mg ionizes faster than X.

### **Expected Responses**

The correct trend is that X is more easily ionized than Mg.

The explanation should focus on some factor that varies, and which leads to the decrease in ionization energy as the group is descended. As the group is descended, the number of shells increases and this causes an increase in the atomic radius. This increase in atomic radius means that the valence electrons are further from the nucleus and therefore are attracted less by it. The increase in the number of shells causes greater shielding of the valence electrons from the nucleus. Both of these factors result in a decrease in ionization energy down the group.

In Part (a) (ii), candidates were required to compare Cl and Y according to their oxidizing power, and to provide a suitable explanation for their answer.

Again, many candidates had the correct trend and correctly stated that Cl is a stronger oxidizing agent than Y, but were unable to provide correct explanation.

### **Common Incorrect Responses**

- Oxidizing power increases down a group.
- Y is more reactive than Cl.
- Y is higher than Cl in the reactivity series.

### **Expected Responses**

As Group 7 is ascended, electronegativity increases. That is, atoms higher up in the group accept electrons more readily from atoms of other elements. As the group is ascended, the number of shells decreases. This means that the outer shell is closer to the nucleus. As a result there is less shielding and so it is easier for electrons to be added to the valence shell.

Part (b) (i) and (ii) required candidates to state (i) ONE similar property, and (ii) ONE different property of X and Y.

Many candidates were able to state correctly that both elements would be solids.

### Common Incorrect Responses

Similar physical property for X and Y:

- They have the same number of shells.
- They have the same number of electron rings.
- They are liquids.

Different physical property for X and Y:

- They have different number of valence electrons.
- They will be in different states.

### Expected Responses

Candidates were expected to suggest physical properties of X and Y, based on their positions in the Periodic Table.

Similar property: Both X and Y are solids. Also accepted that Y could be a liquid or gas. X is in Group 2, and is therefore a metal, so any property that is suggestive of a metal is accepted.

Different property: Some properties accepted were melting point, boiling point, density – with the property of X being greater than the property of Y. Also accepted – X is shiny and Y is dull; X is a metal and Y is a non-metal (which suggests that X is metallic in character while Y is non-metallic).

Part (c) (i) required candidates to state the type of bonding that would occur between phosphorus, P and Element Y.

The majority of candidates correctly stated that the bonding would be covalent.

Part (c) (ii) required candidates to sketch a diagram showing the bonding between P and Y.

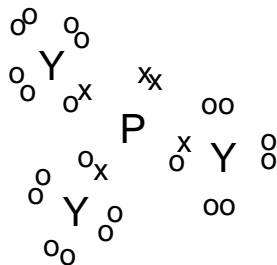
Some candidates had difficulty producing diagrams with the correct number of valence electrons on both P and Y. However, the majority recognized that one atom of P would bond to three atoms of Y.

### Common Incorrect Responses

A number of candidates drew diagrams depicting ionic, rather than covalent bonding, with the transfer of three electrons from one atom of P to three atoms of Y, or with the transfer of electrons from three atoms of P to three atoms of Y.

### Expected Responses

The correct diagram showing covalent bonding between P and Y is:



The electrons on P are represented by 'x' and the electrons on Y are represented by 'o'. Each atom now has eight electrons, that is, a stable octet of electrons, around it.

In Part (c) (iii), candidates were required to write the chemical formula of the compound formed between P and Y, and suggest two properties of this compound.

A number of candidates showed the correct bonding diagram.

#### **Common Incorrect Responses**

- High melting point
- High boiling point
- Conducts electricity in the molten state
- Soluble in water

#### **Expected Responses**

Based on the bonding diagram shown above, the formula of this compound is  $PY_3$ . General properties of simple-molecular covalent compounds include:

- Low melting point
- Low boiling point
- Insoluble in water
- Soluble in non-polar (organic) solvents
- Does not conduct electricity in solution. (However, some compounds may decompose in water to give ionic species. Such solutions will conduct electricity.)

#### Question 3

Syllabus References: B1: 3.3, 3.7, 3.8, 4.2, 4.3, 4.4, 4.6

This question tested candidates' knowledge of the petroleum industry, addition and condensation polymerization, and the acid hydrolysis of proteins.

In Part (a), candidates were required to explain what is meant by cracking, a process that is very important in the petroleum industry.

More than 50 per cent of candidates were able to correctly indicate that cracking involves the breaking up of long chain hydrocarbons into shorter chains.

#### **Common Incorrect Responses**

Some of the misconceptions of candidates regarding this part of the question were evident in their explanation of cracking as (i) a method of separation or (ii) a method of obtaining oil from the earth. Some candidates replaced the term hydrocarbon with units, atoms, particles, elements or substances.

#### **Expected Responses**

Cracking is the process by which hydrocarbons in the heavier fractions produced by fractional distillation of crude oil are broken down into lower molecular weight hydrocarbons.

In Parts (b) (i), candidates were required to draw a structural representation of a monomer of glucose.

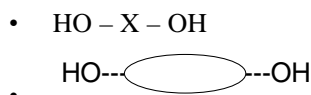
Instead of drawing a 'structural representation' of a glucose monomer, the majority of candidates attempted to draw a molecule of glucose. This was not required. A common error in this question was drawing carbon with fewer than four or more than four bonds.

### Common Incorrect Responses

Many candidates showed a poor interpretation of the formula and drew incorrect straight chain structures, attempting to incorporate 6 carbons, 12 hydrogens and 6 oxygens into the structure.

### Expected Responses

The correct structural representations of a glucose monomer can be shown as:



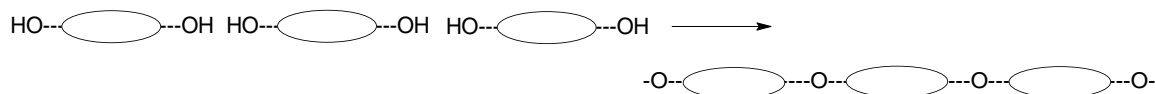
where the two OH groups, that will be used in polymerization, are shown.

In Part (b) (ii), candidates were required to use THREE units of the glucose monomer to show how the monomers are linked together in a partial structure of starch.

This was a challenging area for candidates. Many were unable to draw the polymer since they had little knowledge of the structure of the monomer, or the representation of the monomer unit. Many candidates were unsure as to how to eliminate the water molecule. A common error in this question was that many candidates treated the reaction as an addition polymerization rather than a condensation polymerization reaction.

### Expected Responses

The equation of the reaction, using the three units of glucose is:



where condensation has taken place, and a molecule of water is removed from between adjacent monomer units.

Part (b) (iii) required candidates to state the type of polymerization that glucose undergoes to form starch, and to name the family of polymers to which starch belongs.

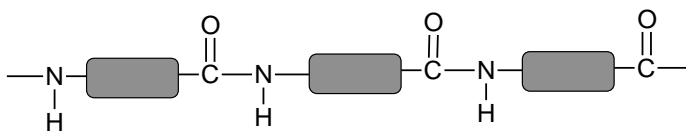
Most candidates correctly stated *condensation polymerization* and *polysaccharides* as the answers and were credited the marks.

### Common Incorrect Responses

Type of polymerization:            Addition polymerization  
Family of polymers:                Carbohydrates



In Part (c), the partial structure of a protein molecule was given as



Candidates were required to describe how the structure of the protein is affected by acid hydrolysis.

The majority of candidates scored no marks for this part. Several candidates were able to say that bonds are broken, but could not identify the type of bond. Those candidates who received at least one mark were able to recognize that amino acids were produced or drew the peptide link and drew a line showing where the bond is cleaved.

### Common Incorrect Responses

- This causes the structure of the protein to break apart.
- Water is added to the structure.
- The protein is broken down.
- The products of hydrolysis are a diacid and a diamine.

### Expected Responses

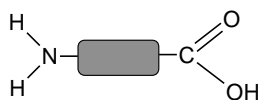
Candidates should refer specifically to what happens to the peptide linkage,  $\text{-CONH-}$ . Acid hydrolysis of proteins results in the cleavage of the peptide bond, and this produces amino acids.

In Part (c) (ii), candidates were required to draw the structure of the monomer unit that results from the hydrolysis of the structure shown above.

Many candidates realized that the protein would be broken into monomer units, but were unable to draw the two functional groups.

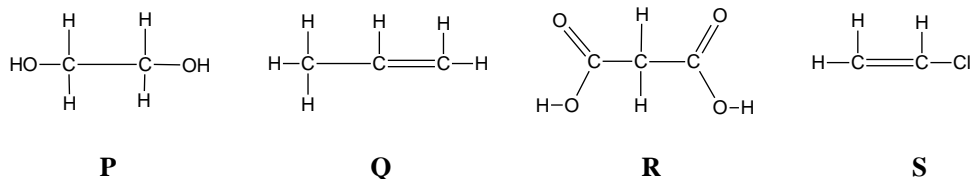
### Expected Responses

The structure of the amino acid, monomer unit is



Where an atom of H is added to the nitrogen to form an amino group,  $\text{-NH}_2$ , and an OH group is added to the carbon to form the carboxylic acid group.

In Part (d), the structures of four different monomers, P, Q, R and S, were given.



In Part (d) (i), candidates were required to identify two monomers that would undergo condensation polymerization, and one that would undergo addition polymerization, selecting from the four given.

The majority of candidates were able to correctly identify these monomers.

### Expected Responses

The two monomers that will undergo condensation polymerization are P and R. A monomer that will undergo addition polymerization is either Q or S.

Part (d) (ii) required candidates to state the name of the family of polymers that would be formed when monomers P and R reacted together. While many candidates gave the correct name, some were incorrect.

### Common Incorrect Responses

Esters  
Esthers

### Expected Response

The correct name is *polyesters*.

### Question 4

Syllabus References: A: 6.27, 7.2, 7.3, 7.4; B2: 5.2

This question was designed to test candidates' knowledge of factors that affect the rate of reaction and of the uses of metal alloys.

The performance of the candidates on this question was fairly satisfactory since the majority of the candidates scored between 6 and 9 marks. In particular, the parts of the question that involved mole calculations and the determination and description of an appropriate laboratory procedure proved challenging for most candidates.

Part (a) of the question was generally well done, with most of the candidates obtaining all 4 marks for stating any four of the following responses: concentration of reactants, pressure, temperature, particle size or surface area, catalyst, light.

### Common Incorrect Responses

Many of the weaker candidates erroneously included solubility and pH as factors affecting rate of reaction.

Part (b) (i) proved challenging for a number of candidates who either experienced problems reading the scale on the y/volume axis or who did not know how to determine the total volume of CO<sub>2</sub>. The expected volume was **124 cm<sup>3</sup>**.

Part (b) (ii) posed some difficulty to candidates who could not accurately convert volume of CO<sub>2</sub> to moles and then relate this to mass of CaCO<sub>3</sub> as shown below:

$$\begin{aligned}\text{Moles of CO}_2 &= 124/24000 = 0.0052 \text{ moles} = \text{moles of CaCO}_3 \\ \text{Mass of CaCO}_3 &= 0.0052 \times 100 = 0.52 \text{ g}\end{aligned}$$

Part (b) (iii) was fairly well done, although it was noted that several candidates did not know how to interpret the graph to determine the total volume of gas. This seems to suggest a lack of experiential knowledge of how such data may be generated.

### Common Incorrect Responses

- The total volume of CO<sub>2</sub> formed in Part (i) was incorrectly interpreted. Candidates summed the volumes at each point on the curve instead of reading the volume at the flat part of the curve.
- Some candidates were confused about the concept of **small** particle size corresponding to **large** surface area and vice versa.
- Another common misconception displayed by many candidates was the incorrect use of the terms 'dissolve' or 'mix' to mean 'react' in their description of the experiment.

### Expected Responses

The expected answer for Part (iii) was *rate of reaction will increase since the surface area increases or particle size decreases* or alternatively *time will decrease since the rate of reaction increases*.

For Part (c) (i), the responses showed that candidates generally understood that *alloys have improved properties and greater flexibility of use or function over the pure metal(s)*. The weaker candidates misinterpreted the question and listed properties of pure metals instead.

Part (c) (ii) proved to be the most difficult part of the question for candidates, who mostly gave no response or responded with incorrect laboratory procedures.

Stimulus material given in the question 'manganese is above hydrogen in the electrochemical series' guided a minority of candidates to the correct procedure for obtaining a sample of dry copper from a sample of the alloy other than electrolysis as stated below on the expected response.

However, many of these candidates failed to include wash/rinse the residue and therefore lost one mark.

Some candidates also spent valuable time unnecessarily explaining the theory for copper not being able to react with acid instead of detailing the laboratory procedure, while others described the process of electrolysis for the extraction of copper from alloys even though the question indicated 'other than electrolysis'.

### Expected Responses

- Allowing a sample of the alloy to react with excess dilute acid
- Filtering the resulting mixture and collect the residue
- Washing with water and dry in air/oven to obtain copper

### Common Incorrect Responses

- Incorrect procedures, such as fractional distillation, use of a magnet or mixing with water to separate copper
- Correctly adding acid to alloy but erroneously crystallising a copper salt from the filtrate

### Question 5

Syllabus References: A: 6.23, 6.24, 6.25, 6.27, 6.28, B2: 3.1, 5.2

This question examined the candidates' knowledge of electrolysis of concentrated sodium chloride and copper(II) sulfate solutions.

Part (a) of the question tested candidates' knowledge of the industrial preparation of chlorine by electrolysis, using the ion exchange membrane cell. In (a) (i), candidates were required to give the name of the electrolyte and the ions present.

The majority of candidates were specific and stated that the electrolyte was concentrated sodium chloride. However, some candidates named the ions from the salt, but did not name the ions from water. Sodium chloride or aqueous sodium chloride was not accepted, since the products of dilute and concentrated sodium chloride are different.

### **Common Incorrect Responses**

Electrolyte:

- Molten NaCl
- Aqueous NaCl
- NaOH
- HCl
- Ions in solution:
- $\text{Na}^{2+}$ , Cl, H,  $\text{Cl}^+$

### **Expected Responses**

The electrolyte is *concentrated* sodium chloride and the ions are  $\text{Na}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$  and  $\text{OH}^-$ .

In Part (a) (ii), candidates were required to provide an explanation for which ions are preferentially discharged at the electrodes. The less than satisfactory performance was due mainly to the incomplete and superficial responses alluded to earlier in the report. Many candidates stated that the reason was the position of the ions in the electrochemical series but did not give the relative positions of the ions in the series. Some candidates knew the factors used to decide preferential discharge but did not identify the ions as  $\text{H}^+$  and  $\text{Cl}^-$ . Others confused the electrochemical and reactivity series, incorrectly assuming that they were the same.

### **Common Incorrect Responses**

- Cations move towards the cathode and anions move towards the anode.
- Sodium is more reactive hence it is discharged first.

### **Expected Responses**

At the cathode, the  $\text{H}^+$  ion is discharged in preference to the  $\text{Na}^+$  ion. For the positive ions, the one that gets discharged at the cathode is the ion of the least reactive metal/element. This occurs because least reactive elements have a greater tendency to be atoms or the more reactive metals have a greater tendency to be ions rather than atoms, therefore, ions like  $\text{Na}^+$  and  $\text{K}^+$  are NOT preferentially discharged.

Part (a) (iii) required candidates to write ionic equations for the electrode reactions. Approximately 50% of candidates wrote the correct equations showing the formation of hydrogen gas and chlorine gas at the cathode and anode respectively.

### **Common Incorrect Responses**

Common incorrect responses showed the incorrect species of the electrons being discharged on the wrong side of the ionic equations. Some equation showed 'ions' without charges, that is, atoms being discharged, instead of ions.

Anode reaction:

- $\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$
- $2\text{H}^+ \rightarrow \text{H}_2 + 2\text{e}^-$

Cathode reaction:

- $4\text{OH}^- \rightarrow \text{O}_2 + \text{H}_2\text{O} + 4\text{e}^-$
- $2\text{Cl}^- + 2\text{e}^- \rightarrow \text{Cl}_2$

### Expected Responses

Anode reaction:  $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$

Cathode reaction:  $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

Part (c) (iv) required candidates to state the role of the ion exchange membrane. This part was poorly done and candidates seemed unfamiliar with the content. Some candidates incorrectly referred to the membrane as semi-permeable.

### Expected Responses

In this cell, the ion-exchange membrane that is positioned between both electrodes separates  $\text{Cl}^-$  ions from  $\text{OH}^-$  ions. When the solution is added to the membrane, the membrane allows  $\text{Na}^+$ ,  $\text{H}^+$  and  $\text{OH}^-$  ions to pass to the cathode chamber and  $\text{Cl}^-$  stays in the anode chamber.  $\text{Cl}^-$  is discharged, while the  $\text{OH}^-$  is trapped in the cathode chamber and cannot pollute the chlorine gas being collected.  $\text{H}^+$  is discharged at the anode and collected.  $\text{Na}^+$  and  $\text{OH}^-$  bond together, forming sodium hydroxide which is extracted from the bottom of the cathode chamber.

In Part (b), an experiment was carried out to purify copper by electrolyzing copper(II) sulfate solution using impure copper as the anode and pure copper as the cathode.

Part (b) (i) required candidates to state what was expected to happen at the anode during the experiment.

This part was well done and most candidates recognized that the anode would decrease in size.

### Common Incorrect Responses

- The anode would increase in size.
- The copper would deposit below the anode.
- Impure copper will be discharged.
- Impurities will fall off leaving the pure copper behind.
- The anode will melt/break off.

### Expected Responses

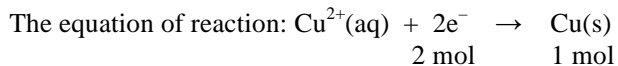
The anode will decrease in size. This happens as the copper atoms from the anode are oxidized and go into solution.

In Part (b), candidates were required to calculate the mass of pure copper that would be produced during the experiment if a current of 5 A flows for 30 minutes. This part was fairly well done. A common error was not converting the minutes to seconds.

### Common Incorrect Responses

Most of the incorrect responses did not account for the 2:1 mole ratio as shown in the equation below.

### Expected Responses



$$2 \times 96\,500 \text{ C} \quad 64 \text{ g}$$

Amount of charge,  $Q = I \times t = 5 \text{ A} \times 30 \times 60 \text{ s} = 9\,000 \text{ C}$

2 x 96 500 C produces 64 g of copper

9 000 C produces  $64 \text{ g} \times 9\,000 \text{ C} / (2 \times 96\,500 \text{ C}) = 2.98 \text{ g}$  of copper

### Question 6

Syllabus References: C1: 2.5, 2.6, 2.7, 2.10

### Part (a) (i) – (ii)

Generally, candidates performed well on this task.

Part (a) (i) required the candidates to name the main pollutants that are responsible for ozone depletion and global warming. Many candidates identified the sources of the pollutants, such as 'burning of fossil fuels' and 'aerosols', rather than the pollutants themselves. The response 'aerosols' was not credited but credit was given for 'CFCs'. Some candidates wrongly identified 'CO<sub>2</sub>' as the pollutant for both ozone depletion and global warming. Candidates who stated both answers together without linking to either ozone depletion or global warming were not credited.

Part (a) (ii) required the candidates to name TWO harmful effects of ozone depletion and global warming.

### Common Incorrect Responses

- Many candidates named only two harmful effects and did not link either of the effects to ozone depletion or to global warming.
- Candidates stated that the effect of increased CO<sub>2</sub> levels resulted in a decrease in O<sub>2</sub> levels.
- Ozone depletion resulted in global warming.
- Ozone depletion led to UV radiation entering the Earth's atmosphere rather than it leading to an INCREASE in penetration of UV radiation.

Responses that were credited include:

- Ozone depletion leads to *increase in skin cancer, reduced immune function or death of phytoplankton.*
- Global warming leads to *melting of polar ice caps, rising sea levels, more severe storms/hurricanes and severe drought.*
- A simple statement of 'climate change' **was not credited.**

Full marks were awarded for the following response to Part (a) (ii).

*Two harmful effects of ozone depletion are (i) increased UV radiation, which will lead to an increase in skin cancers, (ii) the melting of the icecaps at a faster rate, which will contribute to rising sea levels.*

**Part (b) (i) – (ii)**

Part (b) (i) required the candidates to suggest TWO ways a hotelier could ‘go green’ in addressing water use. The major weakness in responses that were not credited was the fact that candidates failed to develop points made. For example, candidates who suggested that water can be ‘conserved’ without stating how this can be done were not awarded any mark for that response. However, responses that were credited include:

- *The hotelier can advise guests to turn off the taps while brushing teeth.*
- *The hotelier can install taps with sensors or with timers.*
- *The hotelier can use water from the kitchen to water plants.*

Part (b) (ii) required the candidates to suggest TWO ways a hotelier could ‘go green’ in addressing garbage disposal. Again vague responses such as ‘Proper disposal’, ‘Do not litter’, ‘Send to a sanitary landfill’ and ‘Bury instead of burning’ were not credited. However, more specific responses were, for example:

- *The hotelier can install recycle bins and encourage guests to use them.*
- *The hotelier can compost vegetable matter from the kitchen to use as fertilizer on the plants.*
- *The hotelier can use more biodegradable products instead of plastics.*

Part (b) (iii) required the candidates to suggest TWO ways in which a hotelier could ‘go green’ in addressing energy use. Most candidates earned marks for naming one alternative source of energy, for example: *Use a solar water heater* or *Switch to energy-saving light bulbs* or *The hotelier can advise guests to turn off lights and air-conditioners when leaving the room.* Candidates who simply stated *Conserve energy* were not credited.

Part (c) required candidates to state their opinion on the setting up of common international standards for pollution control and TWO points to support such a position. While most candidates were able to obtain marks for stating an opinion, many did not go on to give support to the opinion stated but rather stated the effects of pollution.

Examples of points to justify common international standards for pollution control included:

- *Pollution is a global problem and should be dealt with in a global way.*
- *Pollution produced in one country can affect other countries.*
- *There is a serious need for countries to work together to reduce the level of pollution.*

Examples of points AGAINST common international standards for control included the following:

- *Poorer countries would not be able to afford the cost of meeting these standards.*
- *All countries do not have the same problem with pollution and may not need these standards.*

## Paper 032 – Alternative to SBA

### Question 1

Syllabus references: A: 3.3; 8.1; 8.3

The maximum marks available were 25. The highest mark achieved was 23 but the majority of the candidates obtained between 7 and 13 marks.

This question tested the candidates' knowledge of reactions of metals and acids, their ability to test for the gas produced as well as their knowledge of its physical properties. In addition, the ability of candidates to plot a graph and describe its shape, calculate moles from mass and the chemical equation and volume from molar volume, write a possible aim and identify variables was also tested.

Most candidates read the scale and knew how to plot the points on the graph correctly; however, many of them did not draw the smooth curve that was expected. Some candidates plotted the points only and others used a ruler to join the points. Candidates should be reminded that plotting a graph includes drawing the best fit line or curve as well.

Generally, the balanced chemical equation was well done but a few candidates did not know the correct chemical formula for magnesium chloride,  $\text{MgCl}_2$ . In a few cases, the charge of the metal was placed in the equations. Candidates should be reminded that charges are not part of the chemical equation unless the reactants or products are ions.

In Parts (iii) and (iv), candidates were asked to describe the general shape of the graph and to account for the shape. Some candidates accurately described the shape as a curve but sloping upwards – this was also accepted. However, accounting for the shape proved problematic for most of the candidates. Many candidates obtained one mark for stating that the longer the ribbon the more time was needed for the reaction to be completed but they neglected to include the fact the concentration of the acid was not changed or remained constant for the second mark.

For the calculations, most candidates were able to obtain 2 of the 3 available marks for calculating the mass of the 9-cm length of magnesium ribbon and changing the mass to moles. However, many neglected to use the mole ratio from the equation when trying to calculate the moles of acid that would react with it. In addition, many of the candidates knew to multiply the moles of magnesium by 24 to find the volume of gas but some used the moles of acid instead and many did not know the correct units.

When asked to suggest a possible aim for the experiment in Part (b), the language used was unsatisfactory. Many candidates did not include the terms 'to determine', 'to investigate' or 'to find'. Many answers were in the form of a statement for example 'measure the volume of gas produced' or 'measure the rate of reaction'. Some correct responses were 'to determine the rate of reaction between magnesium and HCl' or 'to determine the rate of production of hydrogen for the reaction'.

The variable to be controlled was either the mass of magnesium or the volume of acid. Temperature was also accepted. Candidates should be encouraged to use correct terms of measurement that are scientifically accepted with their units, for example, volume ( $\text{cm}^3$ ) or mass (g) and not use the term 'amount' which has no units. The acceptable variables to be measured were the volume of gas produced and the time taken.

Many candidates confused the test for hydrogen gas with that of oxygen gas. In many cases, using a glowing splint was suggested instead of a lighted splint. However, whether the splint was lit or was glowing most of the candidates expected to hear the 'pop'.



Many candidates did not earn the mark for deducing the physical property of the gas produced in the experiment. Many candidates noted that the gas was less dense than air but this was not accepted because it could not have been deduced from the experiment. Since the gas was collected over water some of its acceptable physical properties were that it was less dense than water, insoluble in water or even colourless.

When candidates were asked to write an observation when the concentration of HCl was doubled, many stated that the rate of reaction was faster. This was not accepted since rate is not simply observed but must be calculated. Acceptable responses included *more bubbles were observed in less time*, *magnesium dissolved faster* and *more effervescence was seen*.

Many candidates were unaware that once the reaction had ceased then the acid was completely used up or that the magnesium ribbon was in excess. In addition, many candidates assumed that the resulting liquid would have been either acidic (reacting with blue litmus only) or basic (reacting with red litmus only). Very few candidates recognized that it would have been neutral, reacting with neither blue nor red litmus paper.

### Question 2

Syllabus references: B2: 7.1, 7.2 and 7.3

Overall, this question was poorly done, with approximately 70 per cent of the candidates scoring 4 or less of the maximum 10 marks. This question focused on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid, Compound P, as well as its aqueous solution.

Again, it appeared that the majority of the candidates were not familiar with qualitative analysis, the tests as well as generally making observations. For example, when told that after heating a portion of P the gas was tested with a glowing splint and was confirmed to be oxygen, many candidates did not know that oxygen would relight the glowing splint or that oxygen would be colourless. Many candidates did recognize that  $\text{Al}^{3+}$ ,  $\text{Pb}^{2+}$  and  $\text{Zn}^{2+}$  would give a white precipitate in sodium hydroxide and  $\text{Zn}^{2+}$  in aqueous ammonia but they did not know that in both cases the precipitate would be soluble in excess. Some candidates knew that a pale yellow precipitate is observed when  $\text{I}^-$  ions react with  $\text{AgNO}_3$  but they didn't seem to know that it would be insoluble in excess aqueous ammonia. However, most candidates did know that  $\text{NO}_2$  is a brown gas.

### Question 3

Syllabus reference: A 6.25

This question tested the candidates' planning and design skill and was poorly done, with about 70 per cent of the candidates earning 4 or less of the maximum 13 marks.

Less than half of the candidates wrote an acceptable aim – many simply rewrote the hypothesis. Many excluded the required variables which were the change in mass of the copper cathode and the different concentrations of the copper(II) sulfate solution.

Not many candidates provided the essential apparatus required to carry out the experiment. The weighing apparatus was excluded from many of the responses. In addition, candidates needed to be more specific in listing appropriate apparatus required for electrolysis.

In many instances, candidates did not relate the procedure to the hypothesis. Many did not recognize that they had to weigh the cathode before and after the electrolytic process as well as vary the concentration of the electrolyte. It was evident that some candidates were never exposed to the process of electrolysis.

Most of the candidates, however, were able to state at least one variable to be controlled in the experiment (that is, time or temperature) so this part was done fairly well. Some also recognized that there was something about the  $\text{CuSO}_4$  that needed to be controlled but rather than being specific and noting that the volume of the  $\text{CuSO}_4$  should be controlled some simply wrote the  $\text{CuSO}_4$  solution. Most candidates stated the mass of the copper cathode as data to be collected but many did not recognize that they also needed to state the varying concentrations of the  $\text{CuSO}_4$  solution as well.

Candidates did not relate the discussion to the hypothesis. It was expected that candidates would identify under which circumstances the hypothesis would be accepted and under which circumstances it would be rejected. Many candidates who attempted the question only noted when it should be accepted.

Many candidates were not able to recognize the possible sources of errors that may occur during the experiment. Accepted answers were *fluctuations in the current or temperature*. Human errors and parallax errors were not accepted as sources of errors for this experiment.

### **Paper 031 – School-Based Assessment**

#### Planning and Design (PD) Skill

Generally the standard of the laboratory exercises assessed for the Planning and Design skill has declined again this year. Teachers and students are urged to consult the June 2012 CSEC Chemistry Subject Report for detailed information regarding the standard and structure expected of the PD labs. In addition, there are 13 suggested PDs for teachers to utilize freely, with details on two of them as examples.

At the same time, teachers are reminded of the following:

- All PD activities should be based on chemical concepts included in the syllabus. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition or any other non-chemistry discipline cannot be accepted.
- Students should undertake at least four PD activities over the two-year period. When this is not done the students are at a disadvantage.
- Some SBA Planning and Design activities were assessed for other skills as well. This suggests that the exercise has been carried out and so cannot be moderated for PD skills. This places the candidates at a serious disadvantage.
- While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does suit all the PD activities submitted. If not, then each PD activity should have a separate mark scheme.
- Ensure that the problem statement is written on the mark scheme and that the students include it in their laboratory books before submission.
- Students should be encouraged to state the variables (control, manipulated) separately and not just have them in the method.
- Students should also be encouraged to review their method to ensure that all the necessary apparatus and materials are listed. One way in which this could be done is to have them write the method before listing the apparatus.

### Analysis and Interpretation (AI) Skill

The Analysis and Interpretation skill continues to be one of the skills on which students demonstrate greater proficiency. In general, the calculations were well done; however, there appears to be a decline in the number of qualitative analysis experiments to which the students are being exposed. This lack of exposure may place the students at a disadvantage and this was also evident in the Alternative to SBA paper.

In order to encourage continual improvement here are a few points to note:

- Samples **should not be submitted** without mark schemes.
- Students should be required to complete their table of contents. This should include the experiment number (corresponding with the mark scheme), the date the experiment took place, as well as its pagination. Keeping good updated laboratory books is a practice that should be encouraged among all aspiring chemists.
- Teachers should spend time developing good analytic rubrics (mark schemes) to accompany the laboratory exercises. Once developed, these can be simply adjusted as changes are made to the exercises.
  - In the case of volumetric analysis, the concentration of reagents being used should be provided in the mark scheme.
  - In the case of qualitative analysis, the name of the unknown or the ions expected should also be included in the mark scheme.
  - If there is more than one teacher at the centre, the teachers should collaborate and submit one common mark scheme.
  - When interpolation from a graph is marked for AI skill the mark schemes need to be more explicit to guide the moderation process.
  - When requiring a balanced chemical equation, teachers are advised to award a maximum of 2 marks. One mark should be awarded if it is unbalanced.
  - Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should not be assessed under AI.
  - Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected by the teacher.
  - Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that the student understands what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again, teachers are asked to refrain from using the equation  $M_1V_1=M_2V_2$ .
  - Teachers should insist that students write correct formulae: for example, sodium chloride as NaCl and not NaCL and Mg not mg for magnesium.
  - Students require more guidance in producing the discussion section of the laboratory report. Perhaps teachers can ask specific questions which will assist students in this section. These questions should be included in the mark scheme to guide the moderation process.
  - When assessing a laboratory exercise for more than one skill, both skills should be clearly stated with their marks separately noted.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2014**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

In 2014, the overall performance of candidates was not markedly different from previous sittings. Thirty-eight per cent of the candidate population achieved Grades I to III on the examination. The best performance was on Paper 01 which showed a mean score of 31.67 while Papers 02 and 032 showed mean scores of 29.66 and 16.16 respectively.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

While general performance on this paper was satisfactory, candidates showed weaknesses in several areas worth noting. Some of these areas of weakness were also noted on performance on Paper 02 and as such signals the need for closer attention.

- Interpretation of data or familiar notations such as
  - atomic notation to identify the symbol, atomic number, mass number and charge
  - diagrams showing atomic structure and arrangement of electrons
  - cooling curves — determining melting point etc
  - graphs such as the determination of the end point of a titration
- Balancing written equations
- Calculations involving gas volumes at RTP and STP where the equation was given
- Deducing periodic trends
- Identification of acid salts from a set of compounds
- Identification of organic compounds, homologous series given structural formula
- Properties of conductors, soapless detergents

Poor performance was noted in:

- Calculations involving
  - Mass and molar mass
  - Manipulating Avogadro's number
- Knowledge of formulae and valencies of common radicals and writing chemical formulae
- Knowledge of chemical reactions and processes required by the syllabus such as:
  - Electrolysis of dilute acids
  - Preparation of salts such as copper sulphate
  - Anodizing
  - Separation of ethanol and water
  - Hydrolysis of fats
  - Polymerization of amino acids
  - Differentiating among reactions between acids and carbonates, metal, bases
  - Catalysts from different reactions e.g. Haber process, esterification,
- Differentiating among the properties of solutions, colloids and suspensions
- Electrochemistry
  - Interpretation of redox equations
  - Differentiating what happens at the electrodes – reactions at the anode and cathode

- Organic chemistry
  - Classifying organic equations e.g. addition and substitution
  - Reactions of alkanes
- Description of metallic bonds

### **Paper 02 – Structured/Extended Response Questions**

Questions 1 and 6 recorded the best performances from among the candidate population. From year to year, the report on performance in the CSEC Chemistry examination highlights the common areas candidates seem to find difficult as well as the kinds of errors that are made. It is hoped that students and teachers will use this information to conduct self-assessment, identify strengths and weaknesses and so better prepare for the examination.

Most candidates demonstrated adequate knowledge in the following areas:

- Reading the volumes from the diagrams of the burette
- Reaction between acids and bases
- Understanding of global warming

Factors that contributed to the poor performance of candidates included

- Superficial responses — candidates wrote in vague terms when describing phenomena or offering explanations.
- Limited understanding of key concepts.
- Inability to correctly write chemical formulae.
- Poor interpretation and writing skills particularly in dealing with equations at the anode and cathode.
- Lack of knowledge in balancing the changes when writing equations to show reactions at anode and cathode.

#### Question 1

Syllabus References: A: 3.3, 3.4, 3.7, 6.10, 6.11, 6.12, 8.1, 8.2, 8.3, B2: 7.1, 7.2

Part (a) was based on candidates' knowledge of the difference between normal salt and acid salt, and how each is formed.

Parts (b) (i) to (viii) were based on candidates' interpretation of burette readings taken from a titration which formed a normal salt from a neutralization reaction. Candidates were required to complete the table of titration results as well as indicate the volume of acid used in the neutralization. Some knowledge of the experimental precautions and errors for this type of titration were also expected as well as the equation for the reaction. The results from the volumetric analysis were expected to be used to calculate the moles of acid used and the expected mass of the salt in the reaction.

For Part (b) (ix), candidates were required to draw an energy profile diagram for this exothermic reaction. Marks were awarded for the correct shape, the correct axes (energy and reaction progress) and correctly identifying the reactants and products on the diagram.

Part (c) tested candidates' knowledge of qualitative analysis. Given the tests and observations, candidates were required to provide the inferences which included writing an ionic equation.

### Performance of Candidates

In Part (a) (i), many definitions were incomplete as they failed to state what was replacing the  $H^+$  ions in the acid or they failed to explain that all of the  $H^+$  ions are replaced when normal salts are formed. A good response that was awarded full marks was that *a normal salt is a compound formed when all hydrogen ions of an acid are replaced by a metal or ammonium ion*. For Part (a) (ii), most candidates were able to give the other type of salt as *acid salt*. However, a number of candidates had difficulty writing the correct chemical formula. In answering Part (a) (iii), candidates could not recall the acids that could produce acid salts. Many monobasic acids were named.

Most candidates were able to give the correct titre volumes from the burette readings and deduced the volume of acid used for Parts (b) (i) and (ii). Candidates also provided a correct reason for eliminating the indicator in Procedure B for Part (b) (iii). Many candidates lost marks in Part (b) (iv) as they did not take into account that the solution first had to be heated to get the crystals or they neglected to filter the mixture to remove the crystals before washing and drying. A fair percentage of candidates were able to determine the number of moles of acid in Part (b) (vi). However, fewer candidates were able to determine the mass of salt in Part (b) (vii). The relative atomic masses of the elements were not provided. As such, many candidates were unable to determine the relative formula masses of the sulfuric acid and sodium sulfate.

Most candidates were able to obtain a mark for identifying the products and reactants on the energy profile diagram drawn in answer to Part (b) (ix) and scored at least one of three marks for this section. Candidates were not able to label both axes of the diagram. Many candidates correctly identified the y-axis as the "energy" axis but failed to get the correct label for the x-axis.

Very few candidates scored full marks for Part (c). Most of them deduced that an acidic gas or a nitrate ion or a nitrogen dioxide gas was produced from the action of heat on X. The majority of the candidates were unable to write a correct ionic equation for the reaction of sodium hydroxide on X. However, a fair number of candidates were able to identify ammonia as the gas that evolved.

### Common Incorrect Responses

For Part (a), common incomplete definitions of acid salt were

- 'A normal salt is a salt that all the  $H^+$  ions have been replaced.' This response was awarded one mark.
- 'This means that the salt is neither acidic or basis.' This is a property of normal salts and no marks were awarded in this case.

Many incomplete responses were presented for Part (b) (iv). Two such responses are below. In the first example, the candidate neglected to include heating the mixture. In the second, the filtration process was omitted from the procedure.

- 'Evaporate some of the water, wash and then rinse the crystals and then leave to dry.'

- ‘Evaporate some of the water and leave to crystallize. Rinse salt with cold distilled water to remove soluble impurities and dry crystals between sheets of filter paper’.

A common incorrect response noted for Part (b) (ix) was that many candidates drew the energy profile diagram of an endothermic reaction.

Common incorrect responses for the reaction of heat on X in Part (c) included:

- Bromine gas produced
- Nitrogen gas produced
- Oxide of nitrogen produced

### Expected Responses

For Part (a) (i), the definition of a normal salt relates to how it is formed from the acid. It must include two critical components.

- Reference to the extent to which (partially or completely)  $H^+$  ions from the acid are replaced
- Reference to what will replace the  $H^+$  ions

The definition of a normal salt, as required for Part (a) (i), is therefore *a substance formed when a metal ion or ammonium ion completely replaces all replaceable hydrogen in the acid when reacted with a base or metal.*

For Part (a) (ii), candidates were expected to recognize that  $H_2SO_4$ , being dibasic can produce both normal and acid salts. Hence, the expected response was *acid salt*. The correct chemical formula was  $NaHSO_4$ .

In stating another acid that can produce the type of salt identified in Part (ii), candidates were expected for Part (a) (iii), to mention any other dibasic or tribasic acid, for example,  $H_3PO_4$  and  $H_2SO_3$ .

Expected responses for Parts (b) (i) to (viii) are noted below.

- (i) The correct burette readings are recorded in the table below

	Titration Number		
	1	2	3
Final Volume ( $cm^3$ )	Given	37.3	40.5
Initial Volume ( $cm^3$ )	0.5	12.2	Given
Volume used ( $cm^3$ )	25.0	25.1	25.0

- (ii) The correct volume of acid used is  $25\text{ cm}^3$  since two of the three titre volumes were  $25\text{ cm}^3$ .



- (iii) This section tested knowledge of salt preparation using the titration method. The correct response for eliminating the indicator from procedure in Part b was *the indicator would contaminate the crystals or the volume of base for neutralizing the acid was already known so there was no need for the indicator.*
- (iv) The remaining steps in the procedure to obtain dry crystals from the solution were to either  
*Heat the contents from the titration removing most of solvent and cool and filter the remaining mixture to remove the crystals.*  
 or  
*Transfer to an evaporating dish and evaporate to dryness.*
- (v) The balanced equation for the reaction between sulfuric acid and sodium hydroxide was:  

$$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$$
- (vi) The correct RFM for sulphuric acid 98. The calculation for determining the number of moles of acid needed to neutralize the base is outlined below.  

$$\text{Moles of acid per litre} = 4.9/98$$

$$\text{No. of moles of acid used} = (4.9/98) \times 25/1000 = 0.00125$$
- (vii) In order to calculate the mass of the normal salt, candidates were expected to do the following:  

$$\text{No. of moles of acid} = \text{No. of moles of salt}$$

$$= 0.00125$$

$$\text{Mass salt} = 0.00125 \times \text{molar mass of salt}$$

$$= 0.00125 \times 142 = 0.178 \text{ g}$$
- (viii) The difference in the mass of the salt may have been due to impurity of reagents, loss during transfer or incomplete crystallization.

The table for Part (c) should have been completed as shown below.

Test	Observation	Inference
A sample of X was heated in a dry test tube.	GIVEN	Nitrate ion present or nitrogen dioxide formed OR acidic gas produced
To one portion of a solution of X aqueous sodium hydroxide was added drop wise until in excess, then heated.	GIVEN	$\text{NH}_4^+(\text{aq}) + \text{OH}(\text{aq})$ $\rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\ell)$

## Question 2

Syllabus References: A 6.22, 6.24, 6.25, 6.2, B.2: 4.1, 4.2

Part (a) (i) and (ii) tested candidates' knowledge of electrolysis and its application to the purification of copper. In Parts (b) (i) to (iv), candidates were required to interpret a diagram of an electrolytic cell used in the electrolysis of molten lead bromide and calculate the mass of lead deposited during electrolysis. In Part (c), candidates were required to interpret two diagrams which highlighted investigations dealing with the reactivity series. They were required to apply knowledge of the series in explaining the observations recorded.

### **Performance of Candidates**

For Part (a) (i), candidates were unable to define the term *electrolysis* completely. Some were able to state in part that an electric current or electricity is passed through a compound while others were able to indicate that there is a *breakdown of electrolyte*.

Candidates did rather poorly on Part (a) (ii), showing a lack of knowledge or understanding of the purification of copper by electrolysis. They were unable to identify the type of anode required confusing it with graphite and even stating an '*inert electrode*' is required. There were cases where candidates recommended reactive metals such as magnesium for the anode.

In Part (b) (i), candidates failed to accurately assign the cathode in the diagram despite the clear negative sign coming from the cell on the diagram. This was very direct question and showed there was some guessing of the answer rather than application of knowledge of electrodes in electrolysis.

In Part (b) (ii) candidates showed a lack of knowledge the ions that made up lead bromide and were unable to correctly write the formula of the bromide ion,  $\text{Br}^-$  which would have migrated towards the anode. This further indicated that candidates were unable to predict the electrode to which ions migrate and a conceptual understanding of what takes place at the electrodes. Candidates also seemed to have had some misconception of *formula* and *equation*.

In Part (b) (iii), when asked to provide the ionic equation occurring at the cathode, very few candidates were able to give the accurate answer. There was some confusion as they showed electrons being lost rather than gained and in many instances the state symbols in the equations were not included. When state symbols were included these were often incorrectly stated. Teachers are encouraged to emphasize the difference between ionic equations and chemical equations and that the former can be derived from the latter. Students may also benefit from being shown how half-cell equations/ionic equations can be used to obtain the overall equation for the electrolysis of any electrolyte.

In Part (b) (iv), candidates generally performed well on this calculation gaining at least 50% of the total marks. Most were able to logically state how they derived the mass of lead that would be deposited at the electrode. The main short comings were in recognising the mole ratio for the deposition of the lead; that is, 2 moles of electrons will be required to form 1 mole of Pb.

For Part (c), candidates were able to recognise the need to apply the reactivity series but did so incorrectly. In some cases they simply re-wrote the observations with no explanations. These displacement reactions should be demonstrated to students during laboratory exercises and should form a source of discussion within the classroom setting. In Experiment 1, while some candidates were able to recognize that Mg was higher than Zn in the reactivity series, they were not able to explain that no displacement would have occurred and hence the reason for no visible change. This was also the same for Experiment 2, some candidates recognized that Zn is higher in the reactivity series some did not indicate that it will displace the  $\text{Cu}^{2+}$  ions from the copper(II) sulphate solution. A few were able to give a complete answer as required.

### Common Incorrect Responses

For Part (a) (i), candidates gave inaccurate definitions such as:

- ‘Electrolysis is when an electrical current or charge is passed through a molten substance.’
- ‘Electrolysis is the distribution or liberation of particles via use of electricity.’
- ‘The process of breakdown electrolytes and forming products from their electronegativity.’

In giving the type of anode that is used in the purification of copper for Part (a) (ii), candidates incorrectly stated

- Magnesium
- An inert electrode
- Anode-graphite

For Parts (b) (i) to (iii), the following incorrect responses were noted.

- |       |  |   |
|-------|--|---|
| (i)   | Electrode 1 (representing the cathode) |   |
| (ii)  | Formula for the bromide ion            | $\text{Br}_2^-$ ; $\text{Br}_2^- + \text{e}^- \rightarrow \text{Br}(\text{s})$          |
| (iii) | Reaction at Cathode                    | $\text{Pb}^{2+} - 2\text{e}^- \rightarrow \text{Pb}(\text{s})$ (Charge is not balanced) |

For Part (c), candidates, in attempting to explain their observations from the experiments, made incorrect statements as shown below.

Experiment 1:

*‘Here, the zinc rod will disintegrate and will deteriorate into the solution as it will be replaced by magnesium as magnesium is higher up in the reactivity series than zinc.’*

*‘Zinc and magnesium do not react with each other, rather both their electrons balance out each other and thus stopping reaction.’*

Experiment 2:

*‘The copper was more reactive based on the physical and chemical properties in which it entiles [entails] having ions to be liberated to their specific destination.’*

*‘A brown precipitate was observed at the base of the reaction.’*

### Expected Responses

For Part (a) (i), candidates were expected to give the definition *electrolysis is the decomposition of an electrolyte by the passage of an electric current through it.*

For Part (a) (ii), *impure copper/active electrode* was the type of anode used in the purification of copper.

Correct answers for Parts (b) (i) to (iv) are noted below.

- (i) The cathode was Electrode 2
- (ii) Formula for the bromide ion (migrating to the anode) is  $\text{Br}^-$
- (iii) Reaction at Cathode  $\text{Pb}^{2+}(\text{l}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$
- (iv) Calculating the mass of lead deposited
 
$$Q = I \times t = 5 \times 5 \times 60 = 1500 \text{ C}$$

$$2 \text{ mol electrons liberate } 1 \text{ mol} = 207 \text{ g Pb}$$

$$2 \times 96\,500 \text{ liberate } 207 \text{ g Pb}$$

$$1500 \text{ C liberate } 1500 \times 207 / (2 \times 96\,500) = 1.6 \text{ g}$$

The following are observations candidates should have explained when answering Part (c).

Experiment 1: Either of the following responses

- Zinc is less reactive than magnesium, hence zinc will not displace magnesium from solutions of its salts.
- Magnesium is higher than zinc in the reactivity/activity series, hence magnesium will not be displaced from its solution of its salts.

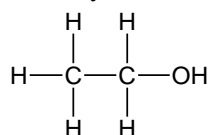
Experiment 2:

- Zinc is more reactive than copper and will displace it from solutions of its salts or Zinc is higher than copper in the reactivity/activity series.

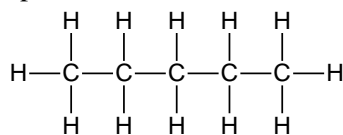
### Question 3

Specific objectives: B1: 2.5, 2.6, 2.7, 2.8, 3.9

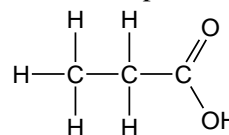
This question tested the candidates' knowledge of the structure and reactions of alkanes, alkenes and carboxylic acids. They were provided with the structures of three unknown compounds:



Compound A



Compound B



Compound C

In Part (a), candidates were required to state the names of the homologous series to which Compound B and Compound C belong. In Part (b), they were required to write a balanced chemical equation for the reaction that occurs when Compound A burns with a blue flame in oxygen. In Part (c), candidates were required to state which of the compounds, A or B, is more soluble in water, and give a reason for

their choice while in Part (d), they were asked to state which of the compounds, A or C, would react more vigorously with sodium metal, and give a reason for their choice. In Part (e), candidates were required to write a balanced equation for the reaction between Compound C, propanoic acid, and sodium metal. In Part (f), they were required to describe a test that could be used to identify the gas that is produced when Compound C, propanoic acid, reacts with sodium metal. Finally, in Part (g), candidates were required to state the name of the catalyst used in the reaction between Compound A, ethanol and Compound C, propanoic acid. They were also required to draw the fully displayed structure of the product formed.

### **Performance of Candidates**

For Part (a), the majority of candidates correctly stated the names of the homologous series and were awarded the two marks. However, for Part (b), less than 50 per cent of candidates wrote the correct equation. Some knew the reactants and products but did not produce a balanced equation.

In responding to Part (c), the majority of candidates correctly stated that Compound A, ethanol is more soluble in water than Compound B, pentane. Many could not give a correct reason. Some candidates knew that the higher solubility of ethanol was related to the presence of the  $\text{-OH}$  functional group, but could not give a reason.

For Part (d), the majority of candidates correctly stated that Compound C, propanoic acid, is more reactive with sodium metal than Compound A, ethanol. Very few candidates gave the correct reason.

Less than 50 per cent of candidates wrote the correct equation for Part (e). Some knew that the reaction produced hydrogen gas, but could not come up with the correct equation. Many candidates wrote the incorrect molecular formula for propanoic acid, even though the fully displayed structure was given.

Most of the candidates who wrote an equation in Part (d) that showed hydrogen gas as a product, gave a correct description of the test for Part (f).

For Part (g), very few candidates stated the correct name of the catalyst, or drew the correct structure of the product.

### **Common Incorrect Responses**

For Part (a), a number of candidates wrote 'acid' instead of carboxylic acid or alkanolic acid. They were not penalized, but 'acids' is NOT acceptable.

Common incorrect reasons given for Part (c) included:

- The presence of the hydroxide
- The presence of the  $\text{OH}^-$  ion

For Part (f), a common incorrect description of the test was 'the gas would 'pop' with a glowing splint'.

For Part (g), some of the incorrect names given to the catalyst were

- Dilute sulphuric acid
- Acidified potassium dichromate
- Sodium hydroxide
- Vanadium pentoxide

In addition, candidates drew incorrect structures showing carbon atoms with FIVE bonds. Some candidates knew that this was a condensation reaction, but showed the loss of a water molecule using the wrong part of the carboxylic acid.

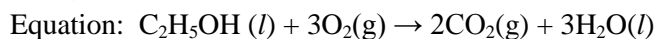
### Expected Responses

Part (a)

Compound B: alkanes

Compound C: carboxylic acids; alkanolic acids

Part (b)



Part (c)

The presence of the polar OH group in ethanol, makes it more soluble in water, a polar solvent.

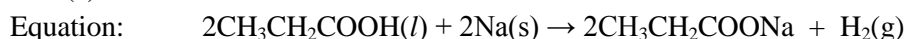
[There is a strong attractive interaction between the polar O–H group of ethanol, and the polar water molecules. This interaction is not present between pentane and water].

Part (d)

Propanoic acid, Compound C, is more reactive since it is a stronger acid than ethanol.

[The strength of an acid is inversely proportional to the strength of the O–H bond, i.e. the weaker the O–H bond the stronger the acid. The O–H bond in propanoic acid is much weaker than the O–H bond in ethanol, hence the H–atom (or more correctly, the H<sup>+</sup> ion) is more easily lost from propanoic acid.]

Part (e)

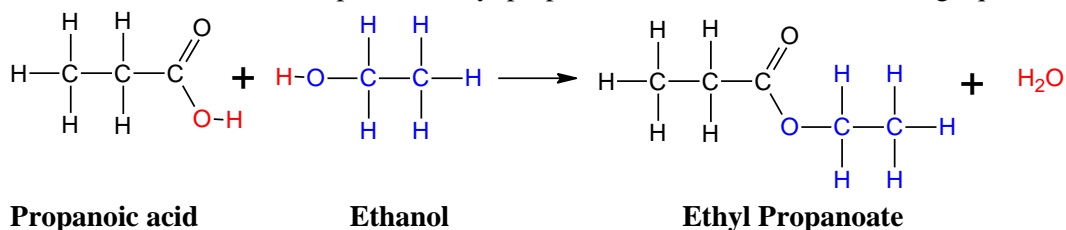


Part (f)

A lighted splint would go out with a ‘pop’ sound.

Part (g)

The correct structure of the product, ethyl propanoate, is shown in the following equation:



Note that in the formation of the ester, the ethyl group comes from the alcohol and the propanoate group comes from the carboxylic acid. The eliminated water molecule is formed from the OH group from the carboxylic acid and the H atom from the alcohol.

#### Question 4

Syllabus References: A: 3.3, 3.4, 4.1, 4.2, 4.5, 4.6, 4.7

Part (a) was designed to test candidates' ability to calculate the relative atomic mass of an unknown element given the relative molecular mass of a compound; write a plausible balanced equation for the formation of a chloride of a given Element M; and describe the formation of a metallic bond as well as ionic bonding in a chloride.

In Part (b) (i), candidates were required to account for the feasibility of the use of graphite as an electrode rather than an Element M (after having worked out the relative atomic mass) and given a description of Element M's physical and chemical properties and making reference to the bonding and relative positions of the elements in the periodic table.

In Part (b) (ii), candidates were required to draw the covalent bonding in chlorine.

#### **Performance of Candidates**

In Part (a) (i), most candidates were able to recognize that they were required to subtract the mass of the chlorine from 159 — the relative formula mass given. However, they failed to recognize that the chloride of M will have the formula  $MCl_2$  since element M was in Group 2. Many used the incorrect formula —  $MCl$  in the calculation.

In Part (a) (ii), the equation for the formation of the chloride of M was not very well done. Candidates did not recognize that chlorine was a diatomic molecule and the formula required was chlorine —  $Cl_2$ . M was assigned the formula  $M_2$  in some cases and the formula for the chloride of M was also stated inaccurately. In some cases, inaccurate ionic equations were given and the formation of sodium chloride was stated instead of the chloride of M. The balancing of the equation and the writing of the state symbols for each of the reactants and the product posed some challenge for candidates. There were few outstanding responses in which candidates were able to provide the reaction of the metal (M) and an acid (HCl) to form the chloride of M.

For Part (a) (iii) a), candidates were able to deduce that Element M contained metallic bonds while others were able to deduce it was a metal. However, they were unable to explain the formation or give an accurate description of metallic bonding, often confusing it for ionic and covalent bonding. They also appeared to confuse the bonding in M with the formation of an ionic bond between chlorine and M.

For Part (a) (iii) b), candidates were unable to identify that ionic bonding was present in the chloride of M, erroneously identifying it as covalent bonding. In few cases, candidates were able to describe accurately the formation of the covalent bond.

Responses for Part (b) (i) varied greatly, the question having posed quite a challenge for candidates. Candidates failed to state that both graphite and M conduct electricity since they can be used as

electrodes. There were instances where only one (either M or graphite) was stated as a conductor, however, the attempts to explain why each was able to conduct electricity left a lot to be desired. Candidates went into great detail in describing the bonding in graphite, outlining its covalent nature and the intermolecular bonds and in some instances the arrangement of the particles. Candidates even stated ‘graphite is a metal’ indicating a clear misunderstanding of the nature of graphite and how it conducts electricity. Most candidates failed to deduce that Element M was lower than calcium in Group 2 based on the relative atomic mass calculated in Part (a) (i). Even if they did not recognize this and recognized that it was a metal, they failed to realize it would have been more reactive than graphite and react with the electrolyte and hence could not be used as an electrode.

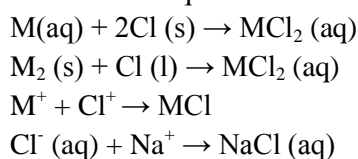
Part (b) (ii), though straightforward, proved difficult for some candidates. The diagrams should have shown mainly a shared pair of electrons together with the correct number of electrons on the outer shell on each chlorine atom. However, diagrams showed an incorrect number of electrons on the outermost shell and diagrams of single chlorine atoms. Most diagrams should have shown only the outermost electrons but the inner shell electrons were also shown.

### Common Incorrect Responses

A common incorrect calculation used in answering Part (a) (i) was:

$$\begin{aligned} \text{RAM} &= \text{mass} - \text{RAM of Cl} \\ &= 159 - 35.5 = 123.5 \end{aligned}$$

A common incorrect equation used in answering Part (a) (ii) was:



Incorrect descriptions for Part (a) (iii) a) included

- *“The formation of the type of bond in element M is one of covalent bond. Whereas M is found in group E of the periodic hence when reacted to chlorine the result would be an element of chloride.”*
- *“M is metal. Its particles are held together closely allowing few electrons to be mobile.”*
- *“Ionic bonding found in element M because it is in group 2 and 2 are metals and metals go through ionic bonding.”*

Incorrect descriptions for Part (a) (iii) b) included

- *“The chloride of Element M goes through covalent bonding because it is in group 7 and group 7 are non-metal, non-metals go through covalent bonding.”*  
[This candidate seems to be confusing chlorine with the chloride of M]
- *“The chloride of Element M will form covalent bonds as the chloride now will react with non-metals therefore an covalent bond is formed.”*

Incorrect explanations for Part (b) (i) included:



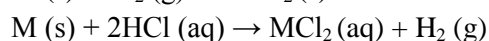
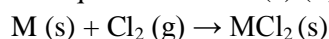
- *“Graphite is used as an electrode because it has free ion and mobile space and does not changes.”*
- *“Because graphite is a metal which contains ions that may conduct electricity, while the element M is an element that contains a limited amount of ions. Since the negative and positive charges are the same the charges cancel out which makes the element neutral. Graphite is also used as an electrode because the amount of electrons found in it and this element can withstand dissolving in a lot of substances.*
- *Graphite is use as an electrode whereas element M is not because graphite has weak Van der Waal forces and is not in any group in the periodic table whereas Element M is in group 2 and group 2 elements only react in aqueous solution, whereas graphite has free mobile electrons.*

### Expected responses

The correct calculations for Part (a) (i) was:

$$\text{RAM M} = 159 - (2 \times 35.5) = 159 - 71 = 88$$

The correct equation for Part (a) (ii) was:



Or any plausible balanced equations which results in  $\text{MCl}_2$

For Part (a) (iii) a), the bond in M- Metallic or M is a metal. Metallic bonding occurs when a metal atom loses valence electrons in the metal lattice leaving cations surrounded by delocalized electrons. (A description of the bond was also accepted)

For Part (a) (iii) b), the bond in  $\text{MCl}_2$  is ionic. The transfer of electrons from a metal to a non-metal OR the bonding between a metal and a non-metal OR occurs when M gives valence electrons to chlorine resulting in positive ions ( $\text{M}^{2+}$ ) and negative ions ( $\text{Cl}^-$ ). (A description of the bond was also accepted)

In responding to Part (b) (i), candidates should have noted that both M and graphite (or M or Graphite only) conduct electricity because they both have mobile, delocalized electrons that can carry an electric current but that graphite is inert as it is the element carbon which is very un-reactive/stable while M is lower in Group 2 than Ca (or very low in the Group 2) and is even more reactive and reacts readily with water OR M is a Group 2 metal and is very reactive.

The bonding diagram drawn for Part (b) (ii) should have shown a:

- Shared pair of electrons.
- Correct number of electrons on outer shell.

### Question 5

Syllabus References: A6.25, B2: 4.1, 6.2

This question examined the candidates' knowledge of electrolysis of concentrated sodium chloride and the water cycle.

In Part (a) (i), candidates were tested on the industrial manufacture of chlorine by the electrolysis of brine and were required to name the two beneficial by-products of this process. In Part (a) (ii), they were asked to write two balanced ionic equations, one for the production of chlorine, and the other for the formation of one of the by-products that they mentioned in Part (a) (i).

Part (b) tested candidates on their knowledge of the water cycle. In Part (b) (i), they were required to identify two physical processes by which water leaves the atmosphere and one physical process by which water enters the atmosphere. Then, for Part (b) (ii), candidates were required to explain one way in which the removal of trees, for the building of houses, can affect the water cycle.

In Part (c), the following information was provided. "R and T are metals and the oxidation state of each is +2. The hydroxide of T is stable to heat but the hydroxide of R decomposes to produce the oxide and water." Candidates were required for Part (c) (i), to write a balanced equation for the action of heat on the hydroxide of R. For Part (c) (ii), they were asked to predict what would happen to the carbonates of R and T when heated strongly and for Part (c) (iii), candidates were required to state a reason why R is more likely than T to be found combined with other elements in nature.

### **Performance of Candidates**

For Part (a) (i), there is a clear indication that the majority of candidates were unfamiliar with the electrolysis of brine, and so very few were able to list the two beneficial by-products.

Part (a) (ii) was poorly done as very few candidates gave two correct equations.

For Part (b) (i), many candidates incorrectly identified two processes by which water enters the atmosphere and one process by which water leaves the atmosphere. Furthermore, many seemed to have confused the processes by which water leaves and enters the atmosphere.

Many candidates were able to gain at least one of the two marks awarded for Part (b) (ii).

For Part (c), many candidates were unable to deduce the charge on the ion of R and so wrote the incorrect formula of the hydroxide of R. However, the majority of candidates correctly stated that R is more reactive than T.

### **Common Incorrect Responses**

For Part (a) (i), candidates incorrectly listed 'chlorine gas' and 'sodium metal' as the two beneficial by-products.

A common incorrect process cited by candidates as the process by which water leaves the atmosphere was 'water leaves the atmosphere through evaporation, transpiration'. In identifying the process by

which water enters the atmosphere, candidates incorrectly stated that ‘water enters the atmosphere through rain, condensation, precipitation’. These answers show confusion between the two processes.

A common incorrect equation given in response to Part (c) (i) was



Many candidates ignored the fact that R has an oxidation state of +2, hence its cation would be  $\text{R}^{2+}$  and would need two  $\text{OH}^-$  ions to form the hydroxide.

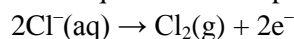
For Part (c) (ii), some candidates incorrectly assumed that since the hydroxide of T was stable to heat, then its carbonate would also be stable to heat.

### Expected Responses

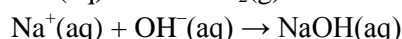
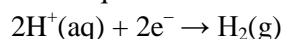
The two beneficial by-products for Part (a) (i) are sodium hydroxide and hydrogen gas.

For Part (a) (ii), the ionic equations should have been as shown below.

(ii) a) The ionic equation for the production of chlorine gas is:



b) The ionic equations for the two by-products are:

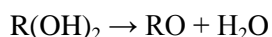


Note: In the electrolysis of brine, there are four ions in solution –  $\text{Na}^+(\text{aq})$  and  $\text{Cl}^-(\text{aq})$  from NaCl, and  $\text{H}^+(\text{aq})$  and  $\text{OH}^-(\text{aq})$  from water ( $\text{H}_2\text{O}$ ). The  $\text{H}^+$  ions and the  $\text{Cl}^-$  ions are preferentially discharged at the cathode and anode respectively, leaving the  $\text{Na}^+$  and  $\text{OH}^-$  ions in solution. Evaporation of the water leaves the solid NaOH.

Expected responses for Part (b) (i) were *water can leave the atmosphere through condensation and precipitation (rain, snow, hail, dew, sleet) and water can enter the atmosphere via evaporation or transpiration.*

A correct response for Part (b) (ii) was: *Trees are important in removing water from the ground, storing it, and returning it to the atmosphere. Removal of trees causes removal of less water by absorption which may lead to flooding and increased run-off. Removal of trees causes less water to be returned to the atmosphere which may lead to reduced rainfall.*

The correct balanced chemical equation for Part (c) (i) was



For Part (c) (ii), the correct prediction was that *both carbonates will decompose to give the oxide and carbon dioxide, for example,  $\text{TCO}_3(\text{s}) \rightarrow \text{TO}(\text{s}) + \text{CO}_2(\text{g})$ .*

## Question 6

Syllabus References: C1: 2.1, 2.2, 2.3, 2.4, 2.5,

This question dealt with the phenomenon of global warming and acid rain. Parts (a) (i) and (ii) tested candidates' knowledge of the definition of the terms pollution and environment. Part (b) required candidates to give a thorough explanation of the impact of global warming and acid rain on agriculture and tourism industries. Candidates in their responses were expected to indicate the sources of the pollutants, chemical equations showing formation of one of the pollutants, one effect of global warming on each of the two named industries and one effect of acid rain on each of the named industries and a suggestion to reduce one of the source pollutants.

### **Performance of Candidates**

Most candidates who attempted this question scored at least two of the four marks awarded for Part (a) and many got full marks. Candidates lost marks if they did not include one or more of the critical components of the definitions. Examples of responses include:

Definition of Pollution:

*Pollution is the contamination of harmful or toxic waste substances in the environment which can cause serious health effects and certain circumstances like death in organisms of not treated properly.*

This response was awarded full marks as it included the negative impact of “serious health effects including, death” on organisms.

Definition of Environment

*Environment is the physical surroundings that exist around the organism's habitat. It also contains the other organisms in the ecosystem that exist*

*Environment is the place of interaction between all biotic and abiotic factors*

Both definitions above were awarded full marks as they made reference to the living and non-living components from the surroundings.

Candidates also performed well on Part (b). The most common mistake was the confusion of global warming with ozone depletion and identifying sources of gases that cause ozone depletion. Many candidates also gave incorrect formulae for nitrogen dioxide. They were also unable to write a correct equation, mainly because of incorrect formulae. Although many candidates could state the outcomes of global warming and acid rain, many lost marks because they did not always show how they could affect the tourist and agriculture industries.

Most candidates were able to supply a plausible suggestion for reducing a named pollutant. For example, many candidates referred to the use of alternative energy sources instead of dependence on fossil fuels, and ensure that factories are equipped with suitable filters to reduce gaseous emissions into the atmosphere.

### Expected Response

A suitable definition for pollution should include reference to the negative impact of pollution on the environment that could cause harm to living organisms. For example, *pollution is any natural or artificial cause which makes the environment less suitable or its living components.*

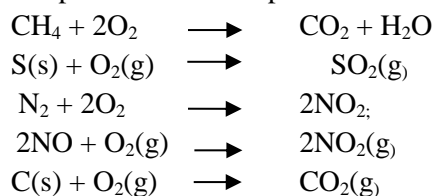
The definition of the environment should include reference to biotic factors and abiotic factors, for example, *environment is all of our surroundings, atmosphere, oceans, soil and all living things.*

Pollutants for global warming include carbon dioxide and methane. Examples of pollutants that lead to acid rain are nitrous oxides and oxides of sulfur.

Sources of these pollutants are:

- Carbon dioxide - burning fossil fuel
- Methane - fermented animal manure, landfills
- Nitrous Oxide - vehicular exhausts, factory emissions
- Sulfur dioxide - factory emissions, fossil fuels, volcanoes

The following equations for production of the pollutant were accepted



Candidates were able to identify many effects of tourism and global warming on tourism and agriculture. Marks were only awarded where candidates showed how the pollutant could have a negative or positive impact on each industry. Examples of the reasons are outlined in the table below.

Type of Pollution	Effect on Tourism	Effect on Agriculture
Global Warming	Damage to coral reefs and rising sea levels, for example, in the Caribbean would make the environment less attractive to tourists and so reduce income from tourism.	Searing temperatures cause drought and damage crops, for example, corn
Acid Rain	Accelerate decay of building materials, plants and so destroy historic buildings, statues and sculptures that tourists wish to see	Damage roots of trees so that they topple. This in effect reduces crop yield

**C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**MAY/JUNE 2014**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

## GENERAL COMMENTS

The overall performance of the candidates on this sitting of the examination was better than the previous two years. This year approximately sixty-eight per cent of the candidate population achieved Grades I-III compared with sixty-two per cent in 2013 and fifty-nine per cent in 2012. The best performance was on Paper 01 which showed a mean score of 34.94 while Papers 02 and Paper 032 the School-based Assessment (SBA), showed mean scores of 38.53 and 31.17 respectively. The mean score for Paper 032, the alternative to the SBA, was 14.97.

## DETAILED COMMENTS

### Paper 01

This paper consisted of sixty compulsory multiple-choice items. The general performance on this paper was satisfactory with approximately seventy per cent of the candidates scoring above the minimum cut score for a Grade III. The mean score obtained was 34.94 and scores ranged from zero to 60 marks. However, there continues to be several areas of weakness in candidates' knowledge and understanding of specific concepts. This suggests that closer attention ought to be given to these specific areas to help boost their understanding of these concepts. It seems as well, that more opportunities ought to be created for candidates to be engaged in learning activities that will strengthen their conceptual understanding of chemistry resulting in deep rather than superficial learning.

#### **Candidates recorded fairly good performance on the following topics.**

- Recall of information related to:
  - atomic notation to identify the symbol, atomic number, mass number and charge
  - particulate nature of matter
  - properties of subatomic particles
- Balancing written equations

#### **Candidates performed poorly on the following topics.**

- Knowledge of the chemical reactions (organic and inorganic) explored in the syllabus. Generally, where the candidates were required to use knowledge of the chemical reactions to answer questions, they performed poorly. However, questions such as "What are the products when X reacts with Y?" posed no problems.
- Calculations involving
  - Use of Formulae – particularly where units such as electrochemistry need to be considered.
  - Mass concentration
- Interpreting equations and symbols e.g. determination of oxidation number, discharge of ions at electrodes, deduction of the basicity of an acid.
- Chemical substances and reactions — Candidates seemed unfamiliar with a number of chemical substances and reactions to which they should have been exposed in the laboratory.
- Electrochemistry
  - Interpretation of redox equations – deduction of the oxidizing and reducing agents
  - Differentiating what happens at the electrodes – confusing reactions at anode and cathode; limited knowledge of special applications of electrolysis

- Organic chemistry
  - Identification of functional groups from structural formulae
  - Knowledge of the chemistry of the various homologous series (including alkenes and alkanes).

## Paper 02

Questions 1, 3 and 5 recorded the best performances. From year to year, the report on performance in the CSEC examination highlights the common areas that candidates seem to find difficult as well as the kinds of errors that they make. It is hoped that students and teachers will use this information to conduct self-assessment, identify strengths and weaknesses and so better prepare for the examination.

### Question 1

Syllabus References: A: 6.7, 6.10, 6.12, 6.13, 6.14, 6.15, 7.1, 7.2, 7.3, 7.4; B2: 7.1, 7.2

#### **Part (a) — Sub-sections (i)–(iv)**

This part of the question tested candidates' knowledge of thermometric titrations. Data for the temperature changes when portions of 0.1M hydrochloric acid were added to 25cm<sup>3</sup> of aqueous potassium hydroxide were provided. Candidates were required to plot a graph from the data, determine the volume of acid required to neutralize the potassium hydroxide solution, and calculate the heat of neutralization.

#### **Expected response**

The data when plotted should have produced two straight lines intersecting at a volume of 25cm<sup>3</sup> which represented the volume of hydrochloric acid required to neutralize the potassium hydroxide. The temperature difference was 11 °C obtained by subtracting the lowest from the highest temperature obtained. The calculation in Part (iv) should be done as follows:

$$\begin{aligned} \text{Total volume of liquid at neutralization} &= 25 + 25 = 50 \text{ cm}^3 \\ \text{Mass} &= 50 \text{ cm}^3 \times 1 \text{ g cm}^{-3} = 50 \text{ g} = 0.05 \text{ kg} \\ \Delta H &= 0.05 \times 4.2 \times 11 = 2.31 \text{ kJ} \end{aligned}$$

#### **Candidates' Performance**

- (i) Candidates were able to score at least one mark on this section as they obtained marks for plotting the graph and plotting the six points correctly. However, they lost marks as they did not draw the best straight lines to show intersection.
- (ii) Many candidates were able to determine the volume of acid required to neutralize the 25 cm<sup>3</sup> of KOH and earned the one mark. However, a few could not and recorded incorrect readings based on the graphs which they had drawn. Some candidates were also careless in their recording of the responses using the wrong units to represent volume e.g. 25g.
- (iii) Many candidates were able to determine the temperature difference for the reaction. Common mistakes were 6 °C as the answer, obtained by subtracting the initial temperature from the final temperature (33-27). The correct procedure was to subtract the lowest from the highest temperature. Some gave a description of the shape of the graph ("temperature increase then decrease") which suggests that they did not carefully read what was being asked.



- (iv) Candidates were required to calculate the heat of neutralization for the reaction between potassium hydroxide and hydrochloric acid. Most candidates were able to correctly substitute values in the equation given. Candidates lost the mark for not correctly determining the total volume of the mixture ( $25\text{cm}^3 + 25\text{cm}^3$ ). Many used  $25\text{cm}^3$  as the volume. Candidates also forgot or did not know how to deduce the mass of the system given the volume and density of the solutions. Some also neglected to convert the mass to kilograms.

### Part (b) — Sub-parts (i)–(v)

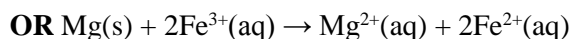
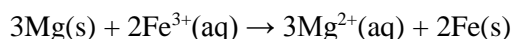
This section tested knowledge of the effect of surface area on the rate of reaction as well as knowledge of the reactivity series and specifically the displacement reactions of metals. Questions were based on two experiments in which magnesium metal reacted with iron(III) chloride.

#### Expected response

- (i) A suitable aim for the experiment was:  
*To investigate the effect of surface area on the rate of the reaction between magnesium ribbon and iron(III) chloride*
- (ii) With respect to what happened in Beaker A after 30 seconds, it was expected that candidates would describe the chemical changes expected to take place in the beaker. Here candidates should have used their knowledge of the displacement reaction between magnesium and iron (III) salts to predict what would take place. The correct response was therefore:

*The colour of liquid (solution) gets paler; Grey black solid (iron metal) formed at bottom of tube; strips of Mg get smaller. Marks were also awarded if the candidates deduced that Mg displaced Fe even if they could not describe the resulting mixture.*

- (iii) Either of the two ionic equations would have been correct.



- (iv) Given that Beaker B had the 5 cm strip while Beaker A had the same length of Mg cut into 5 pieces, candidates were expected to deduce that the rate of reaction in ‘A’ would be faster than in ‘B’ and as such, the reaction in ‘A’ would occur faster. Hence candidates were expected to report the following observations:

*The contents of Beaker B would not be as pale as Beaker A.  
Less solid (iron that was displaced) formed in B than in A.  
Magnesium pieces in A disappear faster than in B*

- (v) The following explanations for Part (iv) were required.

- *Surface area of magnesium in A is more than that in B.*
- *Magnesium in A will displace iron from  $\text{FeCl}_3$  faster than the Mg in Beaker B.*
- *The larger the surface area, then the faster is the rate of the reaction.*

#### Candidates' Performance

- (i) Surprisingly, quite a large number of candidates were unable to deduce the aim of the reaction. Many repeated what was written in the question instead of stating the “various factors” which in this case referred to the surface area.

- (ii) Candidates performed poorly on this section and only a few scored full marks. It seemed that candidates were not familiar with this particular reaction and were not able to deduce what should happen given their knowledge of the reactivity series and the displacement of metals from their salts by more reactive metals. Although many candidates know this principle, they were unable to apply this knowledge to the experiment described. Most candidates were only able to score one mark on this part.

The most common response among candidates was “decrease in size” (strips get smaller). Other common incorrect responses given by candidates were

“Mg strips will be dissolve quickly.” “Mg start to dissolve in iron chloride solution.” “Mg start to dissolve in the solution.” “After 30 seconds the contents of beaker A will be dissolved out in the solution.”

The use of the term “dissolve” in this context suggests that the candidates failed to understand that a chemical reaction was taking place between the magnesium and the iron (III) chloride.

- (iii) Candidates were required to write a suitable ionic equation for the reaction occurring in Beaker A. Few candidates were able to write the ionic equation correctly. There were many incorrect equations given. Candidates gave the molecular equations instead of the ionic equations. The greatest weakness was the failure to write the correct formula for the ions and to balance the charges in the ionic equations.

Parts (iv) and (v) proved most difficult for the candidates. They required knowledge of displacement reactions as well as the effect of surface area of magnesium on the rate of the reactions in Experiments 1 and 2.

- (iv) Many candidates were able to correctly describe how the contents of beaker A differed from the contents of beaker B. Only a few were able to gain full marks. Marks were lost because of superficial responses such as “contents of Beaker A would breakdown more quickly than the contents of Beaker B.”
- (v) Many candidates provided suitable responses that compared the surface areas of the magnesium in Beakers A and B. Hence, they were able to state that the surface area of the magnesium in beaker A was greater than that in Beaker B. However, they failed to link the difference in surface area to the rate of the reaction and there were instances where they totally confused surface area with particle size. They also described the reaction in terms of “decomposition” and “disintegration” instead of “displacement”.

### Part (c)

This final part of the question tested candidates’ knowledge of the confirmatory test for the sulfite ion and drew on knowledge of the differences among the reactions of sulfites, sulfates and carbonates.

### Expected response

The experiment in Figure 3 was a bit different from what candidates would normally do for testing for the sulfite ion. The reactions in Flask 1 should produce sulfur dioxide; with this understanding:

- (i) *Solution Y could be acidified potassium dichromate or permanganate (a suitable oxidizing agent)*
- (ii) *The expected colour changes when sulfite ions react with potassium dichromate or potassium permanganate are below. Candidates were required to give both colours (before and after reaction with sulfur dioxide)*

*Permanganate: purple to colourless*  
*Dichromate: orange to green*

*Explanation: SO<sub>2</sub> is reducing agent and will therefore reduce the oxidizing agent.*

- (iii) In order to test for carbonate instead of sulfite, the contents of Flask 2 would need to be changed to calcium hydroxide.

### **Candidates' Performance**

- (i) Many candidates identified Y as a barium salt such as barium chloride or barium nitrate as they failed to deduce the products of the reaction taking place in Flask 1. It seemed candidates thought that the sulfite ions from Flask 1 reacted with the contents of Flask 2. A few candidates identified Y as phenolphthalein which was also incorrect. Only a few of the candidates were able to identify Y as potassium permanganate or potassium dichromate.
- (ii) Given the widespread response of Solution Y being a soluble barium salt, candidates stated that the expected change in Flask 2 was a white precipitate. The candidates who identified Y as potassium permanganate or potassium dichromate were also able to correctly state the expected colour changes. Very few candidates were able to explain the observation in terms of reducing and oxidizing agents. These concepts continue to be confusing for many candidates. Those candidates who suggested that Y was a soluble barium salt were able to explain the formation of a white precipitate in terms of the solubility of barium sulfite.
- (iii) Most candidates gave the correct answer (lime water or calcium hydroxide). However, candidates are still confusing lime with lime water. A few candidates even wrote "lime juice" as the answer.

### Question 2

Syllabus References: A 3.3, 3.4, 6.3, 6.4, 6.7, B.2: 1.2

For this question, candidates were given a diagram showing part of the periodic table showing the elements Na, Mg, K, O, Cl and unknown elements X, Q and Z.

This question tested candidates' knowledge of trends of elements in Groups 1, 2 and 7 of the periodic table; the nature of the bonding of compounds formed by these elements; the changes observed when a metal nitrate is heated and calculation of the volume of gas produced from such a reaction.

**Part (a):** In Parts (a) (i) and (ii), candidates were required to compare the vigour of the reaction of water with X and with potassium; state and explain the nature of the solution formed.

### **Candidates' Performance**

In Part (i), the majority of the candidates were able to correctly state that X would react more vigorously than K since it is lower down in the group. In Part (ii), they were also able to state that the solution formed would be basic. However, many candidates seemed unsure as to the meaning of the term 'basic' in this context. They equated basic with being a base rather than being alkaline in nature.

Many candidates failed to realize that generally metals do not react with water. Only reactive metals like those in Groups 1 and 2 react and a metal hydroxide is formed, which is basic (alkaline) in nature.

A common incorrect response was that "X reacted with water to form a metal oxide and hydrogen gas." Some gave the definition of a base as a basic oxide or hydroxide.

### **Expected Response**

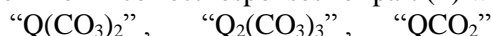
- (i) *Element X is lower down in the Group, is more reactive and would react more vigorously with water than K (potassium).*
- (ii) *The reactive Group 1 metals react with water to form metal hydroxides, which are alkaline in nature.*

**Part (b):** (b) (i), (ii) and (iii) required candidates to (i) write the electron configuration of magnesium (ii) write the formula of the carbonate of Q and (iii) write a balanced equation for the reaction of the carbonate of Q and dilute hydrochloric acid.

### Candidates' Performance

The majority of candidates were able to write the formula of magnesium but many experienced difficulty writing the formula of the carbonate of Q. It seems as though there was some uncertainty as to the correct valency of Q and/or  $\text{CO}_3^{2-}$ . In many cases, candidates had the correct formula of the carbonate but the equation written was not balanced.

Some common incorrect responses for part (ii) were:



### Expected Response

- (i) *Electronic configuration:* Mg 2.8.2
- (ii) *Formula of carbonate:*  $\text{QCO}_3$ ;  $\text{CaCO}_3$  was accepted.
- (iii) *Equation:*  $\text{QCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{QCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)$

**Part (c):** Candidates were required to state and explain the nature of the bonding between sodium and element Z.

### Candidates' Performance

Many candidates were able to correctly state that the compound formed between the two elements would be an ionic compound based on the fact that sodium is a metal and Z a non-metal, since it is in Group 6, and so the transfer of electrons takes place from sodium to Z (ionic bonding).

Some incorrect responses were:

“covalent compound formed”;

Reason given: “two non-metals involved; a sharing of electrons takes place; Sodium gains electrons”

Some candidates gave the correct type of compound as ionic but alluded to covalent bonding in their explanation.

**Part (d) (i):** Candidates were required to state the visible change expected when calcium nitrate is decomposed after being strongly heated.

### Candidates' Performance

Many candidates were able to state the correct observation as “a brown gas released”.

Some candidates incorrectly stated (as an observation) that oxygen would be released or a glowing splint rekindled or a white precipitate would be formed.

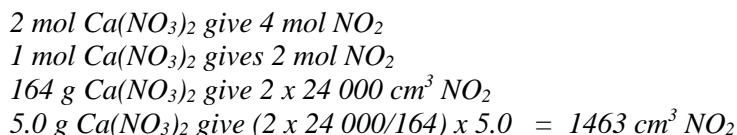
**Part (d) (ii):** Candidates were required to calculate the volume of nitrogen produced at RTP when 5 g of calcium nitrate was heated.

### Candidates' Performance

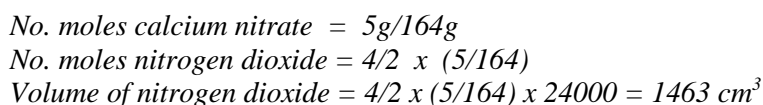
Many candidates were able to correctly calculate the number of moles of calcium nitrate represented but failed to use the mole ratio of the calcium nitrate and the nitrogen dioxide from the equation before converting moles to molar volumes.

Candidates continue to experience difficulty in moles calculations.

### Expected response:



**OR**



### Question 3

Syllabus References: B1: 1.7, 1.8, 2.1, 2.2, 2.3, 2.4, 2.5.

This question tested the candidates' knowledge of structural isomerism in alkanes, and the physical properties and reactions of alkanes and alkenes.

**Part (a) (i):** In this part, candidates were required to define the term 'structural isomers'.

### Candidates' Performance

The majority of candidates gave a correct definition.

### Common Incorrect Responses

- "When molecules have the same elements but different structure"

### Expected Responses

*Structural isomerism is displayed by compounds having the same molecular formula but different structural formulae.*

**Part (a) (ii):** Candidates were required to draw the FULLY DISPLAYED structures of two isomers with formula C<sub>4</sub>H<sub>10</sub>.

### Candidates' Performance

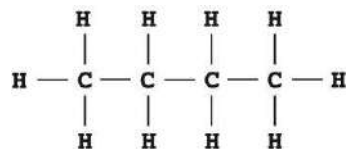
Many candidates gave correct representations

### Common Incorrect Responses

A common incorrect response included a structure in which the 'methyl group' of 2-methyl propane was not FULLY DISPLAYED but was condensed (written as CH<sub>3</sub>):

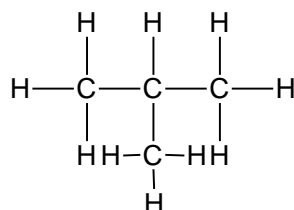
### Expected Responses

The correct structures are:



butane

and



2-methyl, 1 propane

**Part (b) (i):** In this part, candidates were required to describe one test (including the observations) that could be used to distinguish between two gases — Compound A (propene) and Compound B (propane).

### Candidates' Performance

Many candidates described a correct test and observations as shown below. However, some candidates, while describing a correct test, gave the incorrect observations.

### Expected Responses

- (i) *Test: Bubble the gases into an acidified solution of  $\text{KMnO}_4$ , potassium manganate (VII).  
Observation: The purple solution would be decolourized by compound A, the alkene.*
- (ii) *Test: Bubble the gases into a solution of bromine dissolved in a suitable organic solvent.  
Observation: The bromine solution would be decolourized by compound A, the alkene.*

Also accepted was:

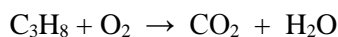
- (iii) *Test: Burn both compounds in air/oxygen.  
Observation: Compound A (the alkene) would burn with a sooty/smoky flame while compound B (the alkane) would burn with a clean blue flame.*

**Part (b) (ii):** Candidates were required to write a balanced chemical equation for the burning of compound B (propane) in air.

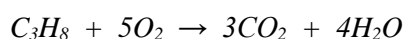
### Candidates' Performance

More than fifty per cent of the candidates wrote the correct equation. Some candidates had the correct reactants and products but the equation was unbalanced. Some candidates wrote the equation for compound A (propene).

### Common Incorrect Response



### Expected Response



**Part (b) (iii):** Candidates were required to give one use EACH of compound A (propene) and compound B (propane)

### Candidates' Performance

The majority of candidates correctly indicated, in some way, that compound B (propane) was a component of cooking gas. Most candidates were unfamiliar with the uses of propene.

### Common Incorrect Responses

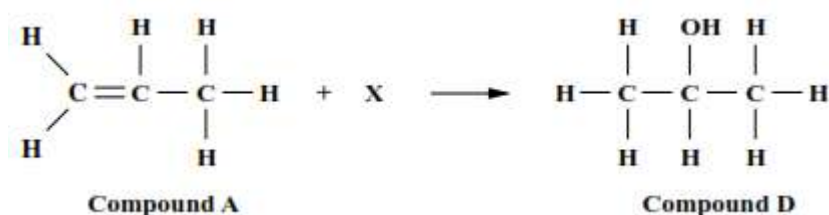
- Propene is used as cooking gas; Propane is used to make plastics
- Propene is used to make alcohols.

### Expected Responses

*Propene is used to make polypropylene. Propene is also a starting material for other compounds, e.g. isopropanol.*

*Propane is mainly used as fuel, e.g. as in cooking gas.*

**Part (c):** Candidates were required to identify X and state the name of compound D, and its homologous series, for the following reaction:



### Candidates' Performance

The majority of candidates correctly identified X as water, (H<sub>2</sub>O) and stated the correct name of the homologous series.

### Common Incorrect Responses

- X is oxygen
- D is propanol

### Expected Responses

- X is water, H<sub>2</sub>O.*
- D is isopropanol.*  
*The homologous series is 'alcohols' or 'alkanols'.*

### Question 4

Syllabus References: A: 4.1, 4.2, 4.4, 4.8, 6.19, 6.20

This question examined the candidates' ability to distinguish between ionic and covalent bonding in two oxides, relate the bonding to the physical properties, and also tested the candidates' understanding of electrolysis.

The following table was provided.

	Oxide of Magnesium	Oxide of Sulfur
Melting Point (°C)	2852	-72
State	Solid	Gas

**Part (a) (i):** In this part, candidates were required, with reference to the bonding, to account for the difference in states of the two oxides.

### Candidates' Performance

Many candidates correctly indicated that magnesium oxide is ionic and the oxide of sulfur is covalent, but they had difficulty in describing the bonding and linking the bonding to the states and melting points of the oxides.

In some cases, candidates simply stated whether the melting point is high or low (which can be obtained from the table) for the respective oxides without giving any further explanation. This was unacceptable, as some link MUST be made between the state of the compound and the inter-particle forces.

### Common Incorrect Responses

- “MgO has strong bonds and a high melting point.” [This was insufficient as there was no mention of the strong electrostatic attraction between the ions which lead to high melting point.]
- “Oxide of sulfur has weak covalent bonds and so low melting point.” [The low melting point is not due to the covalent bonding, but due to the WEAK INTERMOLECULAR forces between the molecules of the oxide of sulfur.]

N.B. There is a general misconception that covalent bonds are weak. Nothing could be further from the truth. The toughness of diamond is as a result of strong covalent bonds between the carbon atoms. Time should be spent in clarifying the differences among inter-ionic forces, inter-atomic forces and inter-molecular forces.

### Expected Responses

*Magnesium oxide is ionic and oxides of sulfur are covalent.*

*Ionic substances have high melting points because of the strong electrostatic attraction between oppositely charged ions. Hence ionic compounds tend to be solids.*

*Covalent substances have weak intermolecular attraction and so have low melting points. Hence they tend to be gases and liquids with low melting and boiling points.*

**Part (a) (ii):** In this part, candidates were required to explain whether the oxides would conduct electricity, and if so, under what conditions.

### Candidates' Performance

Many candidates correctly indicated that the magnesium oxide would conduct electricity, but were unsure whether the oxide of sulfur would conduct. Candidates were unclear as to what particles were responsible for the conduction of electricity.

### Common Incorrect Responses

- “MgO conducts when molten or solid due to free ions and electrons”. [These candidates were unsure].
- “MgO will conduct electricity due to free electrons”. [The charge carriers are ions]
- “MgO does not conduct when in the solid state due to no mobile electrons”.

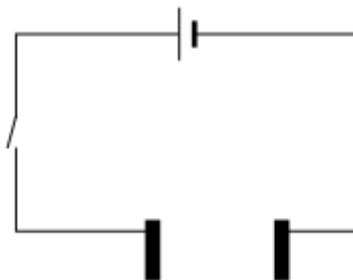


### Expected Responses

*Magnesium oxide will conduct electricity when molten. In the molten state, the ions become mobile and will be free to conduct the electric current. In the solid state, the ions are too tightly held and cannot carry the current.*

*Oxides of sulfur, under normal conditions, will not conduct electricity. These are molecular substances and they have no charged particles to conduct electricity. However, oxides of sulfur can dissolve in water to form acidic solutions, which contain ions, and will therefore conduct electricity*

**Part (b):** Candidates were provided with the following circuit diagram, which some students used to investigate whether lead (II) nitrate, aqueous ammonia and ethanol would conduct electricity.



**Part (b) (i)** In this part, candidates were asked to explain why the circuit in the diagram was unsuitable to achieve the aim of the experiment.

### Candidates' Performance

Most candidates performed well on this part of the question, and showed some understanding of the fundamental principles of electrolysis.

### Common Incorrect Responses

- “The switch is open and so no current will flow.”
- “The circuit is incomplete because there is no electrolyte.”

### Expected Responses

*There is no meter or bulb to indicate when the current is flowing.*

**Part (b) (ii):** Candidates were required to modify the diagram to produce a circuit that would achieve the aim of the experiment.

### Candidates' Performance

The majority of candidates did the correct modification and included a bulb (or meter) in the circuit.

### Common Incorrect Responses

- Some diagrams were drawn with no electrolyte or the electrodes were not dipping in the electrolyte.
- Some candidates had difficulty drawing the correct symbol of the bulb but did label the symbol drawn as ‘bulb’.
- Many candidates' diagrams showed the switch closed as they thought this was the answer.

### Expected Responses

The drawing should include a meter or bulb as well as show the electrodes dipping into the electrolyte.

**Part (b) (iii):** In this part, candidates were required to classify the three substances as a conductor or non-conductor.

### Candidates' Performance

The majority of candidates got two of the three correct.

#### Common Incorrect Responses

- "Ethanol is a conductor."
- "Aqueous ammonia is a non-conductor."

### Expected Responses

*Aqueous lead(II) nitrate is a conductor. [Lead nitrate is a soluble salt and produces mobile ions in solution].*

*Aqueous ammonia is a conductor. [Ammonia dissolves in water as shown in the equation:  $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$ , to produce mobile ions].*

*Ethanol is a non-conductor. [Ethanol is a covalent compound which does not ionize in water]*

### Question 5

Syllabus References B2: 4.1, 4.2, 5.1, 5.2, 6.1

### Part (a) Subsection (i)-(iii)

This part of the question examined the candidates' knowledge of the reactivity of metals and using experimental data to determine the order of reactivity of metals. Candidates were expected to demonstrate their understanding of this reactivity by providing a suitable equation or explanation as required.

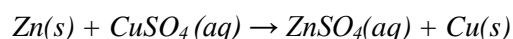
### Candidates' Performance

**Part (a) (i):** Most candidates were able to supply an equation but did not earn the full two marks since some did not include the correct state symbols. There were a few cases where candidates were unable to provide the correct formula or chemical symbol for the reactants and products that were formed.

#### Common Incorrect Responses

- " $\text{Zn(s)} + \text{Cu}_2\text{SO}_4\text{(aq)} \rightarrow \text{ZnSO}_4\text{(aq)} + 2\text{Cu(s)}$ "
- " $\text{Zn}^{2+}\text{(s)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{ZnSO}_4\text{(aq)} + \text{Cu}^{2+}\text{(s)}$ "
- " $\text{Zn(aq)} + \text{Cu}_2\text{S(aq)} \rightarrow \text{ZnS(s)} + \text{Cu(aq)}$ "

### Expected Responses



### Candidates' Performance

**Part (a) (ii):** This part of the question posed somewhat of a challenge for some candidates. While they were able to recognise that zinc was higher in the reactivity series than copper, they did not provide a full explanation in terms of the difference in reactivity. Hence they were unable to capitalize on the full marks for this part of the question. Also, some candidates made comparisons directly between zinc and silver and ignored that the reactivity of each of these was to be compared individually with copper since each was dipped into a copper sulfate solution.

### Common Incorrect Responses

Zinc foil reacted with copper sulfate because copper sulfate has a great reaction and reacted over the zinc foil, while with silver foil it did not react because silver and copper sulfate, both have the same amount of reaction so they neutralized each other and no reaction was observed.

“Zinc reacted rather than silver with copper sulfate because zinc is placed higher on the reactivity series than silver. The more reactive a metal, the easier it would react with other substances.”

### Expected Responses

*Zn is higher than Cu in the reactivity series. So, Zn is more reactive than Cu and will displace Cu. Ag is lower than Cu in the reactivity series. So Ag is less reactive than Cu and cannot displace it.*

### Candidates' Performance

**Part (a) (iii):** Most candidates were able to make the prediction that aluminium will displace copper from the copper sulfate solution and were able to provide the explanation required. There were very few candidates who were unable to answer this question fully and provide the required explanation. Those who did not answer the question well did not seem to fully understand the position of the metals in the reactivity series.

### Common Incorrect Responses

“Aluminium will not displace copper because copper is higher than aluminium in the activity series. This is because aluminium is more reactive than zinc and aluminium would react with the oxygen forming aluminium oxide, while the copper remains.”

### Expected Responses

*Yes, aluminium should displace copper since it is also higher than copper in the reactivity series or more reactive than copper.*

### Part (b) Subsection (i)–(ii)

This part of the question tested candidates' knowledge of the conditions necessary for corrosion of iron as well as to indicate how to prevent it. Candidates were expected to list the conditions required for corrosion as well as explain how painting prevents iron from rusting.

### Candidates' Performance

**Part (b) (i):** This part of the question was generally well answered. Most candidates were able to provide the conditions for corrosion of iron though they did give varying synonyms and in some cases did not specify “oxygen in air” or stated simply “air” or “atmosphere”. Similarly, some candidates stated “moisture” instead of water directly but these responses were accepted.

### Common Incorrect Responses

- “The conditions necessary for corrosion of iron are a catalyst and steel.”
- “Ionization must take place and oxidation.”

### Expected Responses

*Presence of O<sub>2</sub> (air) and H<sub>2</sub>O (moisture).*

### **Candidates' Performance**

**Part (b) (ii):** Most candidates got this part correct but some had difficulty in explaining that the prevention was due to the formation of a coating or barrier. Some candidates stated that the paint contained a substance which prevented rusting, hinting that this oil or substance prevented rusting and did not necessarily form a coating or barrier.

### **Common Incorrect Responses**

“It coats the iron with something else that is more corrosive than iron itself, therefore leaving the iron alone and preventing it from corroding.”

### **Expected Responses**

*Paint covers the metal acting as a barrier to the O<sub>2</sub> and H<sub>2</sub>O, which prevents rusting.*

### **Part (c)**

This part of the question tested candidates' knowledge of duralumin, an alloy of aluminium, and how it is used preferentially instead of aluminium in aircraft manufacture.

### **Candidates' Performance**

This was generally well answered though candidates may not have always earned the final mark for relating either of the named properties to aircraft manufacture. Candidates were able to decipher that duralumin was an alloy of aluminium. They were able to state the properties of this alloy that made it better suited than, aluminium, namely its strength and better resistance to corrosion. However, they did not effectively relate the property to the aircraft manufacture.

This question brought out issues which need to be addressed. Candidates spoke about “aluminium rusting”, they misused density for weight and assumed that duralumin was less dense than aluminium which it is not. Also, the idea that aluminium corrodes faster than its alloy is not correct. Duralumin actually corrodes faster. Candidates also stated that Duralumin was lighter but it is not. It is just as light as aluminium but is stronger.

### **Common Incorrect Responses**

- “Aluminium is a thin metal, this will cause aircraft to move speedily but heavy winds will cause major damages to the aircraft built with aluminium.”
- “Duralumin is used in the manufacturing of an aircraft instead of aluminium because it is more tough and could withstand pressure whereas aluminium is easily destroyed.”

### **Expected Responses**

*Duralumin is an alloy of aluminium. It is lightweight like aluminium but is stronger and more resistant to corrosion. Hence, it is useful for aircrafts, since less fuel will be used/it would be easier to fly/it will last longer.*

## Question 6

Syllabus References: C3: 3.2, 3.3, 3.4, 3.7

This question dealt with some of the essential elements needed for plant growth, the symptoms of these deficiencies, the use of fertilizers in treatment of these deficiencies, soil acidity and their treatment. A scenario was given in which a farmer described the state of the crops where the leaves were yellowing and leaf tips curling and suggestions were made as to the soil quality possibly being acidic and requiring fertilizers.

### **Part (a)**

This part of the question tested candidates' knowledge of essential elements that were needed for plant growth and the effects of their deficiencies.

### **Candidates' Performance**

Most candidates were aware of the missing nutrients that cause yellowing in leaves, however, few knew about potassium being responsible for leaf tip curling. Very few candidates stated that "lack of potassium causes leaf tips to die." In certain instances, candidates failed to indicate the reason for their choices of deficient nutrients and hence were unable to earn the full marks for this part of the question.

### **Common Incorrect Responses**

*Suggestion:* "Nutrients were missing would be phosphorus and calcium."

*Reason:* "It is so because since the leaves were yellowing phosphorus was missing and calcium can be a factor too with the yellowing and because of the tips curling."

*Suggestion:* "The soil is missing sodium."

*Reason:* "When the soil is lacking sodium the leaves start to turn yellow over a period of time."

### **Expected Responses**

*Plants could possibly be missing:*

*N or S, nitrates, sulfates or magnesium since lack of these causes plants to yellow.*

*K since lack of K causes the leaf tip to die. Note it also causes yellowing of the leaf.*

### **Part (b)**

This part of the question required candidates to give two advantages of organic manure over commercial fertilizers.

### **Candidates' Performance**

This part of the question was generally answered well. Most candidates were able to list two advantages.

### **Common Incorrect Responses**

Advantage 1: "Organic manure has more nutrients."

Advantage 2: "Organic manure help plants grow faster."

Advantage 1: "It can be specific in the amounts of nutrients given to plants each and every time it is used."

Advantage 2: "It has a wide variety of nutrients available for intake by the plants giving it more effective results."

### **Expected Responses**

Any two advantages of using organic manure rather than commercial fertilizers from this list were accepted or any two plausible advantages:

- *It is cheaper.*
- *It is more environmentally friendly.*
- *Feeds plant as well as build soil structure.*
- *Provides long-term nutrients.*
- *Retains moisture*

**Part (c):** This part of the question tested candidates' knowledge of the disadvantages of the use of organic manure as compared to commercial fertilizer.

### **Candidates' Performance**

This part of the question was generally well answered with candidates giving a variety of accurate responses.

### **Common Incorrect Responses**

- "It can be harmful to the environment".
- "It could be concentrated therefore causing the soil to be acidic and not producing well, killing the plants and all the nutrients in the soil."

### **Expected responses**

Any of ONE of the following was acceptable:

- *It's smelly*
- *Works slower*
- *Application may be tedious*
- *Difficult to handle*
- *It can also be expensive (this was not accepted if cheap was used as an advantage)*

### **Part (d)**

This part of the question tested candidates' knowledge of soil acidity. It was suggested in the question stem that the soil may have been acidic. Candidates were to use their knowledge of acid base chemistry in determining soil acidity.

### **Candidates' Performance**

Most candidates handled this question well. They were able to indicate that a mixture or some type of solution with water is required first of the soil sample before any kind of analysis was to be done. There were some responses which indicated that candidates did not recognize that a solution was required. For example, some candidates indicated touching litmus paper or pH paper directly to the soil was a method to determine soil acidity. Further, there were some candidates who were not awarded full marks for this part of the question since they did not indicate what a positive test would be. A complete answer should have had all of the components needed, that is, taking a soil sample mixing with water, using an appropriate test and indicating what a positive result will be if the soil is acidic.

### Common Incorrect Responses

“The test I would use for soil acidity is litmus paper test because it would be the pH number of the soil which shows you if it is acidic or if it is not.”

“The steps are as follows:

- Obtain soil sample
- Test the pH [pH] of the soil whether it is acidity or alkalinity
- If it is high in acidity add lime. If it is high in alkalinity treat it with gypsum.”

### Expected responses

To test soil for acidity:

- *Mix soil in water*
- *Test water with pH paper /appropriate indicator/pH meter*
- *Description of positive test depending on the kind of indicator used e.g. If blue litmus is used, blue litmus turns red and therefore soil is acidic, if not it is basic.*

### Part (e)

This part of the question tested candidates’ ability to write the chemical name and formula of lime and indicate when it is to be used.

### Candidates’ Performance

This part of the question was very poorly done with very few candidates being able to give both the chemical name and formula of lime. However, most candidates were able to indicate that it was used when the soil is acidic and hence did not benefit from the maximum marks that could have been obtained.

### Common Incorrect Responses

- “Lime — CaOH. Lime should be used after fertilizers are added. Not at the same time.”
- “Lime should be used when there is a lack of calcium in the plant soil.”
- “The chemical name for lime is citric acid. It should be used when the pH of the soil is not acidic and not all the time.”

### Expected responses

*Lime is calcium oxide and is alkaline. It is added to soil if soil is acidic so as to make it more alkaline.*

### Part (f)

This part of the question tested the candidates’ knowledge of the effect of adding lime to a commercial fertilizer and its effect on soil quality. They were also required to provide a balanced chemical equation.

### Candidates’ Performance

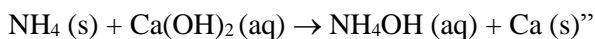
Most candidates were able to describe that adding lime to commercial fertilizer would have the effect of producing ammonia but failed to link a loss of nitrogen to the atmosphere and hence the soil would be deprived of nitrogen.

The chemical equation was poorly done by those candidates who attempted with many of these not including charges or the correct formula for reactants and products. Others did not provide any equation.

### Common Incorrect responses

“One reason why lime should not be used at the same time with ammonium fertilizer is that they are there for the same purpose and when mix together cause a greater reaction.”

“Lime should not be added to the soil at the same time as a commercial ammonium fertilizer because a neutralization reaction occurs. The effects are cancelled out.



### Expected responses

*When lime and ammonium fertilizer are added to the soil at the same time, N is lost to the atmosphere as NH<sub>3</sub>.*

Equation :  $\text{OH}^- + \text{NH}_4^+ \rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}$ ; The balanced molecular equation was also accepted.

## Paper 032 — Alternative to School-Based Assessment (SBA)

### Question 1

Syllabus References: A: 8.1, 8.2, 8.3

Of the three questions on this paper, question 1 recorded the best performance. This question tested the candidates' knowledge of energetics, more specifically Heat of Neutralization and the candidates' skill in plotting a graph, writing an equation and doing calculations involving heat change and moles.

### Candidates' Performance

#### Part (a)

Most candidates were able to accurately read the temperature on the thermometers. However, some candidates placed a response at five minutes even though it was shaded.

#### Part (b)

Most candidates were able to obtain the three marks for plotting the points obtained in Part (a) but some forgot to plot the last two points at eight and nine minutes. The smooth curve mark was also obtained by the majority of candidates, and only a very small percentage incorrectly used a ruler to connect the points. However, the change in temperature mark eluded the vast majority of candidates as they took the initial value as the first temperature reading, rather than the constant temperature reading which indicated that the solution equilibrated. In doing practical work with thermometers, candidates must be given the opportunity to allow them to acclimatize. Too many candidates did not know that an increase in temperature meant that the reaction was exothermic.

#### Part (c)

Too many candidates wrote the wrong formula for sodium sulfate or included hydrogen in the products and did not get any marks for the equation. Some candidates obtained the acid salt in the products and were able to obtain one mark. Many candidates were able to calculate the number of moles in 50 cm<sup>3</sup> of sulfuric acid used, but could not use the mole ratio between the acid and water to determine the number of moles of water produced.



### Part (d)

In this section, the candidates were given the density of the final solution and asked to determine the mass. It appeared that some candidates were unfamiliar with the calculation of mass from density. In addition, the determination of total volume also presented some difficulty. For the calculation of the heat change, many candidates knew the formula but could not substitute appropriately and were only awarded one mark. Even fewer candidates were able to calculate the heat change for the formation of one mole of water as they multiplied  $18 \times 4.2 \times \text{temp.diff}$ . They did not know that the heat change in (ii) had to be divided by the number of moles of water obtained in (c) (iii). Some candidates inaccurately divided by the molar mass.

### Part (e)

In Part (i); very few candidates were familiar with the assumption to be made when carrying out this type of experiment, that no heat was lost. In Part (ii), not many candidates were able to obtain the two marks for knowing that the heat change would decrease or that the temperature reading would be lower (1 mark) as heat would be lost to the surroundings (1 mark) when a glass beaker is used. However, in part (iii) many candidates were able to obtain one mark for a precaution as they were able to state that spilling could be avoided by not stirring roughly, or to use gloves to hold the hot beaker and not touch it with bare hands, or avoid breaking the glass beaker by not hitting the sides with the thermometer. The modification mark was obtained by some candidates who understood that the glass beaker could be insulated by covering with some form of insulating material, or that spilling could be avoided by covering with a lid, or that the thermometer should be used only for measuring temperature and not for stirring, so a stirrer could be included. Many candidates misunderstood and used a styrofoam cup instead of modifying the apparatus used.

### Question 2

Syllabus References: B2: 7.1, 7.2, 7.3

This question tested the candidates' knowledge on qualitative analysis, mainly their observation skills in identifying ions in solution and one gas. This is a practical aspect of the syllabus and from the majority of responses given, it was clear that many candidates had not done or even seen these simple exercises.

### Candidates' Performance

Part (a) was shaded, so candidates were not meant to answer this part and yet many answers were found here.

Part (b) and (c) tested the candidates' ability to write observations in the identification of copper(II) ions with sodium hydroxide and ammonium hydroxide respectively. Many candidates obtained the mark for stating "blue ppt." but many could not remember in which solution the blue precipitate was soluble.

Part (d) tested candidates' knowledge on the identification of sulfite ions. Some candidates knew that a 'white ppt' was formed, but few indicated that it was soluble in the acid. Many candidates omitted this part.

Part (e) — Too many candidates mixed up the identification of hydrogen gas with oxygen gas and so a 'glowing splint' was popped in the gas or it was reignited. Candidates obtained one mark for stating that a "lighted splint went pop" but not for "light with a pop" as this implies that a glowing splint was used. The other mark was for noticing that "bubbling" or "effervescence" would be observed as a colourless gas was evolved.

Part (f) — Some candidates were able to obtain the two marks for this part, as they knew that the "white ppt. formed" would be soluble in excess alkali.

### Question 3

Syllabus References: A: 5.4

This question tested the candidates' ability to plan and design an experiment. They were asked to write an aim and suggest the materials needed for a procedure to obtain pure water from a mixture of sea water contaminated with petroleum. They were also asked to draw the diagram of the apparatus used in obtaining the pure water and to give two sources of error or precautions.

#### **Candidates' Performance**

##### **Part (a)**

Most candidates knew that the aim was "To obtain pure water from a mixture of sea water and petroleum", and were able to obtain the one mark. Few of them stated that the aim was "To investigate" or "To find out how to separate the pure water from the sea water", and were not awarded the mark.

##### **Part (b)**

Candidates were asked to write the list of materials that they would use in the procedure. The marks for this section were awarded dependent on the candidates' proposed procedure. Many candidates were able to do this but many used a volumetric flask or even a beaker to heat the sea water and very few used a round bottom flask. They were not penalized for this, once it was used in the procedure. They confused the separating funnel with a burette and even a pipette. Many candidates poured the mixture in the fractionating column. Some did not use a condenser to condense the vapour but tried to condense it in a tube, or in a funnel or with a piece of glass. Again they were not penalized, once it was used. It should be noted that when a definite volume is used, then a measuring apparatus would be needed.

##### **Part (c)**

Marks were awarded for a plausible procedure which was clearly written and logical and stated the correct separation techniques. It was expected that the candidates would recognize that petroleum must be first separated then the remaining solution distilled in order to obtain pure water. Few candidates recognized this. Most candidates distilled only using the process of fractional distillation, seemingly unaware that petroleum in itself is a mixture and that some of its components had a lower boiling point than water.

##### **Part (d)**

The diagram was not well done. It would seem that candidates were not in the habit of drawing apparatus. Too many candidates lost a mark for leaving out the thermometer or for placing it in the sea water but not at the exit where the vapour entered the condenser. Very few candidates were able to correctly label the entrance and exit of the tap water in the condenser and many placed them in the middle and not at the ends. Some candidates used air to cool the vapour or used a long tube without the tap water. These responses were not awarded any marks. Many candidates correctly labelled the distillate as pure water/water and were able to obtain one mark. Candidates lost a mark once the apparatus was not air tight.

##### **Part (e)**

Many candidates were able to obtain at least one mark for stating that protective wear such as safety glasses, gloves or lab coats had to be worn. Other acceptable precautions or sources of error included those regarding the flammability of the petroleum, the handling of fragile apparatus and the awareness that during distillation, a specific temperature indicates what is coming off as distillate.

## School-Based Assessment

The quality of practical activities done was good.

Some teachers did not convert their scores to the 11 point scale.

A few centres did not submit mark schemes or submitted mark schemes that were inappropriate.

### Observation recording and reporting

There still needs to be a greater emphasis on graph work. Some candidates are not labelling axes, giving a title of graph or drawing the curve of best fit. A very large percentage of candidates were able to plot points accurately.

### Planning and design

Generally the standard of the laboratory exercises assessed was average. In most cases, two of the four activities were acceptable.

Teachers are reminded of the following:

- (1) All PD activities should be based on chemical concepts included in the syllabus. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition or any other non-chemistry discipline cannot be accepted.
- (2) Students should undertake at least four Planning and Design (PD) activities over the two-year period. When this is not done, the candidates are at a disadvantage.
- (3) Some SBA Planning and Design activities were assessed for other skills as well. This suggests that the exercise has been carried out and so cannot be moderated for PD skills. This places the candidates at a serious disadvantage.
- (4) While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does suit all the PD activities submitted. If not, then each PD activity should have a separate mark scheme.
- (5) Ensure that the problem statement is written on the mark scheme and that the students include it in their laboratory books before submission.
- (6) Ensure students state the variables (control, manipulated) separately and not just have them in the method.
- (7) Ensure students write the method in present or future tense.
- (8) Students should also be encouraged to review their method to ensure that all the **necessary** apparatus and materials are listed. It would be very helpful if the students write the method before listing the apparatus.

### Analysis and Interpretation

The Analysis and Interpretation (AI) skill continues to be one of the skills on which candidates demonstrate greater proficiency. In general, the calculations were well done, however, there appears to be a decline in the number of qualitative analysis experiments to which the candidates are being exposed. Candidates continue to write incorrect formulae for chemical equations. For example, sodium carbonate is written  $\text{Na}_2\text{CO}_3$ . In addition, equations are not balanced and state symbols are either absent or written incorrectly.

## Conclusion

In order to encourage continual improvement here are a few points to note:

- (1) Samples should be submitted with a proper mark scheme indicating the skill assessed.
- (2) All students should be required to complete their table of contents, which should include, where appropriate, the skill(s) assessed.
- (3) Teachers should spend time developing simple analytic rubrics (mark schemes) to accompany the laboratory exercises.
- (4) In the case of volumetric analysis, the concentration of reagent(s) being used should be stated in the mark scheme.
- (5) In the case of qualitative analysis, the name of the unknown or the ions expected should be included in the mark scheme.
- (6) If there is more than one teacher at the centre, the teachers should collaborate and submit one common mark scheme.
- (7) When requiring a balanced chemical equation, teachers are advised to award a maximum of two marks. One mark should be awarded if it is unbalanced.
- (8) Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should not be assessed under AI.
- (9) More emphasis must be placed on writing units and writing them correctly. In many cases, students used incorrect units and were neither penalized nor corrected by the teacher.
- (10) Students should be encouraged to show all the steps in calculations. In addition, calculations involving volumetric analyses should be done from first principle using the unitary method. Again, teachers are asked to refrain from using the equation  $M_1 V_1 = M_2 V_2$ .
- (11) Students should be given more guidance in producing the discussion/interpretation section of the laboratory report. Teachers could ask specific questions which will assist students in this section. These questions should be included in the mark scheme to guide the moderation process.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2015**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

## GENERAL COMMENTS

Overall, candidates' performance in this sitting of the examination improved, with 47 per cent of candidates achieving Grades I–III, when compared with performance in January 2014, where 38 per cent of candidates achieved Grades I–III.

The examination consisted of three papers:

Paper 01 — a Multiple Choice,

Paper 02 — a structured essay

Paper 032 — the Alternative to the School-Based Assessment (SBA).

The Paper 032 is not mandatory for all candidates.

This report provides feedback on candidates' performance in this sitting. The expected answers and the common misconceptions will be highlighted with the view that the report can be used to improve the teaching and learning of Chemistry at the CSEC level.

Candidates experienced some challenges with drawing curves after plotting points, distinguishing between solutions and suspensions, and sketching electrolytic circuits. It must be noted that although there was a general improvement was seen in the experimental skills profile, a major area of poor performance and hence concern was candidates' knowledge of qualitative analysis.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper consisted of 60 items which assessed two profiles — Knowledge and Comprehension, and Use of Knowledge.

Performance on this paper improved slightly over that of January 2014. This year, the mean score was 33.67 compared with a mean score of 31.67 in 2014. Out of a total of 60 marks, the maximum score achieved was 59 and the minimum was 10.

### Paper 02 – Structured/Essay

#### Question 1

Syllabus References: A 10.1, 10.2, 10.3, 10.4

This question examined candidates' scale reading and graphing skills, knowledge of factors affecting solubility and qualitative tests for some cations.

The following table was provided:

Experiment Number	Mass of X(g)	Volume of Water (cm <sup>3</sup> )	Temperature at which Crystal Reappear (°C)	Solubility of X/g/100g (water)
1	2	4	91	50
2	2	8	57	
3	2	12		
4	2	16		
5	2	20		

The question was based on solubility and examined candidates' ability to read temperature values from a thermometer scale, substitute values into an expression, transpose the expression, perform calculations, plot the points and sketch the best curve on a Solubility—Temperature graph and interpolate values.

In Part (a) (i), candidates were required to read and record values of temperature from diagrams representing a thermometer scale.

### Performance of Candidates

The majority of candidates performed very well on this part and was able to obtain the maximum three marks.

### Expected Response

The three missing temperature readings are 44, 32 and 26 °C.

Part (a) (ii) required that candidates use the values from the table to determine the solubility of the solid X in water at the different temperatures and enter the values obtained in the spaces in the table.

### Performance of Candidates

The majority of candidates was able to use the provided expression for solubility:

$$\text{Solubility of X (g/100 g water)} = \frac{\text{mass of X}}{\text{mass of water}} \times 100,$$

to calculate the values of solubility at the different temperatures. [*Candidates are reminded to round off numbers correctly*].

### Expected Response

The correct values are 25, 16.7 (or 17 or 16.67), 12.5 (or 13) and 10 g/100 g water.

In Part (b), candidates were required to plot the five values of solubility at the five different temperatures on the axes provided, and draw the best fit curve through the points.

### Performance of Candidates

Many candidates plotted the five points correctly; however, the majority of candidates did not circle the points. Candidates should be reminded that they should circle all plotted points. Some candidates did an incorrect estimation of the magnitude of the divisions on the axes and so plotted some points incorrectly. Very few candidates were able to draw a proper curve through the points. Many candidates simply joined the dots and were not awarded the mark for drawing the curve.

For Part (c), candidates were required to make a deduction about the solubility of X from the graph drawn.

### Performance of Candidates

The majority of candidates stated correctly that *solubility of X increased with increasing temperature, or decreased with decreasing temperature.*

### Common Incorrect Response

As the volume of water increases the solubility of X decreases.

Part (d) required that candidates make use of the given equation and the drawn graph to calculate the minimum volume of water which was required to dissolve 2g of X at 60 °C. Candidates were therefore required to interpolate from 60 °C on the temperature axis to the corresponding value on the solubility axis.

### Performance of Candidates

Many candidates were able to do a successful interpolation, and then substitute the value from the graph into the equation. A number of candidates had difficulty transposing the equation to make *mass of water* the subject of the expression.

### Common Incorrect Response

Some candidates incorrectly used the value of the temperature (60 °C) instead of the interpolated value of solubility.

### Expected Responses

The interpolated value of solubility and the mass of X (2 g) were substituted into the following equation:

$$\text{Solubility of X (g/100 g water)} = \frac{\text{mass of X}}{\text{mass of water}} \times 100.$$

If, for example, the interpolated value was 27.5 (g/100 g water), the equation becomes:

$$27.5 = (2 \text{ g} / \text{mass of water}) \times 100$$

which can be rearranged to give

$$\text{mass of water} = (2 \text{ g} / 27.5) \times 100 = 7.3 \text{ g water}$$

Since the density of water is 1 g cm<sup>-3</sup>,



$$\text{Volume} = \text{mass} / \text{density} = 7.3 \text{ g} / 1 \text{ g cm}^{-3} = 7.3 \text{ cm}^3 \text{ of water.}$$

Candidates were required, in Part (e), to distinguish between *a solution and a suspension*.

### Performance of Candidates

This part proved to be challenging for many candidates. Many were able to state that a solution exists when a solute dissolves in a solvent, but were challenged in giving a correct description of a suspension.

### Common Incorrect Responses

- In a suspension the solute does not completely dissolve
- A suspension is when two substances are immiscible

### Expected Responses

*A solution is a homogeneous mixture of one or more solutes dissolved in a solvent.*

*A suspension is a heterogeneous mixture in which*

- *the components settle out upon standing*
- *the particles are larger than in a solution and are visible to the naked eye*
- *the particles are not individual atoms or molecules but clusters of them.*

Any accurate comparison of a solution and a suspension would be accepted:

- *Usually solutions are transparent, and suspensions are opaque*
- *The particles in a solution cannot be filtered out, but particles in a suspension can.*

In Part (f), candidates were required to state TWO other factors besides temperature that affect the rate at which a solute dissolves.

### Performance of Candidates

Some candidates were able to state two factors, but most were able to state only one.

### Common Incorrect Response

- Catalyst

### Expected Responses

Other factors are seen or implied: *increased surface area (particle size), stirring, pressure, solute concentration, type of solvent.*

NOTE:

- When a gas is the solute and is dissolved in a liquid, pressure greatly affects the solubility. The solubility of liquids and solids is not affected so much by pressure.
- When a solute dissolves, it will dissolve until the solution becomes saturated, at which point no more solute dissolves. The rate of solubility therefore slows down as the solution becomes more concentrated in the solute.

Part (g) tested candidates' knowledge of qualitative analysis. The tests were given along with either the observations or inferences, and candidates were required to provide either the inferences or observations, respectively. They were required to write a balanced ionic equation in one instance.

### Performance of Candidates

This part was not well done and could be a reflection of the lack of exposure to practicals.

The correct observations and inferences are given in the following table:

**TABLE 2: TESTS CARRIED OUT ON SOLUTION M**

Tests	Observations	Inferences
(i) To a portion of M, add aqueous sodium hydroxide until in excess.	<ul style="list-style-type: none"> <li>White precipitate</li> <li>Soluble in excess</li> </ul>	<ul style="list-style-type: none"> <li>Given</li> <li>Given</li> </ul>
(ii) To a second portion of M, add aqueous ammonia until in excess.	<ul style="list-style-type: none"> <li>Given</li> <li>Given</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Al}^{3+}</math>, <math>\text{Zn}^{2+}</math> or <math>\text{Pb}^{2+}</math> present</li> <li><math>\text{Zn}^{2+}</math> present</li> </ul> <p style="text-align: right;"><b>(2 marks)</b></p>
(iii) To a third portion of M, add aqueous sodium iodide.	<ul style="list-style-type: none"> <li>Given</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Pb}^{2+}(\text{aq}) + 2 \text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s})</math></li> </ul> <p style="text-align: right;"><b>(2 marks)</b></p>
(iv) To the fourth portion of the filtrate from (i) above, add aqueous $\text{AgNO}_3$ followed by aqueous $\text{NH}_3$ .	<ul style="list-style-type: none"> <li>Given</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Cl}^{-}</math>, <math>\text{Br}^{-}</math> and <math>\text{I}^{-}</math> absent.</li> </ul> <p>OR <i>no halide present</i></p>

### Performance of Candidates

For Part (g) (i), many candidates had the correct observations, that is, a white precipitate is formed which dissolves when excess aqueous sodium hydroxide solution is added.

### Common Incorrect Responses

- White precipitate is insoluble
- Soluble

NOTE: These tests are carried out via drop-wise addition of the reagent to a solution of the cation. Careful observation needs to be made when a few drops of sodium hydroxide are added, and then any precipitate that is formed should be observed to see whether it is soluble or insoluble when excess sodium hydroxide is added. So there **must** be two observations (i) if a precipitate is formed, and (ii) if the precipitate is soluble or insoluble when excess sodium hydroxide is added.

### Performance of Candidates

Part (g) (ii) was poorly done. Several candidates gave the correct inference for the first part of the test, but were not able to recall the correct inferences for the second part.

### Common Incorrect Responses

Common incorrect inferences for the second part of the test:

- $\text{Pb}^{2+}$
- $\text{Al}^{3+}$
- $\text{Pb}^{2+}$ ,  $\text{Al}^{3+}$
- $\text{Pb}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$

NOTE: This test requires the drop-wise addition of aqueous ammonia to a solution of the metal ion. Three cations  $\text{Pb}^{2+}$ ,  $\text{Al}^{3+}$  and  $\text{Zn}^{2+}$  give an initial white precipitate of the corresponding metal hydroxides ( $\text{Pb}(\text{OH})_2$ ,  $\text{Al}(\text{OH})_3$  and  $\text{Zn}(\text{OH})_2$ , respectively). Only ONE of these hydroxides will dissolve in excess aqueous ammonia and that is  $\text{Zn}(\text{OH})_2$ . Therefore the first inference, corresponding to the formation of the white precipitate, **must** list all three cations. The second inference, corresponding to the white precipitate dissolving in excess aqueous ammonia is  $\text{Zn}^{2+}$ . In excess aqueous ammonia the insoluble  $\text{Zn}(\text{OH})_2(\text{s})$  is converted to the  $\text{Zn}(\text{NH}_3)_2^{2+}(\text{aq})$  cation which is soluble.

### Performance of Candidates

Part (g) (iii) was not done well. A number of candidates recognized that the test and observation confirmed the presence of  $\text{Pb}^{2+}$  ions but could not produce the correct balanced equation.

### Common Incorrect Responses

- $\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$
- $\text{Pb}^{2+} + \text{I}^- \rightarrow \text{PbI}$
- $\text{Pb}^{2+}$

### Performance of Candidates

For Part (g) (iv), a number of candidates recognized that this is a confirmatory test for the presence of the chloride ion,  $\text{Cl}^-$ , and so gave no chloride present as their response, but the **three** halides ( $\text{Cl}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ ) react with aqueous silver nitrate solution to form the corresponding silver halide. The non-formation of a precipitate here means that **no halide** was present in the solution.

NOTE: Silver chloride dissolves in aqueous ammonia, whereas silver bromide and silver iodide do not.

### Common Incorrect Responses

- Halogens present. (Halogens refer to the elemental forms, i.e.  $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$ )

## Question 2

Syllabus References: A: 2.1, 4.2, 4.8, 2.6, 3.1, 6.2, 6.14, 6.17.

Part (b) required candidates to state why the ICl had a low melting point and in Part (c), candidates had to explain why some molecules of ICl had different masses.

In Part (d), candidates were required to write a balanced equation to show the reaction between chlorine and potassium iodide. Based on the balanced equation candidates were required to state in Part (e) (i), the change in oxidation number of the iodide and in Part (e) (ii), whether chlorine was acting as an oxidizing or reducing agent. Candidate had to give a reason for their answer.

### **Performance of Candidates**

Part (a) (i) was done well by the majority of candidates. However, in Part (a) (ii), many candidates had difficulty obtaining full marks. Candidates seemed not to understand that the number of electrons in the last shell is the same as the group number. Therefore, many did not put in the electrons for iodine.

Candidates did Part (b) poorly. Many attributed the low melting point to covalent bonds. Very few showed a distinction between giant covalent compounds and simple covalent molecules. Only a few candidates suggested the presence of weak intermolecular bonds or Van der Waals forces between the ICl molecules.

In Part (c), many candidates had the idea that isotopes were the cause of the different masses but they attributed the isotope to ICl itself or vaguely mentioned it in their discussion. A minority suggested that chlorine or iodine were the isotopes and the change in either mass would cause a change in the molecular mass of the ICl molecule. Too many had no response to the question.

In Part (d), many candidates were able to write the relevant balanced equation. However, too many candidates were unable to determine the correct products. Some stated that the product was ICl. This suggests that candidates were not able to apply the knowledge of the reactivity series, as regards to the halogens. Candidates showed little knowledge of displacement reactions. Teachers should give students unknown situations for them to resolve using chemical principles.

Part (e) (i) was done fairly well by those who wrote the correct equation. Many of the others failed to understand that the oxidation states should have been derived from the equation they wrote.

In Part (e) (ii), too many candidates suggested that chlorine was acting as a reducing agent. Again, many of them failed to understand that their conclusion about chlorine should have been based on their equation. Many candidates suggested reasons for their conclusion about chlorine which was not based on their equation.

### **Common Incorrect Responses**

For Part (b), candidates provided such statements as:

- *ICl were non-metals so they would have low melting points*
- *They have covalent bonds*

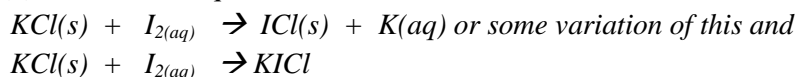
- *Covalent substances have weak bonds*

Common answers for Part (c) were

- *ICl is an isotope*
- *I and Cl are in the same group but different period*
- *I and Cl are isomers*

Many other candidates opted not to answer the question.

In Part (d), some of the equations written were



In some cases potassium was represented by the symbol P.

In Part (e) (i), there were a variety of incorrect answers and/or some candidates opted not to answer the question.

In Part (e) (ii), common errors were:

- *Chlorine is acting as a reducing agent*
- *Chlorine is acting as a reducing agent it gains electrons*
- *It is a reducing agent since it has been oxidized.*

### **Expected Responses**

In Part (a) (i), candidates were expected to draw the chlorine atom showing all the shells and all the electrons.

For Part (a) (ii), candidates were required to draw two intercepting circles and place two electrons in the intercept and six on the unique part of each circle.

In Part (b), the reasons for the low melting point of ICl should have included the ideas that the entity is a simple covalent molecule and that there are weak Van der Waals forces or bonds between the molecules. A distinction must be made between the giant covalent compounds which have high melting points and the molecular covalent compounds with low melting points.

For Part (c), the correct explanation should state that the ICl molecules contain isotopes, whether it is iodine or chlorine. Candidates should also state that when different isotopes are added together, different molecular masses would be obtained.

In Part (d), the expected equation was  $2KI(aq) + Cl_{2(g)} \rightarrow 2KCl(aq) + I_{2(s)}$

In Part (e) (i), the correct response should state that I goes from  $-1$  to  $0$ .

In Part (e) (ii), the correct response based on the correct equation is that chlorine is an oxidizing agent because it increases the oxidation state of iodine or it is reduced during the reaction.

**Question 3**

Syllabus References: B1: 3.1, 3.2, 3.5, 4.4, 4.5, 4.6, 4.7

In this question, candidates were examined on their knowledge of the sources and uses of hydrocarbons, the products of acid hydrolysis of esters, the structure and solubility of glucose and its polymer, and polymers from an amino acid.

For Part (a), the following table showing three fractions from crude oil was provided:

Fraction	1	2	3
Number of Carbon Atoms	C1 – C4	C12 – C18	C20 – C40

Candidates were required to give two natural sources of hydrocarbons.

**Performance of Candidates**

Most candidates were able to identify at least one natural source of hydrocarbon. Candidates who wrote fossil fuels in conjunction with one other natural hydrocarbon were accredited only one of the two marks.

**Common Incorrect Responses**

- Biogas from manure
- Refined gas (instead of refinery gas)

**Expected Responses**

Any two of: natural gas, petroleum/crude oil, peat.

For Part (b) (i), candidates were asked to give the correct name for one of the three fractions listed in the table.

**Performance of Candidates**

Most candidates were able to match the fraction number with the appropriate name.

**Common Incorrect Responses**

- Fraction 1— refined gas, propane, butane
- Fraction 3 — asphalt

**Expected Responses**

*Fraction 1 (C1 – C4): Refinery gas. Also accepted cooking gas, industrial gas, petroleum, gas.*

*Fraction 2 (C12 – C18): Kerosene — fuel, jet fuel, heating fuel, diesel, pitch oil, paraffin oil.*

*Fraction 3 (C<sub>20</sub> – C<sub>40</sub>): Bitumen, fuel oil, greases/wax, diesel, asphalt, paraffin wax.*

Part (b) (ii) asked candidates to give one use of Fraction 3.

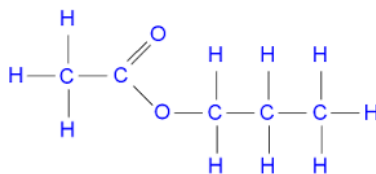
### Performance of Candidates

Most candidates were able to identify one use of Fraction 3.

### Expected Responses

- Any correct use of bitumen: *road surfacing (accepted road construction), roofing compounds, water proofing materials*
- *Fuel oil: fuel for ships*
- *Greases: lubricants*
- *Wax: candles*

Part (c) (i) required candidates to identify the homologous series to which Compound W (which has a fruity smell and is used in fragrances and as a food additive) belonged.



**Compound W**

### Performance of Candidates

Many candidates correctly identified the homologous series as esters but some incorrectly called it an alcohol, alkane and even an acid.

Candidates were required in Part (c) (ii) to write the fully displayed structural formulae of the two molecules that are produced when Compound W is hydrolysed by dilute hydrochloric acid, and to state the name of any one of the structures.

### Performance of Candidates

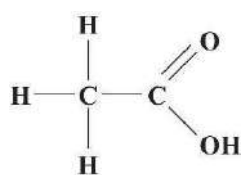
Many candidates were unable to draw the structures for the acid and the alcohol, and hence unable to give the proper name for either one.

### Common Incorrect Responses

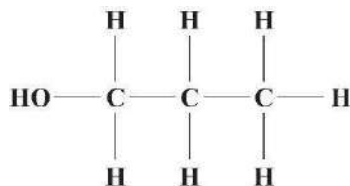
- Propane
- Ethanol

**Expected Responses**

Acid hydrolysis of an ester produces the corresponding carboxylic acid and alcohol. The correct structures are:



Ethanoic acid



Propan-1-ol

NOTE: Propan-1-ol = 1-propanol = n-propanol. Also accepted propanol and propyl alcohol. Ethanoic acid = acetic acid.

Candidates are reminded that complete structures must be drawn.

In Part (d) (i), candidates were required to give the name of a polymer of glucose, and draw a representation of the partial structure of the polymer using three of the units,  $\text{HO}-\text{O}-\text{OH}$ , which was used to represent a monomer of glucose.

**Performance of Candidates**

Many candidates were able to correctly state the name for a polymer of glucose. However, only a few candidates were able to accurately draw the partial structure of the polymer of glucose.

**Common Incorrect Response****Expected Responses**

Name of polymer: starch or cellulose or amylose or glycogen.

The partial structure of the polymer (starch) of glucose is:



Partial structure of polymer (starch)

In Part (d) (ii), candidates were required to state the expected observations in each case, when water was added to separate samples of glucose and its polymer, and stirred.

**Performance of Candidates**

Not many candidates were able to give the correct observations in both cases.



### Common Incorrect Responses

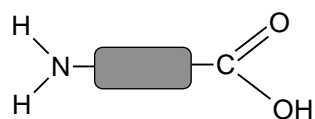
Common incorrect responses listed both glucose and its polymer as being soluble or both as being insoluble.

### Expected Responses

*Glucose:* Soluble, forms a clear solution, solution formed (any one)

*Polymer:* Insoluble, cloudy, suspension (any one)

In Part (d), the following structure was provided for a monomer which undergoes condensation polymerization:



**Monomer**

Candidates were required to name the type of polymer formed and give one of its uses.

### Performance of Candidates

Most candidates were unable to identify the polymer formed and therefore not able to identify the correct use of it. Many candidates referred to it as protein.

### Common Incorrect Responses

- Polyamines
- Proteins

### Expected Responses

*Type of polymer:* Polyamide

*Use:* making rope, textiles, carpet, brushes, bearings, and trolley wheels.

### Question 4

Syllabus References: A: 6.22, 6.23, 6.24, 6.25, 6.28

Part (a) (i) tested candidates' knowledge and understanding of the term *electrolysis*.

In Part (a) (ii), candidates were required to discuss the electrolysis of molten sodium chloride and support this description with the ionic equations which would have indicated the reactions occurring at each electrode.

In Part (b), candidates were required to demonstrate their understanding of how the electrolysis of aqueous sodium chloride would vary from that described in Part (a) (ii) with regard to the products that would be formed from this electrolysis using inert electrodes. The basis of the response depended on candidates' understanding of the preferential discharge of ions depending on the position of the ions in the electrochemical series.

Part (c) required candidates to demonstrate their understanding of anodization of aluminium and required a drawing of the complete electrical circuit that would be used in this process. They were also required to include relevant equations that summarized the major reactions taking place in this process.

### **Performance of Candidates**

In Part (a) (i), most candidates were able to give a sound working definition of electrolysis. However, there were some candidates who did not get the complete concept that electrolysis involves both the breakdown of the electrolyte/the production of a chemical change and the use of electricity.

In Part (a) (ii), a large number of candidates were able to indicate the correct ion that would migrate to each electrode. However, some candidates were unable to give the appropriate response.

Some candidates were confused with the cations and anions present thinking of the molten sodium chloride as aqueous and putting forward the  $H^+$  and  $OH^-$  ions being associated with the cathode and anode respectively.

Some candidates struggled with the ionic equations required since they had a clear misconception of the charges associated with the cathode and anode. By employing the suggestion below this can be greatly reduced.

Further, candidates did not recognize that  $Cl^-$  will be required to lose electrons and  $Na^+$  required to gain electrons and hence there were quite a few responses that were incorrect, with candidates losing marks for inaccurate equations.

### **Suggested association of terms: A rule of thumb to assist candidates is for them to associate the words as follows:**

cations → cathode; Where the "t" in the word cations resembles (+) sign and since 'opposites attract' candidates can therefore see cations as being positive entities that will be attracted to negative entities in this case it must be the positive electrode called the cathode.

anions → anode; where the 'n' in the word anions can be associated with the word 'negative' and candidates can therefore see the anions as being negative entities that will be attracted to a positive entity; in this case the positive electrode called the anode.

For Part (b), most candidates were able to recognize that the aqueous solution of sodium chloride would now have  $H^+$  and  $OH^-$  ions in addition to the  $Na^+$  and  $Cl^-$  ions as well. However, some struggled to apply the principle that those lower in the electrochemical series will be preferentially discharged than those higher up. Some candidates had very little knowledge about the position of the

ions relative to each other in the electrochemical series indicating they did not commit it to memory. A mnemonic device can be found and used for example:

Pretty	K	Potassium
Sally	Na	Sodium
Could	Ca	Calcium
Marry	Mg	Magnesium
A	Al	Aluminium
Zulu	Zn	Zinc
In	Fe/Ni	Iron/Nickel
Tree	Sn	Tin
Lined	Pb	Lead
Honolulu	H	Hydrogen
Causing	Cu	Copper
Many	Hg	Mercury
Strange	Ag	Silver
Glances	Au	Gold

### Halogen ECS Order

<i>Ireland</i>	<i>I</i>	<i>Iodine</i>
<i>Breeds</i>	<i>Br</i>	<i>Bromine</i>
<i>Clinging</i>	<i>Cl</i>	<i>Chlorine</i>
<i>Fleas</i>	<i>F</i>	<i>Fluorine</i>

(As obtained from *Electrochemical Series Mnemonics*,  
<http://www.oercommons.org/courses/electrochemical-series-mnemonic-and-notes/view> Accessed 14  
 February 2015)

Though some candidates were able to indicate the correct ions that would be preferentially discharged, most were unable to answer the question completely by giving the products that would have been formed, that is, either the hydrogen or the oxygen gas.

Responses for Part (c) varied greatly since most candidates struggled to draw an appropriate diagram of the electrolytic circuit required. Maximum scores on this part of the question were not very frequent. Candidates' electrolytic circuits were poorly done with a great deal of confusion seen in the assignment of the terminals of batteries and hence cathode and anode, absence of switches or light bulbs, inappropriate electrolytes such as aluminium oxide, aluminium to be anodized as the incorrect electrode. There was the misconception that the question required the purification of bauxite rather than anodization of aluminium and, in some cases, candidates described the process as the electroplating of aluminium. Very few descriptions of the anodizing process were accurate with

candidates being unable to fully give the required equations. However, descriptions for the formation of oxygen and its subsequent reaction with aluminium to form the aluminium oxide layer was also given some credit.

### Common Incorrect Responses

Part (a) (i)

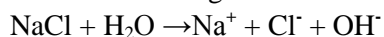
The decomposition of ionic compound to their elements.

Part (a) (ii)

The sodium  $\text{Na}^+$  moves toward the anode, which reduces it ( $\text{Na}^+ + e^- \rightarrow \text{Na}$ ) and then the atom is stable. Chloride ( $\text{Cl}^-$ ) moves toward the cathode where it is oxidized ( $\text{Cl}^- - e^- \rightarrow \text{Cl}$ ) but some chloride is unstable by itself, it combines with another chlorine molecule ( $\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2$ ) to form chlorine gas at the cathode.

Part (a) (ii)

During the electrolysis of molten  $\text{NaCl}$ , the positive  $\text{Na}^+$  ions travel through the electrolyte to the anode and the negative  $\text{Cl}^-$  ions travel to the cathode where they are released as a gas.



Part (b)

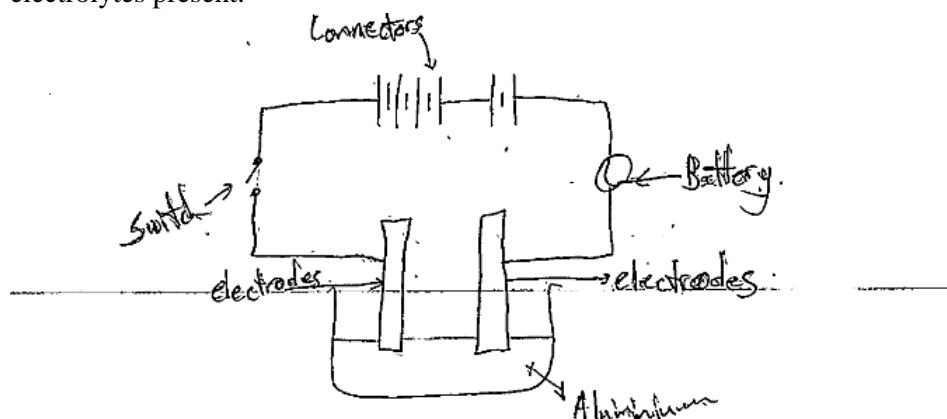
The effect that this would have on the position of the ions would be that the ions discharged would be given a different preference. In this experiment the  $\text{Na}^+$  will still be discharged and the  $\text{OH}^-$  would be discharged instead of the  $\text{Cl}^-$  ions.

According to the electrochemical series, Chlorine ( $\text{Cl}^-$ ) is in a lower position than that of sodium ( $\text{Na}$ ) and is discharged in preference to sodium, because sodium is higher in the electrochemical series.

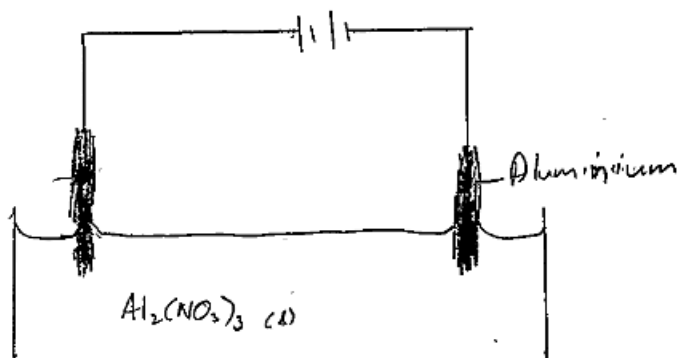
Part (c)

Some incorrect responses with corresponding diagrams are as follows.

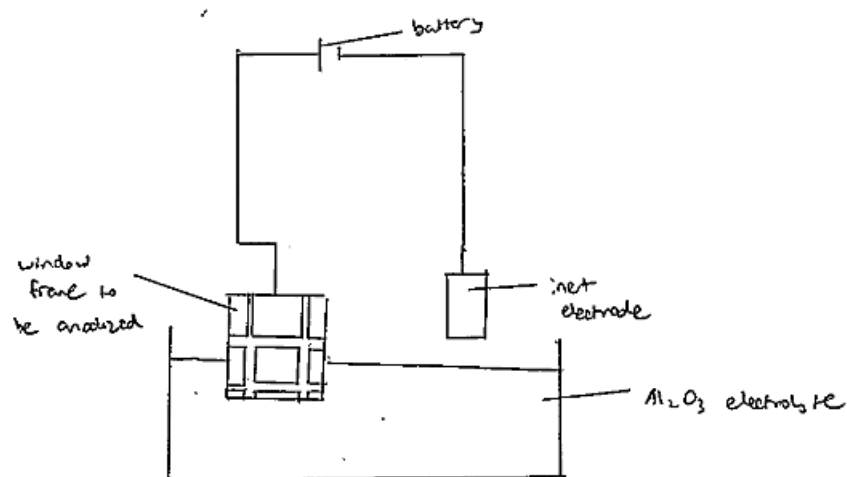
During this anodizing of aluminium process it checks the amount of anions present and how many electrolytes present.



The positive electrons are attracted to the aluminium anode and attaches on it, electrically plating aluminium anode.



Aluminium oxide is the electrolyte being used. When the electrolysis is started oxygen ions migrate to the anode. They react with the window frame which is made of aluminium and a protective layer of aluminium oxide is formed.



### Expected Responses

Part (a) (i)

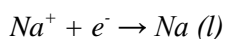
*Electrolysis is the passage of an electric current through an electrolyte, producing a chemical change*  
 Or (Similar type statement combining the two important phrases)

Part (a) (ii)

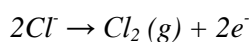
*Sodium ions migrate to the cathode/negative electrode and are discharged.*  
*Chloride ions migrate to the anode/positive electrode and are discharged.*

Or

*At the cathode:*



*At the anode:*



Part (b)

*Ions lower in the electrochemical series are discharged in preference.*

$H^+$  is lower than  $Na^+$  in the electrochemical series OR  $OH^-$  is lower than  $Cl^-$  in the electrochemical series

$H_2$  (or  $O_2$ ) is evolved.

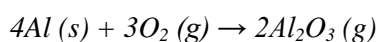
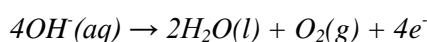
Part (c)

A large labelled diagram that includes all of the following:

1. Complete circuit-switches, bulbs, wires
2. Aluminium at anode (connected at +VE pole of battery/+ve electrode)
3. Named electrolyte (can use a range of acids) in the cell diagram

**Equations:**

At the anode:



Alternative descriptions that were also rewarded were: *Oxygen is produced.*

Al reacts with  $O_2$  to form  $Al_2O_3$ /aluminium oxide layer .

Question 5

Syllabus References: A: 6, 5; B2: 3.1, 5.2, 8.1

This question tested candidates' knowledge of the contact process involving the production of sulfuric acid from sulfur, as well as the uses of metals and their importance in biological systems.

In Part (a) (i), candidates were required to name the anhydride of sulfuric acid and describe its production, stating relevant conditions. In Part (a) (ii), candidates were told to use balanced equations with state symbols to explain how the anhydride was converted to sulfuric acid in the manufacturing process. In Part (a) (iii), candidates were required to state why anhydride is not directly added to water to produce sulfuric acid.

Part (b) tested candidates on the use of metals and their importance in biological systems. In Part (b) (i), candidates were required to give two reasons why the alloy, stainless steel, was preferred to pure iron when making cooking utensils. In Part (b) (ii), candidates were asked to suggest how a lack of iron in the human diet could affect the body.

**Performance of Candidates**

For Part (a) (i), the majority of candidates was unable to correctly name the anhydride of sulfuric acid, consequently they were unable to describe how it was produced and the conditions required for any reactions. A few candidates identified the anhydride but were unable to accurately describe how it was produced.

For Part (a) (ii), the majority of candidates had difficulty writing the two equations which were required. Some candidates chose to describe the process while using formulae. However, a minority of candidates were able to write both balanced equations with state symbols.

In Part (a) (iii), many candidates knew generally that the reaction would be violent or vigorous but few referred to the reaction being highly exothermic. Very few candidates accounted for the corrosive mist which is produced when the sulfur trioxide is added to water. Some said that a mist, gas or fumes would be produced but failed to describe it as corrosive or dangerous.

Part (b) (i) had a variety of answers. The majority of candidates was able to state at least two reasons why the alloy was preferable. The most common answer was that the alloy was more resistant to rust.

In Part (b) (ii), candidates provided a variety of answers and invariably they were correct. However, some candidates misunderstood that the focus was on iron found in haemoglobin.

### Common Incorrect Responses

For Part (a) (i), candidates incorrectly stated that sulfur dioxide was the anhydride of sulfuric acid.

In describing the process by which sulfur trioxide was made, candidates ascribed the use of vanadium pentoxide to the reaction involving sulfur trioxide being added to the sulfuric acid. In some cases they used it in the reaction between sulfur and oxygen.

In Part (a) (ii), many candidates were unable to write the equations and those who did, assigned the state symbol (aq) to the hydrogen sulfate and oleum rather than the state symbol for liquid (l).

Some candidates wrote the equation:  $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$  which was incorrect.

Part (b) (i), some candidates stated as one of the reasons the alloy was preferred ‘steel conducted heat better than iron’ others that ‘steel was cheaper to produce’.

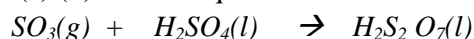
In Part (b) (ii), candidates wrote that one of the effects of lack of iron in haemoglobin was sickle cell anaemia. Candidates also had the misunderstanding that this also contributed to weak bones.

### Expected Responses

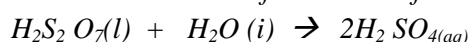
Candidates were expected to state for Part (a) (i) that:

- *Sulfur trioxide –  $\text{SO}_3$  is the anhydride of sulfuric acid.*
- *It is produced by first reacting sulfur with oxygen to produce sulfur dioxide–  $\text{SO}_2$  this is then farther reacted with excess oxygen in the presence of vanadium pentoxide –  $\text{V}_2\text{O}_5$  at about  $450^\circ\text{C}$  and 1–2 atm to produce sulfur trioxide.*

For Part (a) (ii) the two equations were



*Sulfur trioxide is added to sulfuric acid to form oleum. Oleum is then diluted back to the acid.*



For Part (a) (iii), the expected response involved stating that *sulfur dioxide when added to water causes a highly exothermic (vigorous, violent, explosive) reaction which produces a corrosive mist (gas, fume) of sulfuric acid in the air.*

In Part (b) (i), some of the responses which were expected were *steel is used in preference to iron because steel is more resistant to corrosion; it is stronger or more durable; it is more attractive; it reduces the possibility of iron reacting with food.*

For Part (b) (ii), a correct response was *lack of iron in the haemoglobin may cause iron deficiency anaemia and its associated ailments including tiredness/fatigue; paleness; shortness of breath, dizziness, headache, confusion and a decrease in cellular respiration.*

### Question 6

Syllabus References: C1: 3.1, 3.3, 3.6, 3.7, 3.10

This question dealt with plant nutrients, soil acidity and hydroponics.

Part (a) (i) tested candidates' knowledge of minerals and their respective deficiencies.

For Part (a) (ii), candidates had to use their knowledge to design an experiment to investigate the effect of the deficiency stated on plant growth.

Part (b) (i) tested candidates' knowledge of problems associated with plant growth.

Candidates were to write a balanced ionic equation on how lime increases the pH of soils for Part (b) (ii).

For Part (b) (iii), candidates were to explain how lime causes nitrogen to be lost from the soil in addition to writing a balanced ionic equation showing this process.

Candidates were asked to identify two disadvantages of hydroponics for Part (c) and suggest one way to address one of these disadvantages.

### **Performance of Candidates**

Most candidates were able to identify one mineral and give the deficiency associated with it in Part (a) (i). However, some candidates however, identified sunlight, carbon dioxide and water as minerals which quite clearly they are not.



In Part (a) (ii), most candidates were able to plan and design an experiment to investigate this deficiency. However, many did not receive all four UK marks because, in their design, they neglected one or more of the variables (control, manipulated or responding).

Most candidates indicated that the plants would die in acidic soil and therefore were not accredited the one mark for Part (b) (i).

The vast majority of candidates was unable to get any of the two UK marks for writing the ionic equation for Part (b) (ii). This question was poorly done.

Candidates did very poorly on Part (b) (iii). They were unable to identify ammonia gas as being lost and did not write an ionic equation to show this happening.

In Part (c), candidates were able to identify at least one disadvantage of hydroponics. However, most were unable to suggest a remedy for addressing the disadvantage.

### Expected Response

Part (a) (i) Element Deficiency:

- *N, Mg, S – Yellowing of leaves, stunted growth*
- *Weak root system, stunted growth, poor fruit formation, flowers dropping*
- *K – Leaf tip dies*
- *Ca – Stunted growth at shoot*

Part (a) (ii)

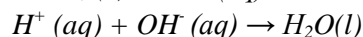
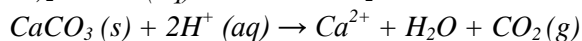
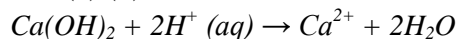
The design should include the following and should follow a logical sequence:

- *Control variable*
- *Manipulated variable*
- *Responding variable*

Part (b) (i)

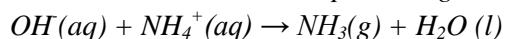
*In acidic soils, plants do not grow well, their leaves become yellow and the roots become burnt.*

Part (b) (ii)



Part (b) (iii)

*Lime reacts with ammonium ions producing ammonia gas*



## Part (c) Disadvantages

- *Expensive to set up/maintain*
- *Workers need more technical knowledge*
- *Soil nutrients must be closely monitored*
- *Can be seen as unnatural/hesitant to buy*
- *Requires lots of energy resources*

## Addressing the disadvantages

- *Provide training for workers*
- *Utilize/implement alternative energy*
- *Seek financial help*
- *Or any reasonable suggestion for addressing any one of the stated disadvantages*

**Paper 032 – Alternative to School Based Assessment**Question 1

This question was set on syllabus objectives A: 3.3; 3.4 and 6.10. It tested candidates' knowledge of an appropriate method of salt preparation based on the solubility of the salt, their practical skill in recording mass readings from a balance and deducing the mass of a precipitate given the mass of the beaker and precipitate.

Candidates were required to

- write a balanced equation with state symbols
- read and record mass readings from a balance
- plot mass readings against volume of acid on the axes provided and draw two lines of best fit
- use the lines of intersection to find the minimum volume of sulfuric acid that reacted with all the silver ions in the silver nitrate solution
- apply the mole concept using the balanced equation
- write sources of error and safety precautions

Most candidates were able to score at least half of the 26 marks.

Part (a) showed candidates' inability to write correct formulae and equations. The majority of candidates did not recognize the reaction as a simple double decomposition or ionic precipitation where one set of ions remains as spectator ions while the precipitate is formed; they included  $\text{NO}_2(\text{g})$  and  $\text{H}_2\text{O}$  in the products. Some candidates did not use the state symbol for the precipitate of silver sulfate as a solid but as an aqueous solution.

The correct equation:  $2\text{AgNO}_3(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Ag}_2\text{SO}_4(\text{s}) + 2\text{HNO}_3(\text{aq})$

For Part (b), most candidates were able to record the readings for the mass of the precipitate and container correctly as 3.1, 3.9, 5.5, 6.2, 6.2, and 6.2. They were also able to subtract the mass of the empty container to obtain the mass of the precipitate. However, in Part (c), although the points of the

graph were correctly plotted, not many candidates followed the instructions to draw two intersecting lines, the first line being one of best fit, so they lost this mark when a curve was drawn. Candidates are reminded to circle all the plotted points and read instructions carefully.

In Part (d), only the few candidates who drew two intersecting lines were able to deduce the minimum volume of sulfuric acid that precipitated all the silver ions. This was  $12.2 \text{ cm}^3$  but  $13 \text{ cm}^3$  was accepted if a curve was drawn.

The calculations in Part (e) (i) proved to be beyond candidates' ability. Those who attempted this part were able to obtain the first mark to determine the number of moles of silver ions in  $50 \text{ cm}^3$  of the  $0.50 \text{ mol dm}^{-3}$  silver nitrate solution. Some candidates divided by 100 instead of 1000. The correct working was:

$$1000 \text{ cm}^3 \text{ contain } 0.50 \text{ mol Ag}^+ \\ 50 \text{ cm}^3 \text{ contain } 0.50 \times 50 / 1000 = 0.025 \text{ mol}$$

In Part (e) (ii), few candidates used the mole ratio as hinted but went on to use the minimum volume of sulfuric acid and the confusion showed in their working. Many used  $2.5 \text{ cm}^3$  and some compared moles and volume.

The correct working:  $2 \text{ mol Ag}^+ \text{ reacts with } 1 \text{ mol H}_2\text{SO}_4$   
 $0.025 \text{ mol reacts with } 1 \times 0.025 / 2 = 0.0125 \text{ mol}$

In Part (e) (iii), few candidates were able to use the volume of acid in Part (d) to find the concentration of sulfuric acid as follows:

$$12.2 \text{ cm}^3 \text{ contain } 0.0125 \text{ mol H}_2\text{SO}_4 \\ 1000 \text{ cm}^3 \text{ contain } 0.0125 \times 1000 / 12.2$$

Many more candidates were able to obtain the mark in Part (e) (iv) for changing the mass of the precipitate in experiment 4 to moles. Thus, they correctly stated:

$$\text{No. of moles} = 3.2 / 312 = 0.01$$

In Part (f), the two possible sources of error included the loss of precipitate during transfer and the incomplete drying of the precipitate. Too many candidates used parallax errors and faulty instruments for which no marks were awarded. Candidates must be able to identify sources of error for specific experiments and not use precautions like zeroing the balance as errors.

The safety precautions that were accepted in Part (g) were mainly the *wearing goggles, gloves and lab coats*. Many candidates used the same sources of error as safety precautions and got no marks.

## Question 2

Syllabus References: B2: 7.1, 7.2, 7.3

This question focused on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on a solution of compounds A and a solid B given the inferences. Overall, the majority of candidates was able to obtain at least four or more of the ten marks.

For Test (i), most candidates were able to obtain the mark for the white ppt. but some did not know the solubility in excess. Test (ii) required candidates to observe that ammonia gas has a pungent odor and that it turns red litmus paper blue. They were not required to state that the blue litmus would remain blue, a few mentioned this but were not awarded any additional marks. The few candidates who gave the colour change for both litmus papers were not awarded any mark. Many candidates were able to obtain the one mark in Test (iii) for the white ppt. but not for the solubility in excess aqueous ammonia. Not many candidates knew Test (iv) which is the test for identifying sulfate(VI) ions and not many were able to identify  $\text{NO}_{2(g)}$  as a brown gas in Test (v), but most knew that it would turn blue litmus paper red. Again, no mark was given if the colour change for both litmus papers were stated.

## Question 3

This question was set on specific objectives A: 5.4 and B2: 7.3

It tested candidates' plan and design skill to use suitable separation techniques to obtain solid sea salt from a mixture of sea water and sand. It also tested their ability to identify the chloride ions in the sea salt. Overall, this question was not badly done as most candidates scored at least six or more of the twelve available marks.

Four marks were awarded for the list of apparatus in Part (a) (i) and most candidates gained two or three marks. For filtering the sand, a funnel and filter paper were needed for two marks; few candidates left out the funnel, some used a mesh, cloth and even a strainer. These received one mark. For obtaining the solid sea salt, a Bunsen burner and an evaporating dish were needed for the other two marks, but if a beaker or a conical flask was used, candidates were not penalized.

For Part (a) (ii), candidates who outlined the procedure of filtration, collecting the filtrate, heating it to saturation point and then cooling to obtain crystals which were filtered and dried, or heating to dryness were awarded the four marks. However, many candidates heated the sea water without filtering or used a separating funnel to filter and some used a fractionating column and distillation apparatus for getting the salt.

The main observations expected in the stages of the experiment in Part (a) (iii) were the sand on the filter paper, a colourless filtrate and white solid/crystals in the evaporating dish. Most candidates were able to obtain two marks for any two of these observations.

Part (b) was very poorly done, with most candidates either leaving it out, or using electrolysis to produce chlorine gas.

The correct response was *to make a solution of the sea salt and add silver nitrate solution to it and a white ppt. would be formed which is soluble in aqueous ammonia or insoluble in nitric acid.*

Concentrated sulfuric acid could also be added to the solid sea salt and the evolution of white fumes of hydrogen chloride gas would identify the chloride ions.

**C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**MAY/JUNE 2015**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

This year, a revised syllabus was examined and there were slight changes in the weighting of Profile 1, Knowledge and Comprehension, and Profile 2, Use of Knowledge. In addition, Question 1 on Paper 032 Alternative to SBA, was examined as a practical question.

There was a decline in performance from 2014, with 58.6 per cent of candidates achieving Grades I – III, compared with 68.9 per cent in 2014 and 62.2 per cent in 2013. A slight improvement in candidate performance was evident on Paper 032; while Paper 01, Multiple Choice, Paper 02, the Structured Essay Paper and Paper 031, the SBA, showed a slight decline in performance from 2014.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper consisted of 60 compulsory multiple-choice items. The general performance on this paper was satisfactory with approximately 62 per cent of the candidates scoring above the minimum cut score for Grade III. The scores ranged from 1 to 60 with a mean score of 32.5.

Candidates performed well in the areas relating to the following topics:

- The particulate nature of matter
- Electronic configuration
- Isotopes
- Rate of reaction
- Properties of a homologous series
- Alloys

However, candidates performed poorly in areas relating to the following topics:

- Qualitative analysis
- Preparation of gases and salts
- Reactivity series
- Calculations involving moles
- Properties of halogens
- Recognition of oxidizing agents from equations
- Acid/base properties of oxides
- Reaction of alkenes and ethanol
- Equations relating to fermentation
- Products of cracking
- Uses of sulfur
- Linking specific pollutants to a particular phenomenon for example, acid rain

## Paper 02 – Structured Essay

This paper consisted of two sections. Section A comprised three questions. Question 1 was mainly a data analysis question and Questions 2 and 3 were structured questions. Section B comprised three essay type questions. The maximum score achieved was 99 out of a total of 100 marks. On average however, this paper continued to be poorly done as the mean score for the paper was 37.3. In fact, the only question with a mean score of more than 50 per cent was Question 1, the data analysis question. Overall, Questions 1, 2 and 3 recorded the best performances. Below are detailed comments on each question.

### Question 1

Syllabus References: A 3.4, 6.8, 7.1, 7.2, 7.4: B2 1.1, 7.1, 7.2

This question consisted of two parts; determination of the heat of combustion of candle wax, using the heat absorbed by a known mass of water and the mass of burnt wax, and qualitative analysis on a solid containing nitrate ( $NO_3^-$ ), chloride ( $Cl^-$ ) and iron(II) ( $Fe^{2+}$ ) ions.

Candidates were required to list two natural sources of hydrocarbons and name one hydrocarbon, other than wax, that can be used as fuel.

The majority of candidates correctly listed *natural gas and crude oil* as the two natural sources. Many candidates listed petroleum instead of crude oil and were awarded the mark. Other acceptable answers included asphalt (from lakes) and fossil fuels.

### **Common Incorrect Responses**

- Refinery gas
- Coal
- Wood
- Trees

Part (b) (i) tested candidates' ability to read masses and temperatures from figures showing scales, and to calculate the difference in mass and temperature.

The vast majority of candidates was able to read and record the correct values from the figures representing a balance and a thermometer, and do the subtraction correctly to obtain the mass of water used, the mass of candle burnt and the difference in temperature of the water.

Parts (b) (ii) and (b) (iii) required candidates to calculate the heat absorbed by a beaker and a mass of water, which involved substituting the appropriate masses, determined from Part (b) (i) into an expression:

$$\text{Heat} = (\text{mass}) \times (\text{specific heat capacity}) \times (\text{temperature change})$$

candidates perform the calculations using a calculator.

The majority of candidates made the correct substitution and was awarded the mark. Less than ten per cent of candidates did an incorrect substitution. A number of candidates, although making the correct substitution, were unable to get the correct answer from a calculator.



Part (b) (iv) required candidates to determine the total heat absorbed by the calorimeter. This involved the addition of the result from Parts (b) (ii) and (iii), and the majority of candidates had no problems doing this.

In Part (b) (v) candidates were asked to calculate the heat of combustion of the candle wax, which required dividing the total heat absorbed by the mass of candle burnt. Again, the majority of candidates performed this manipulation correctly.

For Part (b) (vi) Candidates were required to state the role of the can in the experiment.

More than 50 per cent of candidates correctly indicated that the can was used to minimize or prevent the loss of heat to the environment.

### Common Incorrect Responses

The role of the can was to

- conduct heat
- absorb the heat
- hold the conical flask in place.

### Expected Responses

The role of the can was to reduce the amount of heat being lost to the environment.

Part (b) was based on qualitative analysis and required knowledge of the tests for the nitrate, carbonate and chloride anions and the iron(II) cation.

The responses to this part were disappointing as these very common tests were seemingly unfamiliar to many candidates. Far too many candidates lost marks as they were unable to provide correct inferences for the given observations associated with the nitrate, carbonate and iron (II) ions, or the correct observations for the common tests associated with the chloride anion.

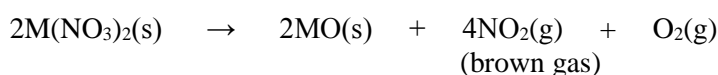
### Common Incorrect Responses included

- Stating that the brown gas is bromine instead of nitrogen dioxide
- Stating that silver chloride had a cream colour instead of white
- Stating that the green precipitate of iron (II) hydroxide is soluble in excess sodium hydroxide instead of being insoluble.

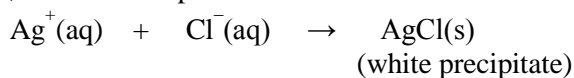
### Expected Responses

The correct observations and equations for the reactions tested are shown below.

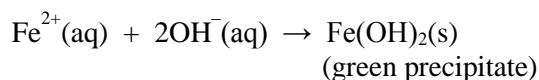
- The action of heat on a solid to produce a brown gas ( $\text{NO}_2$ ), and a gas ( $\text{O}_2$ ) that relights a glowing splint, confirms the presence of nitrate ( $\text{NO}_3^-$ ) ions.



- The addition of silver nitrate to produce a white precipitate, which changes to light purple in sunlight, confirms the presence of chloride ions.



- The correct ionic equation for the reaction of iron(II) ions with sodium hydroxide solution is:



## Question 2

Syllabus References: A: 1.2, 1.3, 5.5, 5.6

This question consisted of three parts testing: states of matter, solid state structure and distinguishing between ionic and molecular solids.

In Part (a) candidates were required to, (i) state the three states of matter; (ii) describe the strength of the forces of attraction between them; (iii) state the name of the process that occurs when iodine changes from one state to another and (iv), describe the accompanying energy changes that occur in the process from (iii).

For Part (a) (i), most candidates answered this correctly. Those candidates who answered incorrectly gave the answer such as: ice, water and steam/water vapour.

For Part (a) (ii) most candidates gave the correct answer but some common misconceptions included

- referring to the energy of the particles instead of the forces of attraction
- particles closely packed in solid and spaced out in liquids and gases.

For Part (a) (iii), most candidates gave *sublimation* as the correct answer. However, some candidates wrote melting, evaporation, boiling or condensation.

In Part (a) (iv), most candidates mentioned that the energy of the particles increased when the solid was heated and got one of the two marks. However, they failed to mention that solid iodine has particles that vibrate only and hence have little energy.

In Part (b), candidates were expected to use appropriate diagrams to illustrate how the bonding in solid sodium chloride differs from that of diamond. It was expected that candidates would draw the solid state structure of each and identify that the bonding in sodium chloride is ionic while that in diamond is covalent.

Very few candidates were able to gain full marks. Some were able to draw the structure of diamond and graphite, but most, however, did not label the ionic and covalent bonds in the different structures.

For the structure of sodium chloride, some candidates

- did not distinguish the sodium from the chloride ions
- drew one face instead of the three dimensional structure
- did not enter all the sodium and chloride ions on some faces
- did not join the ions by bonds.

For the structure of diamond, some candidates

- drew one tetrahedron; they did not show the extended tetrahedral arrangement.
- drew the structure showing the carbon atoms with three or five bonds.

In addition, some candidates drew diagrams the showing sharing of electrons for covalent bonding and the transfer and acceptance of electrons for ionic bonding.

In Part (c), candidates were expected to describe two laboratory tests that should distinguish ionic solids from molecular solids. In addition, they were expected to explain how the results of the test should accurately distinguish between the two types of solids.

While some candidates were able to identify two methods that they could use to distinguish between ionic and molecular solids, most candidates were unable to explain how the results of the test could accurately distinguish between the two different types of solids.

Some common errors included:

- Ionic and molecular solids would conduct electricity in the solid form.
- Not dissolving the solids in water to see if it would conduct electricity
- Referring to diamond and sodium chloride, hence explanations were given for those two solids.
- Referring to iodine as the molecular solid, hence, molecular solids would sublime.
- Describing the reaction between metals and non-metals for ionic solids and reaction between non-metals for molecular solids.

### Question 3

Syllabus References: B: 2.5, 2.6, 2.7, 2.8, 3.4, 4.1, 4.3

The question tested candidates' knowledge of organic chemistry with a focus on hydrocarbons and polymers.

In Part (a), candidates needed to recognize and name a simple alkane and a simple alkene molecule. In Part (b), candidates were asked to define structural isomers and draw structural isomers of the simple hydrocarbons given in Part (a). In Part (c), candidates were asked to define polymers, identify the type of polymerization associated with the manufacture of polyethene, state uses of polyethene and name any other polymer.

Candidates did very well at recognizing the alkane and alkene homologous series to which the simple molecules belonged. They were significantly less successful at naming the compounds (2-methyl butane and 2-butene). The difficulty related to candidates' failure to properly apply numbering to carbon atoms in a molecule.

For Part (b) approximately 50 per cent of candidates were successful at defining structural isomerism. Many candidates were unable to fully recall the required definition and were wrong in replacing *same molecular formula* with 'same number of atoms', 'chemical properties' or 'elements', while *different structural formula* was wrongly replaced with different 'physical properties'.

Less than 25 per cent of candidates gained full marks for drawing a structural isomer each for 2-methyl butane and 2-butene. In most cases, candidates answered the question by drawing rotations of the structures given on the question paper. Candidates also lost marks by failing to ensure that carbon showed a valency of four and there were no missing hydrogen atoms.

In Part (c) approximately 55 percent of candidates were able to define the term *polymer* and identify that addition polymerization was involved in the manufacture of polyethene. Too many candidates wrongly stated 'condensation polymerization' demonstrating a failure to associate the double bond in alkenes with the ability of alkenes to undergo addition polymerization.

Most candidates were able to give at least one use of polyethene. Candidates had the opportunity to choose from an extensive range of plausible uses from plastic bags and wraps to ropes and pipes and identified uses in construction. Unfortunately, a significant number of candidates chose to identify making 'nylon' or PVC.

Candidates were very successful in naming another polymer. Familiar responses were PVC, polypropene and polystyrene.

#### Question 4

Syllabus References A: 7.8, 7.7: C: 5.6, 5.7

This question comprised of two parts. Part (a) subsections (i)–(iii) were designed to test candidates' ability to

- Determine a suitable method for the preparation of an insoluble salt, calcium carbonate and provide relevant equations and steps to support the preparation method.
- Provide an appropriate use of the soluble, common salt, Epsom salts (magnesium sulfate).
- Explain the ability of water molecules to dissolve salts such as Epsom salts.

Part (b) was intended to test candidates' understanding of how permanent hard water is formed which they had and to demonstrate by providing supporting chemical equations.

Part (a) (i), generated a variety of responses from candidates since it indicated one method for the preparation of dry calcium carbonate in the laboratory. A popular response that was observed and accepted was the bubbling of carbon dioxide through aqueous calcium hydroxide 'limewater'. There was a clear misconception of what 'limewater' is since some candidates took this literally to mean lime juice and even went on to describe how to obtain calcium carbonate from it. This misconception needs to be addressed by teachers. There were responses which dwelt more on obtaining the calcium carbonate dry by heating a calcium carbonate sample rather than the preparation of the dry calcium carbonate.

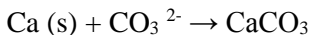
This question showed up candidates' lack of understanding of the solubility tables. There were cases where insoluble salts were put forward as reagents to prepare an insoluble salt via the ionic precipitation method. Greater time and attention needs to be spent on laboratory exercises in preparation of these types of salts. Some candidates even indicated that calcium carbonate is soluble.

The preparation steps were in most cases logical but candidates using the ionic method of preparation often forgot the crucial filtering step opting to warm or heat the contents of the reaction mixture directly. Also, washing the precipitate after filtering was sometimes omitted.

The accompanying equations were generally poorly done with candidates still being unable to provide accurate formulae for the reagents being used in the ionic preparation.

### Common Incorrect Responses

One method of preparation of dry calcium carbonate in the laboratory is through downward displacement in which it is passed through a round bottom flask through a U-tube which sends it through a drying agent commonly known as lime and finally through the tube where then it is collected. It can also be tested through the anions and cations laboratory tests.



- Because  $\text{CaCO}_3$  is soluble in water, to prepare a dry sample a solution has to be crystallized.  
 $\text{CaCO}_3(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$
- First place, an evaporating dish over a water bath to allow the steam to heat the  $\text{CaCO}_3$  solution.
- Then place a flat object over the evaporating dish to prevent any of the  $\text{CaCO}_3$  to escape.
- Heat the water bath.
- After a while the  $\text{CaCO}_3$  crystals will begin to form at the sides of the solution.
- Continue until all of the solute is disappeared and a dry sample of  $\text{CaCO}_3(\text{s})$  will be obtained.

### Expected Responses

The following were accepted as suitable responses:

#### Preparation

##### Step 1:

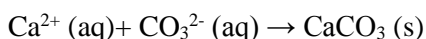
Combining suitable reagents that will give a precipitate as shown in the following equations

Step 2: Filtering of precipitate.

Step 3: Washing of precipitate.

Step 4: Drying of precipitate.

#### Accept ionic equation.

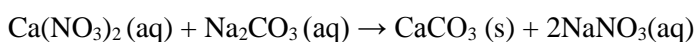
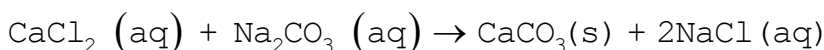


OR

Accept full chemical equations, for example:

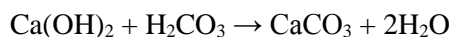
Using calcium chloride (or calcium nitrate) and the soluble sodium, potassium and ammonium carbonates.

Typical equations are shown below



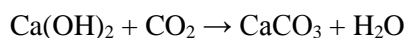
OR

Calcium hydroxide and carbonic acid



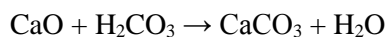
OR

Calcium hydroxide and carbon dioxide



OR

Calcium oxide and carbonic acid



OR

Calcium and carbonic acid

Calcium oxide and carbon dioxide.

Part (a) (ii), was generally well answered with candidates being able to give a variety of responses for the use of Epsom salts. There were, however, misconceptions regarding the use Epsom salts to aid acid indigestion and upset stomach. While Epsom salts has quite a variety of uses in health, beauty, household and cleaning, candidates needed to be specific with responses.

### Common Incorrect Responses

- To neutralize acids in the stomach
- Epsom salts can be used to treat stomach problems (upset/overactive digestion etc.)

### Expected responses:

Any one common household use of Epsom salts, for example, laxative, treatment of arthritis, swelling of joints, etc. any plausible use. Further uses were obtained from the link below  
SALTWORKS: Epsom salts uses and benefits accessed 21 June, 2015 from  
[http://www.saltworks.us/salt\\_info/epsom-uses-benefits.asp](http://www.saltworks.us/salt_info/epsom-uses-benefits.asp)

Part (a) (iii), had some very good responses as candidates were able to understand the similarity in nature of the solute, Epsom salts (magnesium sulfate) and the solvent, water. They were able to describe the polar nature of water giving good detail of the partial charges on the hydrogen and oxygen atoms. However, some candidates chose to describe water as a universal solvent without any attempt to indicate the reason for this. Some candidates described Epsom salts as ‘polar salt’ which is not the appropriate description of the nature of this salt. Some candidates obtained some of the marks for indicating the presence of the magnesium and sulfate ions present in the Epsom salts even though they may not have used the words *ionic compound*. There were very detailed responses which outlined the hydration of the magnesium and sulfate ions which showed superior understanding of the solvation process and candidates were rewarded with full marks for this section of the question.

### Common Incorrect Responses

- Epsom salts are magnesium sulfate, all sulfates are soluble in water except barium sulfate.
- The main ingredient in Epsom salts is magnesium sulfate which is soluble salt. It can dissolve easily in water molecules and this is made into solution.

### Expected Responses

Water is polar and is able to dissolve ionic compounds/complete description of water molecules breaking apart ionic compound.

Epsom salts/magnesium sulfate is an ionic compound/description of ions in ionic compound without stating the term 'ionic.'

For Part (b), there was quite a mixed set of responses in which candidates sometimes discussed temporary hardness instead of permanent hardness and it suggests more attention needs to be paid in making the distinction in each form of hard water. Some candidates earned partial marks for recognizing the fact that magnesium ions are dissolved out of rocks, soil, earth, stones, etc. and becomes soluble. However, they failed to make the connection with the presence of sulfate ions and hence the formation of the magnesium sulfates which together with calcium sulfate also contributes to the formation of permanent hard water.

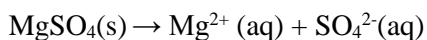
To earn full marks in the question candidates needed to demonstrate superior skills in using the most appropriate equation(s) to show permanent hardness formation. Many candidates again faltered in this regard though very simple equations were required. The dissolving of magnesium salts into solution seemed to give candidates undue problems. Quite a number of candidates erroneously showed magnesium metal from the rocks reacting with water to form hydroxide and hydrogen failing to recognize that magnesium ions are bound as cations in a soluble compound. Most of these candidates did not recognise water as a solvent but as a reactant. This is a serious flaw in understanding how salts become soluble and this was also seen in a previous part of the question.

### Common Incorrect Responses

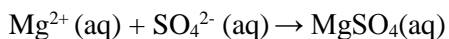
- Permanent hard water is formed when it contains high concentrations of magnesium ions. Therefore when water is exposed to substances containing magnesium, it would react with the substance to form the hard water.  
$$\text{H}_2\text{O} + \text{Mg (s)} \rightarrow \text{H}_2\text{O.Mg (s)}$$
- Permanent hard water is hard water which cannot be softened and this is caused by the presence of magnesium and calcium ions/salts which bonds to the water.  
$$\text{Mg}^{2+} (\text{aq}) + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{MgO (aq)}$$
- Hard water is formed by the presence of magnesium ions  
$$\text{Mg (s)} + \text{H}_2\text{O (l)} \rightarrow \text{MgO (s)} + \text{H}_2 (\text{g})$$
- Hard water is not affected by boiling unlike soft water which can be affected by boiling water.  
$$\text{CaCO}_3 + \text{H}_2\text{O} \rightarrow \text{CaO} + \text{H}_2\text{O} + \text{CO}_2$$
- Permanent water can be purified by filtration.

**Expected Responses:**

$Mg^{2+}/Ca^{2+}$  ions are dissolved out of rocks and become soluble. The aqueous  $Mg^{2+}/Ca^{2+}$  can then combine with sulfates producing magnesium/calcium sulfates in solution which leads to the formation of hard water.



OR



Similar equations with  $Ca^{2+}$  were accepted as well.

Question 5

Syllabus Objectives: B: 3.8, 3.9 A: 2.6

This question consisted of three parts. It focused on the production of sugar from sugar cane, methods of separation, types of reaction and the production of alcohol by fermentation. The question also included the action of base on the acid produced by oxidized wine.

The question was very poorly done with the majority of candidates scoring between 0 and 2 marks. Very few candidates scored above 10 marks.

Part (a), dealt specifically with the operations of a cane sugar factory. It tested candidates' knowledge of the processes involved in the production of sugar from cane and the application of separation techniques in this process. Candidates were also required to demonstrate some knowledge of the by-products produced during the process and how the by-products could be utilized in the factory. This section of the question focused on knowledge and comprehension.

In Part (a) (i), candidates were given a flowchart of the production process and required to identify two of the processes, labelled P and Q. While many of the candidates were able to identify process Q, few were able to identify process P. Some candidates rather than name the process sought to describe the process. Some tried to name the machine or apparatus in which the process was taking place.

**Common Incorrect Responses**

- Process P – Heating process of the juice; the fermentation of the cane juice for crystallization; neutralization; evaporation; purification; boiling
- Process Q – This is the denaturing process of the sugar purification; fermentation

**Expected Responses**

- P: Clarification;  
Other accepted responses – sedimentation; precipitation; coagulation or flocculation
- Q: Evaporation;  
Other accepted responses – vacuum distillation or distillation; concentrate; crystallization

For Part (a) (ii), candidates were asked to state the importance of the centrifugation process.



Few candidates got this part of the question correct. Some gave general descriptions of the purpose of centrifugation, which was not accepted. Candidates were required to be specific as far as sugar production is concerned.

### **Common Incorrect Responses**

- The centrifugation process changes to liquid sugar and solid sugar.
- This process enables the mixture to be converted to sugar and other products such as rum.
- This process is important because without it the sugar would not be formed or manufactured properly, resulting in no crystalline.
- Centrifugation is the process by which solids are separated from liquids.

### **Expected Response:**

Centrifugation removes the liquid product surrounding the crystalline sugar or it separates the solid crystals from the liquid by-product called molasses.

Part (a) (iii), required candidates to identify a product, labelled X, from the centrifugation process. The majority of candidates wrote the correct answer for the identification of product X.

### **Common Incorrect Responses**

- Rum
- Water
- Residue
- Remains from sugar cane

### **Expected Response**

- Molasses

Part (a) (iv), required candidates to state where the bagasse was used in the factory and its purpose. The majority of candidates scored zero on this part of the question, however a large minority scored at least one mark. Some candidates focused on how bagasse may be used outside of the factory while others seemed confused about the identity of bagasse.

Many candidates seemed not to realize that there were two parts to the question – (i) where in the factory the bagasse was used and (ii) for what purpose it was used.

### **Common Incorrect Responses**

- It is used to help breakdown sugar cane to the juice and helps to sustain the juice.
- The bagasse produced forms fibre and is used to produce other products. It is used to make ropes and other materials in the manufacturing part of the factory in which the fibres are produced.
- The bagasse is used to make by-products of sugar cane molasses.

### **Expected Responses**

- The bagasse is used in the boiler house. Other accepted responses were- boiler; boiler station; furnace
- Bagasse is used as a fuel in the boiler station to generate steam for the production of electricity.

Part (b) (i), required candidates to use balanced equations to illustrate how sucrose is converted into ethanol, using a two-step method from sucrose to glucose and then glucose to ethanol. The majority of the candidates scored zero on this part of the question. Many candidates did not seem to understand that sucrose is made of glucose and fructose. In addition, some were not able to write the anaerobic equation depicting glucose going to ethanol. In other cases where attempts were made candidates had problems in writing the correct formulae and/or balancing the chemical equation. A great majority of candidates opted to explain the process using words rather than chemical equations. Many added water to their fermentation equations.

### Common Incorrect Responses

- $C_{12}H_{24}O_{12} \rightarrow 2 C_6H_{12}O_6$
- In fermentation a catalyst is used. This catalyst is yeast. Sucrose is a complex organic compound and can be found in plants. However the catalyst yeast is able to break the organic compound to alcohol used,  $CO_2$  is also produced.
- The fermentation of ethanol from yeast feeds on the sucrose. The enzymes in the yeast feeds on the sucrose will react with the sucrose and convert it into simpler sugars and after a few years in storage these sugars are converted to ethanol
- $C_6H_{12}O_6 + \text{yeast} \rightarrow C_2H_6 + \text{energy}$

### Expected Responses

- Sucrose is converted to glucose and fructose which are then fermented or  $C_{12}H_{22}O_{11} \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$  (Please note that candidates were not required to know the formula for sucrose)
- $C_6H_{12}O_6 \rightarrow 2 C_2H_5OH + 2CO_2$

In Part (b) (ii), candidates were expected to draw on their laboratory experience to determine the type of apparatus that would be required to obtain a concentrated sample of alcohol from a dilute mixture. The majority of candidates scored zero but many managed to score three marks.

### Common Incorrect Responses

Incorrect responses included diagrams for the separation of solids from liquids, distillation apparatus without a condenser or heat source.

### Expected Responses

A simple distillation apparatus including a heat source, reacting vessel, condenser and a collecting vessel. A thermometer should also be included.

In Part (c), candidates were expected to deduce that the alcohol would be oxidized to ethanoic acid and thus can be reacted with a base. Candidates were asked to suggest the type of reaction magnesium oxide would have with the sour wine and to write an equation for this reaction. This part of the question was done very poorly, the majority of candidates scored zero. However, many were able to score one mark especially in the area of identifying the type of reaction or in deducing that the sour taste was due to ethanoic acid. Some candidates who identified the sour taste as ethanoic acid were unable to write the correct formula for the acid. Some candidates also had problems writing the formula for magnesium oxide.

### Common Incorrect Responses

- Reduction; combination; decomposition
- $\text{MgO} + \text{C}_2\text{H}_5\text{OH} - \text{H}_2\text{O} + \text{MgC}_2\text{H}_3\text{O}$
- $\text{MgO}_3 + \text{C}_2\text{H}_3\text{OOH} \rightarrow (\text{C}_2\text{HOOHMg})_2 + \text{O}_2$

### Expected Responses

- Neutralization reaction or acid-base reaction
- $2\text{CH}_3\text{COOH} + \text{MgO} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2\text{O}$

### Question 6

Syllabus References: B: 3.11; C: 5.4, 5.5, 5.9, 5.10

This question dealt with hard and soft water, the effect of detergents on the environment and Green Chemistry.

Part (a) (i), tested candidates' knowledge of hard water and soft water and the formation of scum using soap. In Part (a) (ii), candidates were required to know the impact of using soapless detergents instead of using soap in hard water.

For Part (b), candidates were expected to outline the harmful effects of second generation detergents, containing phosphates, on the environment, with reference to rivers and streams.

In Part (c), candidates were asked to (i) define the term Green Chemistry and (ii) discuss any two benefits of utilizing the principles involved in Green Chemistry.

In Part (a) (i), many candidates were able to identify that hard water was present at Ann's house/ Sally's house the presence of soft water. However, many were unable to identify and relate the presence of  $\text{Mg}^{2+}$  and/or  $\text{Ca}^{2+}$  ions in creating water hardness which led to scum formation with soap.

For Part (a) (ii), candidates recognized that the results would be different if soapless detergents were used, however, many failed to state that no scum would be formed. Some candidates said that no precipitate would be formed or that the compound formed would be soluble, instead of saying no scum and were awarded the marks.

### Expected Responses

In Part (a) (i), candidates were expected to recognize that where Ann lives has hard water / Sally lives has soft water to be awarded full marks. However, if candidates recognized that the difference is due to hard/soft water without being specific to where either Ann or Sally lived, partial marks were awarded.

In addition, candidates should have recognized that hard water contains  $\text{Mg}^{2+}$  or  $\text{Ca}^{2+}$  which reacts with soap to form soap scum to be awarded two additional marks.

In Part (a) (ii), it was expected that candidates would recognize that detergents do not form soap scum.

For Part (b), some candidates simply stated that phosphates killed fishes or they were leached into the ground affecting crops. Neither responses were allocated marks. Most candidates neglected the fact that algal bloom used up oxygen which resulted in the death of pond organisms. Some candidates wrote that eutrophication is caused by phosphates. This response was awarded only one mark since this term means the same as killing pond organisms and does not refer to oxygen being used up.

### **Expected Responses**

It was expected that candidates would recognize that phosphates can provide nutrients/act as fertilizers cause algal blooms/sea grass/vegetation growth. This uses up oxygen in rivers or streams causing eutrophication/dead pond/fish to die.

For Part (c) (i), most candidates were unable to correctly define the term *Green Chemistry*. Many candidates could only correctly provide part of the definition. Some candidates wrongly defined Green Chemistry as protecting the environment.

In Part(c) (ii), many candidates were able to identify and discuss at least one benefit of Green Chemistry. Many candidates, however, repeated themselves, writing the same point twice especially when it came to the point of making the environment safer.

### **Expected Responses**

For (c) (i), Green Chemistry is using principles that reduce/eliminate the use of hazardous materials in the design, manufacture and application of chemical products.

For Part (c) (ii), the expected benefits included:

- Makes the environment safer
- Reduces waste
- Creates new jobs
- Reduces respiratory illnesses
- Atom economy

## **Paper 032 – Alternative to School – Based Assessment (SBA)**

### Question 1

Syllabus References: A 6.5, 6.6, 7.11, 8.5; C 6.1, 6.2

This question was the practical aspect of the examination. It was divided into two parts. Part (a) required the candidates to investigate whether a particular sample of liquid bleach met manufacturing standards utilizing the experimental technique of titration. Part (b) was based on qualitative analysis.

In Part (a) (i), candidates were expected to fill in the initial, final volumes as well as volumes used in Table 1 to two decimal places. Most candidates were able to do so but still too many did not read their burettes to the expected two decimal places. In addition, it was clear that some candidates were not aware of how to accurately read the burette. For example, some candidates had larger initial volumes with smaller final volumes. This suggested that these candidates severely lacked experimental experience.

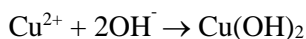
In part (a) (ii), candidates were able to correctly calculate the average volume used, however, most just averaged all three values rather than identifying the two which were closest in value.

Parts (a) (iii) to (viii), took candidates through step by step calculations necessary to determine whether the bleach solution met the required standard. These calculations proved difficult for most candidates, suggesting that candidates are still not familiar with mole calculations which is fundamental to all Chemistry.

For Part (b), candidates were provided with a solid sample labelled D and asked to dissolve it into water. The resulting solution should have been divided into two equal portions in order to carry out the following tests:

- Add BaCl<sub>2</sub> solution followed by excess dilute hydrochloric acid
- Add aqueous NaOH a little at a time until in excess

Most candidates who attempted the question were able to make the correct observations. For example, when BaCl<sub>2</sub> was added it was expected that candidates would see a white precipitate formed which did not dissolve in excess dilute HCl. When NaOH(aq) was added it was expected that a blue precipitate which was insoluble in excess would be formed. However, making the correct inferences proved difficult for most candidates. The white precipitate with BaCl<sub>2</sub> suggested that either sulfate or sulfite ions are present but the fact that the precipitate did not dissolve when HCl was added confirms the presence of sulfate ions. Some candidates mentioned the presence of sulfate ions without any mention of sulfite ions being possibly present. On the other hand, most candidates knew that the appearance of a blue precipitate with sodium hydroxide suggested that Cu<sup>2+</sup> ions were present but many were unable to accurately write the ionic equation:



### Question 2

Syllabus Reference: C 6.1

The total number of marks available for this question was ten but the majority of candidates obtained seven to eight marks.

This question tested the experimental skills of the candidate. It tested the ability of candidates to:

- Record the varying volumes of Solution X (lead (II) nitrate) added to a fixed volume of Solution Y (potassium iodide) and to read the height of the precipitate formed from the ruler next to the test tube.
- Create a scale for the y-axis and then plot the height of the precipitate (y-axis) against the volume of Solution X.
- State the scale used for 1 cm of the y-axis.

It was most surprising that many candidates did not record the volumes of solution X which were placed under the diagrams, but instead determined the volume of the solution inside the test tube. For the height of the precipitate, readings 3, 5, 6 and 7 were to two decimal places and many candidates rounded them off to one decimal place. Marks were lost for these incorrect readings.

The correct readings were as follows.

<b>Volume of Solution X Added (cm<sup>3</sup>)</b>	<b>Height of Precipitate (cm)</b>
0.5	0.4
1.0	0.8
1.5	1.25
2.0	1.40
2.5	1.55
3.0	1.55
3.5	1.55

Candidates are reminded to read the questions carefully in order to understand what is being asked before they start to write. Most candidates were able to plot their recorded points and obtained at least four marks for it. A few candidates used a large scale, so the points occupied one quarter of the graph. However, no marks were deducted for this.

Teachers are encouraged to give students practice in doing graphs and choosing a scale that will occupy at least three quarters of the graph page.

Many candidates were not able to identify the scale used, not realizing that 1 cm represented one block with five lines.

### Question 3

Syllabus Reference: A 7.5

This question tested candidates' planning and design skills. They were asked to plan and design an experiment to investigate the effect of heat on Vitamin C.

The given hypothesis was: "The concentration of Vitamin C decreases with increasing temperature."

Although Part (a) asked for apparatus and materials, candidates must be aware of the procedure for the experiment first, so that if they were able to answer Part (b) before Part (a), then they would be able to record all the apparatus to be used. Two marks were awarded for Part (a) and if one important piece was missing, candidates lost one mark. If more than one piece was missing, then they were not rewarded any marks. Many candidates omitted the measuring cylinder and were using specific volumes in their procedure. Note that heat is not an apparatus.

Part (b) was allotted three marks which were awarded as follows: using a solution of vitamin C tablets at two different temperatures was awarded one mark. If the same number of tablets and the volume of water were the same at the two temperatures, then this was awarded another mark. The third mark was given for a suitable method for determining the concentration of the ascorbic acid in the tablet.

The majority of candidates were able to obtain at least one mark for this part. Many did not obtain the method mark as they used the time to dissolve the tablet to determine the concentration. Note that concentration had to be determined by titration with a standard solution of iodine or with an alkali. The use of universal indicator or pH paper was also awarded the mark.

In Part (c), two marks were awarded for recording the data collected in the experiment in table form. Many candidates were able to obtain at least one mark. Some candidates collected data that was not obtained in the procedure or omitted to record the data that was collected.

The variable to be controlled in Part (d) was awarded one mark and many candidates were able to obtain this mark, once they stated one of the following: the number of tablets used or the volume of water or the concentration of ascorbic acid.

The substance by itself, for example, water was not the controlled variable but a quantity of it that can be kept constant. Teachers must remind students that *amount* has no units, so it should not be used as a measurable quantity.

The mark for the manipulated variable was for *temperature* and this was awarded one mark in Part (e).

The mark for the possible source of error in Part (f) was awarded for any possible error that could have occurred in the procedure for example, parallax error in reading the instruments used.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2016**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

In January 2016, the revised syllabus, effective from June 2015, was examined for the first time. In addition, Question 1 on Paper 032, the Alternative to SBA, was examined as a practical question.

Overall, the performance of candidates in this sitting of the examination declined, with 36 per cent of candidates achieving Grades I–III, when compared with January 2015, where 47 per cent of candidates achieved Grades I–III.

This report is intended to provide feedback on the performance of candidates in this sitting. The expected responses and the common misconceptions will be highlighted with the view that the report can be used to improve the teaching and learning of Chemistry at the CSEC level.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper consisted of 60 compulsory multiple choice items. The general performance on this paper was satisfactory with approximately 49 per cent of candidates achieved acceptable grades, Grade I–III. The maximum score obtained was 52 marks and the mean score obtained was 28 marks.

Candidates recorded excellent performance in the areas related to the following topics:

Particulate nature of matter  
Electronic configuration of atoms  
Trends in the periodic table of elements  
Reactions of compounds with acids  
Solid state structure  
Isomerism

However, candidates performed poorly in the following areas:

Identification of exothermic conversions from graphical representations  
Identification of types of mixtures  
Reactivity series, for example, identification of which metal will displace another in a chemical reaction  
Qualitative analysis  
Reactions with alcohols  
Polymerization

### Paper 02 – Structured/Extended Essay

#### Question 1

Syllabus Objectives: 10.1, 10.2, 10.3, 10.4

This question required candidates to define the rate of reaction, identify factors which affect the rate of a reaction, predict the effect of factors on rates of reaction from given data, and interpret a graphical representation of data obtained in studying rates of reaction.

In Part (a) (i), candidates were required to define the term *rate of reaction*.



### Performance of Candidates

Very few candidates were able to give a correct definition, and gave responses which showed a lack of knowledge of the definition.

### Common Incorrect Responses

- How long a reaction takes
- How much time a reaction takes to occur
- The speed with which a reaction takes place

### Expected Responses

The rate of reaction is the change of concentration of reactant or product in unit time.

In Part (a) (ii), candidates were required to state two factors, other than concentration, which affect the rate of a chemical reaction.

### Performance of Candidates

Many candidates were able to give two factors and were awarded the two marks.

### Common Incorrect Responses

Several candidates gave 'temperature' and 'heat'; temperature is a measure of the amount of heat energy in a system. These responses were awarded only one mark.

### Expected Responses

Temperature/heat, catalysts, particle size/surface area, light (for some reactions), pressure (for gases).

In Part (b) (i), candidates were required to determine the concentration of potassium iodate ( $\text{KIO}_3$ ) in Solution 1,  $100 \text{ cm}^3$  of an aqueous solution containing  $0.214 \text{ g}$  of  $\text{KIO}_3$ .

### Performance of Candidates

Very few candidates were able to calculate the concentration of Solution 1, and most attempts displayed a lack of understanding of the mole concept, and did not show logical steps. However, a number of candidates were able to calculate the molar mass and hence the number of moles of  $\text{KIO}_3$ .

### Expected Responses

The definition of molar concentration is the number of moles of a solute per litre ( $1 \text{ litre} = 1 \text{ dm}^3 = 1000 \text{ cm}^3$ ) of solution. Two methods of the calculation are shown below.

1. Molar mass of  $\text{KIO}_3 = 39.1 + 126.9 + (3 \times 16.0) = 39.1 + 126.9 + 48.0 = 214 \text{ g mol}^{-1}$   
 No. of moles of  $\text{KIO}_3 = 0.214 \text{ g} / 214.0 \text{ g mol}^{-1} = 0.00100 \text{ moles}$   
 $100 \text{ cm}^3$  of Solution 1 contain  $0.00100 \text{ moles KIO}_3$   
 $1 \text{ cm}^3$  of Solution 1 contains  $(0.00100/100) \text{ moles KIO}_3$   
 $1000 \text{ cm}^3$  of Solution 1 contain  $(0.00100/100) \times 1000 = 0.0100 \text{ moles KIO}_3$   
 $[\text{KIO}_3] = 0.0100 \text{ mol dm}^{-3}$

OR

2. Calculate the number of moles of solute and divide by the volume (in dm<sup>3</sup>) of solution:

$$\text{Molar mass of KIO}_3 = 39.1 + 126.9 + (3 \times 16.0) = 39.1 + 126.9 + 48.0 = 214 \text{ g mol}^{-1}$$

$$\text{No. of moles of KIO}_3 = 0.214 \text{ g} / 214.0 \text{ g mol}^{-1} = 0.00100 \text{ moles}$$

$$\text{Volume of solution} = 100 \text{ cm}^3 = (100/1000) \text{ dm}^3 = 0.1 \text{ dm}^3$$

$$\text{Concentration} = 0.00100 \text{ moles} / 0.1 \text{ dm}^3 = 0.0100 \text{ mol dm}^{-3}$$

$$[\text{KIO}_3] = 0.0100 \text{ mol dm}^{-3}$$

In Part (b) (ii), candidates were required to determine the concentration of NaHSO<sub>3</sub> in Solution 2, a 100cm<sup>3</sup> mixture of aqueous sodium hydrogen sulfite (NaHSO<sub>3</sub>), sulfuric acid and starch solution, using information provided in Table 1.

### Performance of Candidates

Candidate performance on this part of the question was very disappointing and showed a lack of understanding of the mole concept.

### Expected Responses

Two approaches to the solution are shown below:

- Volume of Solution 2 used = 10 cm<sup>3</sup>  
 Final volume of reaction solution = 50 cm<sup>3</sup>  
 Dilution Factor = 50/10 = 5  
 $\therefore$  Original concentration (of Solution 2) = 0.0008 mol dm<sup>-3</sup>  $\times$  5 = 0.004 mol dm<sup>-3</sup>

OR

- 1000 cm<sup>3</sup> of reaction solution contains 0.0008 mol  
 50 cm<sup>3</sup> of solution contains (0.0008/1000)  $\times$  50 = 0.00004 mol  
 $\therefore$  10 cm<sup>3</sup> of Solution 2 were used  
 10 cm<sup>3</sup> of Solution 2 contain 0.00004 mol  
 $\therefore$  1000 cm<sup>3</sup> of Solution 2 contain (0.00004/10)  $\times$  1000 = 0.004 mol  
 $[\text{NaHSO}_3] = 0.004 \text{ mol dm}^{-3}$

In Part (c) (i), candidates were required to read the times from diagrams of stopwatches and record the values in Table 2.

### Performance of Candidates

The vast majority of candidates recorded the correct values.

In Part (c) (ii), candidates were required to use the values of time obtained in Part (c) (i) to calculate values of reciprocal times and record them to three decimal places.

**Performance of Candidates**

The majority of candidates did the conversions of time to reciprocal times correctly, but some candidates had difficulty rounding off the values correctly to three decimal places.

In Part (c) (iii), candidates were required to use the axes provided to plot a graph of concentration of  $\text{KIO}_3$  versus reciprocal time for Experiments 1–5, and draw the best straight line through the points.

**Performance of Candidates**

Many candidates made good plots and obtained the maximum marks for this part. However, some candidates were not able to plot the values using the given scales and attempted to modify the scales.

For Part (d), based on the graph drawn in Part (c) (iii), candidates were asked to deduce what effect the concentration of  $\text{KIO}_3$  had on the rate of reaction.

**Performance of Candidates**

A number of candidates did not answer this part of the question, and less than 20 per cent of the candidates were able to deduce that an increase in the concentration of  $\text{KIO}_3$  caused an increase in the rate of reaction. The majority of candidates did not realize that reciprocal time is directly related to the rate of reaction.

**Common Incorrect Responses**

- The more the concentration the more time was taken
- The rate of reaction increases as the time increases
- An increase in the concentration of  $\text{KIO}_3$  caused a decrease in the rate of reaction

**Expected Responses**

- An increase in  $[\text{KIO}_3]$  causes an increase in the rate
- An increase in  $[\text{KIO}_3]$  causes a decrease in the time for the reaction
- Rate increases linearly with  $[\text{KIO}_3]$

In Part (e), candidates were required to use the reciprocal time calculated in Experiment 6 to determine, from the graph drawn, the unknown concentration of  $\text{KIO}_3$  in this reaction mixture.

**Performance of Candidates**

The majority of candidates was able to do the interpolation and determine the unknown concentration of  $\text{KIO}_3$ .

In Parts (f) (i) and (ii), candidates were required to (i) state the responding variable and (ii) state the controlled variable.

**Performance of Candidates**

Many candidates seemed to be unfamiliar with the terms and so were unable to state the correct variable in either case.

**Common Incorrect Responses**

- Responding variable: reciprocal time
- Controlled variable:  $[\text{KIO}_3]$ , distilled water

**Expected Responses**

- Responding variable: time
- Controlled variable: volume of solution, concentration of  $[\text{NaHSO}_3]$

Question 2

Syllabus Objectives: A 8.1, 8.2, 8.3, 8.5, C 6.3

Candidates were examined on the oxidation-reduction reactions with emphasis on defining the processes in terms of oxidation number/state, distinguishing oxidizing and reducing agents and deducing oxidation number/state. Incorporated within this real-life application question were also questions on the use of bleach, the identification of chlorine gas and the use of alternative detergents.

For Part (a), candidates were required to state one use of bleach in laundering of clothing.

**Performance of Candidates**

Generally this question was well answered. Most candidates were able to give a sound reason for the use of bleach in the laundering of clothing.

**Common Incorrect Responses**

- Bleach is used in the laundering of clothing to wash white clothing
- To clean white clothes

**Expected Responses**

- Removal of stains/whiten and brighten washable fabrics
- Disinfect clothing

In Parts (b) (i) and (ii), candidates were required to (i) define, in terms of oxidation state, the terms *oxidizing agent* and *oxidation*.

**Performance of Candidates**

This question posed a problem for most candidates who were only familiar with the definitions in terms of electrons and not in terms of oxidation state/number.

**Common Incorrect responses**

- Oxidizing agent: 'is which become oxidized', 'an agent used to breakdown a substance, can be reduced'.

- Oxidation: 'process of oxidizing', 'loses electrons', 'when a substance gains oxygen and it loses hydrogen and electrons'.

### Expected Responses

(i) Oxidizing agent causes the oxidation state of another substance to increase.

OR

Oxidizing agent undergoes a decrease in its oxidation state.

(ii) Oxidation is a process in which the oxidation state of an element is increased.

In Part (c), candidates were required to deduce the oxidation number of Cl in NaClO.

### Performance of Candidates

This calculation was a challenge for approximately 50 per cent of the candidates. Candidates did not know the oxidation state of the sodium ion in the oxide and hence had difficulty answering this part of the question correctly.

### Common Incorrect Responses

- $\text{NaClO} = \text{Na} = 2 \quad \text{Cl} = 2 \quad \text{O} = 2$   
 $\text{Cl} = 2+2 = 4$
- The oxidation number of Cl in NaClO is 0
- $\text{NaClO} = +2+x+1 = 0$   
 $x = -1-2, x = -3 \quad \text{Cl} = -3$

### Expected Responses

Oxidation state in:  $\text{NaClO} = (+1) + \text{Cl} + (-2) = 0$   
 $\therefore \text{Cl} = +1$

Part (d) expected candidates to examine the process of chlorine gas  $\text{Cl}_2$  becoming a chloride ion,  $\text{Cl}^-$ . They were required to (i) deduce the change in oxidation number, (ii) determine if the process were an oxidation or reduction, and (iii) describe a simple laboratory test for chlorine gas.

### Performance of Candidates

The three subparts of this question were not well answered by candidates and therefore many did not gain the maximum marks. Candidates still could not deduce the change in oxidation number and at times only put one number rather than the change expected. Deducing the process also proved to be difficult for some candidates. The test for chlorine gas was a challenge as well with many candidates suggesting the use of glowing splints and expecting to hear a popping sound. There needs to be a greater focus on laboratory tests for gases and it must be demonstrated and experienced by candidates.

### Common Incorrect Responses

- The change is -2 or 2
- Oxidation
- A simple laboratory test for chlorine gas is purification, litmus paper.

### Expected Responses

- From 0 to -1
- Reduction
- Moist blue litmus paper (1 mark) turns red then white/ bleached (1 mark) in the presence of the gas.

In Part (e), candidates were given an equation for the conversion of hydrogen peroxide to water and oxygen

$2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$  and were required to examine the changes in oxidation number for the reaction to determine whether it was an oxidation or reduction process.

### Performance of Candidates

Candidates seemed not to know how to ascribe the oxidation numbers to either of the ions in the peroxide or the water molecule. Hence, they performed poorly.

### Common Incorrect Responses

- During the stage the oxygen in the reaction moves from a charge of -2 to -1 and then to 0 therefore both process took place it first reduction then oxidation
- This is an oxidation process because the oxygen is reduced as it goes from  $\text{H}_2\text{O}_2$  to  $\text{H}_2\text{O}$

### Expected responses

Oxidation state:

O in  $\text{H}_2\text{O}_2$  is -1

O in  $\text{H}_2\text{O}$  is -2

Decrease in oxidation state from -1 to -2

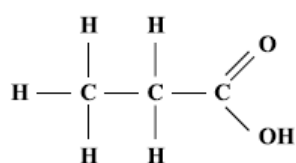
Hence reduction process.

### Question 3

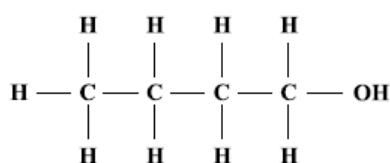
Syllabus Objectives: B: 2.3, 2.4, 3.1, 3.3, 3.4

Candidates were examined on the nomenclature and homologous series for alcohols and carboxylic acids, as well as the chemical reactions and physical properties of alkanes and alkenes.

The following two structures were provided.



Compound D



Compound E

In Part (a) (i), candidates were required to state the name of Compound D.

### **Performance of Candidates**

Many candidates were able to correctly identify Compound D as propanoic acid. However, some candidates wrote the name as 'propanoic' and did not include the word 'acid', which is not acceptable.

### **Common Incorrect Responses**

- Ethanoic acid
- Propanoic
- Propanol

### **Expected Response**

Propanoic acid.

In Part (a) (ii), candidates were required to identify the homologous series to which Compound D belongs.

### **Performance of Candidates**

More than 50 per cent of candidates correctly identified the homologous series.

### **Common Incorrect Responses**

- Organic acids
- Acids
- Alcohols

### **Expected Responses**

- Alkanoic acids
- Carboxylic acids

In Part (a) (iii), candidates were required to state one chemical property of Compound D.

### **Performance of Candidates**

This part of the question proved challenging for candidates and only a few of them could state one chemical property of propanoic acid.

### **Common Incorrect Responses**

- React with water
- Soluble in water
- Has a low pH

**Expected Responses**

Any plausible chemical property, for example:

- Reacts with bases to produce salt and water
- Reacts with alcohols to produce esters
- Reacts with carbonates and bicarbonates to produce carbon dioxide and water

In Part (b) (i), candidates were required to state the name of Compound E.

**Performance of Candidates**

The majority of candidates ignored the position of the OH group when naming Compound E. This is incorrect and candidates *must* take into account the position of any functional group when naming a compound.

**Common Incorrect Responses**

- Butanol
- Butanoic acid
- Ethanol

**Expected Responses**

- Butan-1ol
- 1-Butanol

In Part (b) (ii), candidates were required to identify the homologous series to which Compound E belongs.

**Performance of Candidates**

The majority of candidates was able to correctly identify the homologous series as 'alcohols' or 'alkanols'. Part (b) (iii), required candidates to write the general formula for the homologous series to which Compound E belongs.

**Performance of Candidates**

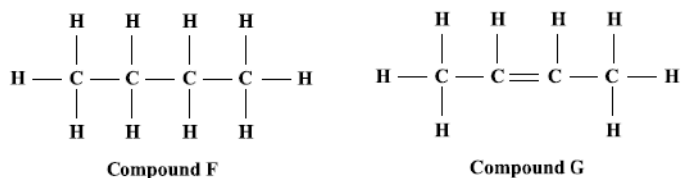
The majority of candidates wrote the correct general formula of the alcohols homologous series as  $C_nH_{2n+1}OH$ .

**Common Incorrect Responses**

Some candidates thought that the general formula is the molecular formula and wrote 'C<sub>4</sub>H<sub>9</sub>OH', which is incorrect.

Part (c), was based on the following two structures:





In Part (c) (i), candidates were required to state one physical property that is common to both Compounds F and G.

#### Performance of Candidates

Less than 50 per cent of candidates were able to state one physical property that is common to butane and 2-butene (but-2-ene).

#### Common Incorrect Responses

- They are both made of hydrogen and carbon.
- They both have four carbon atoms.
- They contain the same number of carbons.
- They are liquids at room temperature.
- 

#### Expected Responses

Any plausible physical property, for example; gaseous, low boiling point, volatile, colourless.

In Part (c) (ii), candidates were required to state which compound, F or G, will react with bromine in the dark.

#### Performance of Candidates

Many candidates correctly stated that Compound G, 2-butene, would react with bromine in the dark.

In Part (c) (iii), candidates were required to draw the fully displayed structure of the product that is formed from the reaction in Part (c) (ii), that is, between bromine and 2-butene.

#### Performance of Candidates

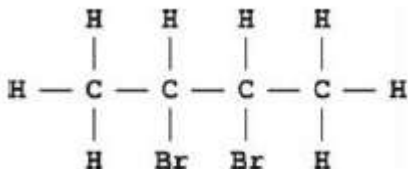
Approximately 50 per cent of candidates wrote the correct structure.

#### Common Incorrect Responses

Some candidates had structures in which the bromine atoms were placed on the same carbon atom, or placed on the two end carbon atoms.

#### Expected Responses

When bromine, Br<sub>2</sub> reacts with an alkene, the two bromine atoms add across the double bond to place the bromine atoms on adjacent carbon atoms. The correct structure of the product for the reaction between 2-butene and bromine in the dark, 2, 3-dibromobutane, is:



For Part (c) (iv), candidates were required to state whether Compound F will burn in air with a clear blue flame.

#### Performance of Candidates

The majority of candidates correctly stated 'Yes'.

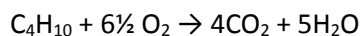
In Part (c) (v), candidates were required to write a balanced chemical equation for the reaction that occurs when Compound F burns in air.

#### Performance of Candidates

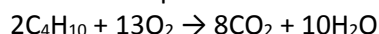
Many candidates were unable to write the required balanced chemical equation.

#### Expected Responses

Burning in air means that the compound reacts with the oxygen that is present in air. Candidates are reminded that all hydrocarbons burn in air to produce carbon dioxide and water as the only products. The correct balanced equation is:



OR if all components are doubled to give,



In Part (c) (vi), candidates were required to state two properties of hydrocarbons that make them good fuels.

#### Performance of Candidates

Some candidates were able to state one property, but very few stated two properties.

#### Common Incorrect Responses

- They burn with a clear blue flame.

#### Expected Responses

Any two plausible properties, for example, combustible, easily transported, generate high energy upon combustion.

#### Question 4

Syllabus Objectives: A 9.5, 9.8, 9.10, 9.11

Candidates were examined on concepts related to electrolysis namely the line drawing of electrolytic cell, ions present in an electrolyte, electrolytic calculations and purification of an impure metal.

In Part (a) (i), candidates were required to define the term *anion*.

### Performance of Candidates

Most candidates were able to give a correct definition and generally this part of the question was well answered.

### Common Incorrect Responses

- An anion is a positive ion in an electrolyte
- A positive charged ion
- An anion is an element with a negative charge

### Expected Response

An anion is a negatively charged ion OR ions that migrate to the anode

In Part (a) (ii), candidates were asked to identify the anions present in a sample of dilute sulfuric acid, the electrolyte in car batteries.

### Performance of Candidates

There were some candidates who struggled with identifying both of the anions and some even included the cations as well showing confusion regarding the concepts. Generally, a large majority of candidates were able to identify the correct anions.

### Common Incorrect Responses

- The anion that would be present is  $\text{SO}_4^{2-}$
- Sulphuric anions
- $\text{OH}^-$

### Expected Response

Anions present in dilute sulfuric acid:  $\text{OH}^-$ ,  $\text{SO}_4^{2-}$

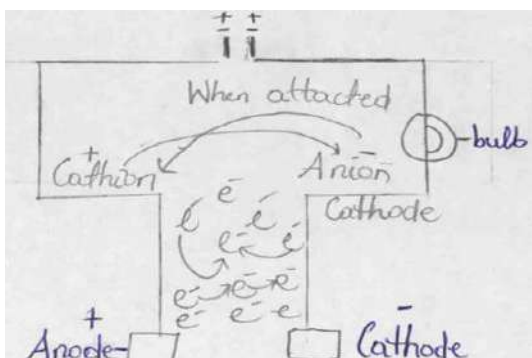
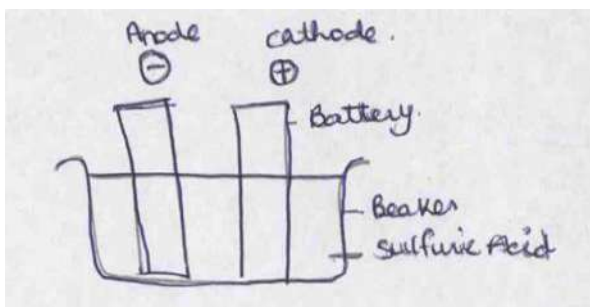
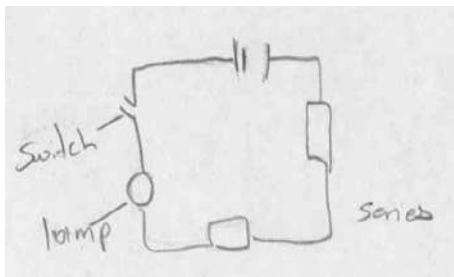
In Part (a) (iii), candidates were required to draw a line diagram to represent an electrolytic cell.

### Performance of Candidates

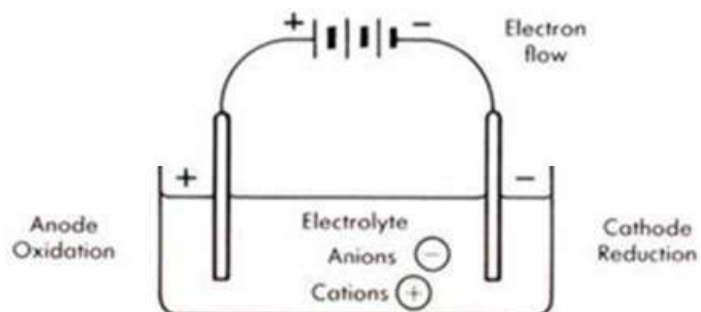
Generally, this question was poorly answered, with many candidates not able to draw a line diagram of the electrolytic cell. Those who attempted the question had difficulty using the conventions of drawing the battery and including the components, especially the correct connections for the anode and cathode to the cell. Candidates were unable to include an electrolyte. As a result, not all candidates were able to obtain high scores on this part of the question.

### Common Incorrect Responses

Some diagrams of candidates' responses are shown below



### Expected Response



In Part (b), candidates were required to calculate the volume of hydrogen gas liberated during the electrolysis of acidified water given the equation for the reaction, the time a certain current is passed through and the conditions at STP.

### Performance of Candidates

This part of the question proved difficult for some candidates. The majority though was unable to obtain the full 5 marks. The conversion of one hour time period to seconds was one of the major errors made as well as the determination of the number of molecules of electrons required to carry the charge. Thus, approximately only 20–25 per cent of candidates obtained full marks on this part of the question.

### Common Incorrect Responses

- $Q = I \times t = 965 \times 60 = 57\,900$

- $F = 9600 \times 22.4$   
 $= 2161600$   
 $\frac{2161600}{965}$   
 $= 2240$

Volume of hydrogen gas = 2240 L

- $Q = I \times t = 965 \text{ A} \times t = 965 \text{ A} \times 60 \text{ t} = 57900$   
 $22.4 \text{ L} / 96500 \text{ mol}^{-1} = 2.32 \text{ mol}$

### Expected Responses

$$Q = I \times t$$

$$= 965 \times 3600\text{s}$$

$$= 3.474 \times 10^6 \text{ C}$$

No. of mols of electrons that carried this charge

$$= \frac{3.474 \times 10^6}{96\,500}$$

$$= 36 \text{ mols}$$

From the equation, 2 molecules of electrons produce 1 mols of H<sub>2</sub>.

36 mols of electrons will produce 18 molecules of H<sub>2</sub>.

At STP, 1 mol of gas occupies 22.4 L

$$\therefore 18 \text{ mols will occupy} = 18 \times 22.4 \text{ L} = 403.2 \text{ L}$$

For Part (c), candidates were asked to suggest how Remi could modify the electrolytic cell drawn in part (a) (iii) in order to purify an impure nickel sample by electrolysis and indicate an observation that would be expected.

### Performance of Candidates

This part of the question was poorly done as candidates were unable to deduce that the electrolysis application was purification. Some candidates thought the application was electroplating and anodizing. Those candidates who did this part were able to indicate that they can modify the electrolytic set up and were able to list one of the observations. Generally, very few candidates gained full marks in this part of the question.

### Common Incorrect Responses

- He could modify the line diagram by placing the substance with dilute hydrochloric acid. One observation is that the impure nickel will purify.
- Remi can simply add nickel to the dilute sulfuric acid at the electrolyte. One observation would be oxygen formed at the anion.
- He could modify the diagram using a spoon placed at the anode and the nickel at the cathode. It can be observed that the nickel will become pure and spoon will become electroplated.

### Expected Responses

The steps that should be taken to purify an impure nickel sample are as follows:

1. Place impure sample at the anode.
2. The electrolyte must be a soluble nickel salt.
3. Place a piece of pure nickel at the cathode.

Observation – any one of the following:

- Cathode gets thicker.
- Anode gets smaller.
- Impurities settle at the bottom.

### Question 5

Syllabus Objectives B: 1.1, 1.2, 1.3, 3.1

This was a free response question which tested knowledge of organic chemistry (Section B). Overall, the question was poorly done with less than 14 per cent of candidates receiving more than 7 out of 15 marks. In fact, no candidate achieved full marks and approximately 60 per cent of candidates received less than 4 out of 15 marks.

In Part (a), candidates were asked to state one natural source of hydrocarbons.

### Performance of Candidates

Most candidates were able to answer this section. However, far too many were not able to give a correct response. In addition, candidates should be reminded to use chemically correct terms rather than colloquial terms such as oil for crude oil.

### Common Incorrect Responses

These included: sugar; starch; petrol; glucose, hydrogen and 'from the earth'.

### Expected Response

The expected responses were petroleum and natural gas. However, crude oil, peat and fossil fuels were also accepted.

In Part (b), candidates were reminded that the naphtha fraction from the fractional distillation of petroleum is used to make plastics. They were asked to list two other fractions, stating one use of each.

### Performance of Candidates

This section was done well by candidates who received more than 7 out of 15 marks.

### Common Incorrect Responses

In some cases, candidates referred to fraction numbers instead of the fraction name, for example, C1-C5. There were also a variety of incorrect responses for fraction names such as rubber, grease and polyester.

### Expected Responses

Fraction	Use
Liquefied petroleum gas LPG (refinery gas)	Cooking gas
Petrol	Fuel for vehicles
Kerosene	Chemical feedstock for making drugs, plastics, other chemicals, jet fuel, cooking
Diesel	Fuel for buses, trucks, taxi
Lubricating oil	Lubricants for engines, machines, waxes and polishes
Fuel oil	Fuel for power stations, factories and ships
Bitumen	Paving roads, making roofing material

In Parts (c) (i) and (ii), candidates were asked to define the term *cracking* as well as explain the difference between thermal and catalytic cracking.

### Performance of Candidates

While many candidates were able to gain marks for this part of the question, far too many were not able to answer the question posed. However, most candidates were able to recognize that thermal cracking required high temperatures and that catalytic cracking required a catalyst. Although not necessary to gain the mark, very few candidates correctly noted the type of catalyst used.

### Common Incorrect Responses

The most common incorrect definition of cracking included ‘the breaking down of carbon’ or just simply cracking means breaking down’.

Many candidates also associated catalytic cracking with the use of enzymes.

### Expected Responses

It was expected that candidates would recognize that cracking is the process by which large molecules from petroleum are broken down into smaller molecules, and that thermal cracking requires heat while catalytic cracking requires a catalyst.

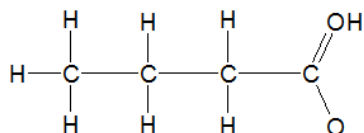
In Part (d), candidates were asked to distinguish between pentane and butanoic acid using sodium hydroxide. In particular they were asked to write equations for reactions showing fully displayed structures of the reactants and the products while naming the products.

### Performance of Candidates

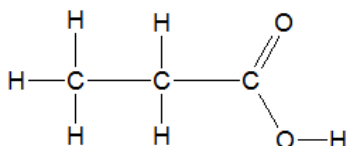
This question was poorly done. Candidates who gained the marks generally did so because they were able to correctly draw the structure for pentane. Unfortunately, many candidates could not accurately draw butanoic acid.

### Common Incorrect Responses

- Incorrect placement of the double bond, for example

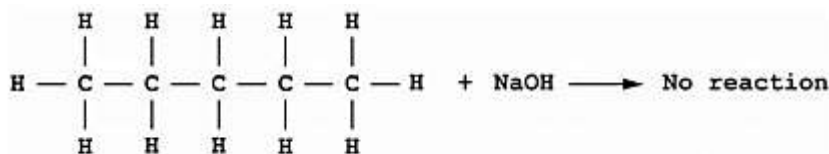


- Incorrect number of carbon atoms, for example



### Expected Responses

(i)



In addition, few candidates recognized that only butanoic acid would react with NaOH.

### Question 6

Syllabus Objectives A: 6.5, 7.4, 7.6; C: 5.2

This free response question was based on the laboratory preparation of ammonia gas. Overall, the question was poorly done, with approximately three per cent of candidates received more than 7 out of 15 marks.

For Part (a), candidates were asked to identify two reagents necessary for the laboratory preparation of ammonia.

### Performance of Candidates

Most candidates were unaware of what is required for the laboratory preparation of ammonia gas.



**Common Incorrect Responses**

The most common incorrect responses were nitrogen and hydrogen. However, most candidates also incorrectly mentioned nitrogen and oxygen as well as calcium oxide and ammonia.

**Expected Responses**

It was expected that candidates would recognize that an ammonium salt along with a strong alkali is needed.

In Part (b), candidates were asked to explain why concentrated  $\text{H}_2\text{SO}_4$  is not a good choice for drying ammonia gas and include a balanced chemical equation in the response.

**Performance of Candidates**

Some candidates were able to give a reasonable response but very few were able to write a representative balanced equation.

**Common Incorrect Responses**

Some incorrect responses included the following:

- The acid is corrosive.
- It would give an impure gas.
- It will absorb the gas.
- It removes water from the solution.
- It is combustible.

**Expected Responses**

It was expected that candidates would recognize that since  $\text{NH}_3$  is basic, it will react with  $\text{H}_2\text{SO}_4$  giving a balanced equation as  $2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$ .

For Parts (c) (i) and (ii), candidates were asked to (i) identify two factors that must be considered when choosing an appropriate method for the collection of the gas in the laboratory and (ii) explain which of the three given methods of gas collection was most appropriate for the collection of ammonia gas while explaining why the other two were inappropriate.

**Performance of Candidates**

A small percentage of the candidates were able to identify two factors that should be considered when choosing an appropriate method to collect gas. The majority of candidates were not awarded any marks. Few candidates were able to answer this question appropriately, although some candidates chose upward delivery and were unable to properly explain why.

**Common Incorrect Responses**

Some incorrect responses for the factors to be considered when choosing an appropriate method to collect gas were temperature, concentration, pH and volume.

### Expected Responses

The two factors to be identified were the density of the gas relative to air and its solubility in water. Additionally, since ammonia is less dense than air, downward delivery could not be utilised. Also, since it is soluble in water, displacement of water could not be utilised. Ammonia was therefore collected via upward delivery.

For Part (d), candidates were asked to draw a labelled diagram of the apparatus which could be used to prepare and collect dry ammonia gas.

It was expected that candidates, as asked, would identify

- where the reagents were placed
- where the ammonia was dried and
- where the ammonia would be collected.

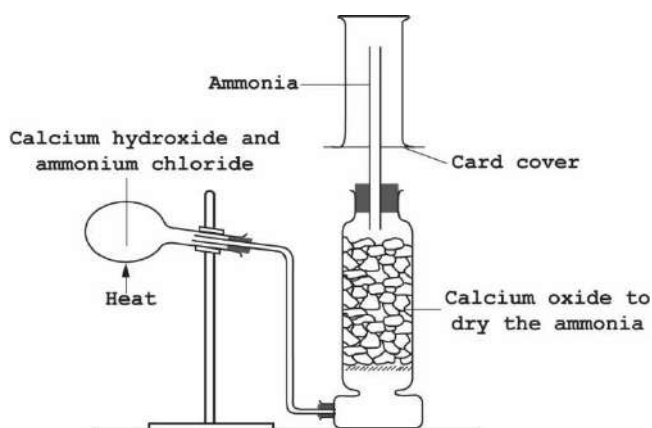
### Performance of Candidates

Very few candidates attempted this part of the question. The one mark candidates who attempted this part were able to achieve was for identifying where the reagents were to be placed.

### Common Incorrect Responses

The most common error in this section was not drawing the apparatus airtight.

### Expected Response



**Paper 032 – Alternative to School Based Assessment****Question 1**

Syllabus Objectives: A: 6.2, 7.4, 11.1, 11.3

Candidates were asked to perform an experiment to determine the heat produced when a strip of magnesium metal reacted with an excess of dilute hydrochloric acid in a Styrofoam cup.

In Parts (a) (i) and (ii), candidates were required to record to the nearest milligram, the mass of the empty Styrofoam cup and the mass of the Styrofoam cup with the magnesium ribbon, and determine the mass and number of moles of the magnesium ribbon.

**Performance of Candidates**

Many candidates were not provided with a milligram balance and so recorded the masses to two decimal places. The majority of candidates demonstrated the required competence in determining the masses. The majority of candidates were also able to determine the number of moles of magnesium present in the ribbon.

**Expected Responses**

The number of moles of magnesium ribbon is equal to the mass of magnesium in grams divided by the RAM of magnesium. An example is shown below:

Mass of magnesium = 0.182 g

No. of moles =  $0.182/24.3 = 0.00749$  mol

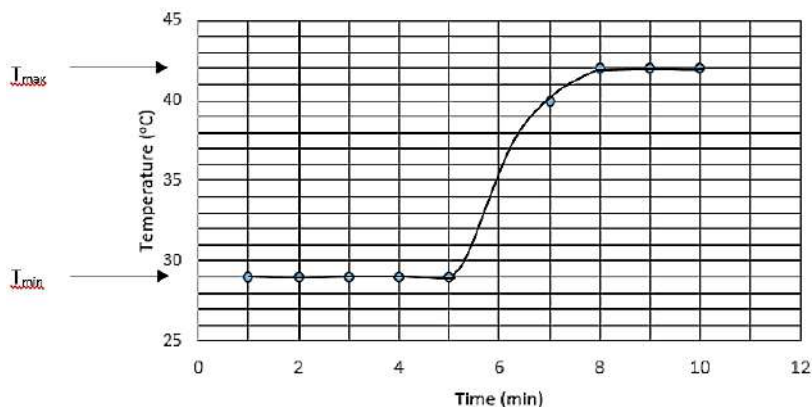
For Parts (b) (i) and (ii), candidates were required to react the strip of magnesium ribbon with the dilute hydrochloric acid, take and record temperature readings of the reaction mixture over a ten-minute period, make a plot of the temperature–time data on the grid provided, and read and record the maximum and minimum temperatures ( $T_{\max}$  and  $T_{\min}$ ) from the plot. A scale was provided for the time axis and candidates were required to choose an appropriate temperature scale.

**Performance of Candidates**

The majority of candidates was able to carry out the experiment as instructed and recorded temperature values which showed that the experiment was successfully completed. However, some candidates' data revealed that they experienced challenges in carrying out the experiment. More than 50 per cent of candidates were able to obtain values of  $T_{\max}$  and  $T_{\min}$ .

### Expected Responses

The temperature–time plot similar to the one shown below was expected:



In Part (c) (i), candidates were required to determine the mass of the solution in the Styrofoam cup, assuming that the solution in the cup has a density of  $1.0 \text{ g cm}^{-3}$ .

### Performance of Candidates

Less than 50 per cent of candidates were able to determine the mass of the solution, and many of them did not use the relationship,  $\text{mass} = \text{density} \times \text{volume}$ .

### Expected Responses

The solution has a volume of  $50 \text{ cm}^3$  and therefore the mass can be calculated as follows:

Density = mass/volume; Mass = volume  $\times$  density

Mass of solution =  $50 \text{ cm}^3 \times 1.0 \text{ g cm}^{-3} = 50 \text{ g}$

For Part (c) (ii), candidates were required to calculate the heat change for the reaction taking place in the Styrofoam cup, making use of the following information.

[ $Q = m \times c \times \Delta T$ ;  $c$ , specific heat capacity of the solution =  $4.00 \text{ J } ^\circ\text{C}^{-1} \text{ g}^{-1}$ ]

### Performance of Candidates

A number of candidates did not attempt this part of the question, but more than 50 per cent of them were able to substitute the required information from Part (c) (i) into the expression.

### Expected Responses

If the temperature change,  $\Delta T = 6 \text{ }^\circ\text{C}$ , then  $Q = m \times c \times \Delta T = 50.0 \text{ g} \times 4.00 \text{ J } ^\circ\text{C}^{-1} \text{ g}^{-1} \times 6 \text{ }^\circ\text{C} = 1200 \text{ J}$

In Part (c) (iii), candidates were required to calculate the heat change that would be expected for ONE mole of magnesium ribbon.

### Performance of Candidates

Many candidates did not attempt this part of the question.

**Expected Responses**

This part required the use of the results from parts (a) (ii) and (c) (ii).

0.00749 mol magnesium generated 1200 J

1 mol magnesium will generate  $(1200/0.00749) = 160\,000$  J

In Part (c) (iv), of the question, candidates were required to state whether the reaction is exothermic or endothermic.

**Performance of Candidates**

The majority of candidates correctly stated that the reaction is exothermic.

In Part (d) (i), candidates were required to write a balanced chemical equation for the reaction between the magnesium ribbon and dilute hydrochloric acid.

**Performance of Candidates**

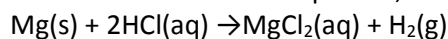
Less than 50 per cent of candidates were able to write the correct equation. Some candidates assumed that the magnesium ion is monovalent.

**Common Incorrect Responses**

- $\text{Mg(s)} + \text{HCl(aq)} \rightarrow \text{MgCl(aq)} + \text{H}_2\text{(g)}$

**Expected Responses**

The balanced chemical equation, including state symbols, is:



In Part (d) (ii), candidates were required to calculate the volume of hydrogen gas (at RTP) that would be produced from the reaction occurring in the Styrofoam cup.

**Performance of Candidates**

The majority of candidates was not able to do this calculation.

**Expected Responses**

From the balanced chemical equation, it can be seen that 1 mole of magnesium produces 1 mole of hydrogen gas.

1 mol Mg produces 1 mol H<sub>2</sub>

1 mol Mg produces 24,000 cm<sup>3</sup> H<sub>2</sub>

0.00749 mol Mg produce  $24,000 \times 0.00749 = 180$  cm<sup>3</sup> H<sub>2</sub>

Question 2

Syllabus Objectives: C: 6.1, 6.2, 6.3

This was a qualitative analysis question. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid. A maximum of ten marks were awarded for this question and it was poorly done. More than 80 per cent of candidates received less than six out of ten for this question. This suggested that candidates had little experience in this area.

Question 3

Syllabus Objectives: B 3.11

Candidates were required to plan and design an experiment to determine whether two liquid laundry detergents, MistiCleen or Freshalwaze, which were manufactured by the same company, have been bottled incorrectly. This was based on the concept of soap and soapless detergents. In fact, the given aim of the experiment was 'To distinguish between soap and soapless detergents using the method of ionic precipitation'.

Candidates were expected to give

- a possible hypothesis for the experiment
- reagents chosen from a list given
- a possible procedure
- apparatus
- variables to be controlled
- data to be collected and
- a probable discussion.

In general, this question was poorly done. Less than 15 per cent of candidates received 6 or more of the 12 marks available.

In Part (a), most candidates were unfamiliar with the concept of hypotheses since very few were able to write one in Part (a). In most cases, candidates either rewrote the aim or just made a connected statement such as "two liquid laundry detergents, manufactured by the same company have been incorrectly bottled".

**Expected Response**

In Part (a) it was expected that candidates would propose hypotheses such as:

- A greater mass of precipitate will be formed from the soap detergent than from the soapless detergent.

OR

- A precipitate will be formed from the soap detergent but not from the soap-less detergent.

In Part (b), most candidates were able to gain the mark awarded for the reagents required. Most candidates however, also included some unnecessary reagents but were not penalized for it.

**Expected Response**

It was expected that candidates would recognize that a soluble magnesium or calcium salt such as magnesium sulfate or calcium chloride along with distilled water was needed.

For Part (c), most candidates were able to acquire at least one of the three marks allotted, usually for adding salt solutions to a detergent. Very few candidates achieved the full three marks and those who did also included unnecessary information included for which they were not penalised.

**Expected Response**

In Part (c), it was expected that candidates would have proposed a procedure which would have allowed for (i) measuring equal volumes of the detergents, (ii) measuring equal volumes (or masses) of salt solutions, (iii) either observing the presence of a precipitate OR filtering, drying and weighing the precipitate.

In Part (d), many of the candidates were able to achieve the marks allotted. This was mainly because the marks awarded for apparatus was based on the procedure proposed by the candidates regardless of the accuracy of their suggested procedure.

In Part (e), it was clear that most candidates had some idea about what needed to be controlled. However, many of them made vague statements such as 'magnesium sulfate' or 'amount of magnesium sulfate' rather than *volume* of salt solution or *mass* of magnesium sulfate and hence were not awarded the marks.

**Expected Response**

In Part (e), when asked about variables to be controlled it was expected that candidates would recognize that these should include the volume of detergents, volume (or mass) of added magnesium sulfate and/or calcium chloride solution or concentration of the salt solution.

For Parts (f) and (g), many candidates were unable to score marks mainly because they were unsure of the procedure. The few candidates who attempted these parts of the question incorrectly itemized as data to be collected 'foam', 'difference in reaction', 'observation of beakers' and 'colour change of solution'.

**Expected Response**

For Part (f), it was expected that candidates would indicate that the presence or mass of precipitate would have been the data to be collected, and, for Part (g), the results were to be discussed as it related to the hypothesis.

**C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE®  
EXAMINATION**

**MAY/JUNE 2016**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

There was a decline in the overall performance of candidates from 2015, with 56 per cent of candidates achieving Grades I–III, compared with 59 per cent in 2015. A slight improvement in candidate performance was evident on Paper 01, the multiple-choice paper, while performance on Paper 02, the structured essay paper and Paper 032, the alternative to the SBA, remained consistent with 2015. There was a slight decline in performance on Paper 030, the SBA, from 2015.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper consisted of 60 compulsory multiple-choice items. The general performance on this paper was satisfactory with approximately 64 per cent of the candidates scoring above the cut score for Grade III. The scores ranged from 0 to 60 with a mean score of 33.8.

Candidates performed well in the areas relating to the following topics:

- The particulate nature of matter
- Definition of atomic mass number
- Distinguishing among solutions, suspensions and colloids
- Trends in Group II
- Giant atomic structures
- Physical and chemical properties of metal
- Arrangement of particles in gases

However, candidates performed poorly in areas relating to the following topics:

- Electronic configuration
- Trends in Period 3
- Reactivity of metals
- Formation of polymers – addition reaction
- Reactions of alkanes and ethanol

### Paper 02 – Structured Essay

This paper consisted of two sections. Section A comprised three questions. Question 1 was mainly a data analysis question and Questions 2 and 3 were structured questions. Section B comprised three essay type questions. The maximum score achieved was 97 out of a total of 100 marks. The mean score for the paper was 37.

## Question 1

### **Syllabus Objectives: A: 1.2, 1.3; C: 6.1, 6.2, 6.3**

This question examined candidates' knowledge of the states of matter (including change of state) and qualitative analysis. Candidates were given a scenario of an experiment which was conducted to determine the melting point of an unknown solid, **A**.

In Part (a), candidates were required to read values of temperature from given scales, plot values of temperature versus time on the axes provided, and determine the melting point from the graph.

Part (a) (i) required candidates to read temperature values from diagrams of thermometer scales. Candidates performed very well on this part with over 90 per cent of them obtaining all the available marks.

For Part (a) (ii) candidates were required to plot a graph of temperature versus time on the provided grid and draw a smooth curve through the points. Plotting the first two temperature points at 73 °C and 68 °C proved challenging for a number of candidates, as they incorrectly divided the temperature scale on the graph. For temperature readings where the points fell on an already marked and labelled scale, for example, 65, 60, 55 and 50 the candidates plotted these well. Too many candidates used a ruler to connect the points and so were not awarded the mark for drawing a smooth curve. Greater effort must be made by teachers to do graphical work to allow candidates sufficient practice in dividing scales correctly, reading scales and drawing best fit curves.

### **Common Incorrect Responses**

- The temperature values of 73 °C and 68 °C were plotted incorrectly at 71.5 °C and 66.5 °C, respectively.
- A ruler was used to connect the points on the graph.

For Part (a) (iii), candidates were required to list the three states of matter. Almost all candidates correctly stated the three states of matter as 'solid, liquid and gas'.

Candidates were required to define the term 'melting point' for Part (a) (iv). Although done satisfactorily, some candidates had difficulty in defining melting point and made no mention of temperature in their definition. Other candidates failed to indicate that a change of state from solid to liquid occurs at the melting point.

### **Common Incorrect Responses**

- The melting point is the point at which a solid changes to a liquid.

### Expected Responses

The melting point is the temperature at which a solid changes state to a liquid.

For Part (a) (v), candidates were required to determine the melting point of the solid from the graph plotted. The majority of candidates were able to identify the melting point. Once the graph was plotted properly, candidates were able to identify the melting point and recognised that the plateau represented a change in state.

Part (a) (vi) required candidates to identify the time range during which there should be a mixture of liquid and solid in the boiling tube. More than 60 per cent of candidates quoted the correct time range. However, many candidates gave time ranges that did not correspond to the plateau on THEIR curve. A few candidates gave temperature ranges, while some gave the melting point (the temperature of the plateau).

### Common Incorrect Responses

- 3 to 6 minutes
- 65 °C

### Expected Responses

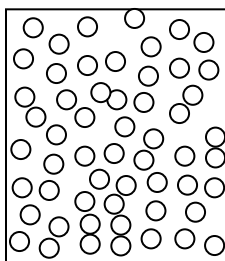
The correct time range is 3.0 to 5.0 minutes (but the accepted range must correspond to the graph).

For Part (a) (vii), candidates were required to state ONE precaution, other than wearing safety apparel, which should be taken during the experiment to avoid injury to the face or hands. This part was satisfactorily done. The two most popular responses were to point the boiling tube away from persons and to use a holding device, for example, a test tube holder.

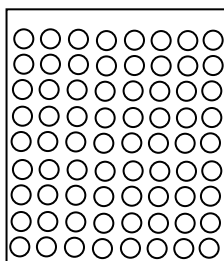
In Part (a) (viii), candidates were required to complete a figure by drawing the arrangement of the particles of **A** at 0 min and at 10 min, using one dot to represent a particle. Candidates showed some carelessness in their approach to this part of the question, and it appeared that they did not read the question properly. More than 70 per cent of candidates failed to recognize that the substance **A** was being transformed from the liquid state to the solid state, and simply assumed that melting was taking place.

### Expected Responses

At zero minutes (in the liquid state), the particles should be randomly placed. At 10 minutes (in the solid form) the particles should be organized more orderly and with less space between them.



At time: t = 0 min



t = 10 min

Part (b) tested candidates' knowledge of qualitative analysis, which was carried out on an unknown sample. The observations were given and candidates were required to fill in the appropriate inferences.

Less than 50 per cent of candidates were able to enter the correct inferences. These are common laboratory tests and it was expected that the performance would have been much better. This probably highlights the candidates' lack of exposure to the qualitative tests as required by the syllabus.

### Expected Responses

	Test	Observation	Inference
(b)(i)	Place a small portion of solid, <b>B</b> , in a test tube and heat strongly using a Bunsen flame.	<ul style="list-style-type: none"> <li>A reddish brown gas evolved</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{NO}_2</math> evolved or nitrates present or <math>\text{Br}_2</math> gas evolved</li> </ul> <p style="text-align: right;"><b>(1 mark)</b></p>
(ii)	Dissolve the remainder of <b>B</b> in about $10 \text{ cm}^3$ of distilled water, stir, then filter. Collect the filtrate and divide it into three equal portions for use in the following tests.		
(iii)	To the first portion of the filtrate from (b)(ii), add $\text{NaOH}$ solution slowly until in excess.	<ul style="list-style-type: none"> <li>White precipitate formed</li> <li>Soluble in excess</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Pb}^{2+}</math>, <math>\text{Zn}^{2+}</math>, <math>\text{Al}^{3+}</math> or <math>\text{Ca}^{2+}</math> present</li> <li><math>\text{Pb}^{2+}</math>, <math>\text{Zn}^{2+}</math> or <math>\text{Al}^{3+}</math> present (or <math>\text{Ca}^{2+}</math> absent)</li> </ul> <p style="text-align: right;"><b>(2 marks)</b></p>
(iv)	To the second portion of the filtrate from (b)(ii), add aqueous $\text{NH}_3$ slowly until in excess.	<ul style="list-style-type: none"> <li>White precipitate formed</li> <li>Insoluble in excess</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Pb}^{2+}</math>, <math>\text{Zn}^{2+}</math> or <math>\text{Al}^{3+}</math> present</li> <li><math>\text{Pb}^{2+}</math> or <math>\text{Al}^{3+}</math> present (or <math>\text{Zn}^{2+}</math> absent)</li> </ul> <p style="text-align: right;"><b>(2 marks)</b></p>
(v)	To the third portion of the filtrate from (b)(ii), add aqueous $\text{KI}$ .	<ul style="list-style-type: none"> <li>Yellow precipitate formed</li> </ul>	<ul style="list-style-type: none"> <li><math>\text{Pb}^{2+}</math> present</li> <li><math>\text{Pb}^{2+} + 2 \text{I}^- \rightarrow \text{PbI}_2(\text{s})</math> (Ionic equation required)</li> </ul> <p style="text-align: right;"><b>(3 marks)</b></p>

## Question 2

### **Syllabus Objectives: A: 6.5, 8.5, 8.6, 9.7**

This question focused on the concepts of redox chemistry as well as the electrochemical series. In Part (a), candidates were asked to distinguish between oxidizing and reducing agents specifically in terms of electron gain or loss, which most candidates were able to complete appropriately.

### **Common Incorrect Responses**

The most common incorrect response was defining the process of oxidation and reduction rather than referring to the agents. For example: *Oxidizing agent is the element that [lost] the electron while the reducing agent is the element that gained the electron.* It was noticed that some candidates also used the concept of 'OIL RIG' without recognising that it referred to oxidation and reduction rather than an oxidizing and reducing agents.

### **Expected Response**

It was expected that candidates would recognise that an oxidizing agent gains electrons/reduces electrons in a species and a reducing agent loses electrons/increases electrons in a species.

For Part (b), candidates were provided with tests and observations and were asked various questions with regard to the information that was provided. The four tests included reactions of an unknown solution with acidified  $\text{KMnO}_4$  and  $\text{KI}$  as well as the effect of dipping silver and iron strips in a solution of copper(II) sulfate.

In Parts (b) (i) to (iii), besides being asked to give the name of another oxidizing agent, candidates were asked to identify whether the solution was acting as an oxidizing or reducing agent as well as to give an explanation for their choice.

Far too many candidates were unable to correctly name an alternative oxidizing agent. However, most candidates were able to identify whether the unknown solution was acting as an oxidizing or reducing agent in Tests 1 and 2. When asked to explain how they arrived at their answer, the majority of candidates were only able to gain 2 of the 4 marks allotted to that question.

### **Common Incorrect Responses**

In terms of the alternative oxidizing agent, the most common incorrect answers were common acids and bases, for example,  $\text{NaOH}$  and  $\text{HCl}$  or  $\text{H}_2\text{SO}_4$ . When asked to explain the observations in terms of changes in oxidation state, many candidates recognised, for example, that when  $\text{KMnO}_4$  was reduced it changed from purple to pale pink but few connected the colour change to a reduction in oxidation state.

### Expected response

In terms of an alternative oxidizing agent, it was expected that the most common answer would have been potassium dichromate. However, any suitable oxidizing agent was accepted including O<sub>2</sub> and hydrogen peroxide. HNO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> were only accepted if it was noted that they were concentrated. When asked to explain the observations, it was expected that candidates would link the change in oxidation state to the change in colour. A response which garnered full marks would have been:

For Test 1 – *‘The decrease in the oxidation state of the potassium manganate(VII) results in the colour change from purple to pale pink, which shows that solution C is acting as a reducing agent’.*  
 For Test 2 – *‘The increase in the oxidation state of potassium iodide results in the solution changing from colourless to brown. This shows that Solution C is acting as an oxidizing agent’.*

In Parts (b) (iv) and (v), candidates were asked to write an ionic equation for the reaction that occurred when a strip of iron was placed in copper(II) sulfate, having observed that the blue solution faded and the brown deposits settled. In addition, they were asked explain the observation made when iron and silver strips were placed in the copper(II) sulfate solution with reference to the electrochemical series. These two parts of the question proved more difficult for the candidates than the other parts. Far too many candidates are still having problems writing ionic equations.

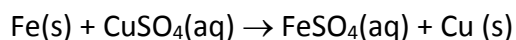
### Common Incorrect Responses

In Part (b) (iv) many candidates wrote full molecular equations and a few presented word equations. In addition, candidates also need to pay attention to the chemical symbols being used. For example, many candidates wrote FeSO<sub>4</sub> rather than FeSO<sub>4</sub>.

For Part (b) (v), candidates spoke to the reactivity of iron and silver without reference to the electrochemical series. For example, iron is very reactive, silver is not very reactive.

### Expected Response

For Part (b) (iv), the ionic equation expected was:



For Part (b) (v), a response that garnered full marks was:

*‘In Test 3, iron displaces the position that copper was in because it is higher up in the electrochemical series. In Test 4, silver does not displace the copper because it is lower down in the electrochemical series than copper.’*

### Question 3

#### **Syllabus Objectives: B: 2.1, 2.5, 2.6, 2.7, 2.8**

Candidates were tested on their knowledge of structural isomerism, nomenclature, physical and chemical properties of alkanes and alkenes, and the dehydration of ethanol.

Candidates were required to define the term 'structural isomerism' in Part (a). More than 75 per cent of the candidates were able to give a correct definition.

#### **Expected Responses**

Structural isomerism is displayed by molecules that have the same molecular formula but different structural formulae (i.e. their atoms are arranged differently).

Part (b) of the question was based on the hydrocarbon Compound P,  $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_2\text{CH}_3$ . Candidates were required to state the name of Compound P on Part (b) (i). The majority of candidates did not write a name that indicated that the double bond is on the first carbon atom.

#### **Common Incorrect Responses**

- Pentene
- Penthene
- Alkene

#### **Expected Responses**

- pent-1-ene
- 1-pentene

Candidates are encouraged to follow the correct procedure when naming organic compounds.

Part (b) (ii) required to state one physical property of Compound P. About 50 per cent of candidates gave a correct physical property. A number of candidates listed a chemical property and thus were not awarded the mark.

#### **Common Incorrect Responses**

- Gas
- It is unsaturated.
- It contains a double bond.

### Expected Responses

Any plausible physical property was accepted, for example, low boiling point, low melting point, liquid at room temperature, volatile, low density, colourless and immiscible with water.

In Part (b) (iii), candidates were required to state one chemical property of Compound P. About 50 per cent of candidates gave a correct chemical property. Again, some candidates incorrectly gave a physical property.

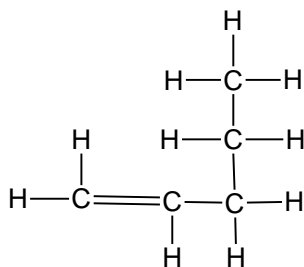
### Expected Responses

Any acceptable chemical property, for example, burns in air, burns to produce  $\text{CO}_2$ , burns with sooty flame, undergoes addition reactions, reacts with  $\text{Br}_2$ , reacts with  $\text{H}_2$ , reacts with oxidizing agents such as  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$ , reacts with water/steam to produce the corresponding alcohol and undergoes addition polymerization.

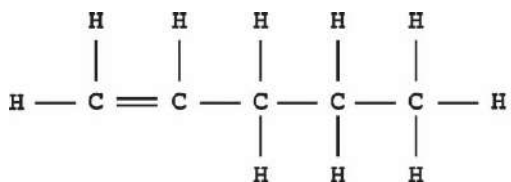
Candidates were required to draw the FULLY DISPLAYED structural formulae of Compound P and one of its isomers on Part (b) (iv). More than 60 per cent of candidates gave the correct structure of Compound P (pent-1-ene). However, many candidates found it challenging to draw an isomer of Compound P.

### Common Incorrect Responses

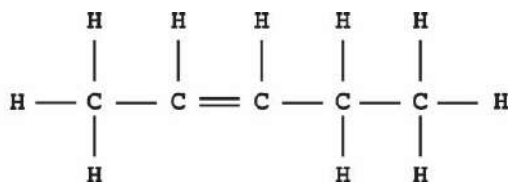
A number of candidates drew structures in which carbon atoms INCORRECTLY had five bonds. Other incorrect structures had bends in the backbone, or had the double bond at the other end of the molecule.





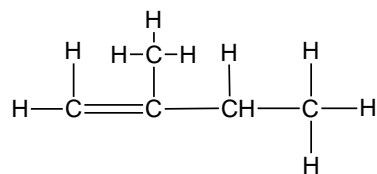
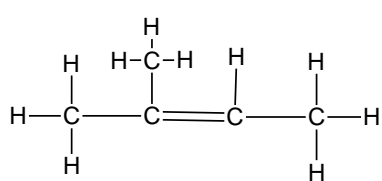
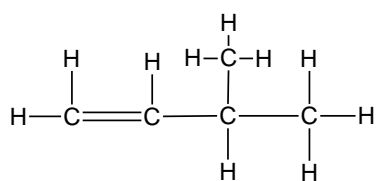
**Expected Responses**

Compound P



Isomer of Compound P

Other correct structural isomers are:



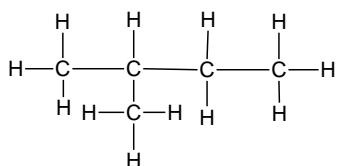
Candidates were required to draw the FULLY DISPLAYED structure of one branched isomer of Compound Q, which is formed from the reaction of Compound P with hydrogen gas in the presence of a catalyst on Part (c) (i). Less than 50 per cent of candidates gave the correct response.

**Common Incorrect Responses**

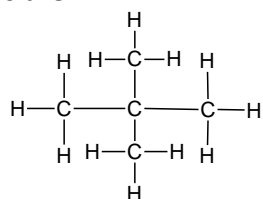
Incorrect structures included the unbranched pentane, or structures in which hydrogen atoms were omitted.

**Expected Responses**

The correct structures of the branched isomers are:



2-methylbutane



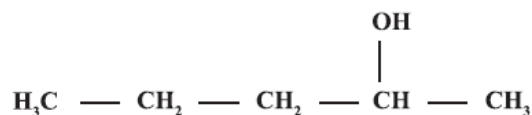
2,2-dimethylpropane

For Part (c) (ii), candidates were required to state one physical property of Compound Q. The performance on this part was very similar to that on Part (b) (ii).

### Expected Responses

Any plausible physical property was accepted, for example, low boiling point, low melting point, liquid at room temperature, volatile, low density, colourless and immiscible with water.

For Part (d), candidates were required to give the name of Compound R.



Compound R

Many candidates gave names which did not reflect the position of the OH group on the carbon chain.

### Common Incorrect Responses

- Pentanol
- Pent-2-anol
- Pent-2-ol

### Expected Responses

- 2-pentanol
- Pentan-2-ol

Part (e) required candidates to state the conditions for the dehydration of ethanol.

### Candidates' Performance

Less than 50 per cent of candidates gave the correct conditions necessary for the dehydration of ethanol.

### Expected Responses

The dehydration of ethanol (and other primary alcohols) requires (i) a temperature of 170 °C with either concentrated sulfuric acid or concentrated phosphoric acid as catalyst, or (ii) activated alumina (Al<sub>2</sub>O<sub>3</sub>) and 450 °C.

#### Question 4

#### **Syllabus Objectives: A: 5.4, 5.5, 5.6, 5.7, 5.8**

This essay question tested candidates' knowledge of allotropy, solid state structures and bonding.

Part (a) required candidates to define the term, 'allotropy' and illustrate their answer by drawing lattice structures for diamond and graphite. Few candidates knew the definition for allotropes. In fact, many did not even attempt to write a definition and it was clear that they were unable even to draw partial structures for diamond and graphite.

#### **Common Incorrect Responses**

The definitions given by the candidates were varied. Some candidates made reference to the same chemical structure but different physical properties. The majority of candidates related allotropy to be a distinct property of carbon only. For example, one response received was that *'allotropes are structural lattice formed from carbon'*.

In terms of the diagrams, most of the candidates who attempted the question were able to draw carbon in a hexagonal arrangement for graphite but were unable to show how the hexagons were arranged in the layer and neglected to indicate by their drawing that the structure consists of layers. For the structure of diamond, whilst attempts to draw the structure as seen in text books were evident, very few candidates recognised that each carbon was bonded to four bonds instead of three.

#### **Expected Responses**

In terms of the definition of allotropy, any of or different forms of the following definitions were accepted and awarded the full marks:

- different crystalline or molecular forms of same element
- more than one form of same element
- different forms of the element in the same physical state

For the diagram for diamond, it was expected that candidates would have shown the carbon atom bonded in a tetrahedral arrangement with some evidence of expansion moving towards a 3D structure.

For the diagram of graphite, it was expected that candidates would have shown the hexagonal arrangement of the carbon atoms within the layers with at least two layers showing the weak bond between them.

In Parts (b) (i) and (ii), candidates were told that, like metals, graphite can conduct electricity but diamond cannot. They were then asked to describe the bonding in metals as well as to explain in terms of bonding why graphite conducts electricity, but diamond cannot. Far too many candidates could not describe the bonding in metals and many were unable to account for the ability of graphite to conduct electricity.

### **Common Incorrect Responses**

When asked to describe the bonding in metals, many candidates simply stated metallic bonding without making an attempt to describe it. The most common incorrect response, however, was ionic bonding or descriptions of ionic bonding. For those candidates who attempted to describe the metallic bonding, many were able to say that there was a sea of electrons or delocalised electrons were present but did not refer to the arrangement of positive ions.

In accounting for the ability of graphite to conduct electricity, many candidates attributed this to the fact that graphite existed as layers or the weak intermolecular forces between the layers.

### **Expected Responses**

It was expected that the candidates would describe metallic bonding as an orderly arrangement of positive ions with a sea of mobile electrons.

In terms of explaining why graphite can conduct electricity but diamond cannot, it was expected that candidates simply recognised that graphite has mobile electrons and hence conducts electricity while the electrons of diamond are all involved in bonding or are not free to move.

In Part (c), candidates told that although CaO and NaCl have similar giant ionic structures with high melting points the melting point of CaO is higher than that of NaCl. They were then asked to sketch the lattice structure for NaCl and suggest why its melting point is lower than that of CaO.

This part of the question was poorly done. It was clear that not many of the candidates were familiar with sketching the NaCl structure. In terms of explaining why NaCl had a lower melting point, very few candidates made the connection between the charge on the ion and the strength of the ionic bond.

### **Common Incorrect Responses**

In terms of the sketch, most of the candidates who attempted the question drew cubes but the arrangement of ions (if any were present) was incorrect. Other common incorrect responses included attempts to draw spheres showing a closed packed arrangement of ions and dot-cross diagrams. In relation to the explanation, some candidates erroneously attributed the difference in melting points to the fact that NaCl is not as closely packed as CaO or that NaCl has weaker intermolecular forces.

### Expected Responses

For the lattice structure of NaCl, the following were expected and awarded marks:

- Cubic arrangement
- Cl<sup>-</sup> ions at each corner and centre of each face
- Na<sup>+</sup> ions at centre of each edge

For the explanation, it was expected that candidates would have recognised that either the charges in CaO are larger than those in NaCl or that the ions in NaCl are smaller than those in CaO and hence the ionic bonding in CaO is stronger than in NaCl.

### Question 5

**Syllabus Objectives: A: 5.1, 5.2; B: 2.5, 3.1, 3.3, 3.9**

This essay question tested candidates' knowledge of the bonding in methane and its reaction with chlorine, identification of compounds from molecular formulae and chemical (qualitative) tests used to distinguish between pairs of compounds.

Candidates were required in Part (a) to identify the bonding present in methane and give an explanation for their answer. The majority of candidates correctly identified the bonding as covalent. However, many did not give a correct reason.

### Expected Responses

There is covalent bonding in CH<sub>4</sub>. Carbon is a non-metal, hydrogen is also a non-metal and two non-metals form covalent bonds.

The following information was provided in Part (b): 'Methane, like other alkanes, is generally unreactive. However, under certain conditions, it can undergo reactions with chlorine, Cl<sub>2</sub>, forming carbon tetrachloride, CCl<sub>4</sub>.'

In Part (b) (i), candidates were required to write a balanced equation for this reaction. A number of candidates were unaware that hydrogen chloride, HCl, is a product of the reaction and so were not able to write the correct equation.

### Common Incorrect Responses

- $\text{CH}_4 + 2\text{Cl}_2 \rightarrow \text{CCl}_4 + 2\text{H}_2$

### Expected Responses

- $\text{CH}_4 + 4\text{Cl}_2 \rightarrow \text{CCl}_4 + 4\text{HCl}$

For Part (b) (ii), candidates were required to state the type of reaction taking place and identify the reaction conditions. Less than 50 per cent of candidates knew that the reaction was a substitution reaction. Many candidates knew that light was a requirement but were not specific in stating UV light.

### Common Incorrect Responses

- Displacement reaction
- Addition reaction

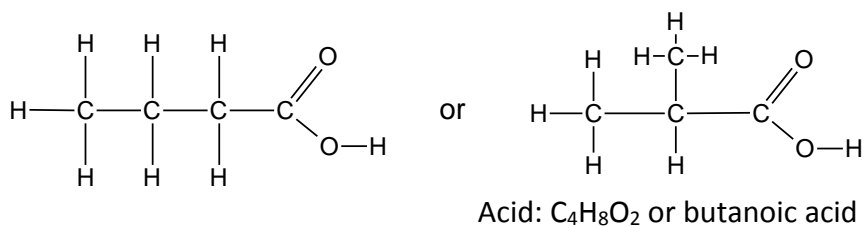
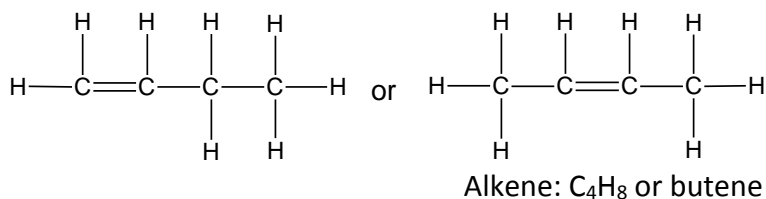
### Expected Responses

The reaction is a substitution reaction and proceeds in the presence of ultraviolet radiation (UV light).

In Part (c), candidates were required to identify and draw the structural formulae of the alkene and the carboxylic acid from the following molecular formulae:  $C_4H_8$ ,  $C_4H_{10}$ ,  $C_4H_8O_2$ ,  $C_4H_{10}O$ . Many candidates found this part of the question to be very challenging and had difficulty in drawing the correct structures even when they had the correct names or molecular formulae.

### Expected Responses

The correct structures, names and formulae for the alkene and carboxylic acid are shown:



Candidates need more practice in drawing fully displayed structures and in deducing names from structures and deducing structures from names and formulae.

Two pairs of compounds were provided in Part (d). For each pair, candidates were required to identify a test (including the expected observations) that can be used to distinguish between them.

This part of the question was very poorly done. Many candidates proposed chemical reactions, but did not recognize the importance of the observations and so, did not describe the observations, or in some cases gave reactions in which there would be NO distinguishing observation.

In Part (d) (i), candidates were required to identify a test that is able to distinguish between an alkane and an alkene.

#### **Common Incorrect Responses**

- Damp litmus paper
- Polymerization

#### **Expected Responses**

React the alkene with solutions of  $\text{Br}_2$  or  $\text{KMnO}_4$  or  $\text{K}_2\text{Cr}_2\text{O}_7$ . The alkene will decolourise solutions of  $\text{Br}_2$  and  $\text{KMnO}_4$ , solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  changes from orange to green; the alkane will not react and so will not give a colour change.

In Part (d) (ii), candidates were required to identify a test that is able to distinguish between an alkane and a carboxylic acid.

#### **Common Incorrect Responses**

- React with a base

#### **Expected Responses**

React with  $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$  or metal or blue litmus paper or perform a solubility test. The carboxylic acid should react with  $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$  with effervescence (or gas evolved which turns lime water milky), the alkane will not react. The carboxylic acid will change damp blue litmus to red, the alkane will not. The carboxylic acid will react with a metal to produce a gas (hydrogen) that pops with a burning splint, the alkane will not. The carboxylic acid will dissolve in water, the alkane will not.

### Question 6

#### **Syllabus Objectives C: 2.3, 3.1, 3.2, 4.3**

This essay question was based on the extraction of aluminium metal from its ore, the alloy of aluminium and the useful and harmful effects of mercury to living systems and the environment. Overall the performance in the question was fairly poor, with approximately 74 per cent of the candidates receiving fewer than 6 of the 15 marks allotted for the question.

For Part (a) (i), candidates were asked to describe the process of extraction of aluminium from its ore, including an ionic equation. They were then asked to suggest one reason why it may be difficult to extract aluminium in the Caribbean.

Many candidates were able to identify bauxite as the ore of aluminium and that electrolysis was necessary for its extraction. Although it was not necessary for the question, it was clear that those candidates, who noted that cryolite was necessary, did not quite understand its role in the process. Not many of the candidates were able to achieve full marks on the ionic equation required.

### Common Incorrect Responses

In terms of the ore, the most common incorrect responses were alumina and cryolite and for the extraction process some mentioned the use of the blast furnace or fractional distillation.

In terms of the ionic equations, some common mistakes were confusing molecular formulae with ionic formulae and writing unbalanced equations. For example:

- $2\text{Al}_2\text{O}_3 (\text{s}) \rightarrow 4\text{Al}^{3+} (\text{s}) + 3\text{O}_2 (\text{g})$
- $2\text{Al}^{3+} + 6\text{e}^- \rightarrow \text{Al}$
- $\text{Al}^{3+} + 3\text{e}^- \rightarrow 3\text{Al}$
- $\text{Al}^{3+} (\text{aq}) + 3\text{e}^- \rightarrow \text{Al}_3 (\text{s})$

### Expected Response

It was expected that candidates would recognise bauxite, the ore of aluminium, is dissolved in cryolite and then electrolysed. An ionic equation for the reaction at either the anode or cathode was acceptable such as **either**  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$  **or**  $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$ . Candidates were not penalised for missing state symbols in the equation for this question.

For Part (a) (ii), candidates were asked to explain why it is difficult to extract aluminium in the Caribbean.

Most candidates were able to get at least one of the two marks for this section. Usually this mark was awarded for stating that the process was too expensive. What most candidates neglected to recognise was that the expense was mainly due to the fact that it required lots of electricity or energy for the process.

### Common Incorrect Responses

Some incorrect responses included the following:

- Too much expensive machinery is needed.



- The climate is too hot.
- Too much labour is required.
- Mountainous region to climb.
- Too much heat is needed.
- Too close to water.
- It causes pollution.

### **Expected response**

It was expected that candidates would recognise that the process was too expensive mainly because too much electricity or energy is needed.

Candidates were asked to identify in Part (b) the alloy of aluminium and magnesium which is used to make aircraft, explaining why it was better to use for that purpose than the pure metals. Many candidates had problems identifying the alloy with aluminium and magnesium and of those who did, most were unable to spell the names correctly. Some candidates were able to correctly suggest why the alloy would be better to use than the pure metals, but had great difficulty relating the property of the alloy to its use in the manufacture of aircraft.

### **Common Incorrect Responses**

Common incorrect alloys cited were steel, magnesium steel and plutonium with steel being the most used. Chemical formulae, for example,  $Al_2Mg_3$  were also given for the name of the alloy. Some incorrect spellings presented were 'magalumin', 'magluminium' and 'duralium'.

Some candidates outlined the benefits to the aircraft without noting the actual property of the alloy that was responsible for that benefit. For example, some candidates noted that using the alloy made the aircraft lighter without noting that the alloy is less dense than the pure metals. Some candidates incorrectly noted that the alloy was more malleable and hence allowed the aircraft to be made into different shapes and sizes.

### **Expected Response**

An example of a good response to this question would have been:

*The alloy of Al and Mg is magnalium (duralumin was also accepted). It is less dense than the pure metals and hence allow aircraft to be lighter. It is also stronger than the pure metals and hence allows aircraft to last longer since it is not easily destroyed.*

In Part (c), candidates were asked explain how mercury could be useful to man yet harmful to the environment. This part was fairly well done by the candidates with the majority of them receiving at least 2 of the 3 marks available. Most candidates identified that mercury was used

in thermometers but can also poison streams, fish and ultimately humans but few highlighted how the mercury was possibly released in the environment.

### **Expected Responses**

It was expected that the ideal response would cater to the following aspects:

1. Benefits of mercury to humans, for example, in thermometers, barometers, in dentistry and gold mining.
2. Entry of mercury to the environment. For example, this could have been through broken thermometers, barometers, or lightbulbs or improper disposal of them or batteries and indiscriminate use in gold mining in Guyana.
3. The identification of a negative impact on the environment such as poisoned fish and the persons who eat the fish, death, mood swings and psychosis.

## **Paper 032 – Alternative to the School-Based Assessment (SBA)**

### Question 1

#### **Syllabus Objectives: A: 6.2, 7.10; C: 6.1, 6.2**

This question was the practical aspect of the examination. It was divided into two parts. Part A required candidates to determine the mass of hydrated sodium carbonate present in a water softener utilizing the experimental technique of titration. Part B was based on qualitative analysis.

In Part a (i), candidates were expected to complete Table 1 by filling in the burette readings for the initial volumes, final volumes as well as volumes used in the titration to 2 decimal places.

In Parts (ii) and (iii), candidates were asked to indicate the titration volumes they would use to calculate the average volume used and hence calculate it. Parts (iv) to (vii) took the candidates through step-by-step calculations necessary to determine the mass of hydrated sodium carbonate in the water softener.

For Parts (b) (i) to (v): The candidates were provided with a solid sample labelled C and asked to dissolve it in water. The resulting solution was filtered if necessary and should have been divided into three equal portions in order to carry out the following tests:

- Add aqueous NaOH dropwise until in excess.
- Add aqueous NH<sub>3</sub> dropwise until in excess.
- Add three drops of an aqueous solution of Ba(NO<sub>3</sub>)<sub>2</sub> followed by dilute HNO<sub>3</sub>.

They were then asked to record the observations and inferences from each test performed.

This question was poorly done, with approximately 77 per cent of the candidates earning fewer than 13 out of the total of 27 marks. This suggests that candidates did not have the requisite laboratory experience.

### Common Incorrect Responses

Candidates continue to experience problems reading the burette to 2 decimal places as well as mole calculations which are fundamental to Chemistry.

For the qualitative analysis, most candidates who attempted the question were able to make the correct observations. However, making the correct inferences proved difficult for most candidates.

### Expected Response

When sample C was dissolved in distilled water, it was expected that candidates would see a pale green solution being formed, which indicated the presence of  $\text{Fe}^{2+}$  ions. When aqueous NaOH was added to the first portion of the solution, it was expected that a dirty green precipitate would be formed that was insoluble in excess, confirming the presence of  $\text{Fe}^{2+}$  ions. When aqueous  $\text{NH}_3$  was added to the second portion, it was expected that a dirty green precipitate would be formed that was insoluble in excess, again confirming the presence of  $\text{Fe}^{2+}$  ions. When an aqueous solution of  $\text{Ba}(\text{NO}_3)_2$  followed by dilute  $\text{HNO}_3$  was added, it was expected that a white precipitate would be formed, insoluble in dilute  $\text{HNO}_3$ , thus indicating the presence of  $\text{SO}_4^{2-}$  ions.

### Question 2

#### Syllabus Objective: A: 2.4

For Parts (a) (i) to (iii), candidates were given the results of an experiment which investigated the solubility of a solid, D, in water at various temperatures. They were required to calculate the missing solubility values of D in the Table, plot a graph, draw a smooth curve and make a deduction regarding the solubility of D from the curve.

Part (b) required candidates to suggest the best method for safely heating the solution of D during the experiment.

The total number of marks available for this question was 9 and more than 55 per cent of candidates obtained between 6 and 8 out of 9.

The majority of candidates were able to plot the graph correctly and draw a smooth curve. However, there were still too many candidates who could not correctly follow the scale that was given. This suggests that candidates still lack practice with graphs in the classroom environment. Many candidates had problems making reasonable deductions from the curve. Very few candidates were able to suggest a safe way to heat solution D during the experiment.

### Common Incorrect Responses

The most common incorrect responses regarding the deduction from the curve were that solubility decreases with temperature and that as temperature decreases, solubility increases.

The most common incorrect response regarding a safe way to heat the solution was to use a Bunsen burner. Some candidates suggested heating in a fume hood.

### Expected Response

It was expected that candidates would recognise from the curve that an increase in temperature causes an increase in the solubility of D. It was also expected that candidates would suggest the use of a water bath or hotplate to safely heat solution D.

### Question 3

#### Syllabus Objective: C: 2.2

This question tested candidates' planning and design skills. They were asked to plan and design an experiment to identify metals X, Y and Z given three reagents, namely  $\text{MgSO}_4$ ,  $\text{CuSO}_4$  and  $\text{FeSO}_4$  solutions. They were told that the metals were believed to be magnesium, iron and copper.

The given aim was "to identify metals X, Y and Z based on their displacement reactions" and the given hypothesis was: "A metal higher in the reactivity series will displace a metal lower than itself in the reactivity series from a solution of its salt."

Candidates were asked to provide a procedure, apparatus/materials required, three controlled variables, a format for table of results and a discussion of results in relation to the aim and hypothesis.

This question was poorly done. Approximately 67 per cent of the candidates got fewer than 6 of the 12 marks awarded for the question. It appeared that very few candidates were aware of the reactivity series and the ability of one metal to displace another metal lower than it in the reactivity series.

### Common Incorrect Responses

There were a few candidates that mixed the various solutions together expecting a result. Most candidates were able to recognise that the metals were supposed to be placed in the solution but many did not recognise that each metal should have been placed in more than one solution.

An incorrect alternatively proposed method was chromatography. Many candidates were able to produce at least two of the three expected controlled variables. The most common mistake was using the word “amount” instead of definite measurements such as “volume” or “mass”.

Most candidates were able to draw a table to display the results they were expecting. However, they were a few candidates who merely drew lines without indicating what information would be placed in each column or row. No marks were awarded in such cases. The discussion section presented the most difficulty to the candidates. Many candidates did not attempt to do this part and the most common incorrect answer posed was just a repetition of the hypothesis.

### Expected Response

For the procedure it was expected that candidates would recognise that they would be required to place a piece of metal strip into a volume of salt solution and repeat the process for the other two metal strips as well as the other two salt solutions. The apparatus marks were awarded based on the procedure given. In terms of the variables to be controlled, the expected answers included the volume of solution, the length of the metal strip, and the time for the reaction to take place or the polar concentration of the solutions. It was expected that the table for results would resemble the following:

<b>Solution</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
Magnesium sulfate			
Copper(II) sulfate			
Iron(II) sulfate			

Likewise, it was expected that the following information could have been included in the discussion:

<b>Solution</b>	<b>Magnesium</b>	<b>Copper</b>	<b>Iron</b>
Magnesium sulfate	No reaction	No reaction	No reaction
Copper(II) sulfate	Copper displaced	No reaction	Copper displaced
Iron(II) sulfate	Iron displaced	No reaction	No reaction

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2017**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The overall performance of candidates was slightly better than 2016. Thirty-nine per cent of the candidate population achieved Grades I-III on the examination. The best performance was on Paper 032 which showed a mean score of 50.2 per cent while Papers 01 and 02 showed mean scores of 48.7 per cent and 29.6 per cent respectively.

## DETAILED COMMENTS

### Paper 01 - Multiple Choice

This paper consisted of 60 compulsory multiple choice items. The general performance on this paper was satisfactory with approximately 49 per cent of the candidates achieving acceptable grades, Grades I-III. The maximum score obtained was 60 marks and the mean score was 29 marks.

Candidates recorded excellent performance in the areas relating to the following topics:

- Particulate nature of matter
- Techniques to demonstrate endothermic changes
- Arrangement of atoms in graphite
- Extraction of iron

However, candidates performed poorly in the following areas:

- Fermentation
- Identification of gases
- Trends in the periodic table
- Salt preparation
- Acid/base nature of oxides

### Paper 02 – Structured/Extended Essay

#### Question 1

Syllabus References: A: 6.2, 6.5, 6.6, 6.7, 7.2, 7.11

This question required candidates to perform calculations based on the mole concept, using volumetric analysis data, and to give observations for qualitative analysis data for iron(II) and sulfate ions.

In Part (a), candidates were required to define the term 'standard solution'. The majority of candidates were not able to give the correct definition for a standard solution.

#### **Common Incorrect Responses**

- When a solute completely dissolves in a solvent.
- It is a solution that is homogeneous.
- A standard solution is a pure substance.

### Expected Response

A standard solution is a solution of accurately known concentration.

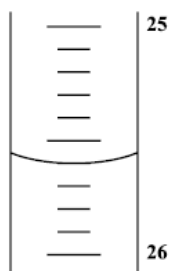
For Part (b), candidates were required to calculate the mass of iron(II) sulfate used in the experiment by subtracting two values in a table. The majority of candidates calculated the mass correctly.

### Expected Response

$$17.11 \text{ g} - 13.95 \text{ g} = 3.16 \text{ g}$$

In Part (c) (i), candidates were required to read and record the final burette volumes from the diagrams in Figure 1.

The diagram of the burette in **Titration 1** is shown below.



**Titration 1**

While the majority of candidates made correct recordings of the final volume of the burette, some candidates read the burette incorrectly.

### Common Incorrect Response

The common incorrect response for Titration 1 was 26.40 cm<sup>3</sup>.

### Expected Response

The correct reading for **Titration 1** is 25.60 cm<sup>3</sup>. It seems that some candidates were unfamiliar with the use of a burette, and so did the readings from bottom up, instead of from top down.

For Part (c) (ii), candidates were required to calculate the volume of solution used in each titration and enter them in the table provided. While the majority of candidates performed the correct calculation by subtracting the initial volumes from the final volumes, some candidates seemed unfamiliar with the process. In many of the incorrect responses, candidates added the initial volume to the final volume.

### Expected Response

An example of the correct way to determine the volume of solution used from the burette is shown below.



Final burette volume = 25.60 cm<sup>3</sup>  
Initial volume = 1.00 cm<sup>3</sup>  
Volume used = 25.60 – 1.00 = 24.60 cm<sup>3</sup>

In Part (c) (iii), candidates were required to determine the average volume of solution used in the titration.

The majority of candidates took an average of all three volumes used, irrespective of whether the values were concordant (agreed to within 0.10 cm<sup>3</sup>).

### Expected Responses

In this case, the three values for volume used for Titrations 1, 2 and 3 are 24.60, 24.25 and 24.35 cm<sup>3</sup>, respectively. The two best (closest) values are 24.25 and 24.35 cm<sup>3</sup>, so the average of these two values should be taken.

$$\text{Average volume} = (24.25 + 24.35)/2 = 24.30 \text{ cm}^3$$

For Part (c) (iv), candidates were required to calculate the number of moles of KMnO<sub>4</sub> in the average volume determined in Part (c) (iii). The majority of candidates did an incorrect calculation, while others chose not to attempt the question. In general, candidates were unfamiliar with the requirement.

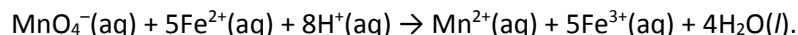
### Common Incorrect Responses

- Some candidates incorrectly divided the concentration by the volume used.
- Others divided (or multiplied) the volume used by Avogadro's number.

### Expected Responses

The concentration of the permanganate solution is 0.010 mol dm<sup>-3</sup>.  
1000 cm<sup>3</sup> of solution contain 0.010 moles of KMnO<sub>4</sub>.  
1 cm<sup>3</sup> of solution contains 0.010/1000 moles of KMnO<sub>4</sub>.  
24.30 cm<sup>3</sup> of solution contain 24.30 x 0.010/1000 = 2.43 x 10<sup>-4</sup> moles of KMnO<sub>4</sub>.

Based on the result from Part (c) (iv), in Part (d) (i), candidates were required to calculate the number of moles of Fe<sup>2+</sup> ions in the 25.0 cm<sup>3</sup> aliquot that reacted with the MnO<sub>4</sub><sup>-</sup> ions (in the volume used from the burette). The following equation was given:



The majority of candidates got this part wrong, while others omitted it. Candidates were unaware of what to do with the equation that was given.

### Expected Responses

From the equation,

1 mole of MnO<sub>4</sub><sup>-</sup> reacts with 5 moles of Fe<sup>2+</sup>  
2.43 x 10<sup>-4</sup> moles of MnO<sub>4</sub><sup>-</sup> react with 5 x 2.43 x 10<sup>-4</sup> = 1.22 x 10<sup>-3</sup> moles Fe<sup>2+</sup>.

In Part (d) (ii), candidates were required to determine the number of moles of  $\text{Fe}^{2+}$  in the  $250.0 \text{ cm}^3$  volumetric flask (that is,  $250 \text{ cm}^3$  of the  $\text{Fe}^{2+}$  solution). Very few candidates did the correct calculations. Some incorrectly used the volume ( $24.30 \text{ cm}^3$ ) from the burette instead of the volume ( $25.0 \text{ cm}^3$ ) from the pipette. Many candidates did not attempt this part.

#### Common Incorrect Responses

$25 \text{ cm}^3$  contained  $1.22 \times 10^{-3} \text{ mol Fe}^{2+}$

$250 \text{ cm}^3$  contained  $(25 / 250) \times 1.22 \times 10^{-3} \text{ mol Fe}^{2+}$

#### Expected Responses

$25.0 \text{ cm}^3$  contain  $1.22 \times 10^{-3} \text{ mol Fe}^{2+}$

$250.0 \text{ cm}^3$  contain  $1.22 \times 10^{-3} \times 250 / 25 = 0.0122 \text{ mol Fe}^{2+}$

For Part (e), candidates were required to use the result from Part (d) (ii) to calculate the mass of anhydrous  $\text{FeSO}_4$  in the  $250 \text{ cm}^3$  volumetric flask. [Given: 1 mole of  $\text{FeSO}_4$  contains 1 mole of  $\text{Fe}^{2+}$  ions; the relative molecular mass of anhydrous  $\text{FeSO}_4$  is 152]. Many candidates realized that this part required multiplying the result from Part (d) (ii) by the RMM of  $\text{FeSO}_4$ , and so gained the mark.

#### Expected Response

Mass of anhydrous  $\text{FeSO}_4 = 0.0122 \times 152 = 1.85 \text{ g}$

In Part (f), candidates were required to calculate the mass of water in the hydrated  $\text{FeSO}_4$  by finding the difference in the results from Parts (b) and (e). The majority of candidates followed the instructions and so were awarded the mark.

#### Expected Response

Mass of water in hydrated  $\text{FeSO}_4 = 3.16 - 1.85 = 1.31 \text{ g}$

In Part (g), candidates were required to calculate the number of moles of water in the hydrated sample. (Given: RMM ( $\text{H}_2\text{O}$ ) = 18.0). More than 50 per cent of candidates did the correct calculations.

#### Common Incorrect Responses

Mass of water from Part (f) multiplied by RMM ( $\text{H}_2\text{O}$ )

#### Expected Response

No. of moles of water in hydrated sample =  $1.31 / 18 = 0.0728 \text{ mol}$

In Part (h), candidates were required to use the results from Part (d) (ii) and (g) to calculate the value of  $n$  in the formula  $\text{FeSO}_4 \cdot n\text{H}_2\text{O}$ , given that

$$\left[ n = \frac{\text{number of moles of water in hydrated sample}}{\text{number of moles of anhydrous FeSO}_4} \right]$$

About 50 per cent of candidates followed the instructions and did the correct calculations.

### Common Incorrect Responses

In their response, many candidates gave the inverse of the required ratio:  $n = 0.0122 / 0.0728 = 0.16$ .

### Expected Response

$$n = 0.0728 / 0.0122 = 5.97 \approx 6$$

For Part (i), candidates were required to state the colour change at the endpoint of the titration of iron(II) sulfate with potassium manganate(VII). Many of them stated the colour at the endpoint instead of stating the colour change. A colour change requires that the colour before and after the endpoint must be stated.

### Common Incorrect Responses

- Pink
- Purple

### Expected Response

The colour change is from a very pale green (almost colourless) to pale pink.

For Part (j), candidates were required to state one reason why there was no need to add an indicator to this titration. About 40 per cent of candidates correctly stated that the manganate(VII) ion is a self-indicator.

### Common Incorrect Response

The manganate(VII) ion is coloured.

### Expected Response

The manganate(VII) ion is a self-indicator – manganate(VII) ions are decolourized in the reaction until the endpoint, when a pale pink colour persists.

In Part (k), candidates were provided with inferences from three qualitative analysis tests and required to state the expected observations. In general, this part was not done well and candidates seemed to be very unfamiliar with the tests.

### Expected Responses

The expected observations are given in the following table.

	Test	Observation	Inference
(i)	<ul style="list-style-type: none"> <li>Aqueous sodium hydroxide was added drop-wise.</li> <li>And then in excess.</li> </ul>	<ul style="list-style-type: none"> <li>A dirty green precipitate formed.</li> <li>Precipitate insoluble in excess.</li> </ul>	Fe <sup>2+</sup> ions present.
(ii)	<ul style="list-style-type: none"> <li>The resulting mixture from (i) was left to stand in air.</li> </ul>	<ul style="list-style-type: none"> <li>The precipitate changed <i>from green (or dirty green) to brown</i>.</li> </ul>	Fe <sup>2+</sup> ions oxidized to Fe <sup>3+</sup> .
(iii)	<ul style="list-style-type: none"> <li>Aqueous barium nitrate was added.</li> <li>Followed by dilute nitric acid.</li> </ul>	<ul style="list-style-type: none"> <li>White precipitate formed.</li> <li>Precipitate insoluble in dilute nitric acid.</li> </ul>	SO <sub>4</sub> <sup>2-</sup> ions present.

### Question 2

Syllabus References: A: 9.4, 9.7, 9.8, 9.11

Candidates were examined on electrolysis. They were expected to be familiar with a simple, standard definition of the terms 'electrolysis' and 'electroplating.' They were also required to be familiar with other real life applications of electrolysis. They were also required to draw the setup of a complete electrolytic circuit using molten lead bromide as an electrolyte and were expected to state the equations for the reactions occurring at the anode and cathode.

Candidates were required to define electrolysis in Part (a) (i). Generally this question was well answered. Most candidates were able to give an accurate definition of electrolysis but some were only able to earn marks for partial responses.

#### **Common Incorrect Responses**

- The passage of ionic substances through electric current to give energy called electricity.
- Electrolysis is the separation of a compound using electricity.

Candidates were required to define the term 'electroplating' in Part (a) (ii). Candidates were only able to supply a simple definition and it was in rare cases that they were able to give the full definition of electroplating as the process of coating a reactive metal with a less reactive metal using electricity.

### Common Incorrect responses

- Electroplating is used to cover a substance in a metal.

### Expected Response

- Electroplating is the covering/coating/plating of a metal with another metal.

Candidates were required to list three other applications of electrolysis in Part (a) (iii). This question proved difficult for some candidates who ignored the requirement to list other applications of electrolysis and to include electroplating in their response.

### Common Incorrect Responses

- Electroplating, preparation of brine, gold plating.

### Expected responses

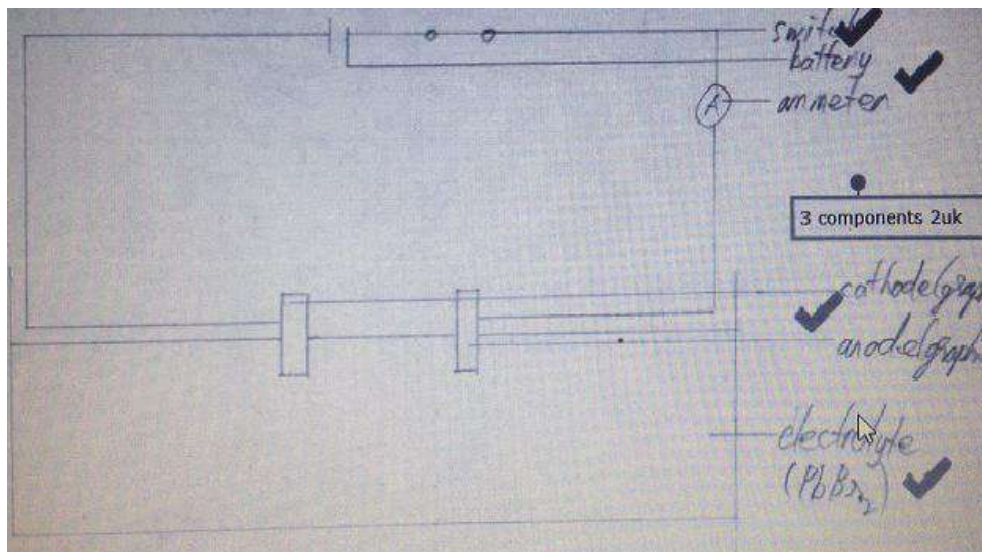
Any three of the following responses were accepted.

1. Electrorefining - purification of impure metal or reduction of metals from metallic compounds to obtain pure form of metal using electrolysis
2. Anodizing - process of making oxide layer on the surface of aluminium thicker, making the surface corrosion resistant
3. Metal extraction/electrowinning - extraction of metals from their ores
4. Producing non-metals such as  $H_2$ ,  $O_2$ ,  $Cl_2$
5. Etching metal surfaces such as tools and knives with a permanent mark or logo
6. Cleaning and preserving old artefacts

In Part (b) (i), candidates were required to draw a fully labelled diagram for the electrolysis of molten lead bromide in the laboratory and state the material from which the electrode must be made.

The responses to this question were mixed, with very good responses coming from candidates who drew well labelled, clear and effective diagrams that showed their full understanding of the setup required. Other candidates were only able to obtain partial marks for their attempts as their diagrams were incomplete or missed key components such as battery/cell, electrolyte or electrodes. Candidates need to be mindful of the correct connection of the electrodes to the respective poles of the cell. There were many cases of inaccurate labelling of the electrodes as a result of this. Most candidates were able to give the correct material for the electrodes.

### Expected Response



The complete circuit is made up of the following:

1. Battery symbol/power source
2. Both electrodes dipping into one vessel
3. Reaction vessel containing molten lead bromide (PbBr<sub>2</sub>) or 'electrolyte'

Material of electrodes: any inert electrode such as carbon or platinum.

For Part (b) (iii), candidates were expected to give balanced equations for the reaction at the anode and cathode for the electrolysis of molten lead bromide. These equations though standard for the electrolysis for molten lead bromide seemed to have given most candidates some difficulty. Though this is a textbook type reaction, some candidates confused the equations that were occurring for the anode with the cathode. Others had difficulty writing the symbol for elemental bromine, bromide ion and electrons.

### Common Incorrect Responses

- $\text{Br}^{2+}(\text{aq}) \rightarrow 2\text{Br}(\text{aq}) + 2\text{e}^-$
- $\text{Pb}^{2+} - 2\text{e}^- \rightarrow \text{Pb}(\text{s})$

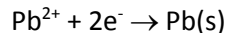
### Expected Responses

At the anode:

Any of the following equations were accepted:



At the cathode:



### Question 3

Syllabus References: B: 3.2, 3.4, 3.6, 4.1, 4.2, 4.3

This question was concerned with the structure and reactions of alkanes and alkenes and with the structure of polymers. The following information was provided:

Compound A,  $\text{C}_4\text{H}_{10}$ , and Compound B,  $\text{C}_3\text{H}_6$ , are both hydrocarbons.

In Part (a) (i), candidates were required to state whether Compound A is an alkane or an alkene. The majority of candidates correctly stated that Compound A is an alkane.

#### **Common Incorrect Response**

Compound A is an alkene.

In Part (a) (ii), candidates were required to state one use of Compound A. The majority of candidates correctly stated that Compound A can be used as fuel or cooking gas.

#### **Common Incorrect Responses**

- Used as gas
- Used as petrol

#### **Expected Response**

Compound A is used as fuel. [The main use is as fuel, but it is also used as a refrigerant gas and as a propellant in aerosol spray cans.]

In Part (a) (iii), candidates were required to state one condition that is necessary for this reaction to take place. They were provided with the following information:

Compound A reacts with chlorine gas to produce a colourless compound and a gaseous by-product.

More than 50 per cent of candidates stated that UV light or sunlight was a necessary condition.

#### **Common Incorrect Responses**

- Heat
- Temperature
- A catalyst must be present

### Expected Response

Condition: UV light or bright light, or light or sunlight

Candidates were required to define the term 'polymer' in Part (b) (i). Many of the definitions were incomplete.

### Common Incorrect Response

- A polymer is formed from monomers.

### Expected Response

A polymer is formed when monomer units are chemically combined to form a chain (or macromolecule) (at least 50 units long).

Compound B undergoes polymerization to form a colourless, hard solid. In Part (b) (ii), candidates were required to state the type of polymerization reaction, the name of the polymer formed, and one possible use for this polymer.

### Common Incorrect Response

- Type of polymerization – condensation polymerization

### Expected Responses

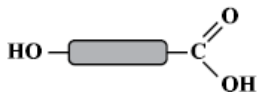
Type of polymerization: *addition* polymerization.

Name of polymer: polypropene, polypropylene.

Use of polymer: polypropene does not crack easily hence its **many** uses include making car accessories, toys, domestic ware, shoe heels, crates, carpets, thermal underwear, bags, plastic bags, packaging, ropes, fishing line, plastic parts and reusable containers of various types.

In Part (c) (i), the following information was provided:

The molecule shown below can be used to produce polymers which are very useful in industry.



A partial structure of the polymer is shown below.





Candidates were required to name the functional group (link) present in the polymer. Less than 50 per cent of candidates correctly identified the link as an ester functional group.

#### Common Incorrect Responses

- Carbon monoxide
- Carboxylic acid
- Alkene
- CO<sub>2</sub>

#### Expected Response

Ester linkage

For Part (c) (ii), candidates were required to name the type of polymerization reaction that has taken place, and state one possible use of these types of polymers. Less than 50 per cent of candidates responded correctly, and many omitted this part of the question.

#### Common Incorrect Responses

- Addition polymerization
- Used to make plastics

#### Expected Responses

Type of polymerization: *condensation* polymerization

Use of polymer: textiles, clothing, ropes, fishing nets; polyesters are also reinforced with fiber glass for strengthening and used for roofing sheets, car bodies, hulls for boats.

In Part (c) (iii), candidates were required to name the by-product that is formed in this polymerization reaction. The majority of candidates did not answer this part of the question.

#### Common Incorrect Responses

- Hydrogen
- Oxygen
- Polyester

#### Expected Response

The by-product is water.

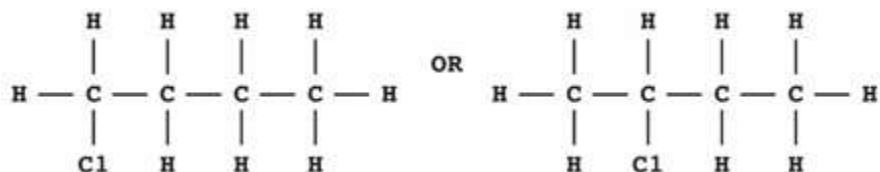
For Part (c) (iv), candidates were required to draw the *fully displayed* structural formula of the product (colourless compound) formed when one mole of Compound A reacts with one mole of chlorine gas. Many candidates drew incorrect structures.

### Common Incorrect Responses

The dichloro compounds, 1,1-dichlorobutane and 1,2-dichlorobutane, were common incorrect responses.

### Expected Responses

The correct structure is that of the mono-substituted alkyl chloride, either 1-chlorobutane or 2-chlorobutane as shown below.



In Part (c) (v), candidates were required to briefly describe one test that can be used to identify the gaseous by-product. Many candidates did not correctly identify the gaseous by-product as hydrogen chloride, and so gave an incorrect test.

### Common Incorrect Responses

- Test with a lighted splint (for hydrogen gas).
- Test with lime water (for carbon dioxide).

### Expected Response

The gaseous by-product is HCl, which forms white fumes with ammonia gas.

### Question 4

Syllabus References: A: 3.6, 3.7, 4.1, 4.5, 5.2, 5.3, 5.6

This was a multiple concept question. Candidates were examined on concepts related to isotopes, uses of radioisotopes, the periodic table and periodicity, structure and bonding.

For Part (a), candidates were given symbols of two isotopes of carbon showing both atomic number and mass number on each symbol. They were to define isotopes and prove by calculations why these were isotopes. Most candidates were able to give a correct definition and generally this part of the question was well answered. The simple calculation when attempted was very accurately done.

### Expected Responses

Isotopes are atoms of the same element with the *same number of protons but different number of neutrons*.

OR

Isotopes are atoms of the same element with the *same atomic number but different mass number*.

C-12: No. of neutrons:  $12 - 6 = 6$  neutrons

OR

$$6n + 6p = 12$$

C-13: No. of neutrons:  $13 - 6 = 7$  neutrons

OR

$$7n + 6p = 13$$

In Part (b), candidates were required to list three other uses of radioisotopes besides its use for energy generation or nuclear energy. Some candidates struggled with listing other uses of the radioisotopes and were not very specific, since there are many specific uses in one sector or area.

### Expected Responses

Any three of the following:

- Carbon dating/radiocarbon dating/radioactive dating
- Chemotherapy, cancer treatment, treat liver and brain tumors
- If candidates state radiotherapy, it must relate to a specific example, for example, cancer treatment, but 'radiotherapy' only is not acceptable.
- Irradiation of food/food preservation
- Sterilization of medical lab equipment, pharmaceutical products, surgical products. 'Sterilization' only is not acceptable.
- In pacemakers
- In smoke detectors
- Tracers, chemical tracers to detect cracks/leaks
- In medicine but it must relate to specific area, for example, diagnosis of thyroid problems, monitoring heart disease, etc.
- In agriculture radioisotopes are used in the nutritional studies of major and minor elements, milk production, and mechanism of photosynthesis studies. Plant protection, plant pathology, action of insecticides, uptake of fertilizers, ions mobility in soil, and plants and food preservation.
- In nuclear weapons/nuclear warheads/making bombs
- In batteries

For Part (c) (i), candidates were required to deduce the group and period for two elements given their electronic configurations. They were also required to indicate the type of bonding and the formula for the compound formed. Generally this question was fairly well done with candidates being able to assign the correct group and period for each element. There were some who were unable to provide the type of bonding. The writing of the formula for the compound was a bit difficult for those who incorrectly assigned X as a non-metal and therefore reversed the formula by writing  $W_2X$ .

### Expected Responses

W: Group 7, period 2

X: Group 2, period 3

Ionic/Electrovalent bonding

Formula:  $XW_2$  or  $MgF_2$

In Part (c) (ii), candidates were required to deduce if the compound formed would have dissolved in water and to give an explanation accordingly. Candidates were able to state that the compound would dissolve in water, but the explanation proved difficult for some candidates. They were unable to clearly express the reason in a logical manner neither describing the nature of the solute and the solvent.

### Expected Responses

The compound is expected to dissolve in water.

It is an *ionic compound which is polar* in nature and hence will be soluble in a *polar solvent such as water*.  
OR

'Like dissolves like', this compound *will contain ions* and since *water contains ions*, it will dissolve easily.

### Question 5

Syllabus References: C 5.1, 5.2, 5.5 and 6.3

Noting that ammonia is used to make fertilizers such as ammonium nitrate, candidates were examined on the properties and laboratory preparation of ammonia as well as the harmful effects that nitrates can have on the environment.

In Part (a), candidates were asked to state two physical properties of ammonia gas. This part of the question was not as well answered as expected. Most candidates, however, were able to gain at least one of the two marks available.

### Common Incorrect Responses

Most of the incorrect responses referred to the chemical properties rather than the physical properties, for example, based on acid/base properties. Some candidates also knew that ammonia was gaseous but noted the wrong colour, for example, brown. Additionally, some candidates made reference to its toxicity.

### Expected Response

Any two of the following were accepted:

- It's a colourless gas.
- It has a pungent/ choking odour.
- It's lighter than air.
- It's soluble in water.

Part (b) was divided into three sections, all based on the laboratory preparation of ammonia. Part (i) required candidates to draw a labelled diagram of the apparatus. Part (ii) required a balanced chemical equation for the laboratory preparation to be written and Part (iii) asked candidates to explain why concentrated  $\text{H}_2\text{SO}_4$  was not a suitable drying agent for the process, while proposing one that was suitable.

In Part (b) (i), most candidates were able to get at least one of the three marks available (usually for the heat source). However, Parts (b) (ii) and (b) (iii) were poorly done. Many candidates did not even attempt to write the equation.

### Common Incorrect Responses

For Part (b) (i), the incorrect responses included the following:

- Incorrect reagents
- Incorrect collection methods
- Incorrect apparatus / techniques e.g. some persons drew distillation apparatus
- Lack of labelling

For Part (b) (ii), the incorrect responses included the following:

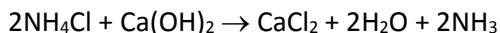
- Incorrect reagents
- Incorrect chemical formulae

Most candidates who attempted Part (b) (iii), simply wrote that  $\text{H}_2\text{SO}_4$  would interfere with the reaction or that it was too strong to be used. Some incorrect alternative drying agents proposed included HCl and CaOH.

### Expected Response

For Part (b) (i), an acceptable response would have included ion, a labelled diagram, a heat source, a reaction vessel with named reagents and a setup for upward delivery.

For Part (b) (ii), any balanced equation with an alkali and ammonium salt except ammonium nitrate (explosive) or ammonium hydroxide ( $\text{NH}_3(\text{aq})$ ) was accepted (see below).



For Part (b) (iii), candidates were expected to recognize that ammonia is basic and hence will react with sulfuric acid. A suitable alternative drying agent is CaO.

In Part (c), the candidates were asked to describe a laboratory test for ammonia gas. Most candidates were able to correctly answer this question.

### Common Incorrect Responses

Incorrect responses included the following:

- Flame test
- A coloured gas produced on heating

### Expected Response

It was expected that candidates would use either moist red litmus, with a positive indicator being the litmus turning blue or HCL gas, with a positive indicator being the formation of white fumes.

For Part (d), candidates were asked to list three harmful effects of excessive nitrates in the environment. Most candidates were able to earn at least one of the three marks.

### **Common Incorrect Responses**

Incorrect responses included the following:

- Depleted ozone layer
- Pollution (this was not specific enough)
- Promote global warming
- Respiratory diseases

### **Expected Responses**

Correct responses included the following:

- Algal bloom
- Eutrophication
- Nitrate poisoning in man
- Fish kills

### Question 6

Syllabus References: B: 3.11, C: 5.6, 5.7, 5.8

This question was based on the properties of water, distinguishing between hard and soft water.

In Part (a), candidates were asked to state two properties of water, explaining how each can assist in the sustenance of life. Very few candidates achieved three or four out of a maximum of four marks. In most cases candidates were able to list the properties gaining two marks, but were unable to relate the properties to the sustenance of life.

### **Common Incorrect Responses**

Incorrect responses included the following:

- Low boiling point
- Easily digested
- Good insulator

### Expected Responses

The expected responses can be seen in the table below.

Property	Sustenance of life
It's a solvent It's polar	Keeps plants alive by dissolving minerals from soil/transporting them throughout the plant. Keeps fish alive by dissolving oxygen. Transports nutrients in blood of animals.
High boiling point Accept 100°C	Allows the body to cool since a lot of heat is required to convert water to a vapour.
High heat capacity	Water is able to absorb a lot of heat from the surroundings without showing changes in body temperature. It therefore allows mammals to maintain constant body temperature or prevents cells from overheating.
High surface tension	Hydrogen bonding present in water makes it hard to separate and hence allows tiny insects to walk on the surface of the water.
Cohesiveness	Aids in capillary action that is responsible for the roots taking in water from the soil and transporting it throughout the plant.
Water is more dense than ice	Large bodies of water, for example, lakes and rivers freeze from the surface first, hence allowing fish and marine organisms to survive the winter.
Translucent/transparent (clear)	This allows the sunlight to reach marine life.
High heat of vaporization	Allows mammals to remain cool (maintain body temperature) via evaporation.  Allows plants to remain cool via transpiration.

Candidates were reminded that when water passes over rocks made of  $\text{CaCO}_3$ , they can be made temporarily hard. Part (b) (i) required candidates to write a balanced equation showing how the hard water formed can be softened using sodium carbonate. Part (b) (ii) required that candidates name and describe another method by which water can be softened.

Part (b) was poorly done. Many candidates were unable to write a balanced equation for the reaction and those who gained marks in Part (b) (ii) were able to name another method of softening but unable to describe it.

### Common Incorrect Responses

The most common issue with writing the equation was that candidates seemed unaware that the hard water was due to the presence of  $\text{Ca}(\text{HCO}_3)_2$ . Most were also unable to write a balanced ionic equation. In terms of another method of softening, the most common incorrect response was to simply state heating. Some candidates also used distillation rather than simple boiling (marks were awarded in these cases).

### Expected Responses

For Part (b) (i), any of the following three equations were accepted:

- (1)  $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$
- (2)  $\text{Ca}(\text{HCO}_3)_2(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + 2\text{NaHCO}_3(\text{aq})$
- (3)  $\text{Ca}^{2+}(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + 2\text{Na}^+(\text{aq})$

For Part (b) (ii), the methods accepted, with accurate descriptions, were boiling and the use of ion exchange resins.

In Part c, candidates were asked to describe a method which could be used to distinguish between hard and soft water specifically, using soap. Most candidates were able to recognize that they needed to mix soap with water. What many were missing in their response was

1. how to distinguish between hard and soft water based on a measurable observation
2. recognizing that there is a need for controlled variables such as equal volumes of water or equal volumes of soap.

## Paper 032 – Alternative to School-Based Assessment

### Question 1

Syllabus Objectives: A: 6.5, 6.6, 7.4; C: 6.1

Candidates were required to perform a volumetric analysis experiment to determine the concentration of a sulfuric acid solution of unknown concentration. This is an acid-base titration using screened methyl orange as the indicator.

For Part (a) (i), candidates were required to record the volume readings to two decimal places in Table 1. From the experimental data presented in candidates' tables, it was clear that many of them were unfamiliar with the technique of volumetric analysis (titration). Some readings were recorded without decimal places. For the majority of candidates, the agreement between titre values was very poor.

### Expected Responses

It is expected that (i) burette readings were to be recorded to two decimal places and, (ii) at least two titre values should be within  $0.10 \text{ cm}^3$ .



In Part (a) (ii), candidates were required to indicate using asterisks (\*), the titration volumes that would be used to calculate the average volume of Solution X. About 50 per cent of candidates indicated the values to be used using asterisks. Some candidates, even when they had good data, indicated all three values instead of the best two values.

### Expected Responses

An example of three titre values with the two best values indicated using asterisks is shown below.

\*25.65 cm<sup>3</sup>, \*25.55 cm<sup>3</sup>, 25.05 cm<sup>3</sup>

[The first two values are the two closest values and are chosen to be used in determining the average volume.]

Part (a) (iii), candidates were required to calculate the average volume of Solution X used in the titration. The majority of candidates used all three values to calculate the average volume.

[The values must be inspected properly to determine if all three are concordant. If not, then use the two closest values.]

### Expected Responses

The calculation of the average volume is done using the following values:

\*25.65 cm<sup>3</sup>, \*25.55 cm<sup>3</sup>, 25.05 cm<sup>3</sup>

The first two values are used, therefore the average volume =  $(25.65 + 25.55)/2 = 25.60 \text{ cm}^3$ .

Part (a) (iv), candidates were required to write a balanced equation for the reaction taking place in the titration. The majority of candidates wrote the correct chemical equation.

### Common Incorrect Responses

- $\text{H}_2\text{SO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  (unbalanced)
- $\text{H}_2\text{SO}_4 + \text{NaOH} \rightarrow \text{NaSO}_4 + \text{H}_2\text{O}$  (incorrect formula for sodium sulfate)

### Expected Response

- $\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$

In Part (a) (v), candidates were required to calculate the number of moles of sodium hydroxide used in the titration. About half of the candidates did the calculation correctly.

### Expected Responses

The concentration of the sodium hydroxide solution is  $0.10 \text{ mol dm}^{-3}$ , and if  $25.0 \text{ cm}^3$  was the pipetted volume used, the calculation should be done as follows:

1000 cm<sup>3</sup> contain 0.10 mol NaOH  
1 cm<sup>3</sup> contains (0.10/1000) mol NaOH  
25.0 cm<sup>3</sup> contain (0.10/1000) x 25.0 = 0.0025 mol NaOH

For Part (a) (vi), candidates were required to calculate the number of moles of sulfuric acid in the volume of Solution X used from the burette, assuming that 1 mole of H<sub>2</sub>SO<sub>4</sub> reacts with 2 moles of NaOH. Many candidates made correct use of the reaction equation and realized that there would be half the number of moles of H<sub>2</sub>SO<sub>4</sub> as NaOH.

### Expected Response

No. of moles of H<sub>2</sub>SO<sub>4</sub> = 0.0025/2 = 0.00125 mol.

In Part (a) (vii), candidates were required to calculate the concentration (in mol dm<sup>-3</sup>) of sulfuric acid in Solution X. Many candidates knew that the concentration can be calculated by dividing the number of moles of substance by the volume in dm<sup>3</sup>, and so gained the mark.

### Common Incorrect Response

Some candidates did not convert the volume from cm<sup>3</sup> to dm<sup>3</sup>.

### Expected Responses

Using the average volume from Part (a)(iii) and the number of moles of sulfuric acid from (a)(vi) to do the calculation,

25.60 cm<sup>3</sup> of sulfuric acid solution contain 0.00125 mol  
1 cm<sup>3</sup> of sulfuric acid solution contains (0.00125/25.60) mol  
1000 cm<sup>3</sup> of sulfuric acid solution contain (0.00125/25.60) x 1000 = 0.0488 mol  
The concentration of Solution X is 0.0488 mol dm<sup>-3</sup> H<sub>2</sub>SO<sub>4</sub>.

For Part (a) (viii), candidates were required to calculate the concentration of sulfuric acid in the original stock solution, knowing that Solution X was prepared by taking 25 cm<sup>3</sup> of a stock solution and diluting it to 250 cm<sup>3</sup> in a volumetric flask. The majority of candidates did not do well on this part.

### Expected Responses

The dilution factor = 250 cm<sup>3</sup>/25 cm<sup>3</sup> = 10. The concentration of the original solution is obtained by multiplying the concentration of Solution X by the dilution factor.

Original concentration = (250/25) x 0.0488 = 10 x 0.0488 = 0.488 mol dm<sup>-3</sup>.

In Part (b), candidates were required to carry out qualitative tests on Solution M. The tests are as indicated under the 'Test' column of the table. Candidates performed fairly well on Test (i) but failed to include the presence of Ca<sup>2+</sup> ions. Many candidates obtained the yellow precipitate for Test (ii) but could not come up with the correct balanced ionic equation.

### Expected Responses

The expected observations and inferences are listed in the table.

	Test	Observation	Inference
(i)	<p>To the first portion of Solution M:</p> <ul style="list-style-type: none"> <li>• Add two drops of aqueous sodium hydroxide solution.</li> <li>• Add aqueous sodium hydroxide drop-wise with intermittent shaking until in excess and no further change is observed.</li> </ul>	<ul style="list-style-type: none"> <li>• White precipitate</li> <li>• White precipitate soluble in excess</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\text{Ca}^{2+}</math>, <math>\text{Pb}^{2+}</math>, <math>\text{Al}^{3+}</math>, <math>\text{Zn}^{2+}</math> possibly present</li> <li>• <math>\text{Pb}^{2+}</math>, <math>\text{Al}^{3+}</math>, <math>\text{Zn}^{2+}</math> possibly present</li> </ul>
(ii)	<p>To the second portion of Solution M:</p> <ul style="list-style-type: none"> <li>• Add two drops of aqueous potassium iodide solution.</li> </ul>	<ul style="list-style-type: none"> <li>• Bright <i>yellow</i> precipitate</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s})</math></li> </ul>

### Question 2

Syllabus Objectives: A: 10.2, 10.4

This question focused on data analysis. The data represented the effect of the concentration of an acid on the rate of production of hydrogen gas by a metal. Candidates were required to plot a graph of rates vs concentration using the data provided. Additionally, they were asked to state two variables that should have been kept constant during the experiment as well as one precaution that should have been taken.

The question was well done. A number of candidates gained full marks and the average score was over 70 per cent.

For Part (a), candidates were required to plot the graph and draw a line of best fit. The majority of candidates was able to get five or more out of a maximum of seven marks. Most candidates were unable to draw a best fit line. A few candidates were unable to accurately read the scale provided and hence could not accurately plot the points.

For Part (b), most candidates were able to state at least one variable that should be kept constant. The most common one suggested was temperature.

### Common Incorrect Responses

- Concentration
- Simply stating 'acid' or 'metal' rather than 'volume of acid' or 'size/mass of metal'
- Time

Some candidates also used 'amount' rather than volume or mass. Another variable that was accepted was surface area or particle size.

In Part (c), most candidates were able to state a reasonable precaution. The most common error was stating a controlled variable as a precaution, for example, "make sure all experiments are done at the same temperature".

### Question 3

Syllabus Reference: A: 7.5

This question tested candidates planning and design skills. They were asked to plan and design an experiment to determine which stain remover (a commercial or home-made one) is more effective at removing rust stains from clothing. A hypothesis was given and candidates were asked to provide the following:

- Apparatus and materials
- Procedure
- Two controlled variables
- Data to be collected
- Discussion of the results as it relates to the hypothesis
- One precaution to be taken during the experiment

Whilst none of the candidates were able to attain full marks on this question, the mean score was above 50 per cent.

For Part (a), most candidates were able to gain maximum marks on the apparatus and materials. This was assessed based on candidates' proposed procedure. A stopclock was the most common apparatus missing, in cases where candidates mentioned a time factor in their procedure.

In Part (b), most candidates were able to gain at least one mark for recognizing that both stain removers should be applied to a piece of cloth. Most candidates lost marks because they failed to leave the stain removers on for a stated amount of time or did not observe and note the change that was taking place.

In Part (c), candidates were required to note two controlled variables. Most were able to state at least one. The most common ones stated were

- volume of stain remover
- the type of material used
- the time the stain remover was left on the stain.

Of concern to the examiners was the fact that in most cases rather than note volume of stain remover, the majority of candidates used the term 'amount of'.

Other reasonable variables to be controlled included

- the extent or type of staining
- equal volumes of water for washing.

For Part (d), data to be collected proved challenging for most of the candidates to articulate. Most recognized that they wanted to know which stain remover was 'most effective' but could not express this in measurable quantities as data.

The expected response was either the intensity/colour of stain before or after treatment or the time taken for each stain to disappear depending on the procedure used.

Since most candidates were unable to provide a reasonable response for Part (d), Part (e) also proved difficult. Candidates were expected to explain how the results could be used to determine which stain remover was better and relate this to the hypothesis.

The majority of those who gained one mark was able to indicate that the home-made stain remover was better but was unable to accurately indicate why based on their expected results.

In Part (f), candidates were asked to state one precaution that could be taken during the experiment. Either a safety or procedural precaution was accepted.

In some cases candidates listed a controlled variable. Other common incorrect responses presented included the following:

- Measurement.
- Clean apparatus before use.
- Avoid spilling reagents.
- Read apparatus carefully or accurately.

It should be noted that general experimental skills and best practices were not accepted as precautions.

**CARIBBEAN EXAMINATIONS COUNCIL**

**REPORT ON CANDIDATES' WORK IN THE  
CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION**

**JANUARY 2018**

**CHEMISTRY  
GENERAL PROFICIENCY EXAMINATION**

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## GENERAL COMMENTS

The overall performance of candidates was much better than it was last year. Forty eight per cent of the candidate population achieved Grades I to III on the examination. The best performance was on Paper 032, on which the mean score was 56 per cent, while the mean scores on Papers 01 and 02 were 54 per cent and 33.4 per cent respectively.

## DETAILED COMMENTS

### Paper 01 – Multiple Choice

This paper consisted of 60 compulsory multiple choice items. The general performance on this paper was satisfactory, with approximately 67 per cent of the candidates achieving acceptable grades, Grade I – III. The maximum score obtained was 59 of the 60 marks and the mean score was 32.3 marks.

Candidates recorded excellent performance in the areas relating to the following topics:

- States of matter
- Atomic structure

However, candidates performed poorly in the following areas:

- Mole concept
- Allotropy
- Deduction of oxidation number from formulae
- Preparation of gases
- Reactivity and extraction of metals
- Reactions of alkanes and alkenes
- Reactions of ethanoic acid

### Paper 02 – Structured/Extended Essay

#### Question 1

Syllabus References A: 7.11, 5.5, 5.6

This question was based on the principles of chemistry and examined the candidates' ability to perform calculations that involve volumetric analysis data derived from an acid-base titration. It also examined candidates' knowledge of molecular crystals and ability to distinguish between ionic and molecular solids based on a cooling curve.

Part (a) (i)

In this part, candidates were required to complete a titration table by recording the final and initial volumes from a figure showing the burette readings. They were also expected to calculate the volume of Solution M (acid) used.

**Candidates' Performance**

More than 75 per cent of candidates were able to produce the correct titre values from the diagrams and calculate the volume of M used. It was noted that candidates had difficulty with reading and recording the burette readings to two decimal places and some were unable to translate the final and initial burette readings to final and initial volume. Also some candidates experienced difficulty in attempting to perform the subtraction required to determine the volume of solution M or the titre volumes.

**Common Incorrect Responses****TABLE 1: TITRATION OF SOLUTION M (HCl) WITH SOLUTION N (NaOH)**

Burette Readings (cm <sup>3</sup> )	Titration 1 (Rough)	Titration 2	Titration 3
Final volume	25.0 cm <sup>3</sup>	38.2 cm <sup>3</sup>	40.3 cm <sup>3</sup>
Initial volume	50 cm <sup>3</sup>	37 cm <sup>3</sup>	34.5 cm <sup>3</sup>
Volume of solution M used	25.0 cm <sup>3</sup>	13 cm <sup>3</sup>	15.4 cm <sup>3</sup>

**Expected Responses**

Burette Readings (cm <sup>3</sup> )	Titration 1	Titration 2	Titration 3
Final Volume	25.70	38.30	40.50
Initial Volume	0.25	13.30	15.50
Volume of Solution M used	25.45	25.00	25.00

Part (a) (ii)

In this part, candidates were required to calculate the average volume of Solution M used.



### Candidates' Performance

The majority of the candidates were able to complete this question but some had difficulty in identifying which titre values to use. While several candidates calculated a rough titre, some were unable to select the two closest titre values for this calculation. Teachers must remind their students that for this type of calculation all three values are used only when no two values are close.

### Common Incorrect Responses

Volume of solution M used	25.45	25.0	25.0
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(9 marks)

(ii) Calculate the average volume of solution M used in the titration.

$$\text{Average vol} = \frac{25.45 + 25 + 25}{2} = 37.725 \text{ cm}^3$$

### Expected Responses

$$(25.00 + 25.00)/2 = 25.00 \text{ cm}^3$$

Or

Average of candidates' two nearest titre values

### Part (a) (iii)

In this part, candidates were expected to determine the concentration of the hydrochloric acid in  $\text{mol dm}^{-3}$ .

### Candidates' Performance

The majority of candidates calculated the molar mass of the hydrochloric acid but some had difficulty in calculating the number of moles of hydrochloric acid.

### Common Incorrect Responses

For example,

$$1 \times 3.6 = 3.6$$

$$35.5 \times 3.6 = 127.18$$

$$= 131.4$$

$$35.5 \text{ mol} / 3.6 \text{ g dm}^{-3} = 9.86 \text{ mol dm}^{-3}$$

**Expected Responses**

$$\text{Molar mass} = 1 + 35.5 = 36.5 \text{ g/mol}$$

$$\text{Mass in } 1 \text{ dm}^3 = 3.6 \text{ g}$$

$$\text{No of mol.} = \frac{3.6}{36.5} = 0.0986 \text{ mol}$$

**Part a (iv)**

In this part, candidates were expected to calculate the number of moles of hydrochloric acid used in the titration.

**Candidates' Performance**

The majority of the candidates did poorly on this part of question as they were not using the average volume calculated in Part (a) (ii) and the molarity of the acid that was calculated in Part (a) (iii).

**Common Incorrect Responses**

$$25.15/36.5 = 0.7 \text{ moles}$$

$$\text{Moles} = 44.6/36.5 = 1.22 \text{ moles}$$

**Expected Response**

$$[\text{Candidate Ans (a)(iii)/1000}] \times [\text{Candidate Ans (a)(ii)}]$$

$$(0.0986/1000) \times 25 = 0.0025 \text{ mols}$$

**Part (a) (v)**

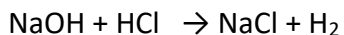
In this part, candidates were required to write the balanced equation for the reaction of hydrochloric acid and sodium hydroxide solutions.

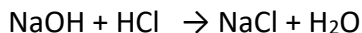
**Candidates' Performance**

Fewer than 50 per cent of candidates correctly wrote the equation for the reaction between hydrochloric acid and sodium hydroxide solutions.

**Common Incorrect Responses**

For example,



**Expected Responses**Part (a) (vi)

In this part, candidates were required to apply the molar ratio from the balanced equation and determine the number of moles of sodium hydroxide in the 25 cm<sup>3</sup> solution used.

**Candidates' Performance**

Some candidates were able to provide the molar ratio but very few candidates gave the correct application of the molar ratio to obtain the number of moles of sodium hydroxide in the volume of solution used. Most candidates appeared to believe a calculation was required.

**Common Incorrect Responses**

$$\begin{aligned} \text{Moles} &= \text{mass/molar mass} \\ &= 25/40 \\ &= .625 \text{ mol} \end{aligned}$$

$$\text{moles} = \frac{25 \text{ cm}^3}{3.6 \times 100} = 6.94 \text{ cm}^3$$

**Expected Responses**

No of mols in 25 cm<sup>3</sup> of NaOH:  
From eqn, Molar ratio 1:1  $\Rightarrow$  Ans part (iv) = 0.0025 mol

Part (a) (vii)

In this part, candidates were required to calculate the mass concentration of the sodium hydroxide (g dm<sup>-3</sup>). They were supplied with the molar mass of sodium hydroxide.

**Candidates' Performance**

Very few candidates could complete this calculation successfully.

**Common Incorrect responses**

$$\begin{aligned} \text{conc} &= \frac{\text{mol}}{\text{Molar Mass}} = \frac{1.6 \text{ mol}}{40 \text{ g mol}^{-1}} \\ &= 0.04 \text{ g dm}^{-3} \end{aligned}$$

$$\begin{aligned} \text{Conc. of NaOH} &= \frac{1.61 \times 100}{40} \\ &= 4 \text{ g dm}^{-3} \end{aligned}$$

### Expected Responses

1000 cm<sup>3</sup> contains

$$\frac{\text{Ans (vi)}}{25} \times 1000 \quad \text{OR} \quad \text{Ans(vi)} \times 40 = 0.1 \text{ mol}$$

$$0.1 \text{ mol NaOH} = 0.1 \times 40 = 4.0 \text{ g/dm}^3$$

### Part (b) (i)

Candidates were required to identify the forces that are present in a molecular solid.

### Candidates' Performance

Many candidates did not identify the forces that are present in a molecular solid.

### Common Incorrect Responses

Some incorrect responses were

- *Stearic acid*
- *Frictional forces between the particles because they are compact*
- *Strong electronegativity*

### Expected Responses

A molecular solid is a solid held together by weak forces or weak intermolecular forces or weak van der Waals forces.

### Part (b) (ii)

Candidates were required to account for the higher melting and boiling points of sodium chloride when compared to that of stearic acid.

### Candidates' Performance

Many candidates were able to give a correct explanation for the higher melting and boiling points of sodium chloride when compared to that of stearic acid.

### Common Incorrect Responses

- Sodium chloride has strong covalent bonds which are hard to break.
- This is so because sodium chloride has stronger molecular bonds.

### Expected Responses

Sodium chloride is an ionic solid and is held together with strong bonds/strong forces/electrostatic/ionic bonds.

### Part (b) (iii)

Candidates were required to use experimental data to plot a graph showing the melting point curve for stearic acid on axes provided.

### Candidates' Performance

The majority of the candidates were able to plot this graph successfully. However, there were a few who did not obtain full marks due to inaccuracies in plotting one or two points.

### Common Incorrect Responses

There were very few incorrect responses.

### Expected Responses

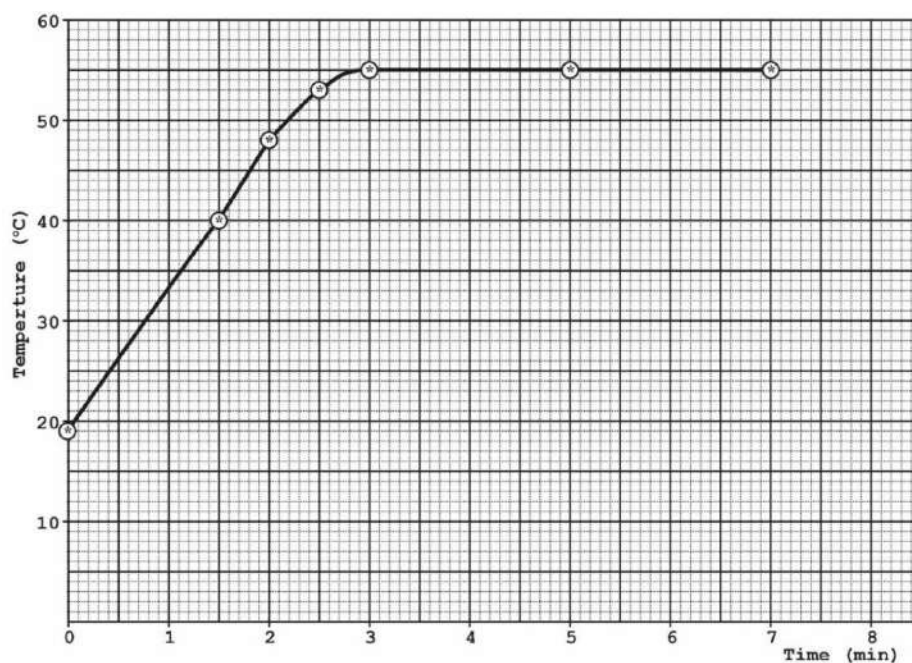


Figure 2: Graph of temperature (°C) against time (min)

## Question 2

Syllabus References: Sec A: 7.1, 7.3, 7.5, 7.9

The question examined the candidates' knowledge of acids, bases and salts.

### Part (a) (i)

In this part, candidates were required to define the terms 'acid' and 'alkali'.

#### **Candidates' Performance**

Most candidates were able to provide correct definitions but too many were still unable to define these two terms.

#### **Common Incorrect Responses**

Some answers were rather vague and hence were awarded no marks.

For example:

- *An acid is a substance that contains H<sup>+</sup> ions*
- *An alkali is a substance that contains OH<sup>-</sup> ions*
- *An alkali is a neutral substance used to neutralise acidic substances*

Some candidates simply gave properties rather than definitions.

For example:

- *An acid usually has a sour taste where as an alkali does not*
- *An acid is a substance that reacts with a base to give salt and water.*

#### **Expected Responses**

The accepted responses for defining the term 'acid' were:

- A substance that produces H<sup>+</sup> ions in water
- A proton donor
- An electron pair acceptor

The accepted responses for defining the term 'alkali' were:

- A base that produces hydroxide ions in water
- A soluble base
- A proton acceptor

- An electron pair donor

### Part (a) (ii)

In this part, candidates were required to define the terms ‘acid salt’ and ‘normal salt’.

### **Candidates’ Performance**

Most candidates were able to provide the correct definition but too many were unable to define these two terms.

### **Common Incorrect Responses**

Some common incorrect definitions for acid salts included the following:

- *Salts formed when some of the ions are replaced*
- *Salts which are partially ionised in water*
- *Salts formed from acids*
- *Salts that cannot be consumed*

Some common incorrect definitions for normal salt included the following:

- *Salts formed when all of the ions are replaced*
- *Salts which are completely ionised in water*
- *Salts formed from alkalis*
- *Salts which can be consumed*

### **Expected Responses**

The accepted responses for the definition of the term ‘acid salt’ were

- A salt formed when only part of the replaceable hydrogen of an acid is removed
- A salt with an ionisable hydrogen

The accepted response for a normal salt is

- A salt formed when all the replaceable hydrogen of an acid is removed

### Part (a) (iii) – (vi)

In these parts, candidates were asked to state the molecular formula for the normal and acidic salts formed from a reaction between phosphoric acid and sodium hydroxide and hence write balanced equations to depict the formations.

### Candidates' Performance

These questions presented some level of difficulty for some of the candidates. Most candidates had problems writing the correct molecular formula and hence a balanced chemical equation. The acidic salt provided the most difficulty.

### Common Incorrect Responses

- For normal salt:  $\text{NaPO}_4$
- For acid salt:  $\text{NaHPO}_4$  and  $\text{Na}_3\text{HPO}_4$ .

### Expected Responses

For normal salt:

- Formula:  $\text{Na}_3\text{PO}_4$
- Equation:  $3\text{NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$

For acid salt:

- Formula:  $\text{NaH}_2\text{PO}_4$  OR  $\text{Na}_2\text{HPO}_4$
- Equation: **EITHER**  $\text{H}_3\text{PO}_4 + \text{NaOH} \rightarrow \text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$   
**OR**  $\text{H}_3\text{PO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{HPO}_4 + 2\text{H}_2\text{O}$

### Part (b) (i)

In this part, candidates were presented with two different acids of the same concentration but different pHs. They were asked to suggest which one was stronger.

### Candidates' Performance

The majority of the candidates were able to answer this question correctly.

### Expected Responses

It was expected that the candidates would recognise that the stronger acid would present a lower pH.

### Part (c)

In this part, candidates were presented with a scenario which suggested that too much orange juice caused pain in a person due to excess stomach acid. They were asked to identify two acids present in orange juice, state the type of chemical reaction that takes place when excess stomach acid is treated and to name one substance that can be used to treat excess stomach acid.



### Candidates' Performance

This question was fairly well done. Most candidates were able to identify at least one acid found in orange juice and one substance used to treat stomach acid. Stating the type of chemical reaction that takes place in the treatment of excess stomach acid proved the most difficult aspect of this question.

### Common Incorrect Responses

- For acids found in orange juice, the most common incorrect responses included: nitric acid, ethanoic acid, carbonic acid and sulfuric acid.
- For the type of chemical reaction, the most common incorrect response was a redox reaction.
- For the treatment of excess stomach acid, the most common incorrect responses included NaOH and Epsom salts.

### Expected Responses

- For acids found in orange juice, any two of the following acids were accepted: ascorbic (Vitamin C), folic, pantothenic, hydroxycinnamic, citric, malic and oxalic.
- For the type of chemical reaction, only neutralisation was accepted.
- For the treatment of excess stomach acid, antacid or any chemical, common or brand name for a known antacid was accepted.

### Question 3

Syllabus References: Sec B: 3.1, 3.2, 4.1, 4.3

This organic chemistry question examined the candidates' knowledge of addition halogenation of alkenes and substitution halogenation of alkanes and polymers.

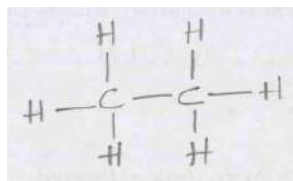
### Part (a) (i)

In this part, candidates were required to draw the fully displayed structure of ethene.

### Candidates' Performance

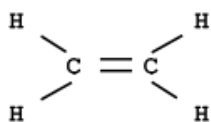
More than 50 per cent of candidates produced the correct structure of ethene, but a number of candidates drew the structure of ethane or some other alkane.

### Common Incorrect Responses



### Expected Responses

The FULLY DISPLAYED structure of ethene is:



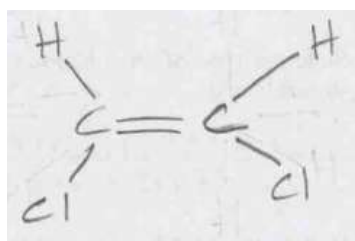
### Part (a) (ii)

In this part, candidates were required to draw the fully displayed structure of 1,2-dichloroethane.

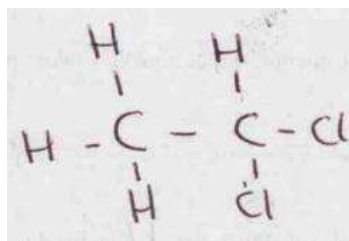
### Candidates' Performance

The majority of candidates drew the correct structure.

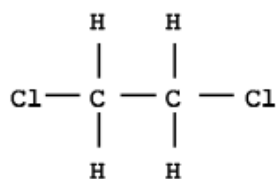
### Common Incorrect Responses



and



### Expected Responses



### Part (a) (iii)

In this part, candidates were asked whether the halogenation of ethene is an addition or a substitution reaction.

**Candidates' Performance**

The majority of candidates stated correctly that the halogenation of ethene is an addition reaction.

**Common Incorrect Responses**

Some candidates incorrectly stated that the reaction is a substitution reaction.

Part (b) (i)

In this part, candidates were required to write the two balanced chemical equations to show each step in the formation of dichloromethane from methane.

**Candidates' Performance**

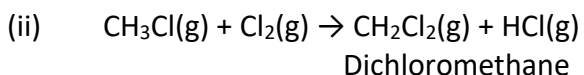
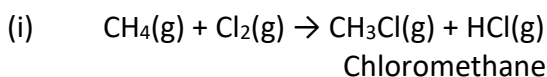
The majority of candidates were not able to give the correct equations. Some gave incomplete equations while others did not make an attempt at an answer.

**Common Incorrect Responses**

- $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_4\text{Cl}_2$
- $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl}$

**Expected Responses**

The two balanced chemical equations are shown below:

Part (b) (ii)

In this part, candidates were asked whether the halogenation of methane is an addition or a substitution reaction.

**Candidates' Performance**

More than 50 per cent of candidates correctly stated that the halogenation of methane is a substitution reaction. Others incorrectly stated that the reaction is an addition reaction or did not give a response.

### Part (c) (i)

In this part, candidates were asked to define the term 'polymer'.

#### **Candidates' Performance**

Many candidates were not specific in their definition. Simply stating that "a polymer is made up of monomers" or "a polymer consists of two or more monomers" was not sufficient. It was necessary to indicate that a polymer is a very large molecule (that is, a chain or a macromolecule), and that it is made by the joining together (linking, bonding) of many monomers.

#### **Common Incorrect Responses**

Common incorrect responses were of the type:

- A polymer is a mixture of monomers
- A polymer is a substance with more than one monomer
- A polymer is a molecule made up of monomers

#### **Expected Responses**

"A polymer is a macromolecule which is made up of a large number of simple molecules called monomers".

Any similar statement was accepted.

### Part (c) (ii)

In this part, candidates were required to define 'addition polymerization'.

#### **Candidates' Performance**

Very few candidates gave the correct definition. Some gave definitions that were either vague or not specific to 'addition polymerization'.

#### **Common Incorrect Responses**

- The addition of two or more monomers
- The process by which monomers are bonded to form a polymer
- The addition of two polymers

**Expected Responses**

Addition polymerisation is a process of adding one monomer to another to form a long chain polymer (without the loss of water or other small molecule). (Any similar statement was accepted.)

Part (c) (iii)

In this part, candidates were required to state one use of each of the following polymers: polyvinylchloride, Teflon, polyethene.

**Candidates' Performance**

Many candidates could list at least one correct use, but some responses were not specific.

**Expected Responses**

Polymers have many uses. It was expected that candidates would give specific uses and not just indicate a broad area, for example, "polyvinyl chloride is used in medicine"; the use should be specific.

Some uses are listed below:

Polyvinyl chloride: PVC fittings, water pipes, furniture, surgical gloves, medical containers and tubing, speciality (for example, water resistant) clothing, bumper stickers, flooring.

Teflon: non-stick pots, pans and kitchen utensils, skin care products, seals, Teflon-treated fabric, Teflon-treated rope (to reduce water damage).

Poly (ethene): plastic containers, cling wrap, bottles, tubing, fabrics, ropes, packaging, diapers (as a liquid barrier).

Question 4

Syllabus References: A: 11.1, 11.2, 11.3

This question tested the candidates' knowledge of thermochemistry - the bond-making and bond-breaking processes, enthalpy changes in the dissolution of a salt, and energy profile diagrams.

Part (a) (i)

In this part, candidates were required to distinguish between the terms 'endothermic' and 'exothermic'.

**Candidates' Performance**

More than 50 per cent of candidates correctly distinguished between the terms 'endothermic' and 'exothermic'.

**Expected Responses**

Endothermic: Reactions that absorb heat from the surroundings. (Reactions in which the energy of the products is greater than the energy of the reactants.)

Exothermic: Reactions that give out heat to the surroundings. (Reactions in which the energy of the products is less than the energy of the reactants.)

Part (a) (ii)

In this part, candidates were required to classify bond-making and bond-breaking as either endothermic or exothermic processes.

**Candidates' Performance**

Many candidates incorrectly classified the bond-making and bond-breaking processes.

**Expected Responses**

Bond-breaking is endothermic, and bond-making is exothermic.

[It should be noted that the bond-breaking process requires that energy is supplied to the bond that is being broken, that is, energy is absorbed from the surroundings by the reactants. When potassium nitrate dissolves in water, the solution gets cold. Note here, that the water forms a part of the surroundings, and energy is absorbed from the water to break the ionic bonds in potassium nitrate.

Part (b) (i)

The following information was provided: "In an experiment, when 12.0 g of potassium nitrate,  $\text{KNO}_3$ , is dissolved in  $100 \text{ cm}^3$  of water, the temperature drops by  $4.20 \text{ }^\circ\text{C}$ . (RMM:  $\text{KNO}_3 = 101$ )"

In this part, candidates were required to calculate the number of moles of  $\text{KNO}_3$  used in the experiment.

**Candidates' Performance**

More than 50 per cent of candidates correctly calculated the number of moles of  $\text{KNO}_3$ .

### Common Incorrect Responses

- $101 / 12.0 = 8.4$  moles
- $100/101 = 0.99$  moles [These candidates divided the mass of 100 cm<sup>3</sup> of water by the RMM of KNO<sub>3</sub>.]

### Expected Responses

- No. of moles =  $12/101 = 0.12$  mol  
[No. of moles = mass of substance (in grams) divided by the relative molecular mass.]

### Part (b) (ii)

In this part, candidates were required to calculate the heat change for the reaction. The following information was provided:

Specific heat capacity of water =  $4.2 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ ; Heat change =  $m \times c \times \Delta T$ ; Density of water =  $1 \text{ g cm}^{-3}$ .

### Candidates' Performance

Many candidates were unfamiliar with this calculation. Most did not know that mass is represented by the symbol, **m**, and some did not attempt this part of the question.

### Common Incorrect Responses

- $12 \times 4.2 \times 4.2 = 212 \text{ g}$  [These candidates incorrectly used the mass (12 g) of salt instead of the mass (112 g) of the solution.]

### Expected Responses

In the expression, Heat change =  $m \times c \times \Delta T$ ,  $m$  = mass of solution,  $c$  = the specific heat capacity of the solution, and  $\Delta T$  = temperature change.

[In this question it is assumed that the specific heat capacity of the solution is the same as the specific heat capacity of water. This assumption is acceptable for dilute solutions. It is to be noted that  $m$  = mass of solution = mass of water + mass of salt =  $100 \text{ g} + 12 \text{ g} = 112 \text{ g}$ . In some instances where the mass of the salt is much less than the mass of water, the mass of solution can be assumed to be equal to the mass of water.]

The accepted answer is,

$$\text{Heat change} = m \times c \times \Delta T = (112 \text{ g}) \times (4.2 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}) \times (4.2 \text{ }^\circ\text{C}) = 1976 \text{ J}$$

### Part (b) (iii)

In this part, candidates were required to calculate the heat change for one mole of potassium nitrate.

#### **Candidates' Performance**

Fewer than 50 per cent of candidates completed the calculation correctly. Many candidates were unfamiliar with this calculation and so gave varying types of incorrect responses or no response.

#### **Expected Responses**

0.12 mol  $\text{KNO}_3$  absorbs 1976 J of heat  
 $\therefore$  1 mol  $\text{KNO}_3$  absorbs  $1976 \text{ J} / 0.12 \text{ mol} = 16,460 \text{ J mol}^{-1} = 16.46 \text{ kJ mol}^{-1}$ .

### Part (b) (iv)

Candidates were required to list two pieces of apparatus necessary to conduct the experiment in a school laboratory, and state how each piece of apparatus is used.

#### **Candidates' Performance**

Fewer than 50 per cent of candidates gave correct responses. The responses to this part of the question revealed that many candidates were unfamiliar with calorimetry experiments, and so they did not list pieces of apparatus that were necessary to successfully perform the experiment.

#### **Common Incorrect Responses**

- Beakers to mix the solutions
- Burette to add the solution
- Bunsen burner to heat the solution

#### **Expected Responses**

Any two of the following were accepted:

- Thermometer – for measuring temperature
- Styrofoam cup (with lid) – for insulation
- Measuring cylinder – for measuring volume of water
- Balance – for measuring mass of salt



Part (b) (v)

In this part, candidates were required to draw a labelled energy profile diagram to represent the enthalpy change for the reaction, and to indicate the sign of  $\Delta H$  for the reaction on the diagram.

**Candidates' Performance**

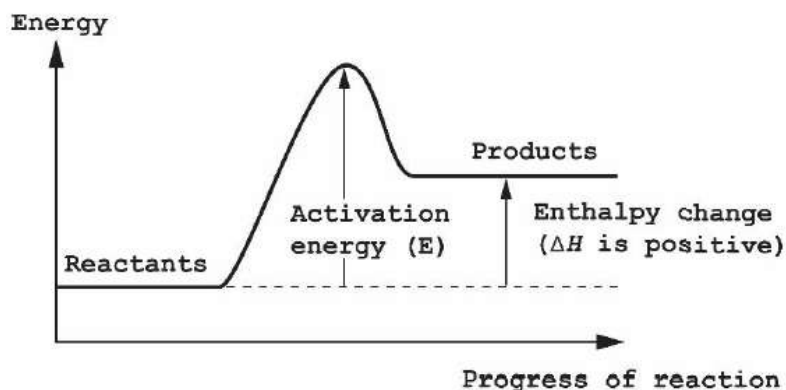
The majority of candidates did not clearly indicate the sign of  $\Delta H$  on the diagram, while some did not have appropriate labels. Several candidates did not attempt this part of the question.

**Common Incorrect Responses**

- A number of candidates misinterpreted this part of the question and presented a sketch of the apparatus.
- Incorrect labels include 'temperature' instead of 'energy'.

**Expected Responses**

The energy profile diagram should have the energy of the products higher than the energy of the reactants, both axes labelled correctly, and the correct sign of  $\Delta H$  indicated. Please see the following diagram.

Question 5

Syllabus References: B3.5, 3.6, 3.10

This organic chemistry question examined the candidates' knowledge of esters, specifically their ability to recognise them based on their name and molecular formula, their structure, properties and formation. The process of soap-making was also tested.

Part (a) (i)

In this part, candidates were given the name 'ethyl pentanoate' and its molecular formula, and were required to state the homologous series to which it belongs.

**Candidates' Performance**

The majority of the candidates were able to correctly identify that ethyl pentanoate is an ester.

**Common Incorrect Responses**

The most common incorrect response was carboxylic/alkanoic acid.

Part (a) (ii)

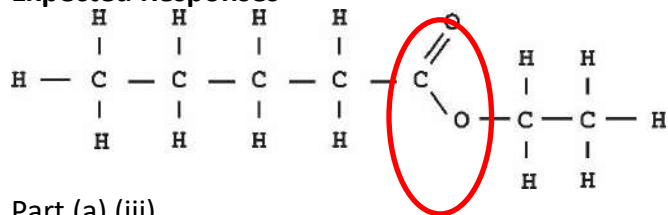
In this part, candidates were required to draw the fully displayed structure of ethyl pentanoate and circle the functional group.

**Candidates' Performance**

The majority of candidates experienced problems drawing the correct structure but had some indication of what the functional group should look like.

**Common Incorrect Responses**

There were several different types of incorrect structures drawn; some were just alkanes. One of the most common mistakes was not being able to circle the correct functional group or not circling any at all after the correct structure had been drawn.

**Expected Responses**Part (a) (iii)

In this part, candidates were asked to write the molecular formulae for the alcohol and carboxylic acid that will react to produce ethyl pentanoate.

**Candidates' Performance**

Most candidates were able to get at least one of the two marks available for this question.

**Common Incorrect Responses**

While the number of incorrect responses varied, the most common incorrect response was  $C_2H_5$ .

**Expected Response**

$C_2H_5OH$  – ethanol and  $C_4H_9COOH$  – pentanoic acid.

Part (a) (iv)

In this part, candidates were required to name the catalyst used in esterification.

**Candidates' Performance**

Fewer than 80 per cent of the candidates were able to correctly answer this question.

**Common Incorrect Responses**

Some candidates incorrectly responded with a variety of metals for example, Ni, Fe. Some candidates stated other methods of increasing rates of reactions, for example, temperature. However, the most common incorrect response was simply stating sulfuric acid without noting that it was concentrated. No mark was awarded for this response.

**Expected Responses**

Concentrated sulfuric or concentrated phosphoric acid was the expected response.

Part (a) (v)

In this part, candidates were asked to give an explanation why esters have low solubility in water but a simple alcohol is very soluble.

**Candidates' Performance**

The majority of the candidates were able to get at least one of the two marks available for this part.

### Common Incorrect Responses

Candidates that were not awarded marks related solubility to incorrect concepts such as

- Simple versus complex molecules
- Density
- Energy required to break bonds

Most of the candidates who were awarded one mark received that mark because they correctly recognised that alcohol was polar but made no reference to the ester.

### Expected response

It was expected that the candidates would recognise that an ester has low solubility since it has no polar OH bonds for bonding with water molecules, whereas with a simple alcohol there is increased hydrogen bonding between polar OH bonds of alcohol and the polar OH bonds in water.

### Part (b)

In this part, candidates were asked to state the reaction condition and reagent used for the alkaline hydrolysis of ethyl ethanoate and to write a balanced chemical equation for the reaction.

### Candidates' Performance

Most candidates were able to state either the reaction conditions or reagent but writing the balanced chemical equation proved difficult.

### Common Incorrect Responses

The most common incorrect answer for reagent was sulfuric acid. This was surprising since the question specifically referred to *alkaline* hydrolysis.

### Expected Responses

Reaction conditions:

- Heating (any temperature value above room temperature)
- Sodium hydroxide.

Equation:

- $\text{CH}_3\text{COOC}_2\text{H}_5 + \text{NaOH} \rightarrow \text{CH}_3\text{COO}^-\text{Na}^+ + \text{C}_2\text{H}_5\text{OH}$

### Part (c)

In this part, candidates were required to name the process used to make soap and state a source for natural esters.

#### **Candidates' Performance**

Most candidates were able to achieve at least one of the two marks allocated.

#### **Common Incorrect Responses**

The most common incorrect response for the process was esterification. Some candidates wrote soapification.

#### **Expected Responses**

Process: Saponification

Source: Vegetable oils / animal fats

### Question 6

Specific Objectives: A:9.8, C:6.3 (H<sub>2</sub>O), 5.6, 5.8

This inorganic chemistry question examines the candidates' knowledge of the laboratory test for water vapour, unique properties of water and the electrolysis of acidified water (dilute sulfuric acid).

### Part (a)

In this part, candidates were required to list four unique properties of water.

#### **Candidates' Performance**

Fewer than 80 per cent of the candidates were able to answer this question correctly.

#### **Common Incorrect Responses**

Some candidates were able to list at least one property accurately to earn partial marks. However, the majority failed to provide the four required properties.

#### **Expected Responses**

Any four of the following:

- Water is a universal solvent. (Water is polar solvent/good solvent dissolving most liquids or similar type statements or expressions.)
- Water has a high heat capacity.
- Water has a relatively high boiling point.
- Water has a high surface tension.
- Water is less dense as a solid than it is in the liquid state.
- Water has a high latent heat of evaporation/vaporization.
- Water has cohesive and adhesive properties (These were not accepted as separate points.)

### Part (b)

In this part, candidates were asked to describe the laboratory test for water vapour.

#### **Candidates' Performance**

The majority of the candidates were able to get at least one of the two marks available for this part.

#### **Common Incorrect Responses**

Candidates were able to identify at least one reagent to identify water vapour but in most cases, they were not able to identify or omitted the colour change that was expected when using the named reagent.

#### **Expected response**

##### **EITHER**

One of the reagents with corresponding color changes:

Dry/blue cobalt chloride paper or cobalt chloride turns from blue to pink in the presence of water vapour.

##### **OR**

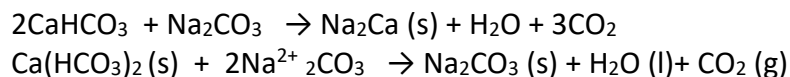
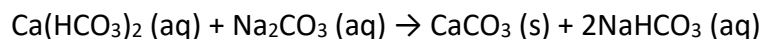
Anhydrous/white copper(II) sulfate turns white to bright/dark blue/blue.

### Part (c)

In this part, candidates were asked to write the balanced equation, including stating symbols to show the removal of temporary hardness of water by use of washing soda (sodium carbonate).

#### **Candidates' Performance**

Most candidates were unable to write the equation accurately.

**Common Incorrect Responses****Expected Responses**Part (d)

In this part, candidates were required to predict the ions that will migrate to the anode and cathode during the electrolysis of dilute sulfuric acid (acidified water). They were also required to write a balanced chemical equation, including state symbols, for the electrolysis of dilute sulfuric acid (acidified water).

**Candidates' Performance**

Most candidates were unable to provide the accurate answers for this question. The majority earned partial marks and there were a great number of no responses for this part of the question.

**Common Incorrect Responses**

Ions at Anode:  $\text{H}^+$

Ions at Cathode:  $\text{OH}^-$ ,  $\text{SO}_4^{2-}$

Balanced half equation:  $4\text{OH}^-(\text{aq}) \rightarrow \text{O}_2(\text{g}) + \text{H}_2(\text{l}) + 4\text{e}^-$

**Expected Responses**

Ions at Anode: hydroxide ion,  $\text{OH}^-$ , sulfate ion,  $\text{SO}_4^{2-}$

Ions at Cathode: hydrogen ion,  $\text{H}^+$

Overall equation:  $2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$

Balanced half equations:  $4\text{OH}^-(\text{aq}) \rightarrow \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^-$

$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$

**OR**

$4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2(\text{g})$

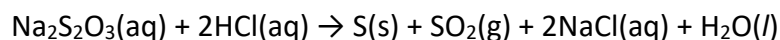
**Paper 032 – Alternative to School-Based Assessment**Question 1

Syllabus References: A:6.2, 6.6, 8.3, 8.5, 10.1, 10.2, 10.4

This question was a practical exercise which examined the candidates' knowledge of *rate of reaction*, and specifically their ability to investigate how the rate of a chemical reaction is affected by the concentration of the reactants.

### Part (a)

The reaction occurring in the experiment produces colloidal sulfur and is as follows:



Candidates were required to carry out five similar experiments in which different concentrations of aqueous sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ , were allowed to react with a fixed concentration of dilute hydrochloric acid, HCl. The reaction beaker was placed on top of a cross, marked on a piece of paper. The colloidal sulfur made the reaction mixture turn opaque, and the cross disappeared. The time taken for the cross to disappear was noted.

### **Candidates' Performance**

The majority of candidates successfully performed the experiment and reported data with the expected trend, that is, the lower the concentration of thiosulfate, the longer the time taken for the cross to disappear.

### **Common Incorrect Responses**

Some candidates did not report all the times in seconds, but reported them in minutes and seconds, as read from the digital timer. For example, 1:25.6 (1 minute and 25.6 seconds) should be reported as 85.6 seconds.

### **Expected Responses**

It was expected that solutions with lower concentration of thiosulfate would have a longer reaction time.

### Part (b)

In this part, candidates were required to calculate the reciprocal times from the times taken and record them in the appropriate spaces in the table.

### **Candidates' Performance**

The majority of candidates performed the calculations correctly; however, some candidates rounded the values too much, ended up with too few significant figures and so the data did not produce a good graph.



### Common Incorrect Responses

- Some candidates did not understand what was meant by the term ‘reciprocal time’ and so did not do the correct calculation.
- Improper rounding; for example, in the data shown in the table, some candidates would have rounded too much and ended up with reciprocal times of 0.02, 0.02, 0.01 and 0.01 for the first four points. (This would have affected the quality of the plot in the next part of the question.)

### Expected Responses

An example of the calculation of reciprocal time is shown:

Time = 44.6 s

Reciprocal time =  $1/\text{time} = 1/(44.6 \text{ s}) = 0.0224 \text{ s}^{-1}$

A section of the table with actual student data of time and correct calculation of reciprocal time, is shown below.

<b>[Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>] (mol dm<sup>-3</sup>)</b>	<b>Time (s)</b>	<b>Reciprocal time (s<sup>-1</sup>)</b>
0.10	<b>53</b>	<b>0.019</b>
0.08	<b>64</b>	<b>0.016</b>
0.06	<b>89</b>	<b>0.011</b>
0.04	<b>122</b>	<b>0.008</b>
0.02	<b>295</b>	<b>0.003</b>

### Part (c)

In this part, candidates were required to plot a graph of reciprocal time against thiosulfate concentration. A graph was provided with the horizontal axis already labelled and with a preselected scale. Candidates were required to select an appropriate scale for the vertical axis which represented reciprocal time.

### Candidates' Performance

The majority of candidates chose appropriate scales, plotted the points accurately, drew a good line of best fit, and so received full marks for this part of the question.

### Common Incorrect Responses

- Some candidates did not choose a uniform scale and so the plot did not give a straight line.

### Part (d)

In this part, based on the graph drawn, candidates were required to determine and record the effect of concentration of aqueous  $\text{Na}_2\text{S}_2\text{O}_3$  on the rate of reaction.

### Candidates' Performance

A number of candidates did not respond to this part of the question. Some candidates were unaware that reciprocal time is an indication of the rate of reaction. However, the majority stated that an increased concentration resulted in an increase in the rate of reaction.

### Common Incorrect Responses

- The rate of reaction decreases with concentration.
- The higher the concentration the shorter the time. (This is an observation from the experiment, and does not address the question.)

### Expected Responses

Any of the following statements would be accepted:

- The rate of reaction increases with an increase in concentration.
- The rate of reaction is directly proportional to concentration.
- There is a linear relationship between the rate of the reaction and concentration.
- The rate of reaction decreases with a decrease in concentration.

### Part (e)

In this part, candidates were required to calculate the number of moles of  $\text{Na}_2\text{S}_2\text{O}_3$  used in Experiment 1.

### Candidates' Performance

Many candidates seemed unfamiliar with this type of calculation, and gave responses which included calculation of the RMM of  $\text{Na}_2\text{S}_2\text{O}_3$ .

### Common Incorrect Responses

- Some candidates viewed the equation of reaction and incorrectly stated that 1 mole of  $\text{Na}_2\text{S}_2\text{O}_3$  was used.
- A large number of candidates assumed that the concentration of the thiosulfate solution was 0.1 M instead of 0.2 M.

### Expected Responses

1000  $\text{cm}^3$  contain 0.2 mol  
 1  $\text{cm}^3$  contains  $(0.2/1000)$  mol  
 50  $\text{cm}^3$  contain  $(0.2/1000) \times 50 = 0.010$  mol

### Part (f)

In this part, candidates were required to calculate the mass of sulfur that would be precipitated if the reaction went to completion.

### Students' Performance

Some candidates gave no response, while some were unaware of how to approach the question, and did not realize that Part (f) is linked to Part (e). Fewer than 50 per cent of the candidates did the correct calculation.

### Common Incorrect Responses

- $1 \text{ mol} \times 32 = 32 \text{ g}$  (Assuming that 1 mole of sulfur is produced)

### Expected Responses

From equation: 1 mol  $\text{Na}_2\text{S}_2\text{O}_3$  produces 1 mole of S  
 0.010 mol  $\text{Na}_2\text{S}_2\text{O}_3$  produces 0.010 mol S  
 Mass of S =  $0.010 \times 32 = 0.32 \text{ g}$

## Question 2

Syllabus References: C 6.1, 6.2

This was a qualitative analysis question. Candidates were required to deduce the observations that would be made when various tests were performed on two unknown solutions. A maximum of 10 marks were awarded for this question and it was poorly done. More than 50 per cent of the candidates received less than 4 out of 10 for this question. This suggests that candidates had little experience in this area.

## Question 3

Syllabus References: C2.1, 2.2

Candidates were required to plan and design an experiment to determine which of the two metals, A or B, is more reactive given the hypothesis that Metal A is more reactive towards acids than Metal B.

The candidates were expected to describe a possible experimental procedure, list apparatus and materials and highlight variables to control. Additionally, candidates were required to draw a table that could be used for data collection as well as discuss possible results as they related to the hypothesis, state a possible source of error and one precaution that should be taken during the experiment.

### **Candidates' Performance**

Overall, the question was fairly well done, and approximately 60 per cent of the candidates were able to achieve 6 out of the possible 12 marks.

For the procedure, most candidates were able to get two of the three marks allotted. The mark most candidates missed was that awarded for a point of measurement, hence comparison between A and B. Additionally most candidates had difficulty with the discussion, the source of error and the precaution.