CARIBBEAN EXAMINATIONS COUNCIL

CAPE®
Chemistry

SYLLABUS
SPECIMEN PAPER
MARK SCHEME
SUBJECT REPORTS

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CAPE® Chemistry Free Resources

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CAPE® Chemistry Subject Reports:

Chemistry

Chemistry is a branch of science concerned with the properties and interactions of the substances of which matter is composed. This CAPE Chemistry Syllabus provides the specific knowledge base and the skills and attitudes associated with advanced study of the subject. It is structured to ensure that students become aware of their moral, social and ethical responsibilities, as well as the benefits to be derived from the practical application of scientific knowledge. Completion of the course of study outlined in this syllabus will enable persons to apply chemical principles to societal concerns such as birth control, communicable diseases, environmental pollution, global warming and the depletion of natural resources.

This syllabus is arranged into TWO Units, each made up of three Modules.

Unit 1: Chemical Principles and Applications I

- Module 1 Fundamentals in Chemistry
- Module 2 Kinetics and Equilibria
- Module 3 Chemistry of the Elements

Unit 2: Chemical Principles and Applications II

- Module 1 The Chemistry of Carbon Compounds
- Module 2 Analytical Methods and Separation Techniques
- Module 3 Industry and the Environment

CARIBBEAN
EXAMINATIONS
COUNCIL

Caribbean Advanced
Proficiency Examination®

SYLLABUS

CHEMISTRY

CXC A11/U2/17

Effective for examinations from May–June 2019

CAPE®

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Contents

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First issued 1999
Revised 2001
Revised 2006
Revised 2017

Please check the website, www.cxc.org for updates on CXC's syllabuses.

Introduction

The Caribbean Advanced Proficiency Examination® (**CAPE®**) is designed to provide certification of the academic, vocational and technical achievement of students in the Caribbean who, having completed a minimum of five years of secondary education, wish to further their studies. The examinations address the skills and knowledge acquired by students under a flexible and articulated system where subjects are organised in 1-Unit or 2-Unit courses with each Unit containing three Modules. Subjects examined under **CAPE®** may be studied concurrently or singly.

The Caribbean Examinations Council offers three types of certification at the **CAPE®** level. The first is the award of a certificate showing each **CAPE®** Unit completed. The second is the **CAPE®** Diploma, awarded to candidates who have satisfactorily completed at least six Units, including Caribbean Studies. The third is the **CXC®** Associate Degree, awarded for the satisfactory completion of a prescribed cluster of eight **CAPE®** Units including Caribbean Studies, Communication Studies and Integrated Mathematics. Integrated Mathematics is not a requirement for the **CXC®** Associate Degree in Mathematics. The complete list of Associate Degrees may be found in the **CXC®** Associate Degree Handbook.

For the **CAPE®** Diploma and the **CXC®** Associate Degree, candidates must complete the cluster of required Units within a maximum period of five years. To be eligible for a **CXC®** Associate Degree, the educational institution presenting the candidates for the award, must select the Associate Degree of choice at the time of registration at the sitting (year) the candidates are expected to qualify for the award. Candidates will not be awarded an Associate Degree for which they were not registered.

Chemistry Syllabus

♦ RATIONALE

Science plays a major role in the evolution of knowledge. It empowers us to use creative and independent approaches to problem-solving. It arouses our natural curiosity and enables us to meet diverse, and ever expanding, challenges. It enhances our ability to inquire, seek answers, research, and interpret data. These skills *use the scientific method* which lead to the construction of theories and laws that help us to explain natural phenomena and exercise control over our environment. Science is, thus, an integral component of a balanced education.

Chemistry is a fundamental science that should be included as a part of our science education. Chemical principles are currently applied to societal concerns, such as, the use of pharmaceuticals, communicable diseases, environmental pollution, forensics and depletion of natural resources. As such, chemistry is a major area of scientific study which impinges on and influences every facet of our daily lives - the food we eat, the clothes we wear, our health, environment, and recreational activities.

The **CAPE®** 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. This syllabus places more emphasis on the understanding and application of chemical concepts and principles. Consequently, students will develop skills that will be of long term value in an increasingly *technological and entrepreneurial* world, rather than focusing on large quantities of factual information. Furthermore, it encourages the use of various student-centred teaching-learning strategies and assessment, while at the same time, catering to the multiple intelligences, and different learning styles and needs.

The most important natural resource in the Caribbean is its people. If the Caribbean is to play an important role in the new global village and survive economically, a sustained development of the scientific and technological resources of its people is essential. This syllabus 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. Students will be given the opportunity to demonstrate 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

The syllabus aims to:

1. acquire the knowledge and understanding of chemical principles so as to be suitably prepared for employment and for further studies at the tertiary level;
2. develop an ability to communicate scientific information in a logical and structured manner;
3. appreciate, understand and use the scientific method in the solving of problems;
4. *assist in the development of critical thinking, analytical, and practical skills;*
5. apply chemical knowledge to everyday life situations;
6. recognise that advances in chemistry are constantly influenced by technological, economic, social, cultural, and ethical factors;
7. appreciate that some of the advances in the field of chemistry are the results of the contributions from scientists in other disciplines;
8. further develop the spirit of inquiry in order to continue the search for new ways in which the resources of our environment can be used in a sustainable way;
9. make use of chemical data, concepts, principles, and terminology in communicating chemical information;
10. recognise the power, impact, and influence which chemistry has in a modern scientific world;
11. develop the ability to work independently and collaboratively with others when necessary;
12. appreciate the significance and limitations of science in relation to social and economic development;
13. integrate Information and Communication Technology (ICT) tools and skills into the teaching and learning of chemical concepts; and,
14. contribute to making the Caribbean scientifically literate.

♦ SKILLS AND ABILITIES TO BE ASSESSED

The skills, students are expected to have developed on completion of this syllabus, have been grouped under three main headings, namely:

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

1. Knowledge and Comprehension (KC)

(a) Knowledge – the ability to identify, remember and grasp the meaning of basic facts, concepts and principles.

(b) Comprehension– the ability to select appropriate ideas, match, compare and cite examples and principles in familiar situations.

2. Use of Knowledge (UK)

(a) Application

The ability to:

(i) use facts, concepts, principles and procedures in familiar and in novel situations;

(ii) transform data accurately and appropriately; and,

(iii) use formulae accurately for computational purposes.

(b) Analysis and Interpretation

The ability to:

(i) identify and recognise the component parts of a whole and interpret the relationship among those parts;

(ii) identify causal factors and show how they interact with each other;

(iii) infer, predict and draw conclusions; and,

(iv) make necessary and accurate calculations and recognise the limitations and assumptions involved.

(c) Synthesis

The ability to:

(i) combine component parts to form a new and meaningful whole; and,

(ii) make predictions and solve problems.

(d) Evaluation

The ability to:

- make reasoned judgements and recommendations based on the value of ideas and information and their implications.

3. **Experimental Skills (XS)**

(a) Observation, Recording and Reporting

The ability to:

- (i) use the senses to perceive objects and events accurately;
- (ii) record the results of a measurement accurately;
- (iii) select and use appropriate formats and presentations, such as tables, graphs and diagrams;
- (iv) organise and present a complete report in a clear and logical form using spelling, punctuation and grammar with an acceptable degree of accuracy; and,
- (v) report accurately and concisely.

(b) Manipulation and Measurement

The ability to:

- (i) handle chemicals carefully and use them economically;
- (ii) appropriately prepare materials for observation or investigation; and,
- (iii) assemble and use simple apparatus and measuring instruments.

(c) Planning and Designing

The ability to:

- (i) recognise the problem and formulate valid hypotheses;
- (ii) choose appropriate experimental methods and sampling techniques;
- (iii) choose appropriate apparatus;
- (iv) plan and execute experimental procedures in a logical and sequential form within the time allotted;
- (v) use controls where appropriate; and,
- (vi) modify experimental methods after initial work or unexpected outcomes.

♦ PREREQUISITES OF THE SYLLABUS

Any person with a good grasp of the Caribbean Secondary Education Certificate (**CSEC®**) Chemistry and Mathematics syllabuses, or the equivalent, should be able to pursue the course of study defined by this syllabus. However, successful participation in the course of study will also depend on the possession of good verbal, written communication skills.

STRUCTURE OF THE SYLLABUS

The subject is organised in two (2) Units. A Unit comprises three (3) Modules each requiring 50 hours. The total time for each Unit, is therefore, expected to be 150 hours. Each Unit can independently offer students a comprehensive programme of study with appropriate balance between depth and coverage to provide a basis for further study in this field.

Unit 1: Chemical Principles and Applications I

Module 1 - Fundamentals in Chemistry
Module 2 - Kinetics and Equilibria
Module 3 - Chemistry of the Elements

Unit 2: Chemical Principles and Applications II

Module 1 - The Chemistry of Carbon Compounds
Module 2 - Analytical Methods and Separation Techniques
Module 3 - Industry and the Environment

It is recommended that of the approximately 50 contact hours suggested for each Module, a minimum of about 20 contact hours be spent on laboratory related-activities, such as conducting experiments, making field trips and viewing audio-visual materials.

SUGGESTIONS FOR TEACHING THE SYLLABUS

It is recommended that Unit 1, Module 1 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. For each Module, there are general and specific objectives. The general and specific objectives indicate the scope of the content, including practical work, on which the examination will be based. However, unfamiliar situations may be presented as stimulus material in a question. Explanatory notes are provided to the right of some specific objectives. These notes provide further guidance to teachers as to the level of detail required. The Suggested Practical Activities indicate those areas of the syllabus that are suitable for practical work. However, practical work should not necessarily be limited to these activities.

Teachers are strongly encouraged to *integrate ICT and 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 *to facilitate the development of teamwork and the entrepreneurial spirit.*

This syllabus caters to varying teaching and learning styles, with specific attention made to ensure the interrelatedness of concepts. 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.

♦ 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. Students should be made aware of the environmental impact of the improper disposal of waste and the associated safety hazards. Teachers should emphasise the use of appropriate safety gear and the need for acceptable laboratory practices. The **CAPE®** Chemistry Syllabus focuses on the skills listed below.

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 exposed wine usually acquires a sour taste after a few weeks.

   Example: Why do wines which are exposed to air acquire a sour taste after a few weeks?

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

   Example: *When wines are exposed to air, they acquire a sour taste after a few weeks.*

   (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; and,

(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) sintered glass crucible;

(xiv) suction pump;

(xv) voltmeter; and,

(xvi) ammeter.

This list is not exhaustive.

(b) Use appropriate apparatus.

(c) Take accurate measurements.

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

(a) **Recording**

Student's ability to record observations and to collect and organise 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, and 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*** *(see 4: Analysis and Interpretation).*

(vii) ***Conclusion*** *(should be related to the Aim).*

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; and,

(g) analyse and interpret results and observations, and make conclusions.

UNIT 1: CHEMICAL PRINCIPLES AND APPLICATIONS I

MODULE 1: FUNDAMENTALS IN CHEMISTRY

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand that theories in chemistry are subject to change;
2. understand the theory of atoms as a useful construct that explains the structure and behaviour of matter, and the impact of nuclear chemistry on society;
3. understand the development of the periodic table for the classification of elements;
4. appreciate that the forces of attraction between particles influence the properties and behaviour of matter;
5. understand the mole concept;
6. understand redox reactions;
7. understand the kinetic theory;
8. understand concepts associated with energy changes; and,
9. develop the ability to perform calculations involving energy changes.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1. **<u>Atomic Structure and the Periodic Table</u>**		
Students should be able to:		
1.1. discuss the process of theoretical change with respect to Dalton's atomic theory;	The postulates of Dalton's Atomic theory and modifications of the theory. Mention the criteria that are considered when theories are accepted, for example, fit between evidence and theoretical constructs, reliability and accuracy of data, replicability of experiments, consensus within the scientific community, societal factors.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>**Atomic Structure and the Periodic Table (cont'd)**</u>		
Students should be able to:		
1.2. describe the structure of the atom;	Simple treatment: properties of protons, neutrons and electrons only; their relative masses and charges, location and their behaviour in electric and magnetic fields.	
1.3. define the following terms:		
(a) mass number;		
(b) isotopes; and,		
(c) relative atomic and isotopic masses based on the ${}^{12}_{6}\text{C}$ scale.	Must include reference to the mass of carbon-12	
1.4. explain the phenomenon of radioactivity;	Write equations representing nuclear reactions involving ∝, β and γ emissions; n/p ratio. For example, when representing alpha: ${}^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\text{He}$ or ${}^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\propto$ Properties of particles are not required. Positrons(r) are not required.	
1.5. cite the use of radioisotopes;	Identification of at least three uses.	

Atomic Structure and the Periodic Table (cont'd)

Students should be able to:

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1.6.	calculate the relative atomic mass of an element, given isotopic masses and abundances;		
1.7.	explain how data from emission spectra provide evidence for discrete energy levels within the atom;	Bohr model, simple treatment of the emission spectrum of hydrogen; Lyman series, Balmer series; ΔE or $dE = hv$.	
1.8.	describe the atomic orbitals;	Principal quantum numbers, s, p and d orbitals; relative energies of 4s and 3d orbitals. Refer to Module, 3 Specific Objective 5.1.	
1.9.	describe the shapes of the s and p orbitals;		
1.10.	determine the electronic configurations of atoms and ions in terms of s, p and d orbitals;	Consider elements from atomic numbers 1 to 30.	
1.11.	state the factors which influence the first ionisation energy of elements;	Include atomic radii, nuclear charge, shielding.	
1.12.	explain how ionisation energy data provide evidence for sub-shells; and,	Use Period 3 as an example.	
1.13.	derive the electronic configuration of an element from data on successive ionisation energies.		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2. <u>**Forces of Attraction**</u>		
Students should be able to:		
2.1. state the various forces of attraction between particles;	Ionic bonds, covalent bonds, hydrogen bonds, metallic bonds, Van der Waals forces. (Permanent-permanent dipole; induced-induced dipole or temporary/instantaneous-induced dipole).	
2.2. state the relationship between forces of attraction and states of matter;		
2.3. relate physical properties of matter to differences in strength of forces of attraction;	Variation in melting points, boiling points and solubilities.	Conduct melting point and boiling point determinations; solubilities in polar and non-polar solvents, electrical conductivity. Illustrate practically the properties of ionic and covalent compounds.
2.4. explain the formation of the following: (a) ionic bonds; (b) covalent bonds; and, (c) metallic bonds.	Covalent bonds should be discussed in terms of orbital overlap which results in the formation of sigma (σ) and pi (π) bonds. Metallic bonding is to be treated as a lattice of positive ions surrounded by mobile electrons. Electronegativity and polarity of bonds should be included.	
2.5. describe co-ordinate (dative covalent) bonding;	Use 'dot-cross' diagrams; refer to simple systems (for example, BF_3/NH_3).	

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Forces of Attraction (cont'd)			
Students should be able to:			
2.6.	describe the origin of inter-molecular forces;	Refer to hydrogen bonding; Van der Waals forces, permanent dipole. Refer to Module 3	
2.7.	predict the shapes of, and bond angles in simple molecules and ions;	*Application of* the VSEPR theory to include the following systems: trigonal (for example, BF_3), linear (for example, $BeCl_2$), tetrahedral (for example, NH_4 $^+$, CH_4), pyramidal (for example, H_3O^+, CH_3, and NH3), non-linear (for example, H_2O), octahedral (for example, SF_6).	Construct molecular models and measure bond angles.
2.8.	explain the shapes and bond angles of simple organic compounds;	Ethane, ethene and benzene; apply the concept of hybridisation and resonance. Include sp^2 and sp^3 hybridisation.	
2.9.	predict the shapes and bond angles of molecules similar to ethane; and,	Simple substituted derivatives, for example, dichloroethane.	
2.10.	describe qualitatively the lattice structure of crystalline solids and their relation to physical properties.	Simple molecular (for example, I_2), hydrogen bonded (for example, ice), giant molecular (for example, SiO_2), ionic (for example, NaCl), metallic (for example, Cu), giant atomic (for example, graphite and diamond) structures.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
3. **The Mole Concept**		
Students should be able to:		
3.1. apply Avogadro's law;	Perform calculations involving molar volumes.	
3.2. define the mole;		
3.3. define the term 'molar mass';		
3.4. write balanced molecular and ionic equations;		
3.5. perform calculations based on the mole concept;	Relate to masses of substances, volumes of gases, volumes and concentrations of solutions.	
3.6. apply the mole concept to molecular and ionic equations;		
3.7. calculate empirical and molecular formulae;	Combustion data; absolute masses or relative abundances of elements.	
3.8. perform titrimetric analyses; and,		Conduct acid/base titrations and redox titrations. (dichromate (VI)), hydrogen peroxide, iodide thiosulfate, manganate (VII); mean (consecutive accurate values within 0.10 cm^3 of each other), significant figures.
3.9. use results from titrimetric analyses to calculate: (a) mole ratios; (b) molar concentration; and, (c) mass concentration.		

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
4.	**Redox Reactions**		
Students should be able to:			
4.1.	explain redox reactions in terms of electron transfer and changes in oxidation state (number);	Refer to Module 1, Specific Objective 3.8.	
4.2.	construct relevant half equations for redox reactions;	*Redox equations should be constructed under both acidic and basic conditions.*	
4.3.	deduce balanced equations for redox reactions from relevant half equations; and,		
4.4.	order elements in terms of oxidising or reducing ability.		Perform simple displacement reactions to order elements in terms of oxidising or reducing ability; addition of zinc to copper (II) sulfate solution; addition of chlorine water to bromide or iodide solutions.
5.	**Kinetic Theory**		
Students should be able to:			
5.1.	state the basic assumptions of the kinetic theory with reference to an ideal gas;		
5.2.	explain the differences between real and ideal gases;	Qualitative treatment only – the conditions which are necessary for a gas to approach ideal behaviour, the limitations of ideality at very high pressures and very low temperatures. Include graphical representations.	

UNIT 1
MODULE 1: FUNDAMENTALS IN CHEMISTRY (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Kinetic Theory cont'd		
Students should be able to:		
5.3. state Boyle's law and Charles' law;	Include graphical representations.	
5.4. perform calculations using: (a) Boyle's law; (b) Charles' law; and,	Calculations involving the use of Van der Waals equation of state are not required.	
(c) the ideal gas equation ($pV = nRT$); and,	Include calculations of relative molar mass.	
5.5. explain the following: (a) the liquid state; (b) melting; and, (c) vaporisation.		
6. **Energetics**		
Students should be able to:		
6.1. state that chemical reactions take place through energy changes (usually in the form of heat) associated with the breaking and making of bonds;	Note that bond making is an exothermic process, that is: ΔH - ve while bond breaking is an endothermic process, that is: ΔH + ve.	
6.2. state that energy changes occur in chemical reactions associated with the making and breaking of bonds;		
6.3. explain the differences between exothermic and endothermic reactions using energy profile diagrams;		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Energetics cont'd</u>		
Students should be able to:		
6.4. explain the term 'bond energy';	Calculations involving bond energy data.	
6.5. explain how bond energy data may be used to show the relationship between strength of covalent bonds and reactivity of covalent molecules;	Lack of reactivity of nitrogen. Consider factors which affect bond energy.	
6.6. apply concepts associated with enthalpy changes;	Include enthalpy change of formation, combustion, neutralisation, reaction, hydration, solution, atomisation, ionisation energy, electron affinity and lattice energy.	
6.7. explain the effect of ionic charge and radius on the magnitude of lattice energy;	No calculation needed.	
6.8. state Hess's law of constant heat summation; and,	Use standard conditions.	
6.9. calculate enthalpy changes from appropriate experimental data.	This will require construction of energy cycles including Born Haber cycles. Data may be obtained experimentally or provided.	Experiments may include heats of reaction, solution and neutralisation.

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

Atomic Structure and the Periodic Table

1. Ask students to read *A Short History of Nearly Everything* by Bill Bryson and discuss the history of the development of the atomic models. (Audiobook available on YouTube).

2. Allow students to carry out practical weighing activities which compare the mass of different objects (for example, coins) in order to develop the concept of relative mass and changing standards of comparison.

3. Ask students to present the story of the discovery of the phenomenon of radioactivity (use video material if available).

4. Have class discussion on the impact of radioactivity in everyday life as cited (from newspaper articles and the electronic media including the Internet).

5. Provide students with appropriate reading material prior to class session. *During the class session, teacher and students engage in a discussion on* the strengths and weaknesses of the Bohr and Rutherford models of the atom.

6. Have class discussions on the evidence that led to modification of Dalton's atomic theory and on the historical development of the Periodic Table.

Forces of Attraction

1. Arrange students in small groups, and provide them with appropriate quantitative data and guided questions which will lead them to infer that forces of attraction vary in strength.

2. Ask students to use ball and stick to make models for different molecular shapes.

The Mole Concept

1. Use appropriate analogies to explain that the mole is a specific amount of particles (atoms, molecules, ions, electrons).

2. Allow students to conduct laboratory work including dilution factor, titration, displacement and yield calculations.

Redox Reactions, Kinetic Theory and Energetics

1. Use practical activities, diagrams, graphs and guided questions to enhance students' understanding of different concepts.

UNIT 1
MODULE 1: FUNDAMENTALS IN CHEMISTRY (cont'd)

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Amateis, P., and Silberberg, M.	*Chemistry: The Molecular Nature of Matter and Change. McGraw-Hill Education, 2014.*
Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Clarke, J.	Calculations in AS/A Level Chemistry. Essex: Pearson Education Limited, 2000.
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Hill, G., and Holman, J.	Chemistry in Context. London: Nelson Thorne Limited, 2001.
Lister, T., Renshaw, J.	Understanding Chemistry for Advanced Level. Cheltenham: Trans-Atlantic Publications, 2000.
Maylin-Moseley, V.	*Advanced Level Chemistry for Life - Unit 1. Barbados: VHM Publishing, 2017.*
Norris, R., Barrett, L., Maynard-Alleyne, A. and Murray, J.	**CAPE®** Chemistry Study Guide: Cheltenham: Nelson Thorne Limited, 2012.
Ramsden, E.	A-Level Chemistry. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the concepts associated with reaction rates;
2. understand the concepts associated with chemical equilibrium;
3. appreciate that equilibrium concepts can be applied to chemical systems; and,
4. appreciate that principles of kinetics and equilibria can be applied to industrial and biological processes.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1. **<u>Rates of Reaction</u>**		
Students should be able to:		
1.1. explain the concepts associated with reaction rates;	Include a study of rate constant, order of reaction, half-life, rate-determining step, activation energy, collision theory, (simple treatment only), and catalysis. Include enzymes in industrial and biological processes.	
1.2. design suitable experiments for studying the factors which affect rates of reactions;	Include effects of concentration, temperature and catalysts.	Conduct suitable experiments for studying the factors which affect rates of reactions; express results in the form of tables and graphs.
1.3. construct rate equations of the form: Rate = $k [A]^n [B]^m$ limited to simple cases involving zero, first and second order reactions;	Rate equations may be derived or deduced from experimental data supplied.	
1.4. deduce the order of reaction from appropriate data;	Include deductions of possible reaction mechanisms.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Rates of Reaction cont'd</u>		
Students should be able to:		
1.5. interpret concentration against time and concentration against rate for zero and first order reactions;	Qualitative and quantitative treatments required.	
1.6. perform calculations from rate data;	Calculate initial rates and rate constants.	
1.7. perform simple calculations using half-life data; and,	Limited to first order reactions.	
1.8. explain the effect of temperature and catalysts on the rate of the reaction using Boltzmann distribution of energies (and of collision frequency).	Include the use of Boltzmann distribution curves.	
2. **<u>Principles of Chemical Equilibrium</u>**		
Students should be able to:		
2.1. explain the concept of dynamic equilibrium;	Consider examples of static and dynamic equilibrium. Refer to physical and chemical processes.	
2.2. state the characteristics of a system in dynamic equilibrium;		
2.3. define the terms K_c and K_p;	Write equilibrium constant expressions in terms of K_c and K_p.	Conduct a simple experiment to determine the value of K_c for a reaction.
2.4. perform calculations involving equilibrium constants in terms of concentration, (K_c) and partial pressure, (K_p);	Conversion of K_c to K_p is not required. Quadratic equations are not required.	

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Principles of Chemical Equilibrium cont'd			
Students should be able to:			
2.5.	state Le Chatelier's principle;		
2.6.	apply Le Chatelier's principle to explain the effects of changes in temperature, concentration and pressure on a system in equilibrium; and,	Include reference to the characteristics of a system in dynamic equilibrium.	
2.7.	interpret how changes in concentration, pressure, temperature or the presence of a catalyst may affect the value of the equilibrium constant.	Include references to the Haber process and the Contact process.	Perform calculations based on the profitability of these processes on manufacturing of commercial commodities.
3.	**Acid/Base Equilibria**		
Students should be able to:			
3.1.	explain the differences in behaviour of strong and weak acids and bases, using Bronsted-Lowry theory;		
3.2.	define the terms K_a, pH, pK_a, and pK_b, K_w and pK_w;		
3.3.	perform calculations involving pH, pOH, K_a, pK_a K_w and pK_w, K_b and pK_b;	Quadratic equations are not required.	
3.4.	describe the changes in pH during acid/base titrations;	Include a study of titration curves.	
3.5.	explain what is meant by the pH range of indicator; and,		

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Acid/Base Equilibria cont'd			
Students should be able to:			
3.6.	state the basis for the selection of acid/base indicator for use in titrations.	Include phenolphthalein and methyl orange. Titration curves.	Perform experiments to show that the effectiveness of different indicators is related to the pH changes which occur during titration.
4.	**Buffers and pH**		
Students should be able to:			
4.1.	define the term 'buffer solution';		
4.2.	explain how buffer solutions control pH;		
4.3.	calculate the pH of buffer solutions from appropriate data; and,		Perform simple experiments to determine the pH of buffer solutions.
4.4.	discuss the importance of buffers in biological systems and in industrial processes.	Include reference to blood buffer systems such as hydrogencarbonate, phosphate and amino- acid systems, enzyme catalysed reactions and the food processing industry.	
5.	**Solubility Product**		
Students should be able to:			
5.1.	define the term solubility product, K_{sp};	Write equilibrium constant expression for $K_{sp.}$	
5.2.	explain the principles underlying solubility product and the common ion effect;		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Solubility Product cont'd</u>		
Students should be able to:		
5.3. perform calculations involving solubility product; and,	Quadratic equations are not required.	Conduct a simple experiment to determine the solubility product of a substance.
5.4. relate the solubility product principle to the selective precipitation of substances.	Include reference to qualitative analysis and kidney stone formation.	
6. **<u>Redox Equilibria</u>**		
Students should be able to:		
6.1. define the terms standard electrode potential and standard cell potential;		
6.2. describe the standard hydrogen electrode;	Include labelled diagram of standard hydrogen electrode.	
6.3. describe methods used to measure the standard electrode potentials of: (a) metals or non-metals in contact with their ions in aqueous solutions; and, (b) ions of the same element in different oxidation states;		
6.4. calculate standard cell potentials from standard electrode potentials of two half cells;		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Redox Equilibria cont'd Students should be able to:		
6.5. use standard electrode potentials of cells: (a) to determine the direction of electron flow; and, (b) to determine the feasibility of a reaction;	Include cell diagram or notation of the type $\text{Zn(s)}\vert\,\text{Zn}^{2+}_{(aq)}\Vert\,\text{Cu}^{2+}_{(aq)}\vert\text{Cu(s)}$.	
6.6. predict how the value of an electrode potential varies with concentration; and,	No treatment of the Nernst equation is required. Apply Le Chatelier's principle.	
6.7. apply the principles of redox processes to energy storage devices.	Include references to two of the following batteries: Leclanche' dry cell, lead acid accumulators (secondary cells); and fuel cells.	

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

1. Use appropriate analogies, for example, a moving object on an escalator in motion to distinguish between static and dynamic equilibria so that students get a better understanding of the changes at the microscopic level as opposed to the apparent lack of change at the macroscopic level.

2. Identify suitable practical activities to enhance the theory. It is important that students are conversant with the manipulation of experimental data. In this respect, students should be given the opportunity to develop the various concepts in a stepwise manner. For example, in the determination of rate constant the following sequence of steps can be used:

Plot concentration time graph → draw tangents to obtain the rates at different concentrations → draw rate concentration graphs → use slope of graphs to obtain a value for the rate constant.

3. Provide students with appropriate data to work out a variety of problems including:

   (a) orders of reactions (practise writing rate equations); and,

   (b) rate and equilibrium constant including K_a and K_b, pH ↔ $[H^+]$, pOH ↔ $[OH^-]$, and K_w.

   It is essential that students be given sufficient practice at these calculations.

4. Emphasise the practical applications of redox reactions to show that the equilibria in electrochemical cells are redox in nature. From here, students may practise writing cell diagrams to determine, for example:

   (a) the direction of electron flow;

   (b) the nature of the electrodes;

   (c) the reaction that may occur; and,

   (d) cell potentials.

5. Engage students in a brief discussion on the importance of Kinetics and Equilibria to industrial and biological processes.

6. Ask students to conduct research on kidney stone formation and its prevention.

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Amateis, P., and Silberberg, M.	*Chemistry: The Molecular Nature of Matter and Change. McGraw-Hill Education, 2014.*
Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Clarke, J.	Calculations in AS/A Level Chemistry. Essex: Pearson Education Limited, 2000.
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Clugston, M. and Flemming, R.	Advanced Chemistry. London: Oxford University Press, 2000.
Hill, G., and Holman, J.	Chemistry in Context. London: Nelson Thorne Limited, 2001.
Lister, T., Renshaw, J.	Understanding Chemistry for Advanced Level. Cheltenham: Trans-Atlantic Publications, 2000.
Maylin-Moseley, V.	*Advanced Level Chemistry for Life - Unit 1. Barbados: VHM Publishing, 2017.*
Norris, R., Barrett, L., Maynard-Alleyne, A. and Murray, J.	**CAPE®** Chemistry Study Guide. Cheltenham: Nelson Thorne Limited, 2012.
Ramsden, E.	A-Level Chemistry. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 1
MODULE 3: CHEMISTRY OF THE ELEMENTS

GENERAL OBJECTIVES

On completion of this Module, students should:

1. use fundamental concepts to rationalise the physical and chemical properties of elements and their compounds;

2. appreciate that the properties of elements are related to their compounds and their uses; and,

3. understand the principles underlying the identification of anions and cations.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1. <u>**Period 3: Sodium to Argon**</u>		
Students should be able to:		
1.1. explain the variations in physical properties of the elements in terms of structure and bonding;	Include reference to melting point and electrical conductivity. Atomic and ionic radii, electronegativity and density. Refer to Module 1, Specific Objective 1.11.	
1.2. describe the reactions of the elements with oxygen, chlorine and water;	No treatment of peroxides or superoxides required.	
1.3. explain the variation in oxidation number of the oxides and chlorides;		
1.4. describe the reactions of the oxides and chlorides with water;	Include equations.	Conduct experiments to investigate the reactions of the oxides and chlorides with water; include relevant equations.
1.5. explain the trend in the acid/base behaviour of the oxides and hydroxides;	Include equations.	Conduct experiments to investigate the acid/base behavior of the oxides and hydroxides; include relevant equations.

UNIT 1
MODULE 3: CHEMISTRY OF THE ELEMENTS (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Period 3: Sodium to Argon cont'd</u>		
Students should be able to:		
1.6. predict the types of chemical bonding present in the chlorides and oxides; and,	Refer to differences in electronegativities and ionic radii of the elements.	
1.7. discuss the uses of some of the compounds of aluminium and phosphorous.	Limited to the use of aluminium hydroxide in antacid medication, white phosphorous used in flares and military applications, red phosphorous used at the side of match boxes and argon used in fluorescent and incandescent lighting.	
2. **<u>Group II Elements</u>**		
Students should be able to:		
2.1. explain the variations in properties of the elements in terms of structure and bonding;	Include reference to atomic and ionic radii and ionisation energies.	
2.2. describe the reactions of the elements with oxygen, water, and dilute acids;	Include equations.	
2.3. explain the variation in the solubility of the sulfates;	Qualitative treatment only is required. Simple explanations in terms of lattice and hydration energies.	
2.4. explain the variation in the thermal decomposition of the carbonates and nitrates; and,	Include equations.	
2.5. discuss the uses of some of the compounds of magnesium and calcium.	Limited to the use of magnesium oxide, calcium oxide, calcium hydroxide and calcium carbonate.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
3. **Group IV Elements**		
Students should be able to:		
3.1. explain the variations in physical properties of the elements in terms of structure and bonding;	Include reference to variations in metallic character and electrical conductivity.	
3.2. describe the bonding of the tetrachlorides;		
3.3. explain the reactions of the tetrachlorides with water;	Include equations.	
3.4. discuss the trends in:	Make reference to E^{θ} values of the elements.	
(a) bonding;		
(b) acid/base character; and,	Include equations.	
(c) thermal stability of the oxides of oxidation states II and IV;		
3.5. discuss the relative stabilities of the oxides and aqueous cations of the elements in their higher and lower oxidation states; and,	Make reference to E^{θ} values of the elements.	
3.6. discuss the uses of ceramics based on silicon (IV) oxide.	Include its use as abrasives, furnace lining, glass and porcelain. Relate use to properties.	
4. **Group VII Elements**		
Students should be able to:		
4.1. explain the variations in physical properties of the elements in terms of structure and bonding;	Volatility, density, colour, and state. (An explanation of colour is not required).	

UNIT 1
MODULE 3: CHEMISTRY OF THE ELEMENTS (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Group VII Elements cont'd		
Students should be able to:		
4.2. explain the relative reactivities of the elements as oxidising agents;	Include reactions with sodium thiosulfate and refer to E^θ values.	Use solutions of the elements with bleach, bromine water, and iodine solution.
4.3. describe the reactions of the elements with hydrogen;	Include equations.	
4.4. explain the relative thermal stabilities of the hydrides;	Include bond energies in explanations.	
4.5. describe the reactions of the halide ions with: (a) aqueous solution of $AgNO_3$ followed by aqueous ammonia; and, (b) concentrated sulfuric acid; and,		*Perform experiments of halide ions with aqueous* $AgNO_3$ *followed by aqueous ammonia.*
4.6. describe the reactions of chlorine with cold and hot aqueous solution of sodium hydroxide.	Include changes in oxidation number and the process of disproportionation. Refer to Module 1, Specific Objective 4.1.	
5. **First Row Transition Elements**		
Students should be able to:		
5.1. define the term transition element;	D-block elements forming one or more stable ions with incomplete d-orbitals.	
5.2. describe the characteristics of transition elements;	Include variation in oxidation number, complex formation, coloured compounds, catalytic activity, magnetic properties.	

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>First Row Transition Elements cont'd</u>			
Students should be able to:			
5.3.	*discuss qualitatively the properties of transition elements when compared to those of calcium as a typical s-block element;*	*Melting point, density, atomic radius, ionic radius, first ionisation energy, and conductivity.*	
5.4.	determine the electronic configuration of the first row transition elements and of their ions;	Mention changes in oxidation number.	
5.5.	explain the relatively small changes in atomic radii, ionic radii, and ionisation energies of the elements across the period;		
5.6.	explain the formation of coloured ions by transition elements;	d-orbital separation of energy in octahedral complexes.	
5.7.	describe the variation in oxidation states of vanadium;	Refer to E^{θ} values.	Perform experiments to include the use of an acidified solution of ammonium vanadate (V) and granulated zinc.
5.8.	predict the shapes of complexes of transition elements;	Octahedral, tetrahedral and square planar.	
5.9.	discuss the use of: $Fe^{3+}{}_{(aq)}/Fe^{2+}{}_{(aq)}$, $MnO_{4(aq)}/Mn^{2+}{}_{(aq)}$, and $Cr_2O_7{}^{2-}{}_{(aq)}/Cr^{3+}{}_{(aq)}$ as redox systems; and,	Refer to Module 1, Specific Objective 4.4.	
5.10.	explain the principle of ligand exchange.	Stability constants and the CO/O_2 haemoglobin and $NH_{3(aq)}/Cu^{2+}{}_{(aq)}$ systems.	Perform experiments to demonstrate ligand exchange. Include reactions involving $Co^{2+}{}_{(aq)}$, $Cu^{2+}{}_{(aq)}$.

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
6.	<u>**Identification of Cations and Anions**</u>		
Students should be able to:			
6.1.	identify cations: K^+, Na^+, Ca^{2+}, Ba^{2+}, Cu^{2+} by their flame tests;	Refer to atomic emission spectra, see Module 1, Specific Objective 1.7.	*Perform flame tests on identified cations.*
6.2.	identify cations $Mg^{2+}_{(aq)}$, $Al^{3+}_{(aq)}$, $Ca^{2+}_{(aq)}$, $Cr^{3+}_{(aq)}$, $Mn^{2+}_{(aq)}$, $Fe^{2+}_{(aq)}$, $Fe^{3+}_{(aq)}$, $Cu^{2+}_{(aq)}$, $Zn^{2+}_{(aq)}$, $Ba^{2+}_{(aq)}$, $Pb^{2+}_{(aq)}$, $NH_4^+{}_{(aq)}$;	Include the reactions with $OH^-_{(aq)}$, $CO^{2-}{}_{3(aq)}$ and $NH_{3(aq)}$ and confirmatory tests.	*Perform experiments of the identified cations with hydroxide and aqueous ammonia.* *Where possible perform confirmatory tests of the identified cations.*
6.3.	explain the principles upon which the reactions in Specific Objective 6.2 are based;	Refer to equilibrium concepts. Module 2, Specific Objective 5.2. Basic, amphoteric oxide and complexation.	
6.4.	write ionic equations for the reactions in Specific Objective 6.2;	Include state symbols.	
6.5.	identify anions: CO_3^{2-}, NO_3^-, SO_4^{2-}, $SO_3^{2-}{}_{(aq)}$, Cl^-, Br^-, I^-, CrO_4^-; and,	Include the reactions with $HCl_{(aq)}$, conc H_2SO_4, $Pb^{2+}_{(aq)}$, $Ag^+_{(aq)}$, followed by $NH_{3(aq)}$, $Ca(OH)_{2(aq)}$, $Ba^{2+}_{(aq)}$, followed by dilute acid. For NO_3^- use copper turnings and conc. H_2SO_4 or add aluminium (powder) or zinc (powder) in the alkaline solution and confirmatory tests for gases where applicable.	*Perform experiments to identify the anions* CO_3^{2-}, NO_3^-, SO_4^{2-}, $SO_3^{2-}{}_{(aq)}$, Cl^-, Br^-, I^-, CrO_4^-. *Where applicable perform confirmatory tests for gases.*
6.6.	write ionic equations for the reactions in Specific Objective 6.5.	Include state symbols.	

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

1. Review fundamental factors which influence the properties of elements and their compounds, for example, ionisation energy, electronegativity, type of bonding.

2. *Allow students to use* charts and tables when establishing trends and differences in properties of elements and compounds.

3. *Allow students to use* computer software in simulations to demonstrate the chemistry of the elements and their compounds.

4. Link theory with appropriate laboratory work and real-life applications such as manufacturing, *and* agriculture.

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Maylin-Moseley, V.	*Advanced Level Chemistry for Life - Unit 1. Barbados: VHM Publishing, 2017.*
Norris, R., Barrett, L., Maynard-Alleyne, A. and Murray, J.	**CAPE®** Chemistry Study Guide: Cheltenham: Nelson Thorne Limited, 2012.
Ramsden, E.	A-Level Chemistry. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

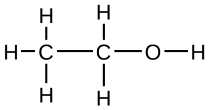
♦ UNIT 2: CHEMICAL PRINCIPLES AND APPLICATIONS II

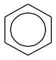
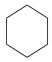
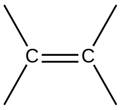
MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS

GENERAL OBJECTIVES

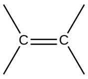
On completion of this Module, students should:

1. appreciate the scope and nature of carbon-based compounds;
2. understand the processes involved in the formation of carbon compounds;
3. understand the reactions of various functional groups of carbon compounds; and,
4. critically assess the impact of carbon-based compounds on our daily lives.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1. **Structure and Formulae**		
Students should be able to:		
1.1. explain the occurrence of carbon compounds with straight chains, branched chains and rings;	Catenation, tetravalency, hybridisation, and resonance of carbon atoms to be used as basis.	
1.2. explain the meaning of the term 'homologous series';	Chemical and physical characteristics.	
1.3. distinguish among empirical, molecular, and structural formulae;		
1.4. determine formulae from experimental data;		
1.5. write structural formulae;	Structural formulae may be written in the following formats: Displayed  $\mathrm{H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-O-H}$	

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Structure and Formulae cont'd</u>			
Students should be able to:			
		Condensed $CH_3(CH_2)_4CH_3$; CH_3CH_2OH Benzene can be represented by  and cyclohexane by 	
1.6.	apply the IUPAC rules to named organic compounds;		
1.7.	define, structural isomerism;	*Examples should be given.* Include chain, functional group, and positional isomers.	
1.8.	explain stereoisomerism; and,	Geometrical (cis/trans) isomers resulting from restricted rotation about  double bond; optical isomerism due to asymmetry in molecules (confined to compounds with one identified chiral centre and drawing the two optical isomers). *Optical isomers have an effect on plane polarised light. (No further treatment required).*	
1.9.	determine the possible isomers from given molecular formulae.		

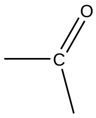
UNIT 2
MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2. **Functional Group Analysis, Reactions and Mechanisms**		
Students should be able to:		
2.1. identify homologous series of organic/carbon compounds;	Include general formulae.	
2.2. describe selected chemical reactions of alkanes;	Halogenation, cracking, and combustion. Equations required.	
2.3. explain the steps involved in the mechanism of free radical substitution;	Steps should include initiation, propagation, and termination. For example, methane and chlorine, homolytic fission. Include movement of electrons to be indicated by curved arrows and fish hook notations.	
2.4. describe selected chemical reactions of alkenes;	Alkenes  with Br_2 (ℓ), $Br_{2(aq)}$, *(addition reaction)* *Cold - $KMnO_{4(aq)}/H^+_{(aq)}$ (oxidation and diol formation),* *Hot - $KMnO_{4(aq)}/H^+_{(aq)}$ (cleavage).* Hydrogen halides. *(Markovnikov rule for addition to asymmetric alkenes).* Include catalytic hydrogenation of fats to produce trans–fats which are harmful, for example, margarine. Equations for reactions of alkenes with $KMnO_{4(aq)}$ $/H^+_{(aq)}$ are not required.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Functional Group Analysis, Reactions and Mechanisms cont'd</u> Students should be able to:		
2.5. explain the steps involved in the mechanism of selected chemical reactions of alkene functional group;	Electrophilic addition of bromine and hydrogen bromide to alkenes. Include movement of electrons. To be indicated by curved arrows and fish hook notation.	
2.6. describe selected chemical reactions of alcohols;	Reactions of alcohols to include primary, secondary and tertiary (1^0, 2^0, and 3^0 respectively) with $KMnO_{4(aq)}/H^+_{(aq)}$ purple to colourless with primary and secondary; no reaction with tertiary; $K_2Cr_2O_{7(aq)}/H^+_{(aq)}$ orange to green with primary and secondary; no reaction with tertiary; Carboxylic acid (R-COOH); conc. sulfuric acid. A solution of I_2 and NaOH (iodoform test). Equations for reactions of alcohols with carboxylic acid and conc. sulfuric acid only are required.	*Perform experiments examining the fragrances produced when different esters are formed.*
2.7. describe selected reactions of halogenoalkanes;	Limited to hydrolysis of primary and tertiary halogenoalkanes using $NaOH_{(aq)}$. *(No elimination reaction required).*	

Functional Group Analysis, Reactions and Mechanisms cont'd

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2.8. explain the steps involved in the mechanism of selected reactions of halogenoalkanes;	Nucleophilic substitution of halogenoalkanes with hydroxyl ions. Include movement of electrons to be indicated by curved arrows and fish hook notation. *Illustrate bond breaking or bond making as occurring in either a stepwise or concerted manner.*	
2.9. describe selected chemical reactions of carbonyl compounds 	NaCN/$HCl_{(aq)}$; 2, 4 – DNP (Brady's Reagent), Tollens' reagent/Fehling's solution; $KMnO_{4(aq)}$)/$H^+_{(aq)}$; $LiAlH_4$; H_2/Pt. No equations required	
2.10. explain the steps involved in mechanisms of selected chemical reactions of carbonyl compounds;	Nucleophilic addition. Include reaction of carbonyl compounds with hydrogen cyanide as an example. *Include movement of electrons to be indicated by curved arrows and fish hook notation.*	
2.11. describe selected chemical reaction of carboxylic acids (R-COOH);	NaOH, $NaHCO_3$, metals, alcohols PCl_5/PCl_3 or $SOCl_2$. Equations are not required for reaction with PCl_5, PCl_3 or $SOCl_2$.	
2.12. describe selected chemical reactions of esters;	Acid and base hydrolysis. Include saponification, transesterification biodiesel production.	*Simple soap production using vegetable oil and NaOH.*

Functional Group Analysis, Reactions and Mechanisms cont'd

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2.13. perform suitable laboratory tests for functional groups in carbon compounds referred to above;	PCl_3 should be used in a fume cupboard. Theoretical considerations are satisfactory *for* $SOCl_2$.	
2.14. describe the chemical reaction of primary amines (RNH_2) with dilute acid;		
2.15. describe selected chemical reactions of benzene methylbenzene and nitrobenzene;	Benzene and methylbenzene with $Br_2/FeBr_3$; conc. HNO_3/conc. H_2SO_4. Equations are required. The reaction of nitrobenzene with Sn/HCl (conc). Equations are not required.	
2.16. explain the steps involved in the mechanism of selected chemical reactions of benzene;	Electrophilic substitutions. Nitration of benzene. Include the movement of electrons to be indicated by curved arrows and fish hook notation.	
2.17. describe selected chemical reactions of phenol;	Phenol with acyl halides, aqueous bromine, sodium hydroxide. Equations are required.	
2.18. describe the formation of an azo compound; and,	Phenylamine with HNO_2 and HCl coupling with phenol to give azo compounds.	
2.19. state uses of azo compounds.	Dyes, intermediates in organic synthesis.	

SPECIFIC OBJECTIVES		**EXPLANATORY NOTES**	**SUGGESTED PRACTICAL ACTIVITIES**
3.	**<u>Acidic and Basic Character of Organic Compounds</u>**		
Students should be able to:			
3.1.	explain the difference in acidity of alcohols, phenols and carboxylic acids;	Include chlorosubstituted acids. Reference should be made to the relationship between acid strength, pH and pK_a. Inductive and conjugative effects.	
3.2.	explain differences in basic character of aliphatic amines, amides, and aromatic amines; and,	pH and pK_b. Inductive and conjugative effects.	
3.3.	explain the acid-base properties of amino acids.	Formation of zwitterions.	
4.	**<u>Macromolecules</u>**		
Students should be able to:			
4.1.	describe the characteristics of addition polymerisation;	Examples to include polyethene; polyvinyl chloride; and, polytetrafluoroethene. Include monomers for each polymer respectively.	
4.2.	describe the characteristics of condensation polymerisation;	Terylene; nylon 6.6, (specific monomers are required); proteins, starch, (representative structure required).	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Macromolecules cont’d		
Students should be able to:		
4.3. predict types of polymer formed from given monomers;		
4.4. deduce the repeat unit of a polymer;		
4.5. identify proteins as naturally occurring macromolecules;	Treat amino acids as monomeric molecules. Generalised monomer and linkage required.	
4.6. identify carbohydrates as naturally occurring macromolecules; and,	Include the following: cellulose, starch, and pectin. Treat simple sugars as monomeric materials. Generalised monomer and linkage required.	
4.7. illustrate the connection between carbohydrates and their monomers.		

Suggested Teaching and Learning Activities

To facilitate students’ attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

1. Arrange for students to view videos and interactive materials on industrial carbon chemistry. This should be followed by class or group discussion.
2. Arrange site visits, wherever possible, to industrial institutions, for example, (refineries, breweries, forensic laboratories, petrochemical plants).
3. *Ask students to create a product which is marketable using simple organic reactions.*
4. Ask students to construct and use models in sections dealing with structures.
5. Discuss articles in relevant reference journals and periodicals, for example, Chemistry in Education.

UNIT 2
MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS (cont'd)

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Brown, T. and Le May, H.	*Chemistry, The Central Science*. New Jersey: Prentice-Hall, Incorporated, 2014.
Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Clugston, M. and Flemming, R.	*Advanced Chemistry*. London: Oxford University Press, 2000.
Hill, G., and Holman, J.	*Chemistry in Context*. London: Nelson Thorne Limited, 2001.
Lister, T., Renshaw, J.	*Understanding Chemistry for Advanced Level*. Cheltenham: Trans-Atlantic Publications, 2000.
Norris, R., Barrett, L., Maynard-Alleyne, A. and Murray, J.	***CAPE®*** *Chemistry Study Guide.* Cheltenham: Nelson Thorne Limited, 2012.
Ramsden, E.	*A-Level Chemistry*. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 2
MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES

GENERAL OBJECTIVES

On completion of this Module, students should:

1. appreciate that all measurements have some degree of uncertainty that is related to both the measuring device and the skills of the operator;

2. *understand the basic theoretical principles of selected methods of analysis and separation techniques;*

3. *demonstrate a knowledge of the basic equipment and operational procedures, as well as carry out experiments associated with selected methods of analysis and separation procedures;*

4. use experimental data to quantify substances or elucidate *partial* structure; and,

5. demonstrate an awareness of the wide applications of various methods of analysis and separation techniques in industry and in medicine by citing examples.

SPECIFIC OBJECTIVES	**EXPLANATORY NOTES**	**SUGGESTED PRACTICAL ACTIVITIES**
1. **<u>Uncertainty in Measurements</u>**		
Students should be able to:		
1.1. apply appropriate concepts to the analysis of scientific data;	Definitions required for: mean, standard deviation, precision, accuracy, calibration curves, and standards. Calculation of the mean and standard deviation from data provided will be required. $S = \sqrt{\frac{\sum(x - \bar{x})^2}{n-1}}$	
1.2. carry out experiments to assess the degree of uncertainty in measurements associated with the use of certain common pieces of laboratory equipment; and,		Perform experiments which should include the use of pipettes, burettes, volumetric flasks, thermometers, top-loading balances and analytical balances.

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Uncertainty in Measurements cont'd			
Students should be able to:			
1.3.	select appropriate pieces of equipment to make measurements, depending upon the degree of accuracy required.	Selection of equipment limited to those in Specific Objective 1.2 above.	

2. **Titrimetric (Volumetric) Methods of Analysis**

Students should be able to:

2.1.	explain the basic principles upon which titrimetric analyses are based;		
2.2.	discuss the criteria used in selecting primary standards;	$NaHCO_3$, Na_2CO_3, KIO_3, $(COOH)_2$ and its salts as primary standards. Definition of primary standards required.	
2.3.	use data obtained from potentiometric, thermometric, and conductrometric methods for titration which do not require the use of indicators;		
2.4.	perform experiments based on titrimetric analyses;		Experiments should be limited to acid-base, back and redox titrations. Include preparation of standard solutions.
2.5.	perform calculations based on data obtained from titrimetric analyses; and,	Refer to Unit 1, Module 2, Specific Objective 3.6.	
2.6.	cite examples of the use of titrimetric analysis in the quantification of various substances.	Refer to vinegar, household cleaners, vitamin C tablets, aspirin, antacids.	

UNIT 2
MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES

3. <u>Gravimetric Methods of Analysis</u>

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
3.1. explain the principles upon which gravimetric analyses are based;	Limited to a discussion on precipitation and volatilisation methods.	
3.2. describe the functions of the various pieces of basic equipment used in gravimetric analyses;	Limited to suction flasks, suction funnels, silica crucibles, sinter glass crucibles, ovens, and furnaces.	
3.3. perform experiments based on gravimetric determinations;		Limited to experiments involving volatilisation methods, such as, moisture content of soils; water of crystallisation.
3.4. perform calculations based on data obtained from gravimetric analyses; and,	Use data from actual experiments carried out or from the literature.	
3.5. cite examples of the use of gravimetric analysis in quality control.	Examples include determination of SO_2 in the air, in wine or fruit drink; determination of the amount of elements such as phosphorous in fertilizers; the chloride ion presence in water supply.	

4. <u>Spectroscopic Methods of Analysis</u>

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
4.1. explain the nature of electromagnetic radiation;	Calculations using the equation: $E = h\nu = hc/\lambda$ are required.	

UNIT 2
MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES (cont’d)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES

Spectroscopic Methods of Analysis cont’d

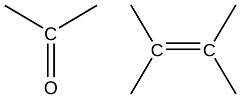
Students should be able to:

4.2.	state the approximate wavelength ranges of the X-ray, UV/VIS, IR and radiofrequency regions of the electromagnetic spectrum; and,	Relative energies and dangers associated with exposure to high energy wavelengths. Insert actual ranges for x-ray, UV, VIS, IR and RF.	
4.3.	recall that the energy levels in atoms and molecules are quantised.	Refer to Unit 1, Module 1.	

5. Ultra Violet-Visible (UV/VIS) Spectroscopy

Students should be able to:

5.1.	explain the origin of absorption in UV/VIS spectroscopy;	Simple treatment based on Unit 1, Module 1. *Consideration of sigma (σ), pi (π), anti-bonding (σ^*, π^*) and non-bonding (n) orbitals.*	
5.2.	explain why some species will absorb light in the UV/VIS region whereas others will not;		
5.3.	describe the basic steps involved in analysing samples by UV/VIS spectroscopy;	Brief mention should be made of the use of complexing reagents to form coloured compounds. Sensitivity and detection limits.	
5.4.	use Beer-Lambert’s Law to calculate the concentration of a given species in solution; and,	Use of standards and calibration curves.	
5.5.	list examples of the use of UV/VIS spectroscopy in the quantitation of substances.	Iron tablets; glucose and urea in blood; cyanide in water.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
6. **Infrared Spectroscopy**		
Students should be able to:		
6.1. explain the origin of absorption in IR spectroscopy;		
6.2. describe the basic steps involved in analysing samples by IR spectroscopy;	Include reference to preparation of solids, use of KBr, NaCl discs/pellets, and nujol mulls.	
6.3. comment on the limitations associated with the use of IR spectroscopy;	The usefulness of IR data when used in conjunction with other data (for example, mass spectrometry).	
6.4. deduce the functional groups present in organic compounds from IR spectra; and,	Groups to be identified include: -OH, $-NH_2$,  $-CO_2H$ $—CONH_2$ Use should be made of IR spectral data. (See Table 6 in the data booklet in Appendix 2).	*Use IR spectra along with absorption tables to deduce the presence or absence of particular bonds or functional groups.*
6.5. cite examples of the use of IR spectroscopy in the monitoring of air pollutants.	CO_2, SO_2.	
7. **Mass Spectroscopy**		
Students should be able to:		
7.1. explain the basic principles of mass spectrometry;	Include block diagram. (Simple schematic diagram of the process).	
7.2. explain the significance of the (M+1) peak in mass spectra; and,		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Mass Spectroscopy cont'd</u>		
Students should be able to:		
7.3. use mass spectral data to: (a) determine relative isotopic masses; and relative isotopic abundance; and, (b) distinguish between molecules of similar relative molecular mass.	Use should be made of mass spectral sheets. *Refer to the (M+1 and M+2 peaks).*	
8. **<u>Chromatographic Methods of Separation</u>**		
Students should be able to:		
8.1. explain the theoretical principles upon which chromatographic methods are based;	These should be explained in terms of adsorption and partition between the mobile and stationary phases; refer to paper, column, thin layer, and gas-liquid chromatography.	
8.2. explain the terms: retention factor (R_f) and retention time (t_R); visualising agent; solvent front;		
8.3. describe the basic steps involved in separating and quantifying the components of a mixture;	Use of R_f values and retention times in the quantitation of substances is required.	*The use of TLC to investigate mixtures and pure compounds. (Plant extracts, dyes and inks may be considered. Visualisation may be done using an iodine chamber). Calculate R_f values.*

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Chromatographic Methods of Separation cont'd		
Students should be able to:		
8.4. name examples of commonly used stationary phases;	Include reference to cellulose, silica gel, alumina.	
8.5. separate the components of mixtures; and,	Suitable mixtures which could be used include amino acids, plant pigments, food colouring.	Perform simple experiments to separate the components of mixtures *using paper and column chromatographic techniques.*
8.6. cite the wide applications of chromatographic methods of separation.	Refer to pesticide analysis, forensic testing, purification of natural products.	
9. **Phase Separations**		
Students should be able to:		
9.1. discuss the chemical principles upon which simple distillation and fractional distillation are based;	State Raoult's Law. *Definition of ideal and non-ideal mixture required.* The interpretation of boiling point composition curves of both ideal and non-ideal mixtures is required. A qualitative treatment of boiling point composition curves of azeotropic mixtures is required.	*Perform simple experiments to illustrate the concept of boiling point elevation.*
9.2. discuss the advantages of carrying out distillation processes under reduced pressures;		

UNIT 2
MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Phase Separations cont'd		
Students should be able to:		
9.3. discuss the chemical principles and use of steam distillation;	Laboratory work on the extraction of essential oils from plant materials. Purification of nitrobenzene and phenylamine. Simple calculations are required.	
9.4. discuss the principles upon which solvent extraction is based;	A discussion on partition coefficient and simple calculations are required.	
9.5. select appropriate methods of separation, given the physical and chemical properties of the components of a mixture;		Conduct simple separation experiments based on solute partitioning between two immiscible solvents. These could include the separation of an acid/base mixture.
9.6. perform distillation experiments; and,	These should include (but not be limited to) a comparison of the efficiency of separation of ethanol in beer or rum by simple and fractional distillation.	
9.7. cite examples of the applications of the distillation methods used in various industries.	Include petroleum, rum, and the fragrance industries.	

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

1. Establish contact with industries and institutions in your locality which make use of the spectroscopic methods or separation techniques in their operations in order to:
    - (a) facilitate site visits with your students;
    - (b) make use of personnel from such industries and institutions to come in and give lectures and demonstrations; and
    - (c) access *appropriate* written, audio or visual material available at such industries and institutions.
2. Prepare handouts compiled from data in literature (readily available) for use by students. This is especially important where spectral data are concerned. Students should be able to work with spectral data sheets.

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Clugston, M. and Flemming, R.	*Advanced Chemistry*. London: Oxford University Press, 2000.
Ramsden, E.	*A-Level Chemistry*. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 2
MODULE 3: INDUSTRY AND THE ENVIRONMENT

GENERAL OBJECTIVES

On completion of this Module, students should:

1. appreciate that chemical principles can be applied to industry;
2. *appreciate that using Green Chemistry principles in industry helps to produce a sustainable world that supports a healthy economy;*
3. understand the sources of pollution and strategies which assist in reduction of pollutants;
4. understand that there are physical and chemical changes occurring in the environment and assess their impact on it;
5. recognise the influence of industrial processes on social and economic life; and,
6. appreciate the impact of man's activities on the environment.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1. **Locating *and Operating* Industrial plants: Benefits and Risk**		
Students should be able to:		
1.1. discuss factors which influence the location of an industrial plant; and,	Factors should be related to the industrial plant. Environmental impact assessment should be carried out.	
1.2. discuss general safety requirements for industry; and,		
1.3. assess the processes of select industries using Green Chemistry principles.	*Brief explanation of the principles of Green Chemistry.* *Selected industries – ammonia and crude oil.*	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2. **Aluminium**		
Students should be able to:		
2.1. describe the processes involved in the production of aluminium from its ores;	Include purification of the ore. Technical details are not required. Include equations. High energy consumption in the production of aluminium.	
2.2. explain the uses of aluminium in relation to its physical and chemical properties; and,		
2.3. assess the impact of the aluminium industry on the environment.	*Refer to Specific Objective 1.3.*	
3. **Crude Oil**		
Students should be able to:		
3.1. explain the method used in the separation of the components of crude oil;		
3.2. discuss the uses of the components of crude oil as fuels and as raw materials for the petro-chemical industry; and,	Refer to Module *2* Specific Objective 9.6. Include fractional distillation, catalytic cracking, and reforming techniques.	
3.3. assess the impact of the petroleum industry on the environment.	*Refer to Specific Objective 1.3.*	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
4. **Ammonia**		
Students should be able to:		
4.1. outline the steps in the manufacture of ammonia from its elements, by the Haber process;	Include the production of the starting materials and manufacturing conditions. Include equations. Apply the principles of chemical equilibrium and kinetics.	
4.2. discuss the uses of ammonia; and,	Including in agriculture and chemical industry.	
4.3. assess the impact of the ammonia industry on the environment.	*Refer to Specific Objective 1.3.*	
5. **Ethanol**		
Students should be able to:		
5.1. explain the process of fermentation and distillation in the manufacture of alcoholic beverages;	Include equations and sources of carbohydrates.	
5.2. discuss the uses of ethanol;	Include fuel, pharmaceutical industry.	
5.3. discuss the social and economic impact of *ethanol* production and consumption; and,	Include physiological changes.	
5.4. assess the impact of the *ethanol* industry on the environment.	*Refer to Specific Objective 1.3.*	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
6. **Chlorine**		
Students should be able to:		
6.1. describe the chemical processes involved in the electrolysis of brine using the diaphragm cell;		
6.2. discuss the economic advantages of chlorine production by the diaphragm cell method;	Include sodium hydroxide.	
6.3. discuss the industrial importance of the halogens and their compounds; and,	Bleaches, PVC, halogenated hydrocarbons, solvents, aerosols, refrigerants, anaesthetics.	
6.4. assess the impact of the chlor-alkali industry on the environment.	*Refer to Specific Objective 1.3.*	
7. **Sulfuric Acid**		
Students should be able to:		
7.1. describe the Contact process for the manufacture of sulfuric acid;	Include the principles of chemical equilibrium and kinetics. Include equations.	
7.2. discuss the industrial importance of compounds of sulfur; and,	SO_2 in food preservation and H_2SO_4 manufacture.	
7.3. assess the impact of the sulfuric acid industry.	*Refer to Specific Objective 1.3.*	

UNIT 2
MODULE 3: INDUSTRY AND THE ENVIRONMENT (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
8. **Water**		
Students should be able to:		
8.1. describe the importance of the water cycle;		
8.2. discuss methods of water purification;	Include desalination.	
8.3. discuss the importance of dissolved oxygen to aquatic life;		
8.4. discuss the sources of water pollution;	*Definition of the terms persistent and bio-accumulation in relation to all forms of pollution. Refer to Specific Objectives 9.2 and 10.3.* *Sources of water pollution may* include nitrates, phosphates, heavy metals (lead and mercury), cyanides, trace metals, pesticides, herbicides, petroleum residue, suspended particles.	
8.5. perform experiments to test for some pollutants specified in Specific Objective 8.4; and,		Tests may be carried out for presence of NO_3^- PO_4^{3-}, Pb^{2+}, CN^-. Turbidity test.
8.6. assess the impact of the pollutants in Specific Objective 8.4 and Specific Objective 9.2 on the aquatic environment.		

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
9. <u>**The Atmosphere**</u>		
Students should be able to:		
9.1. explain how the concentration of ozone in the atmosphere is maintained;	Photodissociation.	
9.2. discuss the environmental significance of CFCs in the ozone layer;	Include reference to free radical reactions in the upper atmosphere.	
9.3. discuss the effects of ozone on human life;	Refer to both stratosphere and troposphere, and Specific Objective 9.2.	
9.4. explain the importance of maintaining the balance of carbon dioxide concentration in the atmosphere;	Equilibrium concepts, carbon cycle and reforestation. Brief analysis on the impact of climate change.	
9.5. explain the following terms: green-house effect, global warming, photochemical smog;	Include re-radiation of energy from the infrared region.	
9.6. discuss the effects of the products of combustion of hydrocarbon-based fuels;	Consider CO, SO_2, oxides of nitrogen, lead compounds and volatile organic compounds. Primary and secondary pollutants, for example, NO and NO_2, respectively.	
9.7. explain how the atmospheric concentrations of the oxides of nitrogen may be altered; and,	Nitrogen cycle and acid rain.	

UNIT 2

MODULE 3: INDUSTRY AND THE ENVIRONMENT (cont'd)

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
9.8.	discuss methods of control and prevention of atmospheric pollution.	For prevention include alternative and cleaner fuels improved technology and mass transit. For control include sequestering, filters, washers and scrubbers.	
10.	**<u>Solid Waste</u>**		
Students should be able to:			
10.1.	distinguish among the terms reduce, reuse, recycle.		Visit a landfill, bauxite mines, alumina plant, mineral quarry.
10.2.	describe the *processes* involved in waste reduction; and,	Consider reusing and recycling of glass, paper, plastic, steel and aluminium. *(A simple process approach is adequate).*	
10.3.	assess the impact of solid wastes on the terrestrial environment.	Include reference to iron, glass, plastic, paper, lead, biodegradable and non-biodegradable materials, proper and improper disposal techniques- dumps and sanitary landfills.	

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Module, teachers are advised to engage students in the teaching and learning activities listed below.

1. Arrange visits to industrial plants and view video materials. This should be followed by class/group discussions.

2. Invite personnel from environmental groups (Non-Governmental Organisations, Community Based Organisations) and the Environmental Management Authority (EMA) in their territories to be guest lecturers on environmental issues.

3. Have students collect newspaper articles and journal articles, and conduct web-based searches on issues relating to industry and environment *(include in the study the benefits of Green Chemistry). Engage in discussion on the main issues of the article collected.*

4. Conduct class discussions and debates on the social and economic issues that arise from degradation of the environment.

5. Have students do a survey on community awareness about environmental issues.

RESOURCES

Teachers and students may find reference to the following resource materials useful. The latest editions are recommended.

Cann, P. and Hughes, P.	*Chemistry, International AS and A Level. London: Hodder Education, 2015.*
Conoley, C. and Hills, P.	*Chemistry, 3rd Edition. London: HarperCollins, 2008.*
Clugston, M. and Flemming, R.	Advanced Chemistry. London: Oxford University Press, 2000.
Hill, G., and Holman, J.	Chemistry in Context. London: Nelson Thorne Limited, 2001.
Norris, R., Barrett, L., Maynard-Alleyne, A. and Murray, J.	**CAPE®** Chemistry Study Guide: Cheltenham: Nelson Thorne Limited, 2012.
Ramsden, E.	A-Level Chemistry. Cheltenham: Nelson Thorne Limited, 2000.

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

www.asc.org

www.epa.gov

www.rsc.org

♦ OUTLINE OF ASSESSMENT

EXTERNAL ASSESSMENT *(80%)*

Paper 01 (1 hour 30 minutes)	Forty-five multiple-choice items, 15 from each Module.	*40%*
Paper 02 (2 hours 30 minutes)	Three compulsory structured essay questions, one from each Module. Each question is worth 30 marks.	*40%*
Paper 032 ***For private candidates only (2 hours)***	*Three questions, one from each Module, as follows:* *(a) a practical-based question to be executed by the candidate;* *(b) a question based on data analysis; and* *(c) a data analysis/a planning and design exercise.*	*20%*

SCHOOL-BASED ASSESSMENT *(20%)*

The School-Based Assessment will consist of selected practical laboratory exercises and one research project aligned to any Unit of the ***CAPE®*** *Sciences (Biology, Chemistry or Physics).*

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 during Term 2/3. This is conducted by visiting External Moderators who will visit the centre.

Teachers are required to present to the Moderator ***ALL*** *Assessment Sheets (Record of Marks),* ***ALL*** *lab books, Mark Schemes and the project or evidence of the project. This is also required when marks are being transferred from one Unit/subject to another. Candidates marks are to be recorded on the School-Based Assessment Record Sheets which are available online via the* ***CXC®****'s website www.cxc.org.* ***All candidates' marks are to be submitted electronically*** *using the SBA data capture module of the Online Registration System (ORS).* ***Teachers are NOT required to submit to CXC® samples of candidates' work, unless specifically requested to do so by the Council.***

The Moderator will re-mark the skills and projects for a sample of five candidates using the guidelines below. This is ***only*** *applicable if the candidates selected in the sample are not using transferred marks for the projects.*

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; and,

   (e) mark midway between the middle and lowest Total Mark.

3. *The Moderator will also re-mark the laboratory practical activities for the other skills (ORR, AI and PD) that are recorded in the lab books for the five candidates in the sample.*

4. *The Moderator will re-mark the skills for **ALL** the candidates where the total number of candidates is five or less than five.*

5. *The Moderator will provide teachers with feedback. Please note that Candidates' marks may be adjusted as a result of the moderation exercise.*

*The Moderators are required to submit the moderated marks (Moderation of SBA Sample Form), the Moderation Feedback Report and the External Moderator Report to the Local Registrar by **30 June** of the year of the examination.*

*A copy of the Assessment Sheets and all candidates' work must be retained by the school for t**hree months** after the examination results are published by **CXC®**.*

ASSESSMENT DETAILS

Each Unit of the syllabus is assessed as outlined below.

<u>**External Assessment by Written Papers (*80%* of Total Assessment)**</u>

1. Paper 01 consists of 45 multiple-choice items. There will be a combined question paper and answer booklet for Paper 02.

2. S.I. Units will be used on all examination papers.

3. The use of silent, non-programmable calculators will be allowed in the examination. Candidates are responsible for providing their own calculators.

4. Data not specifically required to be recalled, defined or stated will be made available for this examination.

Paper 01 (1 hour 30 minutes – *40%* of Total Assessment)

1. **Composition of the Paper**

   This paper will consist of *45* multiple-choice items, *15* from each Module.
   All questions are compulsory and knowledge of the entire Unit is expected. The paper will assess the candidate's knowledge across the breadth of the Unit.

2. **Mark Allocation**

   The paper will be worth 45 marks, which will be weighted to 90 marks.

3. **Question Type**

Questions may be presented using diagrams, data, graphs, prose or other stimulus material.

Paper 02 (2 hours 30 minutes – *40%* of Total Assessment)

1. **Composition of Paper**

   This paper will consist of three questions, one from each module. *All questions are compulsory.*

   Questions on this paper test all three skills KC, UK and XS.

   Knowledge of the entire Unit is expected.

2. **Mark Allocation**

   The paper will be worth 90 marks, 30 marks per question *and distributed across the question sub-parts.*

3. **Question Type**

   Questions will be presented in *structured essay format. The questions will test the skills of KC, UK and XS.* Answers are to be written in the question booklet.

School-Based Assessment (*20%*)

School-Based Assessment 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 associated with the subject. *Students are encouraged to work in groups.*

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

School-Based Assessment provides an opportunity to individualise a part of the curriculum to meet the needs of students. It facilitates feedback to the student at various stages of the experience. This helps to build the self- confidence of students as they proceed with their studies. School-Based Assessment also facilitates the development of the critical skills and abilities emphasised by this **CAPE®** subject and enhances the validity of the examination on which candidate performance is reported.

School-Based Assessment, therefore, makes a significant and unique contribution to both the development of relevant skills and the testing and rewarding of students for the development of those skills.

The Caribbean Examinations Council seeks to ensure that the School-Based Assessment scores that contribute to the overall scores of candidates are valid and reliable estimates of accomplishment. The guidelines provided in this syllabus are intended to assist in doing so.

Award of Marks

The following skills will be assessed through the laboratory practical activities:

1. Analysis and Interpretation;
2. Manipulation and Measurement;
3. Observation, Recording and Reporting; and,
4. Planning and Designing.

The candidates are also required to do an investigative project in any one Unit of the ***CAPE®*** *Sciences. The table below shows how the marks are allocated for each Unit.*

Table 1
School-Based Assessment Skills

Skill	**Unit 1**	**Unit 2**
Observation, Recording and Reporting	*12*	*12*
Manipulation and Measurement	*12*	*12*
Analysis and Interpretation*	*12*	*12*
Planning and Designing*	*12*	*12*
TOTAL	*48 marks*	*48 marks*

***Includes *an* investigative project**

Teachers are required to provide criteria which clearly indicate how they award marks.

Please note that candidates will be required to do one investigative project in any Unit of any of the **CAPE®** Sciences (Biology, Chemistry or Physics) *in the first sitting, and can* use that mark for the other Units of the Sciences. So for example, a candidate may do the investigative project in Unit 2 Physics *in the first sitting*, and then (transfer) use the AI and PD marks for Unit 1 Physics, Units 1 and 2 Chemistry and Units 1 and 2 Biology.

Each Module will carry a maximum of *16* marks.

Each candidate's total School-Based Assessment mark for any Unit should be divided in three and allocated to each Module equally.

Fractional marks should not be awarded. Wherever the Unit mark is not divisible by three, then

(a) when the remainder mark is 1, it should be allocated to Module 1; and,

(b) when the remainder is 2, one of the marks should be allocated to Module 2 and the other mark to Module 3.

Appropriate practical exercises for assessing any skill may be selected from any Module in the relevant Unit.

♦ INVESTIGATIVE PROJECT

Objectives of the Investigative Project

The Investigative Project must focus on a challenge to be addressed within the environment or society. *On completion of the Investigative Project students should:*

1. *Appreciate the use of the scientific method for discovery of new knowledge and to the solution of problems;*
2. *Communicate accurately and effectively the purpose and results of research;*
3. *Apply experimental skills and theory to the solution of problems; and,*
4. *Synthesise information based on data collected.*

Students are encouraged to work collaboratively. Where collaborative work is done, group sizes must not exceed six (6) persons per group. The teacher is expected to use the group mark for the project and add it to the marks for the other skills for each individual candidate within the group.

CRITERIA FOR ASSESSING INVESTIGATIVE SKILLS

A.	**PLANNING AND DESIGN**			
	• **HYPOTHESIS**		**1**	
	• **AIM**		**1**	
	• **MATERIALS AND APPARATUS**		**1**	
	• **VARIABLES STATED** - Controlled - Manipulated - Responding	 1 1 1	**3**	

	• **METHOD**		2	
	- Clearly outlining how manipulated variable will be changed and measured.	1		
	- Clearly outlining how the responding variable will be measured.	1		
	• **RESULTS**		**2**	
	- Expected Results	1		
	- Treatment of Results	1		
	• **PRECAUTIONS AND LIMITATIONS/ASSUMPTIONS**		**2**	
	- Two or more stated	2		
	- Anyone stated	1		
	TOTAL			**(12)**

B.	**ANALYSIS AND INTERPRETATION**			
	• **RESULTS**		**2**	
	- Complete set of results from quantities mentioned in method.	2		
	• **DISCUSSION**		**4**	
	- Complete set of calculations or statement of observations or trends.	2		
	- Interpretations of calculated values, observations or trends linked to data in results.	2		
	• **LIMITATIONS AND SOURCES OF ERROR**		**2**	
	- Limitation stated	1		
	- Source of error stated	1		
	• **REFLECTIONS**		**3**	
	- Relevance of experiment to real life.	1		
	- Impact of knowledge gained from experiment.	1		
	- How can experiment be changed and improved.	1		
	• **CONCLUSION**			
	- Clearly stated and related to Aim in PD.	1	**1**	
	TOTAL			**(12)**

SCHOOL-BASED ASSESSMENT – GENERAL GUIDELINES FOR TEACHERS

1. Each candidate is required to keep a laboratory workbook which is to be marked by the teacher. Teachers are also expected to assess candidates as they perform practical exercises in which Manipulation and Measurement skills are required.

2. A maximum of two skills may be assessed by any one experiment.

3. The mark *awarded* for each skill assessed by practical exercises should be the average of at LEAST TWO separate assessments. *The average mark for AI and PD* ***must*** *include the mark from the investigative project.* In each Unit, total marks awarded at the end of each Module will be 0 to *16.*

4. The maximum mark for any skill will be *12.* The mark *awarded* for each skill assessed by practical exercises should be the average of at LEAST TWO separate assessments. In each Unit, total marks awarded at the end of each Module will be 0 to *16.*
5. Candidates who do not fulfil the requirements for the School-Based Assessment will be considered absent from the whole examination.

Candidates' laboratory books should contain all practical work undertaken during the course of study. Those exercises which are selected for use for the School-Based Assessment should be clearly identified. The skill(s) tested in these selected practical exercises, the marks assigned and the scale used must be placed next to the relevant exercises.

♦ REGULATIONS FOR PRIVATE CANDIDATES

1. Candidates who are registered privately will be required to sit Papers 01, 02 and 032. Detailed information on Papers 01, *02 and 032* is given on page 64 of this syllabus.

2. Paper 032 will constitute *20 per cent* of the overall assessment of the candidates' performance on the Unit.

♦ REGULATIONS FOR RESIT CANDIDATES

1. *Candidates may reuse any moderated SBA score within a two-year period. In order to assist candidates in making decisions about whether or not to reuse a moderated SBA score, the Council will continue to indicate on the preliminary results if a candidate's moderated SBA score is less than 50 per cent in a particular Unit.*

2. *Candidates re-using SBA scores should register as "Re-sit candidates" and must provide the previous candidate number when registering.*

3. *Resit candidates must complete Papers 01 and 02 of the examination for the year in which they register.*

◆

ASSESSMENT GRID

The Assessment Grid for each Unit contains marks assigned to papers and to Modules and percentage contribution of each paper to total scores.

Paper	***Module 1***	***Module 2***	***Module 3***	***Paper Total (Weighted Total)***	***% Weighting of Papers***
Paper 01	*15* (30)	15 (30)	15 (30)	45 (90)	40
Paper 02	*30*	*30*	*30*	*90*	40
Paper 031	*16* *(15)*	*16* *(15)*	*16* *(15)*	*48* *(45)*	*20*
Paper 032	*15*	*15*	*15*	*45*	*20*
Module Totals	60	60	60	180 (225)	*100*
Weighted Module	75	75	75	225	*100*

APPENDIX I

♦ GLOSSARY OF EXAMINATIONS TERMS

KEY TO ABBREVIATIONS

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

WORD	DEFINITION	NOTES
Annotate	requires a brief note to be added to a label.	Simple phrase or a few words only; KC
Apply	requires the use of knowledge or principles to solve problems.	Make references or conclusions; UK
Assess	requires the inclusion of 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	requires a numerical answer for which working must be shown.	Steps should be shown; units must be included; UK
Cite	requires a quotation or a reference to the subject.	KC
Classify	requires a division into groups according to observable and stated characteristics.	UK
Comment	requires a statement of an opinion or a view, with reason supporting.	UK
Compare	requires a statement about similarities and differences.	An example of a significance of each similarity and the difference stated may be required for comparisons which are other than structural; UK
Construct	requires either the use of a specific format for the representations, such as graphs, using data or material provided or drawn from	Such representations should normally bear a title, appropriate headings and legend; UK

WORD	DEFINITION	NOTES
	practical investigations, or building of models or the drawing of scale diagrams.	
Deduce	the making of logical connections between pieces of information.	UK
Define	requires a formal statement or an equivalent paraphrase, such as defining equation with symbols identified.	This should include the defining equation or formula where relevant; UK
Demonstrate	show; direct attention to.	KC
Derive	implies a deduction, determination or extraction of some relationship, formula or result from data by a logical set of steps.	UK
Describe	requires a statement in words (using diagrams where appropriate) of the main points of the topic. This can also imply the inclusion of reference to (visual) observations associated with particular phenomena or experiments. The amount of description intended should be interpreted from the context.	Description may be words, drawings or diagrams or an appropriate combination. Drawings or diagrams should be annotated to show appropriate detail where necessary; KC
Design	includes planning and presentation with appropriate practical detail.	UK/XS
Determine	implies that the quantity concerned should not be measured directly but should be obtained by calculator or derivation.	Where hypotheses are stated or when tests are to be conducted, possible outcomes should be clearly shown or the way in which data will be analysed and presented; XS
Develop	implies an expansion or elaboration of an idea or argument with supporting evidence.	KC/UK

WORD	DEFINITION	NOTES
Differentiate or Distinguish (between or among)	requires a statement and brief explanation of the differences between or among items.	KC
Discuss	requires a critical account of the points involved in the topic.	UK
Draw	requires a line representation of the item, showing accurate relationship between the parts.	KC/UK
Estimate	implies a reasoned order of magnitude statement or calculation of the quantity concerned, using such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included.	UK
Evaluate	requires the weighing of evidence and judgements based on stated criteria.	The use of logical supporting reasons for a particular point is more important than view held; usually both sides of an argument should be considered; UK
Explain	implies that a definition or a description should be given, together with some relevant comment on the significance or context of the term or situation concerned. The amount of supplementary comment intended should be interpreted from the context.	KC/UK
Find	requires the location of a feature or the determination as from a graph.	UK
Formulate	implies the articulation of a hypothesis.	UK
Identify	requires the naming of specific components or features. Implies a clear demonstration, using appropriate examples or diagrams.	KC

WORD	DEFINITION	NOTES
Label	implies the inclusion of names to identify structures or parts as indicated by pointers.	KC/XS
List	requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.	KC
Measure	implies that the quantity concerned can be directly obtained from a suitable measuring instrument.	XS
Name	requires only the identification of the item.	No additional information is required; KC
Note	implies the writing down of observations.	XS
Observe	implies the direction of attention to details which characterize reaction or change taking place and examination of scientific notations.	Observation may involve all the senses and extensions of them but would normally exclude the sense of taste; XS
Outline	requires basic steps only.	
Plan	implies preparation to conduct an exercise or operation.	XS
Predict	implies the use of information to arrive at a likely conclusion or the suggestion of possible outcomes.	UK
Record	implies an accurate account or description of the full range of observations made during a given procedure.	This includes the values for any variable being investigated; where appropriate, record data may be depicted in graphs, histograms or tables; XS
Relate	implies the demonstration of connections between sets of facts or data.	UK

WORD	DEFINITION	NOTES
Show	see Demonstrate.	
Sketch	in relation to graphs, implies that the shape or position of the curve need only be qualitatively correct and, depending on the context, some quantitative aspects may need to be included. In relation to diagrams, implies that a simple, freehand drawing is acceptable, provided proportions and important details are made clear.	KC/UK/XS
State	implies a concise statement with little or no supporting argument.	KC
Suggest	could imply either that there is no unique response or the need to apply general knowledge to a novel situation.	No correct or incorrect solution is presumed but suggestions must be acceptable within the limits of scientific knowledge; UK
Test	implies the determination of a result by following set procedures.	XS
Use	implies the need to recall and apply in order to come to a conclusion.	UK

Western Zone Office
9 August 2018

APPENDIX II

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION (CAPE®)

CHEMISTRY DATA BOOKLET

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

DATA BOOKLET

DO NOT TAKE AWAY FROM THE EXAMINATION ROOM

Revised: January 2015

TABLE 1: SOME IMPORTANT CONSTANTS

The Avogadro constant	L	$= 6.02 \times 10^{23}$ mol^{-1}
Electronic charge	e	$= -1.60 \times 10^{-19}$ C
The Faraday constant	F	$= 9.65 \times 10^{4}$ C mol^{-1}
Ionic product of water	K_w	$= 1.00 \times 10^{-14}$ mol^{2} dm^{-6} (at 298 K)
Molar gas constant	R	$= 8.31$ J K^{-1} mol^{-1}
Molar volume of gas	V_m	$= 22.4$ dm^{3} mol^{-1} at s.t.p $= 24$ dm^{3} mol^{-1} under room conditions
The Planck constant	h	$= 6.63 \times 10^{-34}$ J s
Rest mass of electron, ${}^{0}_{-1}\mathrm{e}$	m_e	$= 9.11 \times 10^{-31}$ kg
Rest mass of neutron, ${}^{1}_{0}\mathrm{n}$	m_n	$= 1.67 \times 10^{-27}$ kg
Rest mass of proton, ${}^{1}_{1}\mathrm{H}$	m_p	$= 1.67 \times 10^{-27}$ kg
Specific heat capacity of water	C_{water}	$= 4.18$ kJ kg^{-1} K^{-1}
Speed of light in a vacuum	c	$= 3.00 \times 10^{8}$ m s^{-1}

TABLE 2: IONISATION ENERGIES OF SELECTED ELEMENTS

Element	Proton Number	Ionisation Energies (kJ mol^{-1})			
		First	Second	Third	Fourth
H	1	1310	–	–	–
He	2	2370	5250	–	–
Li	3	519	7300	11800	–
Be	4	900	1760	14800	21000
B	5	799	2420	3660	25000
C	6	1090	2350	4610	6220
N	7	1400	2860	4590	7480
O	8	1310	3390	5320	7450
F	9	1680	3370	6040	8410
Ne	10	2080	3950	6150	9290
Na	11	494	4560	6940	9540
Mg	12	736	1450	7740	10500
Al	13	577	1820	2740	11600
Si	14	786	1580	3230	4360
P	15	1060	1900	2920	4960
S	16	1000	2260	3390	4540
Cl	17	1260	2300	3850	5150
Ar	18	1520	2660	3950	5770
K	19	418	3070	4600	5860
Ca	20	590	1150	4940	6480
Sc	21	632	1240	2390	7110
Ti	22	661	1310	2720	4170
V	23	648	1370	2870	4600
Cr	24	653	1590	2990	4770
Mn	25	716	1510	3250	5190
Fe	26	762	1560	2960	5400
Co	27	757	1640	3230	5100
Ni	28	736	1750	3390	5400
Cu	29	745	1960	3350	5690
Zn	30	908	1730	3828	5980
Ge	32	762	1540	3300	4390
Br	35	1140	2080	3460	4850
Sr	38	548	1060	4120	5440
Sn	50	707	1410	2940	3930
I	53	1010	1840	2040	4030
Ba	56	502	966	3390	–
Pb	82	716	1450	3080	4080

TABLE 3: ATOMIC AND IONIC RADII OF SELECTED ELEMENTS

		Atomic/nm		**Ionic/nm**	
(a)	Group II				
	Metallic	Be	0.112	Be^{2+}	0.031
		Mg	0.160	Mg^{2+}	0.065
		Ca	0.197	Ca^{2+}	0.099
		Sr	0.215	Sr^{2+}	0.113
		Ba	0.217	Ba^{2+}	0.135
		Ra	0.220	Ra^{2+}	0.140
(b)	Group IV				
	Single covalent	C	0.077		
		Si	0.117	Si^{4+}	0.041
		Ge	0.122	Ge^{2+}	0.093
		Sn	0.162	Sn^{2+}	0.112
		Pb	0.175	Pb^{2+}	0.120
(c)	Group VII				
	Single covalent	F	0.072	F^{-}	0.136
		Cl	0.099	Cl^{-}	0.181
		Br	0.114	Br^{-}	0.195
		I	0.133	I^{-}	0.216
		At	0.140		
(d)	Period 3				
	Metallic	Na	0.186	Na^{+}	0.095
		Mg	0.160	Mg^{2+}	0.065
		Al	0.143	Al^{3+}	0.050
	Single covalent	Si	0.117	Si^{4+}	0.041
		P	0.110	P^{3-}	0.212
		S	0.104	S^{2-}	0.184
		Cl	0.099	Cl^{-}	0.181
	Van der Waals	Ar	0.192		
(e)	First row transition elements				
	Single covalent	Sc	0.144	Sc^{3+}	0.081
		Ti	0.132	Ti^{2+}	0.090
		V	0.122	V^{3+}	0.074
		Cr	0.117	Cr^{3+}	0.069
		Mn	0.117	Mn^{2+}	0.080
		Fe	0.116	Fe^{2+}	0.076
				Fe^{3+}	0.064
		Co	0.116	Co^{2+}	0.078
		Ni	0.115	Ni^{2+}	0.078
		Cu	0.117	Cu^{2+}	0.069
		Zn	0.125	Zn^{2+}	0.074

TABLE 4: SELECTED BOND ENERGIES

Bond	Energy/kJ mol^{-1}
(a) Diatomic molecules	
H—H	436
D—D	442
N≡N	994
O═O	496
F—F	158
Cl—Cl	244
Br—Br	193
I—I	151
H—F	562
H—Cl	431
H—Br	366
H—I	299
(b) Polyatomic molecules	
C—C	350
C═C	610
C≡C	840
C⋯C (benzene)	520
C—H	410
C—Cl	340
C—Br	280
C—I	240
C—N	305
C═N	610
C≡N	890
C—O	360
C═O	740
N—H	390
N—N	160
N═N	410
O—H	460
O—O	150
Si—Cl	359
Si—H	320
Si—O	444
Si—Si	222
S—Cl	250
S—H	347
S—S	264

TABLE 5: STANDARD ELECTRODE AND REDOX POTENTIALS

Electrode Reaction	$E^\ominus$/volts at 298 K (25 °C)
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Al^{3+} + 3e^- \rightleftharpoons Al$	–1.66
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	–2.90
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	–2.87
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$2HOCl + 2H^+ + 2e^- \rightleftharpoons Cl_2 + 2H_2O$	+1.64
$Co^{2+} + 2e^- \rightleftharpoons Co$	–0.28
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+1.82
$[Co(NH_3)_6]^{2+} + 2e^- \rightleftharpoons Co + 6NH_3$	–0.43
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	–0.91
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	–0.74
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	–0.41
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Cu^+ + e^- \rightleftharpoons Cu$	+0.52
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+0.15
$[Cu(NH_3)_4]^{2+} + 2e^- \rightleftharpoons Cu + 4NH_3$	–0.05
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	–0.44
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	–0.04
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$[Fe(CN)_6]^{3-} + e^- \rightleftharpoons [Fe(CN)_6]^{4-}$	+0.36
$Fe(OH)_3 + e^- \rightleftharpoons Fe(OH)_2 + OH^-$	–0.56
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$K^+ + e^- \rightleftharpoons K$	–2.92
$Li^+ + e^- \rightleftharpoons Li$	–3.04
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	–2.38
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	–1.18

TABLE 5: STANDARD ELECTRODE AND REDOX POTENTIALS (CONT'D)

Electrode Reaction	$E^{\ominus}$/volts at 298 K (25 °C)
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+0.56
$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2 + 2H_2O$	+1.67
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$NO_3^- + 3H^+ + 2e^- \rightleftharpoons HNO_2 + H_2O$	+0.94
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^- + 3H_2O$	+0.87
$Na^+ + e^- \rightleftharpoons Na$	–2.71
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	–0.25
$[Ni(NH_3)_6]^{2+} + 2e^- \rightleftharpoons Ni + 6NH_3$	–0.51
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+0.68
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	–0.83
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	–0.13
$Pb^{4+} + 2e^- \rightleftharpoons Pb^{2+}$	+1.69
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	–0.14
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$V^{2+} + 2e^- \rightleftharpoons V$	–1.20
$V^{3+} + e^- \rightleftharpoons V^{2+}$	–0.26
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00
$VO_3^- + 4H^+ + e^- \rightleftharpoons VO^{2+} + 2H_2O$	+1.00
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	–0.76

TABLE 6: SELECTED INFRARED ABSORPTION SPECTROSCOPIC DATA

Bond		**Characteristic Absorption Ranges* (Wave Number, cm^{-1})**
O—H	'free'	3580 to 3670
N—H	primary amines	3350 to 3500
O—H	'hydrogen-bonded' in alcohols, phenols	3230 to 3550
C—H	alkanes, alkenes, arenes	2840 to 3095
O—H	'hydrogen-bonded' in acids	2500 to 3300
C≡N		2200 to 2280
C≡C		2070 to 2250
C=O	aldehydes, ketones, acids, esters	1680 to 1750
C=C		1610 to 1680
C—O	alcohols, ethers, esters	1000 to 1300
C—Cl		700 to 800

*due to stretching vibrations

The Periodic Table

Group																	
I	II											III	IV	V	VI	VII	0
1.0 H 1																	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	0.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.5 Cl 17	39.9 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52 0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.4 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	– Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	La* to Lu	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	– Po 84	– At 85	– Rn 86
– Fr 87	– Ra 88	Ac** to Lr															

*	139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	– Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	163 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
**	– Ac 89	– Th 90	– Pa 91	– U 92	– Np 93	– Pu 94	– Am 95	– Cm 96	– Bk 97	– Cf 98	– Es 99	– Fm 100	– Md 101	– No 102	– Lr 103

Key $^{a}_{b}X$

a – relative atomic mass
X – atomic symbol
b – proton (atomic) number

CARIBBEAN EXAMINATIONS COUNCIL

Caribbean Advanced Proficiency Examination®
CAPE®

CHEMISTRY

Specimen Papers and Mark Schemes/Keys

Specimen Papers:

Unit 1 Paper 01
Unit 1 Paper 02
Unit 1 Paper 32
Unit 2 Paper 01
Unit 2 Paper 02
Unit 2 Paper 32

Mark Schemes and Key:

Unit 1 Paper 01
Unit 1 Paper 02
Unit 1 Paper 32
Unit 2 Paper 01
Unit 2 Paper 02
Unit 2 Paper 32

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

SPECIMEN 2017

TABLE OF SPECIFICATIONS

Unit 1 – Paper 02

Module	Question	Specific Objective	Content	Cognitive Level Marks			Total
				KC	UK	XS	
1	1	3.1, 3.2, 3.3, 3.5, 3.6, 3.8, 3.9, 6.1, 6.2, 6.4, 6.6, 6.7, 6.16	The Mole Concept Energetics	10	15	5	30
2	2	3.1, 3.2 , 3.3, 4.1, 4.2, 6.3, 6.4, 6.5	Redox Equilibria Principles of Chemical Equilibria, Buffer Solutions	10	15	5	30
3	3	2.1, 3.4, 5.2, 5.6, 5.10	Transition Elements Group II Group IV	10	15	5	30
Total				**30**	**45**	**15**	**90**

Unit 1 – Paper 032 (Alternative to SBA)

Module	Question	Specific Objective	Content	Cognitive Level Marks			Total
				KC	UK	XS	
1	1	Practical	Module 1 – 3.8, 3.9	0	5	10	15
2	2	Data Analysis	Module 2 – 1.4 – 1.6	0	5	10	15
3	3	Planning & Design	Module 2 – 6.26	0	5	10	15
Total				**0**	**15**	**30**	**45**

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

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

SPECIMEN 2017

TABLE OF SPECIFICATIONS

Unit 2 – Paper 02

Module	Question	Specific Objective	Content	Cognitive Level Marks			Total
				KC	UK	XS	
1	1	1.8, 2.1, 2.2, 2,3 2.6, 2.7, 2.13, 2.11, 2.14	Structures and Formulae Functional Group Analysis – Alcohols, Acids, Ketones Haloalkanes	10	15	5	30
2	2	7.1, 7.2, 8.1, 8.2, 8.3, 8.5	Chromatography Mass Spectroscopy	10	15	5	15
3	3	1.3, 4.1, 8.4, 8.5, 9.6, 9.7	Water and the Atmosphere Manufacture of Ammonia	10	15	5	30
Total				**30**	**45**	**15**	**90**

Unit 2 – Paper 032

Alternative to SBA

Module	Question	Specific Objective	Content	Cognitive Level Marks			Total
				KC	UK	XS	
1	1	Practical	Module 2	0	5	10	15
2	2	Data Analysis	Module 2	0	5	10	15
3	3	Planning & Design	Module 1	0	5	10	15
Total				**0**	**15**	**30**	**45**

CANDIDATE – PLEASE NOTE!

PRINT your name on the line below and return this booklet with the answer sheet. Failure to do so may result in disqualification.

____

TEST CODE **02112010**

SPEC 2017/02112010

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

Unit 1 - Paper 01

1 hour 30 minutes

SPECIMEN PAPER

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This test consists of 45 items. You will have 1 hour and 30 minutes to answer them.
2. In addition to this test booklet, you should have an answer sheet.
3. Do not be concerned that the answer sheet provides spaces for more answers than there are items in this test.
4. Each item in this test has four suggested answers lettered (A), (B), (C), (D). Read each item you are about to answer and decide which choice is best.
5. 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

Which of the following is the highest energy transition in an organic compound?

Sample Answer

Ⓐ Ⓑ ● Ⓓ

(A) n to σ^*
(B) n to π^*
(C) σ to σ^*
(D) π to π^*

The correct answer to this item is "σ to σ^*", so (C) has been shaded.

6. If you want to change your answer, erase it completely before you fill in your new choice.
7. 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, go on to the next one. You may return to that item later.
8. You may do any rough work in this booklet.
9. Figures are not necessarily drawn to scale.
10. You may use a silent, non-programmable calculator to answer items.

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

1. When a Group I metal atom, Q, forms ion Q^+, the

(A) positive charge on the nucleus increases
(B) number of protons increases
(C) number of occupied electron shells decreases by one
(D) radius of the particle increases

2. Radioactivity is hazardous because it

(A) can cause cancer and sterilization in human beings
(B) is accumulative and interacts with matter
(C) needs to be transported and disposed of properly
(D) has particulate as well as high energy emissions

3. In which of the following compounds will hydrogen bonding NOT be present?

(A) C_2H_5I
(B) C_2H_5OH
(C) CH_3NH_2
(D) H_2SO_3

4. Which of the following species has a structure with a bond angle less than 109° 28′ ?

(A) NF_3
(B) NH_4^+
(C) CH_4
(D) BF_3

5. The molar volume of a gas at room temperature and pressure (r.t.p) is 24 dm^3. If 0.032 g of a gas occupies 48 cm^3 at r.t.p., what is the molar mass?

(A) 0.016 g
(B) 2 g
(C) 16 g
(D) 64 g

6. Propane is a fuel used in lamps. The equation for the combustion of propane is

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

What volume of CO_2 is produced when 8.8 g of propane is burnt in oxygen at r.t.p.?

(The molar volume of gas at r.t.p = 24 dm^3)

(A) 1.44 dm^3
(B) 4.8 dm^3
(C) 14.4 dm^3
(D) 72 dm^3

7. Which of the following are redox reactions?

I. $2H_2O_2\ (aq) \rightarrow 2H_2O\ (l) + O_2\ (g)$
II. $Fe_2O_3\ (s) + 2Al\ (s) \rightarrow Al_2O_3\ (s) + 2\ Fe\ (s)$
III. $BaCl_2\ (aq) + H_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2HCl\ (aq)$

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

8. In the reaction between potassium manganate (VII) and potassium iodide in acid solution, the following relevant half equations can be written:

$2I^- \rightarrow I_2 + 2e-$
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Which of the following is the overall balanced equation?

(A) $MnO_4^- + 8H^+ + 2I^- \rightarrow Mn^{2+} + 4H_2O + I_2$
(B) $MnO_4^- + 8H^+ + 2I^- \rightarrow Mn^{2+} + 4H^2O + I_2 + 2e^-$
(C) $2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 8H_2O + 5I_2$
(D) $2MnO_4^- + 16H^+ + 4I^- \rightarrow 2Mn^{2+} + 8H_2O + 2I_2$

9. Which of the following is NOT true about a dynamic equilibrium?

(A) It is reversible.
(B) Macroscopic properties are constant.
(C) Microscopic processes are in balance.
(D) It cannot be achieved in a closed system.

Item 10 refers to the following equation

$C_2H_5NH_2\ (g) + HNO_2\ (aq) \rightarrow C_2H_5OH\ (l) + H_2O\ (l) + N_2\ (g)$

10. The volume of nitrogen gas collected at r.t.p. when 0.01mol of ethylamine completely reacts with an excess of nitrous acid is

(A) $0.224\ dm^3$
(B) $0.24\ dm^3$
(C) $2.24\ dm^3$
(D) $2.40\ dm^3$

11. A mass of 25 g of an unknown gas, X, is pumped through an industrial pipeline of volume 60 cm^3 at a pressure of 120 kPa and temperature of 150 ^oC. (Molar gas constant = 8.31 $J K^{-1} mol^{-1}$.)

What is the relative molecular mass of the gas?

(A) 1.2×10^{-2}
(B) 4.3×10^{-2}
(C) 4.3
(D) 12.2

12. The melting points and boiling points of two pure substances, X and Y, are given below:

	Melting point/K	Boiling point/K
X	273	373
Y	317	400

Which of the following statements about X and Y are correct?

I. At 298 K, the particles of X can occupy the volume of its container.
II. At 298 K, the particles of Y are in fixed positions.
III. At 380 K, the particles of X have more energy than the particles of Y.

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

Items 13 and 14 refers to the following options.

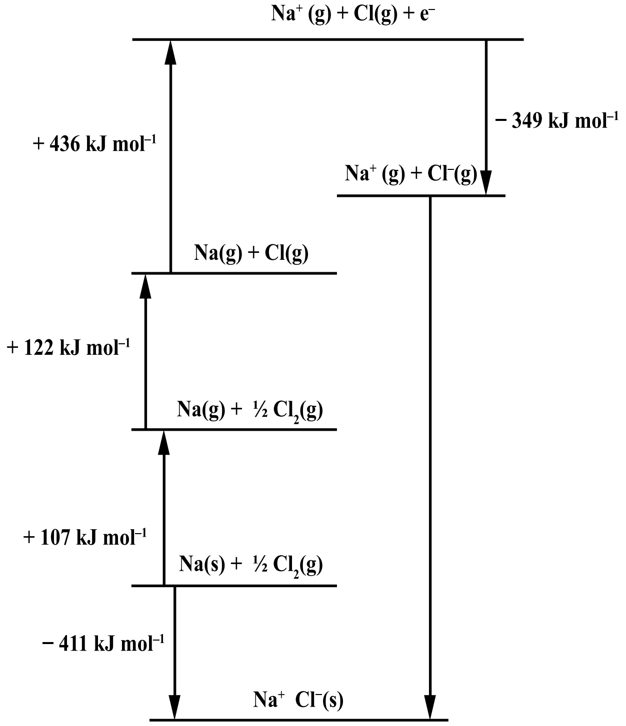
(A) Enthalpy of formation
(B) Lattice energy
(C) Enthalpy of solution
(D) Enthalpy of hydration

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

13. $Y (s) + O_2 (g) \rightarrow YO_2 (g)$

14. $XY (s) + water \rightarrow XY (aq)$

Item 15 refers to the diagram below which shows a Born-Haber Cycle for NaCl.



15. What is the lattice energy of sodium chloride?

(A) -727 kJ mol^{-1}
(B) -95 kJ mol^{-1}
(C) +663 kJ mol^{-1}
(D) +727 kJ mol^{-1}

16. The general form of a rate equation is given by: Rate = k $[A]^a[B]^b$

The rate constant, k, is defined as the rate of reaction when the concentration of each reactant (in mol dm^{-3}) is

(A) 0
(B) 1/2
(C) 1
(D) 2

Item 17 refers to the data in the table, obtained for the reaction between molecules X and Y at 500 K. The stoichiometric equation for the reaction is

$$2X\,(g) + Y_2\,(g) \rightarrow X_2\,Y_2\,(g)$$

Experiment Number	**Initial concentration/ mol dm^{-3}**		**Inital rate/ mol dm^{-3}s^{-1}**
	X	**Y**	
1	0.01	0.02	2.4 x 10^{-6}
2	0.02	0.02	4.8 x 10^{-6}
3	0.01	0.01	1.2 x 10^{-6}

17. The correct orders of reaction with respect to X and Y are

	X	Y
(A)	0	2
(B)	2	0
(C)	1	0
(D)	1	1

Item 18 refers to the following data for the reaction between propanone, iodine and hydrogen ions.

$$CH_3COCH_3 + H^+ + I_2 \rightarrow ICH_2COCH_3 + 2H^+ + I_2$$

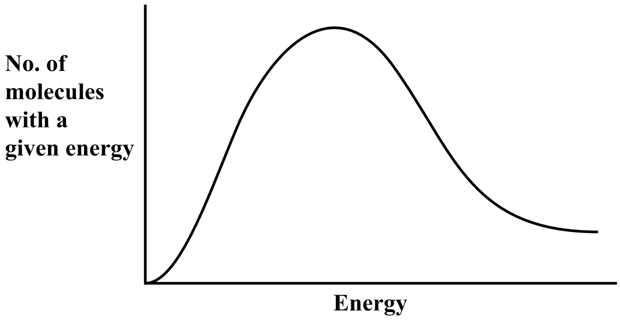
Expt. no	**Concentration/mol dm^{-3}**			**Rate/ mol dm^{-3}s^{-1}**
	CH_3COCH_3	**H^+**	**I_2**	
1	0.1	0.1	0.1	0.04
2	0.2	0.1	0.1	0.08
3	0.1	0.2	0.1	0.08
4	0.1	0.2	0.2	0.08

The rate of reaction is given by
Rate = $k[CH_3COCH_3]^x\,[H^+]^y\,[I_2]^z$

18. The values of x, y and z are

(A) x = 1, y = 1, z = 1
(B) x = 0, y = 1, z = 1
(C) x = 1, y = 1, z = 0
(D) x = 0, y = 0, z = 1

Item 19 refers to the graph below which shows the Boltzmann distribution of kinectic energies in a gas.



19. Which of the following statements are correct for the Boltzmann distribution?

Increasing temperature

I. causes the maximum of the curve to move to the right
II. increases the number of molecules
III. increases the number of molecules with energy greater than the activation energy

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

20. Based on Le Chatelier's principle, which combination of obervations is NOT true?

	Type of Reaction	**Temperature Change**	**Effect on K_c**	**Effect on Reactants**
(A)	Endothermic	decrease	decrease	increase
(B)	Endothermic	increase	increase	decrease
(C)	Exothermic	increase	increase	decrease
(D)	Exothermic	decrease	increase	decrease

<u>Item 21</u> refers to the data in the table below

Gas	**Equilibrium Partial Pressure**
N_2	a
H_2	b
NH_3	c

21. What is the expression for K_p for the equilibruim $N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$?

(A) $\dfrac{c^2}{a^3b}$

(B) $\dfrac{a^3b}{c^2}$

(C) $\dfrac{ab^3}{c^2}$

(D) $\dfrac{c^2}{ab^3}$

22. Which of the following are Bronsted-Lowry acids?

I. NH_4^+
II. C_6H_5OH
III. CH_3COO^-

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

23. What is the K_w value of 2.0 mol dm^{-3} NaOH(aq) at 298K?

(A) $2.0 \times 1.0 \text{ x } 10^{-14}$
(B) $1.0 \times 10^{-14}/2.0$
(C) 1.0×10^{-14}
(D) 4.0×10^{-14}

24. Which of the following indicators would be suitable for use in titrating a strong acid against a weak base?

	Indicator	pH range
I.	Bromophenol blue	2.8 - 4.6
II.	Methyl red	4.2 - 6.3
III.	Alizaren yellow	10.1 - 13.0

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

25. A buffer solution consists of ethanoic acid and sodium ethanoate solution.

Which equations show how the buffer maintains constant pH in solution?

I. $CH_3COO^- + NH_4^+ \rightarrow CH_3COONO_4$
II. $CH_3COO^- + H^+ \rightarrow CH_3COOH$
III. $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

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

Item 26 refers to the following reaction:

$CH_3COOH\ (aq) \rightleftharpoons H^+\ (aq) + CH_3COO^-\ (aq)$
[sodium ethanoate] = 0.5 mol dm^{-3} and
[ethanoic acid] = 0.3 mol dm^{-3}

26. Given that $K_a = 1.8 \times 10^{-5}$, what is the pH of the buffer solution?

(A) 3.25
(B) 4.97
(C) 6.50
(D) 9.94

27. When solid silver chloride is added to a solution of potassium iodide, a yellow precipitate of silver iodide forms because

(A) chlorine is more electronegative than iodine
(B) potassium chloride and potassium iodide are both soluble
(C) silver chloride has a lower K_{sp} value than silver iodide
(D) silver iodide has a lower K_{sp} value than silver chloride

28. Which of the following is NOT a standard condition for measurement of electrode potentials?

(A) Solutions have a concentration of 1 mol dm^{-3}.
(B) Gases have a pressure of 1 atmosphere.
(C) Temperature is 25 °C.
(D) Metal alloys are used as electrodes

29. Which pair of half cell potentials would produce an $E^{\ominus}/V$ of 1.1 when combined to form a cell?

(A) $Cu^{2+}(aq)/Cu(s)$ and $Fe^{3+}(aq)/Fe^{2+}(aq)$
(B) $Cu^{2+}(aq)/Cu(s)$ and $Zn^{2+}(aq)/Zn(s)$
(C) $Al^{3+}(aq)/Al(s)$ and $Zn^{2+}(aq)/Zn(s)$
(D) $Ag^+/Ag(s)$ and $Cu^{2+}(aq)/Cu(s)$

30. The standard electrode potentials for dichromate and iodide are:

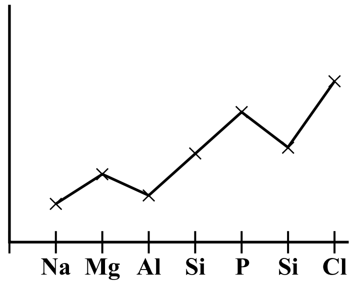
$1/2\ Cr_2O_7^{2-}\ (aq) + 7H^+(aq) + 3e \rightleftharpoons Cr^{3+}(aq) + 7/2\ H_2O \qquad + 1.33\ V$
$I_2(aq) + 2e^- + 2e^- \rightleftharpoons 2I^-\ (aq) \qquad + 0.54\ V$

From this it can be deduced that

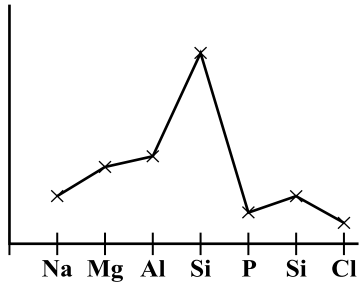
(A) acidified dichromate ions would oxidise iodide ions to iodine
(B) iodine would oxidise chromium (III) ions to dichromate
(C) combining both half cells would produce a cell potential of 1.87
(D) electrons would flow from the dichromate half cell to the iodine half cell if the two are connected

Items 31 and 32 refer to the following graphs.

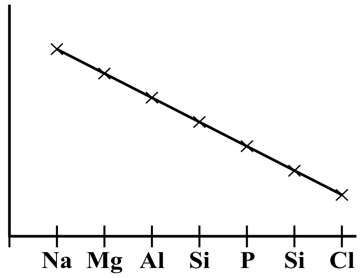
(A)



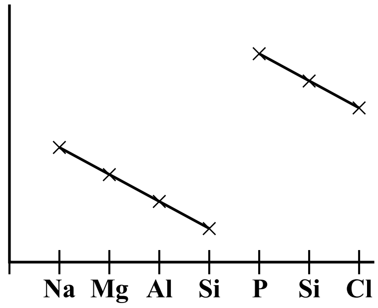
(B)



(C)



(D)



In answering Items 31 and 32, match each item with one of the graphs.
Each graph may be used once, more than once or not at all.

31. Atomic radius

32. First ionization energy

Items 33 and 34 refer to the following oxidation states.

(A) +1
(B) +3
(C) +6
(D) +7

Match each element below with one of the options above, each of which may be used more than once, once or not at all

33. P_4O_6

34. Na_2O

35. Which of the following has a simple molecular structure?

(A) Sodium oxide
(B) Magnesium chloride
(C) Aluminium chloride
(D) Silicon (IV) oxide

36. In descending Group II of the periodic table, the first ionization energy value of the elements decreases. This is due to which two of the following?

I. Atomic radius increases down the group.
II. Electrons are more delocalised as ionic radius decreases.
III. Each succeeding atom has one more quantum shell than the other.

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

37. Group IV elements show an increasing tendency towards metallic character as atomic number increases. Which of the following may account for this?

I. The +2 state becomes more stable than the +4 state.
II. The +4 state becomes more stable than the +2 state.
III. The valence electrons in the +4 state do not take part in bonding.

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

38. Which of the following oxides of elements in Group IV is the LEAST acidic in character?

(A) SnO_2
(B) PbO
(C) CO_2
(D) SiO_2

39. The decrease in volatility going down Group VII CANNOT be described by which of the following?

(A) Strength of van der Waals forces increases
(B) Electropositivity increases
(C) Size of atoms increases
(D) Molecular mass increases

40. A student tests an unknown sample with a few cm^3 of $AgNO_3(aq)$ followed by a few cm^3 of dilute $NH_3(aq)$. Which of the following observations would confirm that the sample contains the Br^- ion?

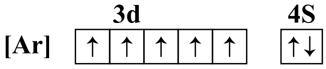
	Precipitate with $AgNO_3$	**Dissolves in dilute NH_3**
(A)	white	sparingly
(B)	white	readily
(C)	off-white	sparingly
(D)	off-white	readily

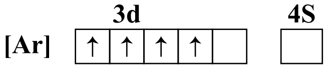
41. Transition metal complexes contain a central metal atom or ion surrounded by ligands. Which of the following does NOT explain why these complexes are formed?

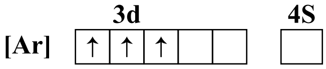
(A) The presence of lone pairs of electrons on ligands
(B) The presence of vacant d-orbitals on the metal atom or ion
(C) The formation of covalent bonds between the metal and ligands
(D) The complex ion formed is stable with respect to its constituents

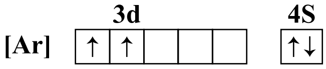
42. Which of the following represents the electronic configuration of Mn^{3+}?

Note: $[Ar] = 1s^2, 2s^2 2p^6, 3s^2 3p^6$

(A) 

(B) 

(C) 

(D) 

43. Transition metals can exhibit more than one oxidation state because they

(A) have more than one free electron
(B) exist in different colours
(C) have similar energy levels for 3d and 4s
(D) have incomplete d-orbitals

Item 44 refers to the following information.

An unknown salt sample, *FAl*, is subjected to analysis and the results are shown in the table.

Reaction	**Results**
KI (aq) + FA*l* (aq)	No visible reaction
NH_3 (aq) + FA*l* (aq)	White precipitate, insoluble in excess NH_3 (aq)

44. It can be deduced that the cation is MOST likely

(A) Al^{3+}
(B) Zn^{2+}
(C) Na^+
(D) Pb^{2+}

45. When silver nitrate solution followed by dilute ammonia is added to a solution containing chloride ions, which of the following is the formula for the complex formed?

(A) $Ag(NH_4)^+$
(B) $AgNH_2$
(C) $[Ag(NH_3)_2]^+$
(D) $[Ag(NH)_4]^{2+}$

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

Question	Syllabus Reference	Profile	Key
1.	1.1.13	KC	C
2.	1.1.5	KC	D
3.	1.2.6	UK	A
4.	1.2.7	UK	A
5.	1.3.1	UK	C
6.	1.3.5	UK	C
7.	1.4.1	UK	A
8.	1.4.3	UK	C
9	1.2.1	KC	D
10.	1.3.5	UK	B
11.	1.3.6	UK	D
12.	1.2.3	KC	C
13.	1.6.6	KC	A
14.	1.6.6	KC	C
15.	1.6.9	UK	A
16.	2.1.3	UK	C
17.	2.1.6	UK	D
18.	2.1.4	UK	C
19.	2.1.8	KC	A
20.	2.2.6	KC	C
21.	2.2.4	UK	D
22.	2.3.1	KC	A
23.	2.3.3	UK	C
24.	2.3.6	KC	B
25.	2.4.2	KC	C
26.	2.4.3	UK	B
27.	2.5.2	KC	D
28.	2.6.3	KC	D
29.	2.6.4	UK	B
30.	2.6.5	UK	A
31.	3.1.3	UK	B
32.	3.1.3	UK	A
33.	3.1.6	KC	C
34.	3.1.1	KC	C
35.	3.1.1	KC	A
36.	3.2.1	KC	B
37.	3.3.1	KC	A
38.	3.3.1	KC	B
39.	3.4.1	KC	B
40.	3.6.5	UK	C
41.	3.5.8	KC	D
42.	3.5.4	KC	B
43.	3.5.2	KC	C
44.	3.6.1	UK	A
45.	3.6.5	KC	C

Unit 1 Paper 01 Keys

Question	Syllabus Reference	Profile	Key
1.	1.1.13	KC	C
2.	1.1.5	KC	D
3.	1.2.6	UK	A
4.	1.2.7	UK	A
5.	1.3.1	UK	C
6.	1.3.5	UK	C
7.	1.4.1	UK	A
8.	1.4.3	UK	C
9	1.2.1	KC	D
10.	1.3.5	UK	B
11.	1.3.6	UK	A
12.	1.2.3	KC	C
13.	1.6.6	KC	A
14.	1.6.6	KC	C
15.	1.6.9	UK	A
16.	2.1.3	UK	C
17.	2.1.6	UK	D
18.	2.1.4	UK	C
19.	2.1.8	KC	B
20.	2.2.6	KC	C
21.	2.2.4	UK	D
22.	2.3.1	KC	A
23.	2.3.3	UK	C
24.	2.3.6	KC	B
25.	2.4.2	KC	C
26.	2.4.3	UK	B
27.	2.5.2	KC	D
28.	2.6.3	KC	D
29.	2.6.4	UK	B
30.	2.6.5	UK	A
31.	3.1.3	UK	C
32.	3.1.3	UK	A
33.	3.1.6	KC	B
34.	3.1.1	KC	A
35.	3.1.1	KC	C
36.	3.2.1	KC	B
37.	3.3.1	KC	A
38.	3.3.1	KC	B
39.	3.4.1	KC	B
40.	3.6.5	UK	C
41.	3.5.8	KC	D
42.	3.5.4	KC	B
43.	3.5.2	KC	C
44.	3.6.1	UK	A
45.	3.6.5	KC	C

SPEC 2017/02112020

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

SPECIMEN PAPER

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

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

“*”Barcode Area”*”
Sequential Bar Code

Answer ALL questions.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

1. (a) Define the terms

(i) Mole

....

....

....

[2 marks]

(ii) Molar mass

....

....

....

[1 mark]

(iii) State the units of molar mass

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....

....

[1 mark]

(iv) State Avogadro's Law.

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....

....

[1 mark]

GO ON TO THE NEXT PAGE

(b) 20 cm^3 of a solution of phosphorous (V) acid containing 1.96 g dm^{-3} reacted with 25 cm^3 of a solution containing 1.28 g dm^{-3} sodium hydroxide.

Relative atomic masses: P = 31.0, H = 1.0, Na = 23.0, O = 16.0

Calculate the number of moles of

(i) phosphorous (V) acid that reacted

[2 marks]

(ii) sodium hydroxide that reacted

[1 mark]

(iii) sodium hydroxide that reacted with 1 mole of the acid.

[1 mark]

(iv) Derive the equation for the reaction that occurred in Part (b) above.

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[1 mark]

(v) Outline the steps involved in carrying out the reaction described in (b) above.

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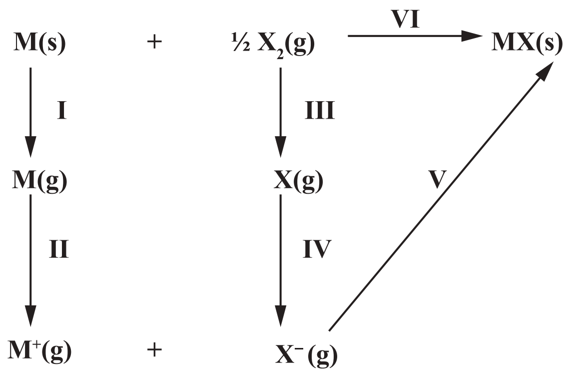
[5 marks]

GO ON TO THE NEXT PAGE

(c) The following diagram represents the Born Haber cycle for the formation of compound MX(s).



The associated enthalpy changes in kJ mol^{-1} for the cycle above are as follows:

ΔH M(s) = + 86; ΔH M(g) = + 408; ΔH (MX(s)) = – 431; ΔH X_2 = + 122; ΔH X(g) = –372

(i) State Hess' Law of heat summation.

....

....

[1 mark]

(ii) Define standard enthalpy change of formation.

....

....

[1 mark]

(iii) Which enthalpy values correspond to EACH of the stages I, III and IV in the cycle above?

....

....

[3 marks]

(iv) Define lattice energy.

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(v) Calculate the lattice energy of MX(s).

[3 marks]

(d) Account for the difference in the lattice energy for $MgCl_2$(s) and NaCl(s).

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[4 marks]

(e) Explain why the molar enthalpy changes for the following reactions have identical values.

$HCl (aq) + NaOH (aq) \rightarrow NaCl (aq) + H_2O (l)$
$H_2SO_4 (aq) + 2KOH (aq) \rightarrow K_2SO_4 (aq) + 2H_2O (l)$

....

....

....

[2 marks]

Total 30 marks

GO ON TO THE NEXT PAGE

MODULE 2

KINETICS AND EQUILIBRIA

2. A student is attempting to find the cell potential of a Daniell (Zn/Cu) cell.

(a) (i) Outline the steps he has to follow to obtain a reading of approximately 1.10 V on his voltmeter.

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[5 marks]

(ii) Write the ionic equation for the reaction occurring at EACH of the electrodes.

....

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[2 marks]

(iii) Identify the anode and the cathode.

Anode: ....

Cathode: ....

[1 mark]

(iv) Explain the direction of electron flow.

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(v) Write the cell diagram.

....

....

[1 mark]

(vi) Write the equation to represent the cell reaction.

....

....

[1 mark]

(b) Use the E° value for each electrode (in the data booklet) to determine the E° cell. Does your calculated value concur with the measured value of E° cell = 1.10V given on page 8?

....

[2 marks]

(c) Suggest TWO changes which could be made to the cell in (a) to cause the cell potential to be greater than 1.10V.

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[2 marks]

(d) Account for the observations in the statement below.

Pure water is a poor conductor of electricity whereas pure water in the presence of a trace of $H^+(aq)$ is a good conductor.

....

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....

[3 marks]

(e) (i) Derive the relationship for the ionic product of water, Kw.

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....

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[2 marks]

(ii) State how the value of Kw varies with temperature.

....

....

[1 mark]

(f) (i) Calculate the pH of EACH of the solutions A, B and C, given that their concentrations are as shown in the table below.

Solution	Concentration of $H^+(aq)$ mol dm^{-3}
A	2×10^{-5}
B	1×10^{-2}
C	1×10^{-14}

[3 marks]

(i) Place the solutions A, B and C in 5 (c) (i) on a pH scale relative to the pH of pure water.

Solution	pH

[1 mark]

GO ON TO THE NEXT PAGE

(g) A student is asked to prepare a buffer solution using an aqueous solution of sodium hydroxide and one of the aqueous solutions, X(aq) or Y(aq). The dissociation constants for X is $K_a = 1.8 \times 10^{-5}$, and for Y is $K_b = 1.8 \times 10^{-5}$.

(i) Define the term ‘buffer solution’.

....

....

[1 mark]

(ii) Which of the solutions, X or Y, would you use with the sodium hydroxide to prepare a buffer solution? Justify your answer.

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[2 marks]

(iii) Explain how small additions of H^+ and OH^- ions are accommodated in the buffer solution prepared above.

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[2 marks]

Total 30 marks

GO ON TO THE NEXT PAGE

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. (a) Transition elements form coloured compounds.

State THREE other characteristic properties of transition elements

....

....

....

....

[3 marks]

(b) What are the colours of aqueous

(i) CO^{2+}?

....

[1 mark]

(ii) Mn^{2+}?

....

[1 mark]

(c) If aqueous CO^{2+} is heated to dryness, what colour is observed?

....

[1 mark]

(d) Explain what is meant by the term ‘ligand’.

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(e) Write the formula of the species formed, and describe what occurs when

(i) ammonia solution is added to aqueous copper (II) sulphate (IV)

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[2 marks]

(ii) an excess of ammonia solution is added to (e) (i).

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[2 marks]

(f) The presence of carbon monoxide in the blood can prevent oxygen from reaching the tissues.

Use the ligand exchange theory to account for this occurrence.

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[5 marks]

GO ON TO THE NEXT PAGE

(g) Calculate the oxidation number of the first mentioned element in EACH of the following compounds, and explain the variation in these oxidation numbers:

$MgCl_2 \rightarrow [Al(OH)_4]^- \rightarrow SiF_6^{2-} \rightarrow PO_3^{3-}$

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[5 marks]

(h) (i) Explain the terms ‘atomic radius’ and ‘ionic radius’.

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[2 marks]

GO ON TO THE NEXT PAGE

(ii) Account for the variation in atomic and ionic radii of the elements in Group II.

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[2 marks]

(i) Explain the variation in the acid/base character of the oxides of oxidation state +2 of the elements of Group IV.

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[5 marks]

Total 30 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐

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CHEMISTRY

UNIT 1 — PAPER 02

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question 1

S.O.: Module: 1 —3.1, 3.2, 3.3, 3.5, 3.6, 3.8, 3.9, 6.1, 6.2, 6.4, 6.6, 6.7, 6.16

	KC	UK	XS
(a) (i) mole: an amount of a substance that contains as many particles as C atoms in 12g of C-12 isotope **[2 marks]** [C amount of a substance containing 6 x 10^{23} particles – 1 mark only]	2		
(ii) Mass of 1 mole of a substance in grams **[1 mark]**	1		
(iii) Unit of molar mass is g mol^{-1} **[1 mark]**	1		
(iv) Avogadro's Law: Equal volumes of all gases contain the same number of molecules under the same conditions of temperature and pressure. **[1 mark]**	1		
(b) (i) Molar mass H_3PO_4 = 3 + 31 + 64 = 98g 98g of H_3PO_4 is the mass of 1 mole 1.96g of H_3PO_4 is the 1/98 x 1.96 mole = 0.02 mole **[1 mark]** 1000 cm^3 H_3PO_4 soln contains 0.02 mole ∴20 cm^3 H_3PO_4 soln contains $\frac{0.02}{1000}$ X 20 = 0.0004 mole **[1 mark]**		2	
(ii) No of mole NaOH = $\frac{1}{40}$ X 1.28 = 0.032 mole 25 cm^3 Na OH solution contains $\frac{0.032}{1000}$ X 25 = 0.0008 mole **[1 mark]**		1	
(iii) 0.0004 mole acid reacts with 0.0008 mole NaOH ∴1 mole acid reacts with $\frac{0.0008}{0.0004}$ = 2 moles **[1 mark]**		1	
(iv) $H_3PO_4(aq) + 2\ NaOH(aq) \longrightarrow Na_2HPO_4(aq) + 2H_2O(l)$ **[1 mark]**		1	
(v) • Measure 25 cm^3 NaOH solution with a clean pipette • Deliver this solution in a clean 250 cm^3 conical flask • Add a few drops of phenolphthalein indicator • Fill a clean burette to the zero mark with phosphoric acid • Add acid dropwise to the alkali until the solution goes colourless **[5 marks]**			5

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

	KC	UK	XS
(c) (i) Hess's law of constant heat summation states that for any extensive property (enthalpy), the ΔH in going from reactants to products is a constant regardless of the path taken, as long as the reaction goes from the same initial state to the same final state. **[1 mark]**	1		
(ii) Standard enthalpy of formation is the enthalpy change when one mole of a compound is formed from the elements in their standard states. **[1 mark]**	1		
(iii) Stage I: ΔH^{θ}_{A} **[1 mark]** Stage III: ΔH^{θ}_{D} **[1 mark]** Stage IV: ΔH^{θ}_{E} **[1 mark]**		3	
(iv) Lattice energy is the enthalpy of formation for one mole of the ionic compound from gaseous ions under standard conditions. **[1 mark]**	1		
(v) Lattice energy of MX(s)= $\Delta H^{\theta}_{F} - (\Delta H^{\theta}_{A} + \Delta H^{\theta}_{I} + \Delta H^{\theta}_{D} + \Delta H^{\theta}_{E})$ **[1 mark]** $= -431 - (+86 + 408 + 122 - 372)$ **[1 mark]** $= -675\ \text{kJ mol}^{-1}$ **[1 mark]**		2	
(d) The difference in lattice energies • For Mg, one has to take into consideration the 1st and 2nd ionization energies of Mg. (+736, 1450). **[2 marks]** • For Cl, the two electrons that are released are given one each to 2 chlorine atoms. Adding one electron as a time – you need to multiply E.A by 2. **[2 marks]**		4	
(e) The same overall reaction for each since a strong acid and a strong base are reacting. $H^+ + OH^- \longrightarrow H_2O$ $2H^+ + OH^- \longrightarrow 2H_2O$	1		
Since one is dealing with molar enthalpy change the values of ΔH will be the same. **[2 marks]**		1	
Total 30 marks	10	15	5

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question 2

S.O.: Module: 1 –3.1, 3.2 , 3.3, 4.1, 4.2, 6.3, 6.4, 6.5

			KC	UK	XS
(a)	(i)	Place a strip of zinc in 1 mol dm^{-3} $Zn^{2+}(aq)$ in a beaker - Place a strip of copper in 1 mol dm^{-3} $Cu^{2+}(aq)$ in a beaker - Connect the two metal strips to a high resistance voltmeter - Connect the two solutions by means of a salt bridge a strip filter soaked in $KNO_3(aq)$ or KCI(aq) (or solutions in the tube fitted with porous plugs) - Try to maintain temperature if 25^0C **[5 marks]**			5
	(ii)	$Zn(s) \rightleftharpoons Zn^{2+} + 2e$ **[1 mark]** $Cu^{2+}(aq) + 2e \rightleftharpoons Cu(s)$ **[1 mark]**	2		
	(iii)	The anode is Zn; the cathode is Cu **[1 mark]**	1		
	(iv)	The electrons flow from zinc to the copper half cell since the zinc gives up electrons more readily than copper. **[1 mark]**		1	
	(v)	$Zn(s)\backslash Zn^{2+}(aq)\backslash\backslash Cu^{2+}(aq) + Cu(s)$ **[1 mark]**	1		
	(vi)	$Cu^{2+}(aq) + Zn(s) \rightleftharpoons Zn^{2+}(aq) + Cu\ (s)$ **[1 mark]**	1		
(b)		$E^{\theta}_{cell} = E^{\theta}_{Cu\backslash Cu^{2+}} - E^{\theta}_{Zn\backslash Zn^{2+}}$ $=0.34-(-0.76)=1.10V$ **[2 marks]**		2	
(c)		As the reaction in (a)(v) proceeds $Cu^{2+}_{(aq)}$ decreases while $Zn^{2+}_{(aq)}$ increases. Hence, according to Le Chatelier's principle, a shift to the right will increase the cell reaction and the cell voltage. Therefore, increasing $Cu^{2+}_{(aq)}$ or decreasing $Zn^{2+}_{(aq)}$ will result in a larger voltage than 1.10V. **[2 marks]**		2	

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

	KC	UK	XS
(d) Pure water is a poor conductor of electricity due to the following equilibrium which lies to the far left $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$. Since the degree of ionization is very small, it is a poor conductor. **[2 marks]** In the presence of H+, pure water is a good conductor as the concentration of free ions present increases. **[1 mark]**	3		
(e) (i) The K_c expression for water becomes $K_c = \frac{[H^+(aq)][OH^-(aq)]}{[H_2O(l)]}$ Since the H_2O is effectively constant, this is incorporated into the K_c constant giving a new constant $K_w = [H^+(aq)][OH^-(aq)]$ **[2 marks]**		2	
(ii) K_w increases with temperature. As T increases, more energy is available to ionize H_2O. $[H^+]$ increases, hence K_w increases. **[1 mark]**	1		
(f) (i) pH of soln A = $-\log(2 \times 10^{-5}) = 4.7$ **[1 mark]** pH of soln B = $-\log(1 \times 10^{-2}) = 2$ **[1 mark]** pH of soln C = $-\log(1 \times 10^{-14}) = 14$ **[1 mark]**		3	
(ii) pH scale relative to water: **solution** **pH** C 14 Pure Water 7.0 A 4.7 B 2.0 **[1 mark]**		1	
(g) (i) A buffer solution is one that resists changes in pH when small quantities of acid or base are added to it. **[1 mark]**	1		

(ii) From the dissociation constants, solution X is a solution of weak acid while solution Y is a solution of a weak base.

Sodium hydroxide will therefore react with X to form the sodium salt. The mixture will consist of the weak acid and the salt of that acid, which contains the conjugate base of the acid. This will act as a buffer solution.

Weak acid dissociating: $HX = H^+ + X^-$
Salt dissociating: $NaX = Na+ + X^-$

[2 marks]

(iii) On addition of small amounts of H^+, the excess X^- ions from the salt will react with the added H^+ and maintain the pH almost constant, hence buffering action.

[1 mark]

On addition of small amounts of base, e.g. OH^- ions H^+ from the acid will react and the acid equilibrium will then shift to the right in this way almost nullifying the effect of the added H^+ and the pH remains effectively constant, hence buffering action. **[1 mark]**

	KC	**UK**	**XS**
Total 30 marks	**10**	**15**	**5**

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question **3**

S.O: Module 3: — 2.1, 3.4, 5.2, 5.6, 5.10

				KC	**UK**	**XS**
(a)	(i)	variable oxidation number	**[1 mark]**			
	(ii)	form complex ions	**[1 mark]**	3		
	(iii)	act as catalysts	**[1 mark]**			
(b)	(i)	pink	**[1 mark]**	2		
	(ii)	pink	**[1 mark]**			
(c)		Blue	**[1 mark]**			1
(d)		Ligands are groups that can donate electron pairs to metal ions thus forming a co-ordinate bond.	**[1 mark]**	1		
(e)	(i)	blue precipitate	**[1 mark]**			1
		$Cu(OH)_2$	**[1 mark]**			1
						1
	(ii)	blue ppt dissolves forming deep blue solution	**[1 mark]**			
		$[Cu(NH_3)_4]^{2+}$	**[1 mark]**			1
(f)		Oxygen is transported to the tissues as a complex with the haemoglobin that is found in the red blood cells.	**[1 mark]**			
		CO can also form a complex with haemoglobin.	**[1 mark]**			
					5	
		The stability constant for the haemoglobin – CO complex is much higher than that of the haemoglobin – O_2 complex, so CO competes successfully with oxygen.	**[2 marks]**			
		Therefore, the presence of CO can prevent oxygen from reaching the tissues.	**[1 mark]**			

O_2 + haemoglobin $\rightleftharpoons$ oxhaemoglobin

CO + haemoglobin $\rightarrow$ carboxyhaemoglobin

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

			KC	UK	XS
(g)		Mg = +2 $[\text{Al OH}_4]^-$: X − 4 = −1; X = +3; Al = +3 SiF_6^{2-} : x − 6 = −2; x = +4; Si = +4 $PO^{3-}{}_3$: x − 6 = −3; x = +3; P = +3 **[4 correct = 4 marks]** **[3 correct = 3 marks]** **[2 correct = 2 marks]** **[1 correct = 1 mark]** Oxidation number results from the need of elements to Achieve configuration of ns^2np^6 Hence, oxidation numbers: +2, +3, +4, +3 **[1 mark]**		5	
(h)	(i)	Atomic radius: half the distance between two covalently bonded atoms. **[1 mark]** **OR** Distance of nearest approach to another identical atom. **[1 mark]**	1		
		Ionic radius: this is assigned by considering the distance between the two centres of adjacent ions in a crystal lattice. **[1 mark]**	1		
	(ii)	As Group II is descended, atomic size increases due to electrons in additional valence shell. **[1 mark]**	1		
		As Group II is descended, ionic size increases: ion has E.C. given by $(n-1)s^2(n-1)p^6$. **[1 mark]**	1		
(i)		Oxides vary: CO, SiO are neutral; SiO are neutral; GeO, SnO, PbO are amphoteric. **[1 mark]** CO, SiO – no reaction with acids or bases **[1 mark]** GeO, SnO, PbO – with acids give divalent ions (M^{2+}) **[1 mark]** GeO, SnO, PbO – with alkalis produce complex ions $[M(OH)_4]^{2-}$ **[2 marks]**		5	
		Total 30 marks	**10**	**15**	**5**

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CHEMISTRY

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. You are advised to take some time to read through the paper and plan your answers.
8. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
9. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

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

“*”Barcode Area”*”
Sequential Bar Code

Answer ALL questions.

1. You are provided with TWO solutions:

(i) a solution of ammonium iron (II) sulphate hexahydrate, $(NH_4)_2SO_4FeSO_46H_2O$ containing 39.00g of the salt in $1dm^3$ of solution labelled R.

(ii) a solution of potassium manganate(VII), $KMnO_4$, labelled S.
The ionic equation for the reaction is
$5Fe^{2+-}(aq) + MnO_{4-}(aq) + 8H^{+}(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$.

Carry out the following procedure to determine the concentration for potassium manganate (VII) solution S.

The results are to be entered into Table 1.

(a) **Procedure**

A. Pipette 25 cm^3 of the solution R into a clean conical flask.
B. Add an approximately equal volume of dilute sulphuric acid to the conical flask.
C. Fill the burette with the solution S.
D. Titrate the mixture of R with the solution S.
E. Record both your initial burette reading and reading at the end point to two decimal places.
F. Repeat steps A-E until consistent results are obtained.

TABLE 1: DATA FOR EXPERIMENTAL PROCEDURE

	1	**2**	**3**
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of $KMnO_4$ used (cm^3)			

[6 marks]

(b) Describe the colour of the mixture at the end point of the titration.

....

....

[1 mark]

(c) Calculate the volume of $KMnO_4$ used for the titration.

[1 mark]

(d) Calculate the number of moles of iron (II) ions in 1 dm^3 of solution, R.

[1 mark]

(e) Calculate the number of moles of iron (II) ions in the volume of 25 cm^3 of R.

[1 mark]

(f) Calculate the number of moles of potassium manganate (VII) in 1 dm^3 of solution.

[2 marks]

(g) (i) State TWO reagents that can be used in testing for the presence of Fe^{2+} ions.

....

....

[2 marks]

(ii) Describe what should be observed when any ONE of the reagents in (g) (i) is added to a solution containing only Fe^{2+} cations.

....

[1 mark]

Total 15 marks

2. A student is required to investigate the rate of reaction in which a fixed mass of magnesium metal (0.12 g) is added to different volumes of 1.5 mol dm^{-3} hydrochloric acid. The acid is added from a burette and water added to make the final volume of 50 cm^3. The time taken for the magnesium ribbon to disappear is recorded. Figure 1 below shows the burette reading for the volume of acid added and the time taken for the magnesium to disappear for each reaction. The initial burette reading is always 0.0 cm^3.

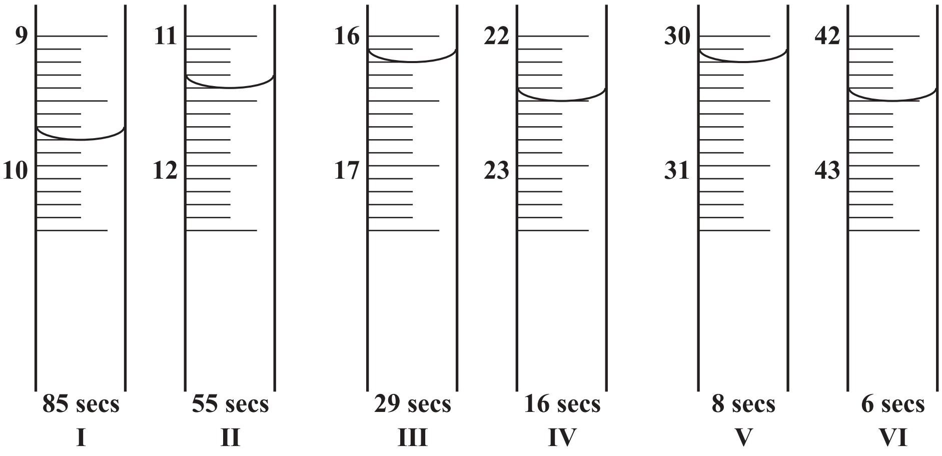

Figure 1

(a) From the results shown in Figure 1, construct a table to show experiment number, volume of acid added from the burette, volume of water added to the acid, and the time taken for the magnesium to disappear.

[5 marks]

(b) On the graph paper on page 7, plot a graph of time taken for the magnesium ribbon to disappear against volume of acid added from the burette. **[5 marks]**

GO ON TO THE NEXT PAGE

(iii) Explain the shape of the graph.

....

....

[2 marks]

(iv) From the graph, determine the rate of reaction at 10, 20 and 30 seconds.

Rate at 10 s: ....

Rate at 20 s: ....

Rate at 30 s: ....

[3 marks]

Total 15 marks

3. Four bottles labelled A, B, C and D are found in the laboratory. One bottle contains a strong monobasic acid, 1 mol dm^{-3}; another contains a weak monobasic acid, also of concentration 1 mol dm^{-3}; the third bottle contains a reducing agent of $E^{\circ} = -1.39V$, and the fourth contains another reducing agent of $E^{\circ} = -0.14V$. All are colourless liquids.

You have access to all laboratory equipment, and reagents including H_2O_2.

(i) Hypothesis:

....

....

[1 mark]

(ii) Apparatus and materials:

....

....

....

....

[2 marks]

(iii) Method:

....

....

....

....

....

....

[3 marks]

GO ON TO THE NEXT PAGE

(iv) Variables:

....

....

....

....

[2 marks]

(v) Expected results:

....

....

....

....

....

[2 marks]

(vi) Chemical principles:

....

....

....

[3 marks]

(vii) TWO sources of error:

....

....

....

[2 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐

EXTRA SPACE

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Question No. ☐

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CHEMISTRY

UNIT 1 — PAPER 032

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 1

S.O.: Module: 1 —3.8, 3.9

(a)

Burette readings $KMnO_4$ /H^+			
Reading/cm^3	**1**	**2**	**3**
Final **Initial** **Difference**			

Correct burette readings **[6 marks]**

(If one incorrect = 5 marks)
(If two incorrect = 4 marks)
(If THREE incorrect = 3 marks)
(If FOUR incorrect = 2 marks)
(If FIVE incorrect = 1 mark)

(More than FIVE incorrect = 0 marks)

Volumes recorded to 2 decimal places – 1 mark

(b)

Pink tinge **[1 mark]**

(c)

Candidate’s average of closest values **[1 mark]**

(d)

No. of moles of Fe^{2+}(aq) in 1 dm^3

$$= \frac{39}{392}$$

$$= \mathbf{0.1}\ \text{mol dm}^{-3}$$ **[1 mark]**

(e)

No. of moles Fe^{2+} in 25 cm^3 = (0.1 x 0.025) = 0.0025 moles **[1 mark]**

KC	**UK**	**XS**
		6
		1
	1	
	1	
	1	

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

		KC	UK	XS
(f)	# of Moles $KMnO_4$ reacted = 0.0025÷5 = 0.0005 moles **[1 mark]** # of Moles $KMnO_4$ in 1 dm^3 = 0.0005 moles ÷ candidate’s average volume x 1000 **[1 mark]**		**2**	
(g)	(i) NH_3 (aq), NaOH (aq) **[2 marks]**			**2**
	(ii) Green ppt. **[1 mark]**			**1**
	Total 15 marks		**5**	**10**

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 2

S.O.: Module: 2 —1.4 – 1.6

(i)

Expt. #	**Volume of Acid (cm^3)**	**Volume of water (cm^3)**	**Time (seconds)**
1	9.8	40.2	85
2	11.4	38.6	55
3	16.2	33.8	29
4	22.5	27.5	16
5	30.3	19.7	8
6	42.1	7.9	4

Table headings = 1 mark
4 or more rows correct = 4 marks
3 rows correct = 3 marks
2 rows correct = 2 marks
1 row correct = 1 mark

[Total 5 marks]

(ii) Axes correct = 2 marks
Shape of graph = 1 mark
4-6 points correct = 2 marks
<4 points correct = 1 mark

[Total 5 marks]

(iii) As the volume of acid increases the reaction time increases. Any other reasonable expression.

[2 marks]

(iv) Use the candidates’ graphs to determine rate of reaction at 10, 20, and 30 seconds.

[1 mark each = 3 marks]

KC	**UK**	**XS**
		5
		5
	2	
	3	
	5	**10**

Total 15 marks

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 3

S.O.: Module: 2 —6.26

(i) Hypothesis
Any correct answer, for example:

A is a strong monobasic acid
B is ...
C is ...
D is ...

[1 mark]

(ii) Apparatus and materials **[2 marks]**

(iii) Method

Any reasonable workable set of procedures, for example:

- use of pH meter for weak and strong acids;
- react acids with metal or carbonate and record time taken for reaction to stop;
- for each reducing agent, set up a cell with H_2O_2 as one half-cell and the reducing agent in the other half-cell. Measure the voltage on a high resistant voltmeter.

[3 marks]

(iv) Variables
Correct and relevant **[2 marks]**

(v) Expected results
Any reasonable answer **[2 marks]**

(vi) Chemical principles

- Weak acid has low $[H^+]$ and strong acid has high $[H^+]$. $pH = -\log_{10}[H^+]$. Therefore, weak acid has high pH, and strong acid has low pH.

- Low $[H^+]$ in solution produces slow rate of reaction and vice versa.

- H_2O_2 half-cell reaction:

$$H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O(l) \quad E^{\theta} = +1.77V$$

- Reducing agent half-cell reaction:

$$-e \rightarrow \text{Product} \qquad E^{\theta} = +1.39V$$

$$E_{cell} = +3.16V$$

- E_{cell} is produced for the weak reducing agent.

[3 marks]

KC	UK	XS
		1
		2
		3
		2
		2
	3	

	KC	**UK**	**XS**
(vii) Sources of error/assumptions/limitations Any correct answer, for example: • It is assumed that the reducing agents are non-acidic. **[2 marks]**		2	
Total 15 marks			
		5	**10**

CANDIDATE – PLEASE NOTE!

PRINT your name on the line below and return this booklet with your answer sheet. Failure to do so may result in disqualification.

____

TEST CODE **02212010**

SPEC 2017/02212010

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CHEMISTRY

UNIT 2 – Paper 01

1 hour 30 minutes

SPECIMEN PAPER

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This test consists of 45 items. You will have 1 hour and 30 minutes to answer them.
2. In addition to this test booklet, you should have an answer sheet and a data booklet.
3. Each item in this test has four suggested answers lettered (A), (B), (C), (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.

<u>Sample Item</u>

Which of the following energy transitions is the HIGHEST in an organic compound?

<u>Sample Answer</u>

Ⓐ ● Ⓒ Ⓓ

(A) n to σ^*
(B) σ to σ^*
(C) n to π^*
(D) π to π^*

The correct answer to this item is "σ to σ^*", so (B) 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, go on to the next one. You may return to that item later.
7. You may do any rough work in this booklet.
8. Figures are not necessarily drawn to scale.
9. You may use a silent, non-programmable calculator to answer items.

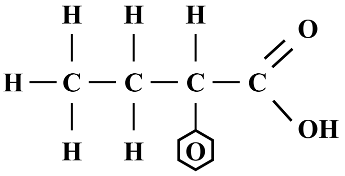
DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

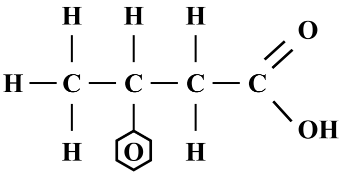
1. Which of the following may be responsible for the wide diversity of organic compounds?

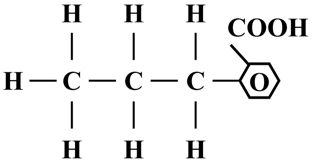
1. Carbon forms strong bonds with itself.
2. Carbon forms four bonds.
3. Carbon exists in three allotropic forms.
4. Carbon acquires a full octet of electrons.

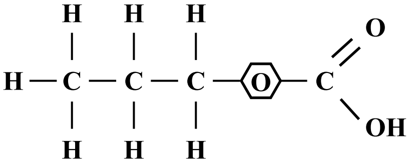
(A) I and II only
(B) I, II and III only
(C) I, II and IV only
(D) I, II, III and IV

2. Which of the following is the structure of 2-phenyl butanoic acid?

(A)


(B)


(C)


(D)


3. Which of the following compounds can be resolved into optical isomers?

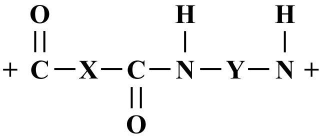
(A) $(CH_3)_2CHCH_2OH$
(B) NH_2CH_2COOH
(C) $NH_2CH(CH3)$ $COOH$
(D) $(CH_3)_2CHOCH_3$

4. Which of the following features may be characteristic of condensation polymers?

1. Presence of OH and COOH groups in monomers
2. Elimination of a small molecule
3. Region of unsaturation in the monomers

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

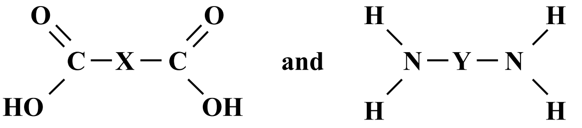
5. Qiana is a polymer that feels like silk and has the following generalized partial structure:



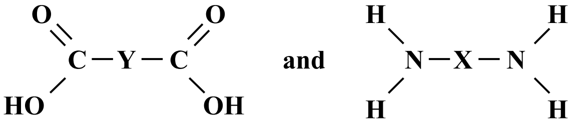
$$+\overset{O}{\overset{\|}{C}}-X-\underset{O}{\underset{\|}{C}}-\overset{H}{\overset{|}{N}}-Y-\overset{H}{\overset{|}{N}}+$$

The pair of monomers in Qiana is

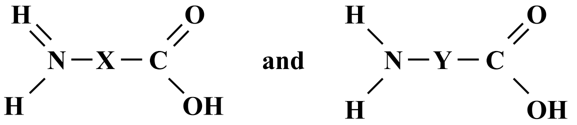
(A)



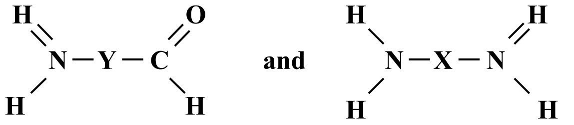
(B)



(C)

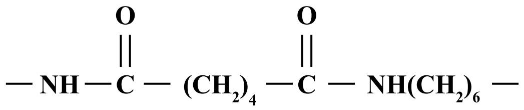


(D)



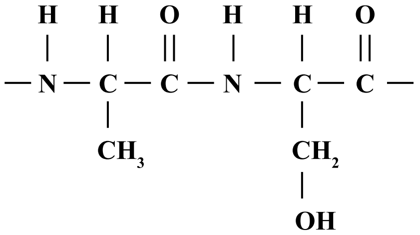
6. Which of the following represent naturally occuring macromolecules?

(I)



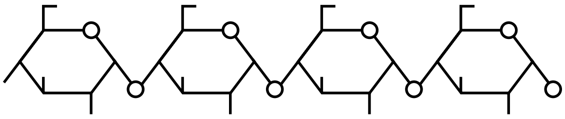
$$-\mathrm{NH}-\overset{\overset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-(\mathrm{CH_2})_4-\overset{\overset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-\mathrm{NH(CH_2)_6}-$$

(II)

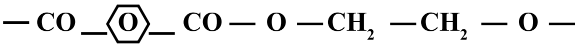


$$-\overset{\overset{\displaystyle \mathrm{H}}{|}}{\mathrm{N}}-\underset{\underset{\displaystyle \mathrm{CH_3}}{|}}{\overset{\overset{\displaystyle \mathrm{H}}{|}}{\mathrm{C}}}-\overset{\overset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-\overset{\overset{\displaystyle \mathrm{H}}{|}}{\mathrm{N}}-\underset{\underset{\underset{\displaystyle \mathrm{OH}}{|}}{\displaystyle \mathrm{CH_2}}}{\underset{|}{\overset{\overset{\displaystyle \mathrm{H}}{|}}{\mathrm{C}}}}-\overset{\overset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-$$

(III)

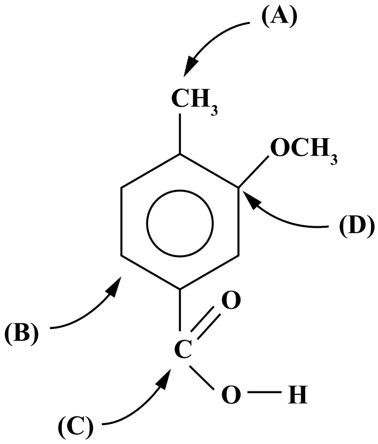


(IV)



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

7. To which carbon atom in the compound below will an electrophile be attached?



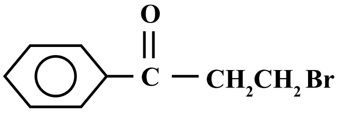
(A) A
(B) B
(C) C
(D) D

8. Chlorine reacts with methane to form chloromethane. The organic intermediate in the reaction is

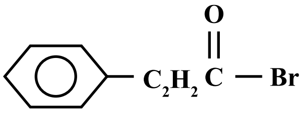
(A) an ion
(B) an electrophile
(C) a nucleophile
(D) a free radical

9. Compounds X, Y and Z below are isomers.

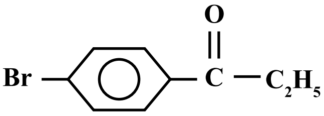
X



Y



Z



The order of decreasing ease of removal of the bromide ion by hydrolysis is

(A) X > Y > Z
(B) Z> Y > X
(C) Y > X > Z
(D) Y > Z > X

Items **10-11** refer to the following compounds:

(A) $CH_3CH_2COCH_3$
(B) $CH_3CH_2\ CONH_2$
(C) CH_3CH_2CHO
(D) $CH_3COOCH_2CH_3$

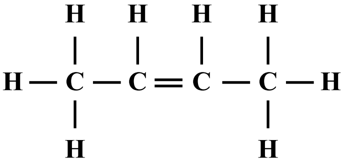
Match EACH item below with one of the options above, each of which may be used once, more than once or not at all.

10. Aldehyde

11. Ester

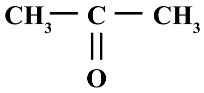
12. Which of the following is NOT oxidised by $KMnO_4/H^+(aq)$?

(A)



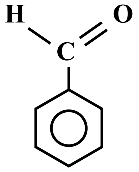
$H-\underset{H}{\overset{H}{C}}-\overset{H}{C}=\overset{H}{C}-\underset{H}{\overset{H}{C}}-H$

(B)

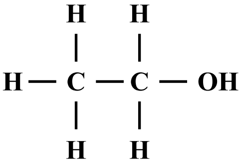


$CH_3-\underset{O}{\underset{\|}{C}}-CH_3$

(C)



(D)

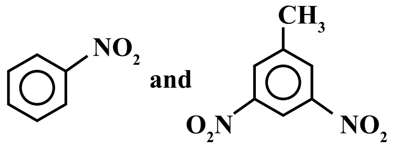


$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-OH$

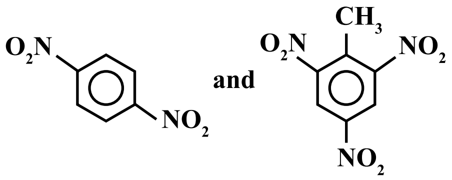
GO ON TO THE NEXT PAGE

13. Which pair of compounds is formed when benzene and methyl benzene undergo nitration?

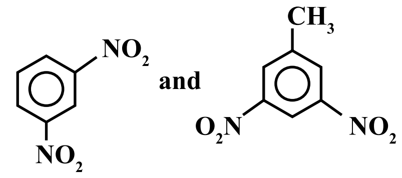
(A)



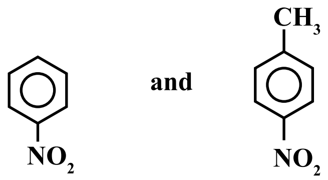
(B)



(C)



(D)



14. Ethanoic acid turns blue litmus red but ethanol does not, because ethanoic acid

(A) has a polar − OH bond but ethanol does not
(B) has a higher pka value than ethanol
(C) is a stronger acid than ethanol
(D) is more miscible with water than ethanol

15. Which of the following statements about aminoethanoic acid, NH_2CH_2COOH, is NOT true?

(A) Its aqueous solution has a pH of 7
(B) It has a high melting point
(C) It is soluble in base only
(D) It is soluble in both acid and base

16. In an iron determination, a student obtains a mean value of 35.50% for the iron content and a standard deviation of 0.01. The actual value for the percentage of iron in the sample is 39.45. In terms of precision and accuracy, which option best describes the student's results?

(A) High accuracy and high precision
(B) High accuracy and low precision
(C) Low accuracy and high precision
(D) Low accuracy and low precision

17. Which of the following is NOT a characteristic of primary standards used in titrimetric analysis?

(A) High purity
(B) Stable in air
(C) Deliquescent
(D) Soluble

18. For which pair of titrations is methyl orange (indicator range 2.9 - 4.6) BEST suited?

(A) Strong acid - strong base AND strong acid - weak base
(B) Strong base - weak acid AND weak acid - weak base
(C) Strong acid - strong base AND weak acid - weak base
(D) Strong acid - weak base AND strong base - weak acid

---

19. 25.0 cm^3 of an aqueous iron (II) salt is acidified with an equal volume of dilute sulphuric acid and titrated against 0.02 mol dm-3 potassium manganate (VII) solution. The endpoint is 30.0 cm3.

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O\,(l)$$

The correct concentration of the iron (II) ions, in mol dm^{-3}, is

(A) $\dfrac{5 \times 25.0}{0.02 \times 30.0}$

(B) $\dfrac{5 \times 0.02 \times 30.0}{25.0}$

(C) $\dfrac{5 \times 0.02 \times 25.0}{30.0}$

(D) $\dfrac{25.0}{5 \times 0.02 \times 30.0}$

20. Treatment of an 8.00g sample containing a lead ore with excess sulphuric acid yields 4.75g of lead (II) sulphate.

The correct expression for the percentage of lead in the sample is

(A) $\frac{207 \text{ x } 8.00}{303 \text{ x } 4.75}$ x 100

(B) $\frac{303 \text{ x } 4.75}{303 \text{ x } 8.00}$ x 100

(C) $\frac{207 \text{ x } 4.75}{303 \text{ x } 8.00}$ x 100

(D) $\frac{303 \text{ x } 8.00}{207 \text{ x } 4.75}$ x 100

21. Sintered glass crucibles are used in gravimetric analysis because they

(A) have negligible weight
(B) can tolerate high temperatures
(C) have a small coefficient of expansion
(D) are porous and allow mixtures to be filtered directly

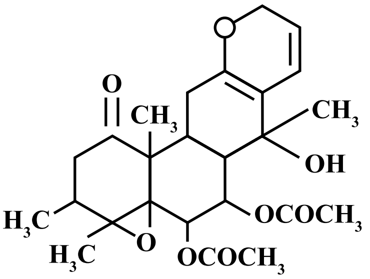
22. In the determination of the purity of a sample of magnesium carbonate by a back titration method, which of the following statements is INCORRECT?

(A) Phenolphthalein or methyl orange are suitable indicators.
(B) The amount of excess acid remaining is determined by titration with standard alkali.
(C) The sample is reacted with excess alkali.
(D) Unreacted magnesium carbonate is filtered off and weighed.

23. Which of the following substances would be produced by fractionating a 20% solution of nitric acid in water?

(A) Azeotrope then nitric acid
(B) Water then azeotrope
(C) Nitric acid only
(D) Water only

Item **24** refers to the following structure of caesalpinin.



The compound caesalpinin exhibits absorption at wave numbers 3400 cm^{-1} and 1750 cm^{-1} in the IR spectrum.

24. Which functional groups are responsible for these absorptions?

(A) **$-\text{OH}$ and $>\text{C}=\text{O}$**

(B) **$\text{C}-\text{H}$ and $-\text{OH}$**

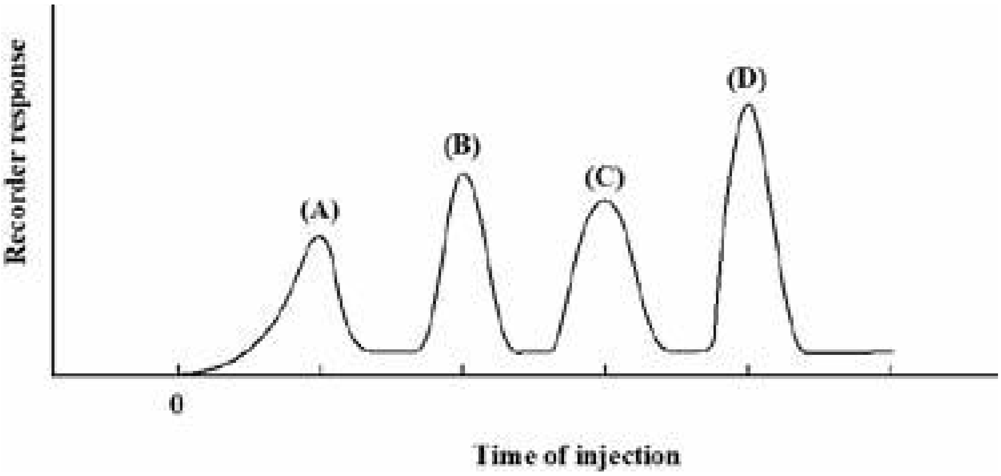
(C) **$-\text{OH}$ and $-\overset{|}{\underset{|}{\text{C}}}-\text{O}$**

(D) **$-\overset{|}{\underset{|}{\text{C}}}-\text{O}$ and $>\text{C}=\text{O}$**

25. The use of IR Spectroscopy in identifying structure of organic molecules is limited because

(A) it helps to determine the presence or absence of some functional groups
(B) the spectrum of molecules can be complex where some absorption frequencies are superimposed
(C) the position of the peaks makes it difficult for the identification of the functional groups in the molecule
(D) vibrations due to a certain bond occur in the same region of the spectrum, which makes identification difficult

Item **26** refers to the following gas/liquid chromatogram.



26. Based on the chromatogram which of the liquids is present in the LARGEST quantity?

27. Which of the following atomic nuclei pairs both have nuclear spin?

(A) ^{2}H and ^{13}C
(B) ^{1}H and ^{24}Mg
(C) ^{19}F and ^{23}Na
(D) ^{32}P and ^{31}p

28. Which of the following equations governs the determination of an unknown compound, X, in a solution by UV/VIS spectroscopy?

(A) $\log_{10} (I_o/I) = \in cL$

(B) $\log_{10} (I/I_o) = \in cL$

(C) $\log_{10} (I_o/I) = \frac{\in c}{L}$

(D) $\log_{10} (I/I_o) = \frac{\in c}{L}$

29. Whcih of the following are all examples of commonly used stationary phases in chromatography?

(A) Cellolose, alumina, starch
(B) Silica gel, alumina, cellulose
(C) Silica gel, cellulose, sodium chloride
(D) Alumina, silica gel, aluminium chloride

30. A solution of 5g of an organic compound X in 200 cm^3 of water is shaken with 100 cm3 of choloroform. 1.3g of the acid remain in the aqueous solution at equilibrium. The partition coefficient of X between water and chloroform is

(A) $\frac{3.7}{6.5}$

(B) $\frac{3.7 \text{ X } 10^{-2}}{6.5 \text{ X } 10^{-3}}$

(C) $\frac{6.5}{3.7}$

(D) $\frac{6.5 \text{ X } 10^{-2}}{3.7 \text{ X } 10^{-2}}$

31. In the conversion of bauxite to pure aluminium oxide, what is the compound obtained after filtering and adding carbon dioxide to the impure bauxite?

(A) $\mathrm{A1(OH)_3}$

(B) $\mathrm{A1(OH)_4^-}$

(C) $\mathrm{SiO_3^{2-}}$

(D) $\mathrm{A1_2(CO_3)_3}$

32. Crude oil is separated into petroleum products by use of fractional distillation.

Which fractions would be obtained between 20 - 200 °C and 275 - 375 °C respectively?

	20 - 200 °C	275 - 375 °C
(A)	Bitumen	refinery gas
(B)	Diesel	kerosene
(C)	Naphtha	refinery gas
(D)	Diesel	gasoline

33. Purified N_2 gas and H_2 gas are reacted together to form ammonia as shown below.

N_2 (g) + $3H_2$ (g) catalyst $\rightleftharpoons$ $2NH_3$ (g)
$\Delta H = -92$ kJ mol^{-1}

Based on Le Chatelier's principle, which combination of pressure and temperature would give the highest yield of ammonia?

(A) Low temperature, low pressure
(B) Low temperature, high pressure
(C) High temperature, high pressure
(D) High temperature, low pressure

34. Ethanol formed by fermentation will destroy the enzyme-producing yeast. What is the lowest percentage of alcohol at which this occurs?

(A) 3
(B) 13
(C) 20
(D) 30

35. The oxygen gas used in the contact process must be dust free to avoid poisoning the vanadium (V) oxide catalyst. Which reaction would be affected if dust is present?

(A) $S (g) + O_2 (g) \rightarrow SO_2 (g)$
(B) $2S (g) + 3O_2 (g) \rightarrow 2SO (g)$
(C) $2SO_2 (g) + O_2 (g) \rightarrow 2SO_3 (g)$
(D) $2S (g) + 3O_2(g) + 2H_2O (l) \rightarrow 2H_2SO_4(aq)$

36. What is the purpose of green chemistry?

(A) Removing wastes from industrial reactions
(B) Designing chemical products that maximize profits
(C) Inventing technologies that will promote recycling of products
(D) Designing safer chemical products and processes that reduce or eliminate the use of and generation of hazardous substances

37. A polluted river near a paint factory is tested with acidified potassium iodide and a bright yellow precipitate is observed. Which of the following pollutants is likely to be present?

(A) PO_4^{3-}
(B) CN^-
(C) Cr^{3+}
(D) Pb^{2+}

38. The substance formed in combustion engines of vehicles, which may lead to the formation of acid rain is

(A) C
(B) NO
(C) CO
(D) C_4H_{10}

39. It is estimated that one chlorine radical can break down 100 000 ozone molecules.

Which feature of chlorine radicals may account for this?

(A) Regeneration by reacting with ozone
(B) Ionization of oxygen gas
(C) Chlorine monoxide radicals formed with oxygen
(D) Reaction with ozone to form more oxygen gas

40. Which of the following CANNOT be used to control atmospheric pollution?

(A) Using cleaner fuels in industrial plants
(B) Using catalytic converters in vehicles
(C) Decreasing vegetation in urban areas
(D) Using chemical scrubbers

41. Water can be purified by all of the following EXCEPT

(A) desalination
(B) reverse osmosis
(C) distillation
(D) sublimation

42. The ozone layer is a thick blanket over the earth's surface. It prevents ultraviolet radiation from entering the earth's atomosphere. Where is the ozone layer located?

(A) Troposphere
(B) Stratosphere
(C) Ionosphere
(D) Mesosphere

43. Which properties of aluminium make it suitable for constructing airplanes?

I. Low density
II. Imperneable oxide
III. Conducts electricity

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

44. The term 'residence time' for gases in the atmosphere refers to the length of time the gas

(A) takes to move from the earth's surface to the upper regions of the atmosphere
(B) remains in the atmosphere until it is removed in a sink
(C) takes to move from the troposphere to the stratosphere
(D) reaches a concentration to become a pollutant in the atmosphere

45. Which of the following chemicals forms a non-toxic substance when it reacts with nitrogen monoxide?

(A) CH_4
(B) H_2O
(C) SO_2
(D) CO

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

Unit 1 Paper 02 Keys

Question	Module/Syllabus Reference	Profile	Key
1.	1.1.1	KC	A
2.	1.1.5	KC	A
3.	1.1.8	UK	C
4.	1.4.2	KC	C
5.	1.4.3	UK	A
6.	1.4.5	KC	B
7.	1.2.5	UK	B
8.	1.2.2	KC	D
9	1.2.7	UK	C
10.	1.2.1	KC	C
11.	1.2.1	KC	D
12.	1.2.6	UK	B
13.	1.2.15	UK	D
14.	1.3.1	KC	C
15.	1.3.3	UK	C
16.	2.1.1	UK	C
17.	2.2.2	KC	C
18.	2.2.3	UK	A
19.	2.2.5	UK	B
20.	2.3.4	UK	C
21.	2.3.2	KC	B
22.	2.2.4	KC	B
23.	2.9.1	UK	C
24.	2.6.4	UK	A
25.	2.6.1	KC	B
26.	2.8.5	UK	C
27.	2.8.3	UK	C
28.	2.5.3	KC	A
29.	2.8.4	KC	B
30.	2.9.4	UK	B
31.	3.2.1	KC	A
32.	3.3.2	KC	D
33.	3.4.1	UK	B
34.	3.5.1	KC	B
35.	3.7.1	UK	C
36.	3.1.3	KC	D
37.	3.8.5	UK	D
38.	3.9.6	KC	B
39.	3.9.1	KC	A
40.	3.9.8	KC	C
41.	3.8.2	KC	D
42.	3.9.2	KC	B
43.	3.2.2	KC	A
44.	3.9.1	KC	B
45.	3.9.6	KC	D

TEST CODE **02212020**

SPEC 2017/02212020

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CHEMISTRY

SPECIMEN PAPER

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

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

“*”Barcode Area”*”
Sequential Bar Code

Answer ALL questions.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

1. Dopamine is a neurotransmitter found in the human brain.

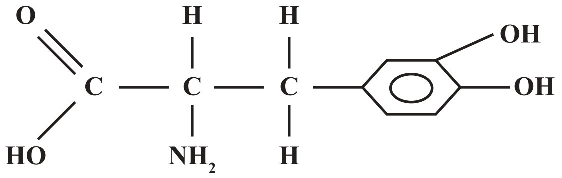

Figure 1. Dopamine

(a) (i) Name AND write THREE functional groups in the dopamine molecule.

....

....

....

[3 marks]

(ii) Explain whether or not the dopamine molecule would exhibit optical activity.

....

....

[2 marks]

GO ON TO THE NEXT PAGE

(b) Draw the structural formula of the organic product formed when dopamine is dissolved in excess aqueous sodium hydroxide.

[2 marks]

(c) A sample of dopamine is first dissolved in dilute hydrochloric acid and then subjected to an electric current.

(i) Draw the structure of the organic species formed on the addition of the acid.

[1 mark]

(ii) To which electrode would the species formed be expected to migrate?

....

[1 mark]

GO ON TO THE NEXT PAGE

(d) Draw the fully displayed structural formula of the organic product formed when dopamine is treated with ethanol in the presence of concentrated sulphuric acid and refluxed.

[2 marks]

(e) Dopamine is subjected to chemical analysis and some of the results are presented in Table 1 below. Complete Table 1 by writing the missing test, observation and inference.

TABLE 1: RESULTS OF CHEMICAL ANALYSIS OF DOPAMINE

Test	Observation	Inference
PCl_3 or PCl_5 is added to dopamine.	•	•
•	White crystals are produced on heating.	•

[5 marks]

GO ON TO THE NEXT PAGE

(f) State THREE characteristic properties of members of a homologous series.

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....

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[3 marks]

(g) A reaction of 2-methylpropane with chlorine in sunlight results in the production of different substituted species.

(i) By examination of the reaction mechanism, account for the production of the different monosubstituted species.

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[5 marks]

(ii) Name the primary monosubstituted species. Justify your answer.

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[2 marks]

(h) 2- chloro-2-methylpropane (tertiary butyl chloride) can be converted to the corresponding alcohol by reacting with aqueous sodium hydroxide. Outline the mechanism for the reaction.

[4 marks]

Total 30 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

2. The chromatogram in Figure 2 is obtained when a mixture of organic compounds, A – D is analysed by gas-liquid chromatography.

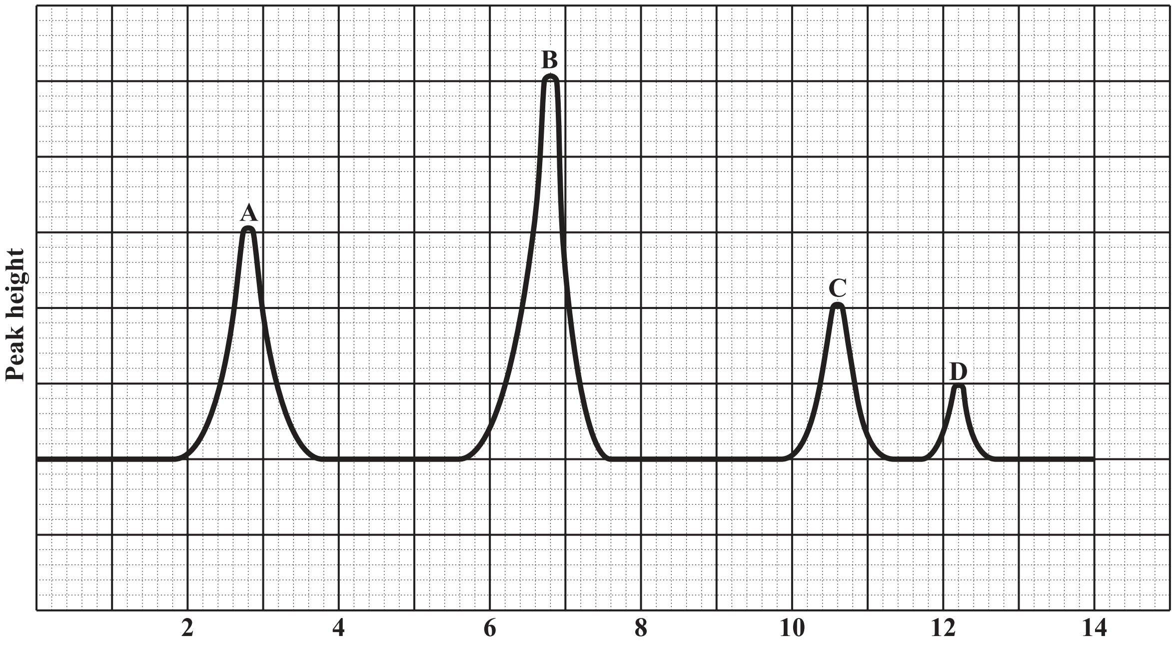

Figure 2: Chromatogram

(a) Define EACH of the following terms:

(i) Retention time

....

....

[1 mark]

(ii) Mobile phase

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Name TWO commonly used mobile phase in gas-liquid chromatography.

....

....

[2 marks]

(b) Explain the chemical principle upon which the separation of A–D can be achieved.

....

....

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....

....

....

[3 marks]

(c) (i) Which of the compounds, A—D, is present in the highest concentration?

....

[1 mark]

(ii) For how long was the compound identified in (c) (i) retained on the column?

....

[1 mark]

(d) Assuming that the mixture contained methanol, methanal, propane and propanoic acid, suggest the identities of A, B, C, D. Give reasons for your response.

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Reasons:

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[6 marks]

(e) Outline how a mixture of plant pigments could be separated by column chromatography.

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[5 marks]

GO ON TO THE NEXT PAGE

(f) Explain the principles upon which mass spectrometry is based.

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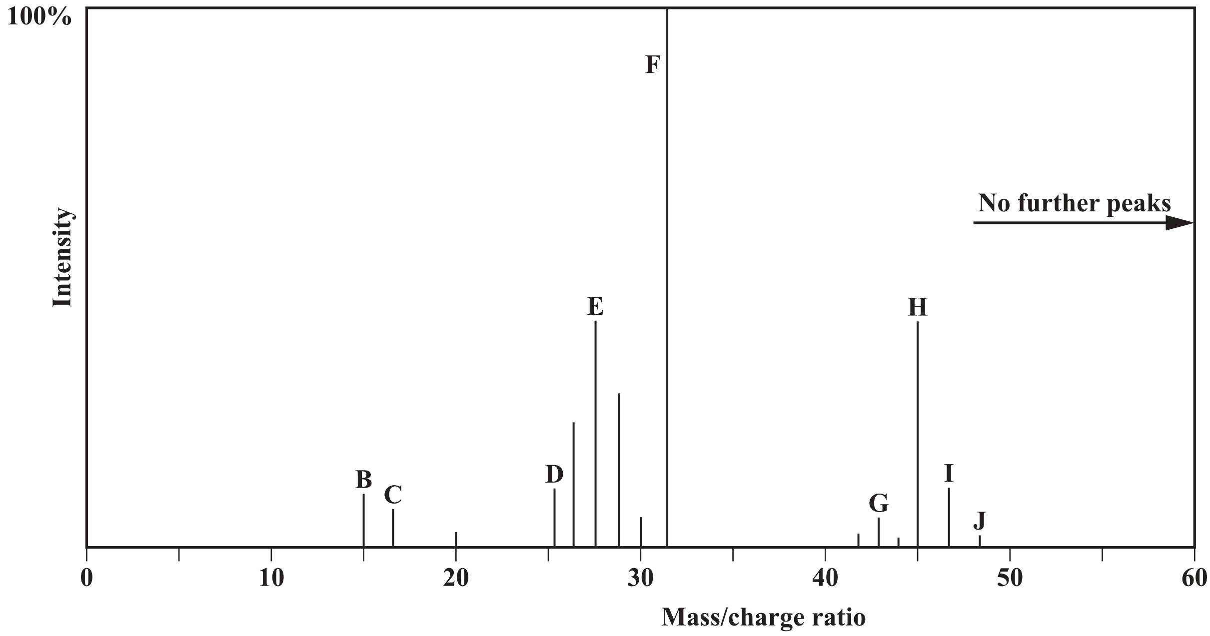
[3 marks]

(g) An organic compound, A, contained only carbon, hydrogen and oxygen. The following mass spectrogram was obtained upon analysis.



(i) State the relative molecular mass of A.

....

[1 mark]

(ii) State the name of the M^{+1} peak in the spectrum.

....

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Suggest a possible identity for EACH of the species corresponding to peaks.

B: ....

C: ....

F: ....

[3 marks]

(iv) Calculate the relative abundance of the species corresponding to peak E.

[1 mark]

(v) What is the significance of 100% intensity for peak F?

....

....

....

[1 mark]

Total 30 marks

MODULE 3

INDUSTRY AND THE ENVIRONMENT

3. (a) In industrial laboratories, the cadmium reduction method is widely used, instead of the chemical tests that are normally used in school laboratories, to determine if nitrate ions are present as a pollutant in water samples.

(i) Give TWO sources of nitrate ions in water.

....

[2 marks]

(ii) Describe a chemical test that is often used in school laboratories to detect the presence of aqueous nitrate ions.

....

....

....

[2 marks]

(iii) State ONE ion that cannot be distinguished from the NO_3^- by the chemical test that you described in 3 (a) (ii) above.

....

[1 mark]

(iv) Suggest ONE possible reason why the laboratory test that you described in 3 (a) (ii), for the determination of nitrate ions as a pollutant in water samples, is not as appropriate as the cadmium reduction method.

....

....

....

....

[2 marks]

(b) Figure 3 shows the average concentration of pollutants NO and NO_2 in an urban area during a 24–hour period.

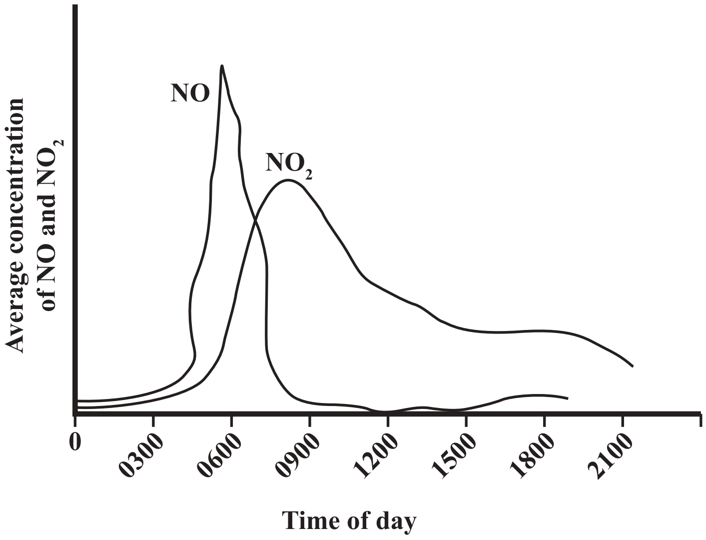


Figure 3: Concentration of NO and NO_2

(i) Using the following equilibrium reaction

N_2 (g) + O_2 (g) $\rightleftharpoons$ 2NO (g); ΔH = +180 kJ mol^{-1}

account for the formation of NO(g) as a pollutant in urban areas.

....

....

....

[2 marks]

(ii) Suggest a reason for the time lapse between maximum concentrations of NO(g) and NO_2 (g) shown in Figure 3.

....

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Indicate, by drawing a curve on Figure 3, how you would expect the concentration of ozone (O_3) in an urban area to vary during the course of the day. Explain your answer.

....

....

....

[3 marks]

(c) The chemical equation for the formation of ammonia by the Haber Pprocess is as follows.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \quad \Delta H = -92\text{ kJ/mol}$$

(i) State the source of nitrogen and name the process by which it is obtained.

....

....

[2 marks]

(ii) Use the equation above to predict the conditions of temperature and pressure which would maximize the yield of ammonia.

....

....

[2 marks]

(iii) State whether the conditions used in industry are similar to those you predicted in (c) (ii). Account for any variations in these conditions.

....

....

....

[2 marks]

(iv) Write a balanced chemical equation to show how hydrogen is obtained from methane, which is a source of hydrogen.

....

....

....

[2 marks]

GO ON TO THE NEXT PAGE

(d) (i) Identify TWO Green Chemistry principles that are implemented in the manufacture of ammonia by the Haber Process.

....

....

[2 marks]

(ii) Choose one of the Green Chemistry principles identified in (d) (i), and explain how that principle is adhered to in the process.

....

....

....

....

[3 marks]

(iii) Using a named Green Chemistry principle not already utilized in the Haber Process, explain how the manufacture of ammonia may be improved.

....

....

....

....

[3 marks]

(e) Air serves as an important chemical resource for the biosphere. State ONE process by which nitrogen in the atmosphere can enter the nitrogen cycle.

....

[1 mark]

Total 30 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐

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CHEMISTRY

UNIT 2 — PAPER 02

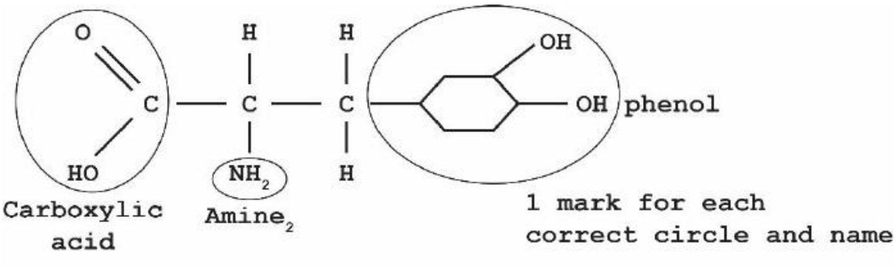
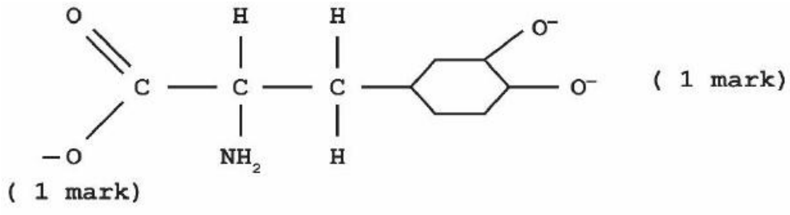
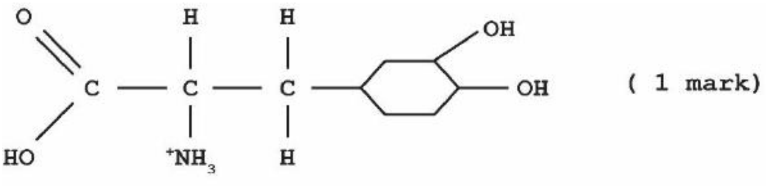
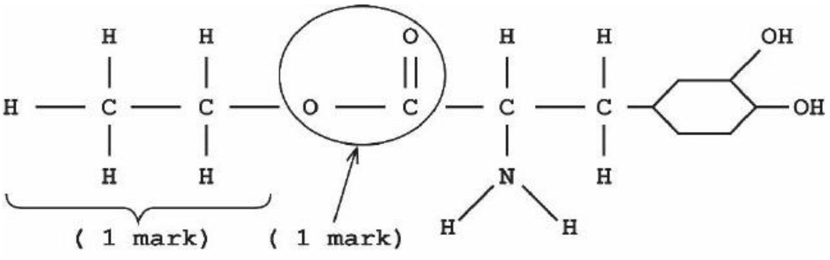
MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

Question 1

S.O.: Module: 1 —1.8, 2.1, 2.2, 2,3 2.6, 2.7, 2.13, 2.11, 2.14

	KC	UK	XS
(a) (i)  1 mark for each correct circle and name	**3**		
(ii) Yes (1) - A chiral carbon is present (1)		2	
(b)  (1 mark) (1 mark)		2	
(c) (i)  (1 mark)	1		
(ii) Negative electrode or cathode (1)	1		
(d)  (1 mark) (1 mark)	2		

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

			KC	UK	XS
(e)	(i)	Colourless gas evolves (1) which forms dense white fumes with NH_3 (1) **[2 marks]**			5
	(ii)	COOH/Carboxylic acid group present **[1 mark]**			
	(iii)	Dil. HCl is added and the resulting solution heated gently **[1 mark]**			
	(iv)	The NH_2 and amine group present **[1 mark]**			
(f)		• They show a steady gradation in physical properties • Chemical properties are similar • Relative molecular mass of consecutive members increase by H or CH_2 **[1 mark each]**	3		
(g)	(i)	$Cl - Cl \xrightarrow{uv/sumlight} 2\ Cl\bullet$ **[1 mark]** $Cl\bullet + CH_3CHCH_3CH_3 \rightarrow CH_3\dot{C}CH_3CH_3 + HCl$ **[1 mark]** $Cl\bullet + CH_3CHCH_3CH_3 \rightarrow \dot{C}H_2CHCH_3CH_3 + HCl$ **[1 mark]** $CH_3\dot{C}CH_3CH_3 + \dot{C}l \rightarrow CH_3CClCH_3CH_3$ **[1 mark]** $\bullet CH_2CHCH_3CH_3 + \dot{C}l \rightarrow CH_2ClCHCH_3CH_3$ **[1 mark]** (propagation steps also acceptable)		5	
	(ii)	$CH_3CClCH_3CH_3$ Stability of the tertiary free radical in the intermediate stage **[2 marks]**		2	
(h)		For 2 – methylpropene, the mechanism is electrophilic addition (1). The double bond causes polarization of the Chlorine molecule which produces the electrophile by heterolytic fission (1). The mechanism for the 2-methyl propane is free radical substitution (1) involving homolytic fission. (1) **[4 marks]**		4	
		Total 30 marks	10	15	5

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

Question 2

S.O.: Module: 2 — 7.1, 7.2, 8.1, 8.2, 8.3, 8.5

			KC	UK	XS
(a)	(i)	Length of time a solute remains in the column, before entering the detector **[1 mark]**	1		
	(ii)	Mobile phase: The solvent or solvent mixture which moves over the stationary phase carrying the solutes with it **[1 mark]**	1		
	(iii)	Commonly used mobile phase in GLC: nitrogen, helium, argon. **Any two** **[2 marks]**	2		
(b)		Partitioning **[1 mark]** Substances A-D have different solubilities in the solvent being used. Based on the differences in their solubilities the substances have different speeds as they pass through the column. **[2 marks]**	3		
(c)	(i)	B **[1 mark]**		1	
	(ii)	Approximately 6.8 minutes 0.1 minute **[1 mark]**		1	
(d)		A – methanal B – propane C – methanol D – propanoic acid **[1 mark each]**		4	
		Methanol has lowest density Propane is more volatile than methanol and propanoic acid Propanoic acid is the heaviest or densest **[Any 2]**		2	
(e)		• Pack a glass column with a paste of SiO_2, $CaCO_3$ or Al_2O^3 Ensure there are no air spaces. • Using a Pasteur pipette, place about 5cm^3 of liquid plant pigment mixture in the column. • Add the solvent (water) slowly to the mixture ensuring that the paste is not disturbed. • Open the tap at the base of the column and collect fractions of equal volumes into separate conical flasks. • Evaporate contents of flask and analyse via TLC. **[5 marks]**			5

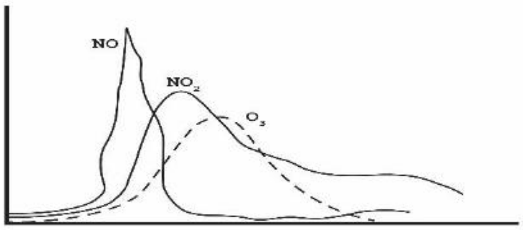
CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

		KC	**UK**	**XS**
(f)	• Vapourised sample may be broken into positively charged fragments by bombardment with high-speed electrons. • Fragments are deflected in a magnetic field, proportionate to the mass/charge ratio. • These fragments can be used to deduce the structure of the original molecule. **[1 mark each]**	**3**		
(g)	(i) 46 **[1 mark]**		**1**	
	(ii) J **[1 mark]**		**1**	
	(iii) B: CH_3 C: OH F: CH_2OH **[3 marks]**		**3**	
	(iv) $\frac{3}{7}$ x 100% = 43% **[1 mark]**		**1**	
	(v) Most stable fragment **[1 mark]**		**1**	
	Total 30 marks	**10**	**15**	**5**

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

Question 3

S.O: Module 3: — 1.3, 4.1, 8.4, 8.5, 9.6, 9.7

	KC	**UK**	**XS**
(a) (i) Fertilisers, decaying plants or animals	2		
(ii) Add aluminum metal or zinc metal followed by sodium hydroxide solution and warm. If nitrate ions are present, ammonia gas is produced OR Add copper turnings followed by conc. Sulphuric acid poured carefully down the side of the testy tube. If nitrate ions are present a brown ring is produced. **[2 marks]**			2
(iii) NO_2^- **[1 mark]**			1
(iv) Pollutants are usually present in trace (small) quantities. School laboratory tests are not As sensitive as the cadmium reduction method to small quantities of NO_3^-. **[2 marks]**			2
(b) (i) In urban centres, there is a heavy flow of traffic. The burning of fuels in the internal combustion engine is an exothermic reaction, and the high temperatures produced provide the conditions that favour the forward endothermic reaction for the production of NO from nitrogen and oxygen that are present in the air. **[2 marks]**		2	
(ii) NO is produced first as the primary pollutant after which NO_2 is formed by the oxidation of NO. **[1 mark]**		1	
(iii)  The ozone concentration begins to increase after NO_2 has been formed. If NO_2 absorbs a quantum of light the molecule can decompose into NO and atomic oxygen, a radical. The very reactive radical can then react with molecular oxygen to form ozone. The concentration of the ozone falls as it reacts with NO to re-form NO_2 and molecular oxygen. **[2 marks]** **[1 mark for graph]**		3	

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

	KC	UK	XS
(c) (i) Air; obtained by liquefication of air **[2 marks]**	**2**		
(ii) Conditions for maximum yield: High pressures and low temperatures **[2 marks]**	**2**		
(iii) Conditions used in industry: No, a set of compromise conditions are used Award marks based on a discussion of the applications of the principles of equilibrium coupled with economic factors. **[2 marks]**		**2**	
(iv) Hydrogen from Methane $CH_4 + H_2O \rightarrow CO + 3H_2$ Accept also $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ $CO + H_2O \rightarrow CO_2 + H_2$ **[2 marks]**		**2**	
(d) (i) Prevent waste Use catalysts not the stoichiometric reagents Maximise atom efficiency **[2 marks]**	**2**		
(ii) Prevent waste: the raw materials, nitrogen gas and hydrogen gas are recycled through the reactor. In the reactor only 15% is converted to ammonia, by continued recycling of the reactants there is 98% conversion of the reactants very little is wasted by recycling the reactants there is very little waste generated in the Haber process. Use of catalysts: the iron catalyst (aided by the potassium hydroxide as a promoter overcomes the inefficiency in the stoichiometric equation. The reaction is favored by low temperature but the rate of the reaction slows down significantly under these conditions. The catalyst speeds up the reaction thereby overcoming this. Maximize atom efficiency: the synthesis of the ammonia requires just the materials (elements) that are in the raw material. There are no side reactions or loss of elements during the reaction. 98% of the N_2 and H_2 end up in the final NH_3 molecule.	1	**2**	
(iii) Use renewable feedstocks: the H_2 currently is obtained from natural gas which is a non-renewable resource. The hydrogen can be obtained from a renewable/alternative source. For example, Electrolysis of water using electricity from hydroelectric or some other renewable source of energy. Or any other reliable process.	1	**2**	
(e) Nitrogen fixation Electrical discharges (thunderstorms) Accept also combustion of fuels from aircrafts **[1 mark]**	**1**		
TOTAL 30 marks	**10**	**15**	**5**

SPEC 2017/02212032

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

SPECIMEN PAPER

UNIT 2 – Paper 032

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

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

“*”Barcode Area”*”
Sequential Bar Code

Answer ALL questions.

1. You are provided with Sample A, which is a mixture of fine sand and $CuSO_4 . nH_2O$ crystals in a crucible. You are required to determine the value of n by following the procedure outlined below and recording your data in Table 1.

(a) Procedure

A. Weigh the crucible and Sample A (M1).

B. Heat the sample over a bunsen burner for approximately 15 minutes.
Record any changes in appearance of the sample.

C. Remove the sample from the heat, cool in a dessicator for five minutes and reweigh the crucible and sample (M2).

D. Remove the sample as completely as possible in 250 cm^3 of water.
Record your observation.

E. Filter the mixture from Step D above through Whatman #4 filter paper.
Wash and dry the crucible.

F. Wash the residue in the filter paper with two separate 100 cm^3 aliquots of water.
Record the colour of the filtrate from each of these washings.

G. Transfer the washed residue to the previously dried crucible.

H. Dry the transferred residue over a bunsen flame. Record your observations.

I. Cool the dried residue in a dessicator for five minutes.

J. Weigh the dried cool residue in the crucible (M3).

(b) Outline the procedure that would have been followed to obtain the results in (a).

....

....

....

....

[5 marks]

GO ON TO THE NEXT PAGE

TABLE 1: DATA FOR EXPERIMENTAL PROCEDURE

STEP	DATA
A	Initial mass of Sample A in crucible, M1. ....
B	Change in appearance of Sample A. ....
C	Mass of Sample A in crucible after the first heating process, M2. ....
D	Colour of mixture. ....
E	Colour of filtrate obtained from washing residue: first washing .... second washing ....
F	Change in appearance of sand....................................... ....
G	Mass of dried residue and crucible, M3..........................

[10 marks]

(b) Determine EACH of the following:

(i) The mass of the water of crystallization in $CuSO_4.n\ H_2O$

....

....

....

[1 mark]

(ii) The mass of anhydrous copper sulphate

....

....

....

[1 mark]

(iii) The value of n

....

....

....

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

2. After being opened and used, a bottle of AR iron (II) sulphate was left on the laboratory shelf for some time. 10 g of the sample were then dissolved in some dilute suphuric acid and 1 dm^3 of solution was prepared. 20 cm^3 of this solution was placed in a conical flask and titrated with 0.02 mol dm^{-3} $KMnO_4$ (aq) / H^+ (aq). The ionic equation for the reaction is
$5Fe^{2+-}(aq) + MnO_{4-}(aq) + 8H^+ (aq) \rightarrow 5Fe^{3+} (aq) + Mn^{2+} (aq) + 4H_2O (l)$.

Figure 1 below shows the readings on the burette before and after each titration.

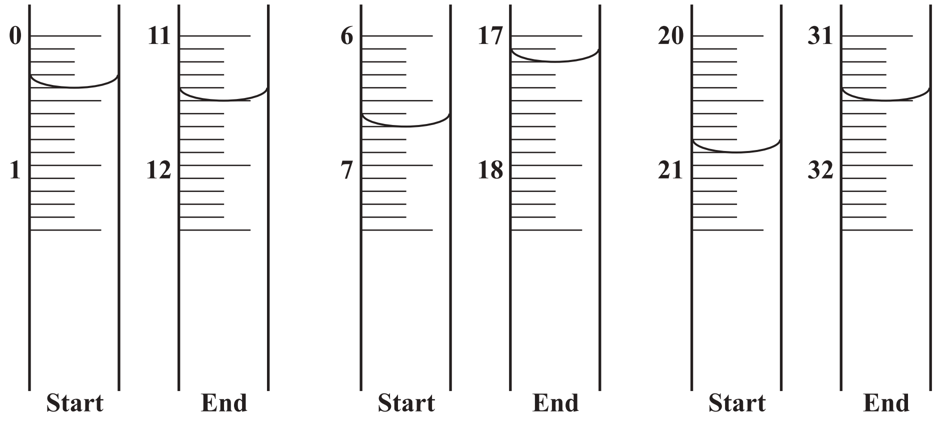


Figure 1. Readings on the burette

(a) (i) What colour change would you expect at the end point of the reaction?

....

[1 mark]

(ii) Complete Table 2 to record the tritration results. You should include the initial and final burette readings and the volumes of $KMnO_4$ (aq)/H^+(aq) used.

TABLE 2: TITRATION RESULTS

	1	2	3
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of $KMnO_4$ used (cm^3)			

[4 marks]

GO ON TO THE NEXT PAGE

(iii) What is the volume of $KMnO_4$ (aq) / H^+ (aq) to be used for calculation?

....

....

[1 mark]

(v) Calculate the concentration of the Fe^{2+} ions in the given solution in g dm^{-3}.

....

....

[3 marks]

(vi) Calculate the percentage purity of the sample.

....

....

....

[1 mark]

(b) Outline the steps that you would take to prepare 1 dm^3 of the iron (II) sulphate solution.

....

....

....

....

....

....

[4 marks]

(c) State why it is not usually good practice to store iron (II) sulphate for extended periods of time after its bottle has been opened.

....

....

....

....

[1 mark]

Total 15 marks

GO ON TO THE NEXT PAGE

3. Plan and design an experiment to determine whether the protein in beef and chicken contains the same amino acids.

Your answer should include the following:

(i) Hypothesis

....

....

[1 mark]

(ii) Aim

....

....

[1 mark]

(iii) Procedure

....

....

....

....

....

....

[6 marks]

(iv) Variables to be controlled

....

....

[1 mark]

(v) Variables to be manipulated and responding variables

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(vi) Discussion of results

....

....

....

[1 mark]

(vii) TWO possible sources of error

....

....

....

[2 marks]

(viii) TWO precautions

....

....

....

[2 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

UNIT 2 — PAPER 032

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

Question 1

S.O.: Module: 2 —3.3

			KC	UK	XS
(a)	**Data**				10
	Candidate’s reading for M_1.	**[1 mark]**			
	Colour changes from blue/green to white.	**[2 marks]**			
	Candidate’s reading for M_2.	**[1 mark]**			
	Blue/green mixture.	**[1 mark]**			
	First washing: light blue/green	**[1 mark]**			
	Second washing: colourless	**[1 mark]**			
	Candidate’s reading for M_3.	**[1 mark]**			
	2 marks for 3 correct units **[1 mark for 1 - 2 correct units]**	**[2 marks]**			
(b)	(i) $M_1 - M_2 =$	**[1 mark]**		1	
	(ii) $M_2 - M_3 =$	**[1 mark]**		1	
	(iii) $\frac{M_1 - M_2}{18} = P$	**[1 mark]**		1	
	$\frac{M_2 - M_3}{63.5} = Q$	**[1 mark]**		1	
	$\frac{P}{Q} / \frac{Q}{P}$	**[1 mark]**		1	
		Total 15 marks		5	10

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

(a)

Question 2

S.O.: Module: 2 —2.4, 2.5

(i) Pale yellow → pink tinge **[1 mark]**

(ii)

Burette readings $KMnO_4$ /H^+			
Reading/cm^3	**1**	**2**	**3**
Final	11.50	17.20	31.50
Initial	0.50	6.70	20.90
Difference	11.00	10.50	10.60

Correct burette readings = **[4 marks]**

(If one incorrect = 3 marks)
(If two incorrect = 2 marks)
(If THREE incorrect = 1 mark)

(More than THREE incorrect = 0 marks)

Volumes recorded to 2 decimal places

(iii) $\frac{10.5+10.6}{2}$ = 10.55 cm^3 **[1 mark]**

(iv) Conc. of $MnO_4^-(aq)$ = 0.02 mol dm^{-3}
No. of moles of MnO_4^- = $(10.55 \times 0.02 \times 10^{-3})$
No. of moles of $Fe^{2+}(aq)$ = $(5 \times 10.55 \times 0.02 \times 10^{-3})$
[1 mark]

No. of moles of $Fe^{2+}(aq)$ in 1 dm^3

$$= \frac{5x10.55x0.02x10^{-3}}{20}$$

= 5.275×10^{-2} mol dm^{-3} **[1 mark]**

Conc. of Fe^{2+} = $(5.275 \times 10^{-2} \times 56)$ = 2.95g dm^{-3} **[1 mark]**

KC	UK	XS
		1
		4
	1	
	3	

			KC	UK	XS
(v)	% purity = $\left(\frac{2.95}{10}x100\right)$ = 29.5%	**[1 mark]**		1	
(b)	Steps Dissolve the 10g of $FeSO_4$ in minimum volume of H_2SO_4 in a beaker. Transfer quantitatively to a 1 dm^3 volumetric flask. Make up to mark with distilled water. Stopper and shake/invert to ensure thorough mixing.	**[4 marks]**			
(c)	It is oxidised in air from Fe^{2+} to Fe^{3+}.	**[2 marks]**			
		Total 15 marks		5	10

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

Question 3

S.O.: Module: 1 —3.3

	KC	UK	XS
(i) Hypothesis: For example, chromatograms will be identical/different from beef and chicken. **[1 mark]**			1
(ii) Aim **[1 mark]**			1
(iii) Apparatus and materials (Subtract one mark if fume hood missing) **[2 marks]**			2
(iv) Procedure • Hydrolyse with dilute acid • At least 30 mins • Use of visualising agent • Use of appropriate solvent • Separate using chromatography • Compare 2 chromatograms **[2 marks]**			2
(v) Variables to control: amount of each protein, time of hydrolysis, Vol. acid. **[2 marks]**			2
(vi) Variables to be manipulated: proteins **[1 mark]**			1
(vii) Responding variable **[1 mark]**			1
(viii) Discussion of results as it relates to Hypothesis: compare R_f values of different components of the 2 proteins. **[1 mark]**		1	
(x) Possible sources error: For example: proteins could be incompletely hydrolysed – introduction of extraneous protein from improper handling. **[2 marks]**		2	
(xi) Precautions For example: use of fume hood; be careful not to touch chromatography paper with fingers; introduce protein to sample, etc. **[2 marks]**		2	
Total 15 marks		5	10

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2004

CHEMISTRY

St Michael, Barbados

CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2004

GENERAL COMMENTS

UNIT 1

Candidates again demonstrated a weakness in the comprehension of the Organic Chemistry theory and the application in mechanistic questions. The performance of the candidates in Module 2 was below satisfactory.

Many candidates experienced difficulty in constructing both molecular and ionic equations.

UNIT 2

The candidates demonstrated knowledge of the syllabus objectives in this unit. However, candidates' performance reflected inattention to descriptive details and a weakness in explaining underlying principles and concepts.

INTERNAL ASSESSMENT

The overall level of performance in the internal assessment was satisfactory. However, there are several recurring problems that require urgent attention.

A. Projects (Analysis and Interpretation)

This component was poorly done. Teachers are again reminded that the candidates are required to carry out individual analysis of the data acquired and not be given credit for simply regurgitating aspects of the literature review.

Examples of points for consideration in the analysis and interpretation section of the project are

- limitations of the application(s)
- historical, social and economic impact
- expected outcomes.

B. Laboratory Practicals

Teachers are reminded that the Planning and Design (P&D) assignments should be structured so as to pose the students with a problem from which a hypothesis can be developed. The hypothesis will then form the basis for the design of the chemical investigation to solve the problem.

P&D problems continued to be too simple or vague in their structure. In addition, mark schemes were inappropriate. In some instances, candidates were not given credit for feasible designs because the mark scheme was too rigid. In other instances mark schemes did not adequately assess the skills required for P&D.

Teachers are also reminded that each skill, for example, Manipulation and Measurement (M/M) or Observation, Recording and Reporting (ORR) must be assessed twice to avoid placing the candidates at a disadvantage.

All mark schemes used to assess the skills per module must be submitted. The absence of appropriate mark schemes was especially noted in practical assignments involving qualitative analysis of unknown compounds. General schemes for marking ORR and AI in such practical assessments proved inadequate for moderation. It is essential that all unknowns be identified in the mark schemes provided.

DETAILED COMMENTS

UNIT 1

PAPER 01

Question 1

Candidates were expected to demonstrate their understanding of the underlying principles of dynamic chemical equilibrium.

Most candidates were able to give a partial explanation of the term ‘dynamic equilibrium’. However, candidates were unsure of the requirement of a closed system. Many candidates stated that a closed vessel or container was a requirement.

Another common error made was the inclusion of the $NH_4Cl(s)$ in the expression for the equilibrium constant.

Question 2

This question required candidates to use the kinetic model to explain the properties of the liquid state. In addition, the properties of an ideal gas had to be applied in a calculation.

Generally, performance on this question was satisfactory. However, candidates demonstrated some difficulty in clearly describing the nature of the liquid state in terms of the strength of the intermolecular forces and energies of particles.

The calculation posed little difficulty in terms of manipulation of the appropriate mathematical expression. However, too many candidates omitted to convert the given temperatures to the Kelvin scale.

Many candidates were unable to deduce that the balloon would burst as the gas expanded under reduced pressure.

Question 3

The application of the concepts of reduction and oxidation formed the basis of this question. Candidates were required to **explicitly** explain redox in terms of the reaction between sodium and bromine.

Surprisingly, the performance on this question was below the acceptable standard for advanced proficiency. Many candidates simply stated that sodium was oxidized and bromine was reduced without subsequently explaining the changes that actually occurred, for example, sodium lost one electron and was oxidized while bromine gained one electron and was reduced **OR** sodium showed an increase in oxidation number from 0 to +1 and was oxidized while bromine showed a decrease in oxidation number from 0 to –1 and was reduced.

Many candidates were unsure of the direction of electron transfer and some thought that the reaction was initiated by the ionic species of the elements.

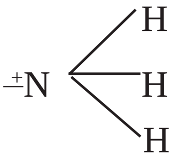
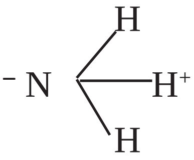
Some difficulty was encountered by candidates in writing the equation for the reaction between zinc and nitric acid. Many candidates were unable to explain the difference in the reactions of the acids with zinc in terms of the oxidizing power of the nitrate (V) ion.

Question 4

This question focused on the dipolar nature of amino acids and their acidic and basic character.

The performance on this question was generally unsatisfactory. Candidates demonstrated deficiencies in a number of areas including inability to draw an accurate displayed formula of the zwitterion, including the correct assignment of charges.

Common errors were

- writing  as  or $^{-}NH_3^{+}$ instead of placing the positive charge on the nitrogen
- lack of knowledge of the properties of amino acids in terms of the consequences of ionic bonding between zwitterions
- lack of knowledge of the response of the acidic and basic functional groups to change in pH. Many candidates ignored using the zwitterionic form of the amino acid in the reactions

Candidates had difficulty in identifying the functional groups of the amino acid. Some did not know the difference between the CARBONYL and CARBOXYL GROUPS.

A few candidates also identified the amine group as the amide group.

Question 5

Candidates were required to demonstrate their knowledge and understanding of addition and condensation polymerization.

The performance on this question was generally good. Most candidates were able to score 5-8 marks out of the total of 10. The area of greatest difficulty in this question was the drawing of the repeat unit of nylon 6,6 or nylon 6.

Also, the determination of the structure of the monomer from the given repeat unit in Part (c) proved challenging to some candidates.

Candidates did not write the displayed formula to show the bonding between the O-H and tended to write it as OH. Candidates need to be reminded that in the displayed formula all bonds must be shown.

Question 6

This question required candidates to demonstrate their understanding of the relationship between structural features of amines and amides and their basic character.

This question was poorly done. Candidates were unable to relate the pK_b to the basic strength of the species given and were therefore unable to identify the strongest base as that with the lowest pK_b value.

Candidates were also unable to relate the pK_b values to the structures of phenylamine, ethylamine and ethanamide and several misconceptions were brought forward including

- the alkyl group as electron withdrawing
- the benzene ring as electron releasing.

They failed to realize that the lone pair on the nitrogen becomes unavailable for accepting a proton due to the presence of the carbonyl group in ethanamide and the phenyl group in phenylamine.

Question 7

This question required candidates to show their knowledge of the electromagnetic spectrum and the transitions occurring on absorption of specific wavelengths of radiation by molecules.

Most candidates scored in the range of 0-5 marks out of the total of 10 for this question.

Knowledge of the radiation sequence in the electromagnetic spectrum and the relationship between wavelength and frequency /energy was notably lacking.

Many candidates were unable to account for the curves in the ultraviolet and visible spectra in Part (b)(i), in terms of the absorption that occurs over a band of wavelengths.

Most candidates were unaware of the contribution of vibrational modes to the absorption spectrum in (b)(ii).

Many candidates were unable to clearly explain molecular excitation in terms of electron promotion from a molecular orbital of lower energy to one of higher energy. Few candidates demonstrated knowledge of electron promotion occurring between bonding and antibonding molecular orbitals.

Question 8

Knowledge and understanding of the application of Atomic Absorption Spectroscopy (AAS) in quantitative analysis were required in this question.

Performance in this question was satisfactory. However, weaknesses were noted in knowledge of the theory underlying the application of AAS. Identification of potential sources of error proved to be challenging for some candidates. Many candidates were unaware of the direct relationship between detection limit and the standard deviation.

Candidates require practice in the use of calibration curves.

Question 9

This question dealt with the application of thin layer chromatography.

The performance on this question was very variable.

The advantages of thin layer chromatography over paper chromatography were not well known.

Many candidates showed little knowledge of two-dimensional chromatography as required in Part (d).

UNIT 1

PAPER 02

Question 1

Candidates were required to apply their knowledge of titrimetric analysis in this question.

Performance here was generally good.

Candidates, however, displayed difficulty in completing the equation using the formula H_2X for the acid. Many candidates gave the formula of the salt as NaX.

Surprisingly, a few candidates suggested the use of a measuring cylinder as appropriate for the quantitative measurement of the wine.

It is recommended that students be given adequate practice in this area of analysis and the use of proper techniques.

Question 2

This question tested the candidates' knowledge of the acidity of phenols, alcohols and carboxylic acids.

Performance on this question was unexpectedly below standard. The use of pKa as an indicator of relative acidity proved difficult for most candidates.

In many instances, appropriate observations were not given for the reaction between the organic acids and sodium carbonate. A common error was the use of inferences instead of observations.

The test for carbon dioxide was not known by some candidates and therefore reagents such as lime juice, soda lime water, calcium carbonate, soda lime were given. A few candidates wrote the formula for calcium hydroxide as CaOH.

In addition, candidates persisted to describe the result of the test for carbon dioxide with lime water as a 'milky' or 'cloudy' precipitate. It must be stressed that this is not acceptable. Furthermore, the use of 'no reaction' for an observation is also not an acceptable response. Candidates should have stated explicitly that no effervescence would have been observed for both reactions with phenol and ethanol.

The responses to this question reflected a poor foundation in structure-activity relationships for the organic compounds.

Question 3

The application of solvent extraction as a separation technique was the focus of this question.

All aspects of this question proved challenging to the candidates.

Noted deficiencies included:

- Lack of knowledge of the use of solvent extraction in the separation of organic compounds

- Limited comprehension of the process of separation involving the reaction between the organic acid and the sodium carbonate and the subsequent dissolving of the product in the aqueous layer

- Limited knowledge of the use of anhydrous sodium sulphate as an agent to remove water and the use of inorganic solvents to remove inorganic residues from organic solutions

It is recommended that students be given adequate practice in the separation techniques taught in Module 3.

Question 4

This question tested the candidates' knowledge and understanding of the concepts of chemical energetics and proved to be unpopular. Performance, however, was generally satisfactory.

Some errors were made in the definitions for enthalpy and enthalpy change. Most candidates were unaware of the need for constant pressure as a required condition in the definitions.

In addition, candidates were unsure of the solution to the calculation which involved the application of Hess's Law. See Appendix 1 for solution.

Question 5

This popular question dealt with periodicity of ionization energy and required candidates to demonstrate proficiency in writing electron configurations.

Most candidates did fairly well on this question. However, a few errors were noted:

- Candidates also had difficulty writing the electronic configuration given the atomic number. Many candidates were unable to determine the correct electronic configuration of the ion formed as they did not realize that the elecctrons would be lost from the 4s orbital instead of the 3d.
- Candidates were often unable to explain the periodic anomalies due to the presence of the electron entering a new sub level for Aluminium and the stability of a half-filled sub level for Phosphorus relative to the repulsion caused by the pairing in the sub level of Sulphur.
- Candidates must be reminded of using an appropriate scale when plotting graphs which should see the graph occupying more than half of the page and be convenient for plotting of points.
- Many candidates had difficulty in explaining the shape of the graph. Some were able to identify the three different energy levels but were unable to explain the pattern with respect to the increase in the effective nuclear charge as each electron was removed.

Question 6

This question expected candidates to demonstrate their knowledge of the reactions of organic functional groups and the results of successive treatment with specific arrangements.

Candidates lost marks readily in this question when asked to give equations for specific functional group conversions. In some instances, knowledge of the functional group conversion was demonstrated but the chemical change of the reagent was unknown. For example, the treatment of the given organic molecule, vanillin, with Fehling’s reagent was correctly identified to cause oxidation of the aldehyde functional group but the conversion of copper ions to copper(I) oxide was unknown by many. Many candidates thought that copper(II) oxide was the inorganic product.

This was a common error for all the equations required and, in addition, knowledge of the details of the reactions was limited.

Candidates also found it challenging to focus on the reactions of the individual functional groups and seemed confused by the complexity of the vanillin structure as presented. The structure of the 2,4-dinitrophenylhydrazone product of the reaction between vanillin and 2,4-dinitrophenylhydrazine was correctly illustrated by few candidates.

Candidates continue to display severe weaknesses in the reactions and mechanisms of organic functional groups. Teachers are advised to ensure that students are given adequate practice in writing organic reactions and mechanisms for consolidation of the concepts involved.

Question 7

This question proved to be challenging to the candidates and was answered by few. Knowledge and understanding of the unimolecualr and bimolecular mechanisms of the nucleophilic substitution reactions of the halogenoalkanes were tested.

Again, this was a weak area for most candidates. In Part(a), candidates demonstrated knowledge of the details of the SN1 and SN2 mechanisms but were unable to provide an appropriate structure for the corresponding halogenoalkane.

Part(b) challenged the candidates, as an appreciation of the stereochemistry of the mechanisms was required. Little knowledge of the inversion of stereochemistry associated with the SN2 mechanism was demonstrated. In many instances the use of the mechanistic arrows was incorrect.

These features of organic reaction mechanisms need to be reinforced. Candidates must recognize that mechanistic arrows always flow from the site of the electron pair to the electron deficient site being attacked.

Question 8

The principles of gravimetric analysis formed the basis of this question. Generally, candidates experienced difficulty with this question.

Most candidates were unaware of the principles of gravimetric analysis.

Surprisingly, in Part (b), writing the equation for the reaction between free chloride and silver nitrate proved to be difficult for some candidates. In many instances, marks were lost for the absence of state symbols or the use of incorrect state symbols. The subsequent calculation of the mass of chloride present in the analyte sample was poorly done. See Appendix 2 for solution.

This performance suggests that students need reinforcement in the underlying principles of gravimetry as a quantitative method of analysis.

Question 9

This question tested the knowledge and understanding of titrimetric and AAS methods of analysis. Performance was satisfactory. Most candidates were knowledgeable on the requirements of a primary standard. However, some common errors were noted. These included:

- Inability to identify titrimetric operations that would impact on accuracy or precision
- Incorrect plotting and drawing of the calibration curve
- Taking incorrect readings from the graph
- Giving readings taken from the graph to too few or too many decimal places
- Incorrect calculation of the standard deviation
- Inappropriate use of the rules for assigning significant figures

It is recommended that students be given more practice in the statistical analysis of quantitative data.

UNIT 2

PAPER 01

Question 1

The focus of this question was acid/base equilibria. The candidates' performance was quite satisfactory.

A common error, however, was the recognition that the dilute NaOH solution would not be a strong alkali and hence the titration would actually be more of a weak acid / weak base titration where no indicator would adequately signal the equivalence point.

Question 2

Candidates were expected to demonstrate their knowledge and understanding of the principles of buffer systems.

Performance was satisfactory but candidates still demonstrate a weakness in manipulation of the acid equilibrium expression to calculate the pH of the buffer system. See Appendix 3 for solution.

Question 3

This question tested candidates' knowledge and understanding of standard electrode potential and standard cell potential.

This question was fairly well done.

Candidates were able to correctly define the standard electrode potential but many candidates omitted the conditions of $25^{o}C$ and 1 atmosphere.

Teachers are reminded that candidates need to practice calculations involving standard electrode potentials.

Question 4

This question examined the trends and properties of Group II compounds including the carbonates, sulphates and oxides.

This question was done fairly well.

Few candidates, for Part (c), did not know the formula for quicklime (CaO) and therefore could not get the equation for the reaction with water. Some did not recognize the reaction with water to be exothermic and wrote that the quicklime reacted with the boat to start fires.

Question 5

In this question candidates were expected to show their knowledge of the qualitative tests for iron(II), iron(III), chloride and bromide ions.
Candidates were quite familiar with the results of the test for iron (II) and iron(III) with NaOH and also the test for the halides with $AgNO_3$. However, some candidates were unable to write the equation for the reaction of the silver chloride with NH_3(aq).

Question 6

This question dealt with the chemistry of the halogens including oxidizing power and reaction with $AgNO_3$. Candidates were, however, expected to apply their knowledge of standard electrode potentials.

Most candidates were able to predict the oxidizing power of the halogens down the group.

In Part (b) (i), candidates misinterpreted the required response and therefore gave descriptions of the product for the reactions as observations and did not identify the reactions as displacement or oxidation/reduction reactions.

Quite a few candidates wrote incorrect statements such as 'the bromide ion displaced iodine' instead of bromine displacing iodide ions.

In (b)(ii), few candidates were able to write the balanced equation for the reaction between the bromide ion and chlorine and hence calculate E_{cell} for the reaction.

Question 7

Knowledge of the natural recycling of carbon was required for this question.

The performance was generally good.

The term 'sinks', however, seemed unfamiliar to some candidates and led to incorrect responses. The concepts of negative and positive feedback also proved challenging to many candidates.

Question 8

The industrial synthesis of ammonia formed the basis of this question and most candidates performed well.

Question 9

Candidates were tested on their understanding of the concepts of reduce, reuse and recycle in environmental management.

Performance was satisfactory.

UNIT 2

PAPER 02

Question 1

The candidates' understanding of the theory of reaction kinetics was examined in this question.

The overall performance on this question was not satisfactory. Some of the candidates wrote the rate equation as k = [A] instead of rate = k[A].

The mechanism for the reaction was poorly done. Candidates seem unfamiliar with writing mechanism for a reaction and where mechanisms were given the rate determining step was not identified.

Question 2

This question again proved challenging. Candidates failed to apply the underlying chemistry of complex formation, ligand displacement and stability constants in Part(a), to explain the reaction between CO and haemoglobin. The competitive nature of CO as a ligand in comparison to O_2 especially at low O_2 concentration and hence its higher stability constant was recognized by only a few candidates.

Most candidates were, however, aware that the inhalation of CO could lead to oxygen starvation and eventually death.

Some candidates were unable to write the equation for the reaction between Cu^{2+} ions and NH_3(aq).

Question 3

Part (a) of this question required knowledge of the natural recycling of nitrogen in the environment. Part(b) involved the application of spectrophotometry in the quantitative estimation of nitrate(V).

This question was also poorly done. Common deficiencies were:

- Limited knowledge of the chemistry of the nitrogen cycle
- The reaction of NO_2 and H_2O was not well known
- Incorrect interpolation from the graph

Question 4

This question required candidates to apply the concepts of chemical equilibrium to the formation of precipitates. Calculation of k_{sp} and the explanation of the common ion effect were also components of the question.

This was not a popular question but some of the candidates who attempted it did fairly well.

Most candidates were able to write the expression for the K_{sp} of AgCl. However, some included the AgCl(s) in the expression.

Few candidates were able to say how they would have calculated the [OH^-] and hence the K_{sp} value for $Ca(OH)_2$. The stoichiometry of the reaction was also ignored in the expression.

Some candidates were able to recognize the introduction of a common ion. However, they were then unable to explain the observation in terms of the equilibrium shifting to favour the formation of a precipitate.

Question 5

This question dealt with the conditions under which the dynamic equilibrium between N_2O_4 and NO_2 exists and the macroscopic properties of the system.

Candidates confused equilibrium position with rate of reaction. For Parts (c) (i)and (iii) candidates did not mention observations. Instead, they stated that more of NO_2 or more of N_2O_4 were produced.

Few candidates wrote K_c in terms of partial pressures, failing to realize that concentration should be used.

Question 6

Knowledge of the periodicity of the Period 3 oxides and chlorides was examined in this question.

This question was the favourite in this section but also showed some weaknesses.

- Candidates did not mention all of the oxidation states and instead wrote ranges. Some even wrote negative oxidation states for Cl and P not realizing that oxygen, being higher in electronegativity, would give those elements positive oxi dation states.

- Candidates found it difficult to relate the acid/base behaviour of the oxides to their structure and bonding. Few candidates incorrectly wrote metallic bond ing for ionic oxides. Although some mentioned the type of bond, they did not refer to the structure. Some candidates also referred to the metal Al being amphoteric instead of the oxide.

Question 7

The chemistry of the Group IV elements, as required in this question, also proved challenging to the candidates.

Most candidates failed in (b)(ii) to relate the electronegativity of silicon and chlorine to the polar nature of the Si-Cl bond. Instead they made reference to chlorine being able to attract the water molecule to itself.

Question 8

The industrial extraction of aluminium and the properties of the metal were the fundamentals of Question 8.

This question was the favourite from this section. Surprisingly, candidates did not score marks easily for this familiar process. They lost marks readily for being vague in their responses and inattention to the details of the process. In addition:

- Labelling of the diagram was unsatisfactory.
- Few of the candidates gave the correct anode equation.

Question 9

The limited knowledge of the petroleum and petrochemical industries and their environmental impact and regulation, as demonstrated by the candidates, was again troubling. These objectives are clearly stated in the syllabus, yet the percentage of candidates showing unfamiliarity with the material was too high.

- Candidates could identify the fractional distillation process, however, they were unable to explain how the process works.

- Four benefits of petroleum refining could not be identified by many candidates

- Candidates did not show awareness of the environmental problems associated with the industries.

- Many candidates did not know what was meant by the term ‘photochemical’ in relation to the formation of smog. They commonly omitted to mention the presence of sunlight/UV light being a necessary condition. Candidates also did not realize that in peak hour traffic there would be maximum photochemical activity.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2005

CHEMISTRY

St Michael Barbados

CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2005

Unit 1 Paper 01

Question 1

Specific Objectives: 5.5 – 5.7

Candidates were expected to demonstrate their understanding of empirical and molecular formulae by definition, illustration (by selecting appropriate examples) and by calculation based on data provided. Most candidates defined empirical formula appropriately, however, a common error was the notion that the molecular formula showed the number of atoms in a compound/molecule instead of the number of atoms of each element present in the compound/molecule. Candidates selected appropriate examples to illustrate the concepts of empirical and molecular formula, and their performance on Part (c) - the determination of the molecular formula of X– was satisfactory.

Question 2

Specific Objectives: 6.1 – 6.3

This question assessed candidates' understanding of redox in terms of gain/loss of electrons and changes in oxidation number.

Many candidates correctly identified redox as reduction – the gain of electrons, and oxidation – electron loss. However, they often identified copper or the brass alloy instead of Cu^{2+} ions or the ionic paste as part of the redox reaction. Candidates continue to experience difficulty in writing balanced ionic equations and in calculating oxidation number. Some stated that the oxidation number of S in SO_2 changed from O to +2; others wrote the change in oxidation number of chromin as Cr^{6+} to Cr^{3+} instead of from +6 to +3.

In responding to Part (c) many candidates selected appropriate elements – metals and non-metals and they gave adequate experimental details. However, a common omission was a statement that described how the result/observation would be used to list the elements in order of oxidation or reducing ability. Candidates should be reminded that sodium and potassium metal react violently/explosively and should not be selected to illustrate reactions with acids..

Question 3

Specific Objectives: 8.2 – 8.3

Candidates were expected to demonstrate their knowledge and understanding of the gas laws and kinetic theory and to perform a simple related calculation.

Candidates' knowledge of Boyle's Law and Charles' Law was satisfactory. The most common error was the omission of conditions - for Boyle's Law constant temperature and for Charles' Law - constant pressure. Candidates should also be reminded that the term "indirectly proportional" cannot be substituted for "inversely proportional"

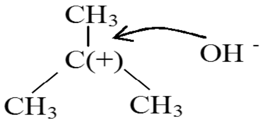
In general, the calculation was done well. However, some candidates did not convert the temperature from ^{0}C to K.

Question 4

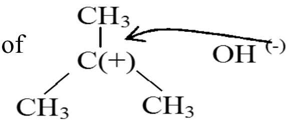
Specific Objectives: 2.1, 2.3 (v)

This question focused on organic functional groups, reacting species as electrophiles and nucleophiles, bound fission and reaction mechanism as applied to the specific example given. Some candidates identified the -C = 0 group of the - C group as a kestine.

Many candidates defined electrophiles and nucleophiles as positively and negatively charged species. A general definition of these terms as electron seekers and electron donors was expected. The use of arrows in illustrating the bond-breaking and bond-making steps was satisfactory. However, candidates must be reminded that the convention is that arrows indicate the movement of a pair of electrons so that



is used instead of



Question 5

Specific Objectives: 2.3; 4, 3.4

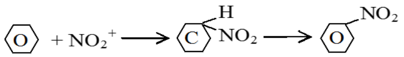
This question focused on the nitration of benzene and the reduction of nitrobenzene to phenylanine.

Many candidates correctly identified the role of concentrated sulphuric acid in the production of NO_2^+ (nitryl cation). However, some were unable to write the balanced equation for the reaction between nitric acid and concentrated sulphuric acid. Most candidates were unable to use arrows correctly to illustrate the mechanism of the reaction . The following are some examples.

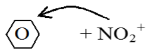
Surprisingly, some candidates identified the mechanism as electrophilic addition. In addition, the product of reduction of nitrobenzene was sometimes identified as a chlorosubstituted product such as chlorobenzoate or nitrochlorobenzene.

Question 6

Specific Objection: 3.5 - 3.7



(without arrows)



(incorrect use of arrows)

Candidates were expected to demonstrate their understanding of pKa as it relates to acid strength and the acid/base properties of amino acids.

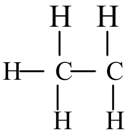
Most candidates related the pKa values given to degree of acidity but failed to include a statement on the degree of ionization as part of the explanation. The explanation of acidity in terms of molecular features was satisfactory, with candidates demonstrating their understanding of resonance stabilization of the ethanoate ion and of the role of the alkyl CH_3 group in reducing the acidity of ethanol.

Few candidates recognized that the NH_2 group would be protonated in acidic solution. It seemed too that candidates were unfamiliar with the term zwitterion and as applied to L-threonine that the presence of strong electrostatic forces would account for the high melting point. Most candidates however provided a satisfactory explanation for the soluility of L-threonine in water.

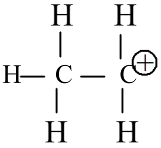
Question 7

Specific Objectives: 2.21, 3.6

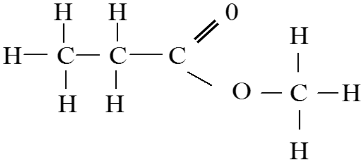
This question was based on the mass spectrometer and its use in determining molecular formulae. The most common error was the omission of the charge in the ionic species produced. Responses included



instead of



Many candidates used the mass spectrum data to deduce a structural formula for the compound. However, they ignored the information that the compound was synthesized by reacting an acy1 halide with an alcohol, indicating that the product was an ester:



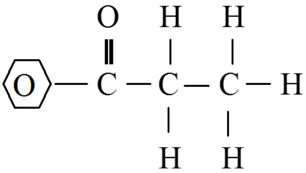
Question 8

Specific Objectives: 2.23, 2.27, 3.24

This question was based on Nuclear Magnetic Resonance (NMR) spectroscopy.

Candidates performed fairly well in terms of their knowledge and understanding of the properties of nuclei that allow their detection in NMR analysis and the changes that occur upon exposure to an external magnetic field and radio wave signal. Many candidates scored at least two out of four marks. Candidates, also, correctly identified the functional groups present from the given chemical shift data as C = 0 and C_6H_5. However, many omitted the explanation in terms of deshielding by the C = O group and the benzene ring.

Most candidates obtained at least one out of the two marks allotted for the structure



Question 9

Specific Objectives: 2.36, 2.37

Candidates were expected to demonstrate their understanding of solvent extraction in terms of the properties of an organic solvent and the principles underpinning this method of extraction. Candidates were also expected to apply their knowledge of extraction techniques to the specific problem posed.

A large proportion of candidates suggested a named solvent instead of a type of solvent to which the question referred. Responses for the properties and principle of solvent extraction were satisfactory. Candidates mentioned, for example, that the solvent should be (i) immiscible with water; (ii) inert; (iii) able to dissolve the solute and they wrote that high solubility in the organic phase allows for the removal of the compound from the reaction mixture.

A satisfactory number of candidates identified steam distillation as the appropriate method for extracting the base material from the plant. However, some candidates stated that chromatography was appropriate. In general, candidates who identified steam distillation mentioned that the organic material is obtained at a temperature below its boiling point, which prevents decomposition or preserves the structure of the molecule.

Unit 1 Paper 02
Detailed Comments

Section A

Question 1

Specific Objectives: 4.1, 4.3 - 4.5

The question was based on laboratory determination of melting point. Candidates were also expected to provide an explanation for physical properties of substances in terms of structure of bonding.

Candidates performed satisfactorily on the description of melting point determination, with most being awarded at least two of the four marks. However, it was evident that many candidates had not actually performed this activity in the laboratory when inappropriate apparatus such as beakers and conical flasks were selected.

As in past years, candidates associate melting with cleavage of the covalent bond (intramolecular forces) and in cases where Van der Waals induced dipole-induced dipole forces of attraction were correctly identified, many candidates were unable to describe how they arise.

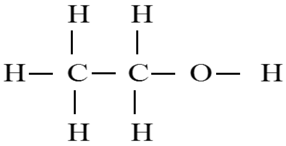
Candidates' description of metallic/ionic bonding was satisfactory.

Question 2

Specific Objectives: 3.1-3.2 (i), (ii)

This question focused on functional group analysis – reactions of alcohols.

Approximately 56 per cent of the candidates scored at least four of the 10 marks. Candidates are evidently familiar with the reactions of alcohol and most correctly identified Z as



$$\begin{array}{ccccccccc} & & H & & H & & & & \\ & & | & & | & & & & \\ H & - & C & - & C & - & O & - & H \\ & & | & & | & & & & \\ & & H & & H & & & & \end{array}$$

Candidates should be reminded that all atoms and all bonds must be shown when a displayed formula is written, for example, -O-H instead of –OH. In addition, too many candidates were unable to state reagents and conditions necessary for hydrolysis of the ester.

<u>Question 3</u>

<u>Specific Objectives: 2.1 - 2.3, 2.5, 4.1</u>

Candidates were expected to use their knowledge and experience of titrimetric analysis in the laboratory to answer this question.

Most candidates appropriately selected NaOH as the titrant for the reaction with salicylic acid. Their responses to Part (b) suggest that many candidates have not actually prepared a standard solution in the laboratory. However, it was evident that candidates were familiar with acid/base titrations.

Most candidates selected the correct indicator - phenolphthalein. However, some were unable to use the graphs to suggest that the change in pH at equivalence point matched the pH range data of the indicator (phonolohthalein) as given in the table, and instead they repeated their knowledge that a weak acid/strong base was used.

SECTION B

<u>Question 4</u>

<u>Specific Objectives: 7.1 - 7.3</u>

This question focused on equilibrium concepts.

Candidates' descriptions of the features of a system in dynamic equilibrium was generally well done. However, there were instances of imprecise use of language when candidates, for example, wrote that at equilibrium the concentration of the reactants and products is the same or equal instead of remains constant. Candidates also referred to Kc and Kp as the concentration and pressure constants respectively instead of as the equilibrium constant using concentrations (Kc) partial pressures for gases (Kp).

Most candidates wrote the correct expression for Kc for the reaction given. It was surprising, however, that candidates who had previously correctly described the features of a system in a state of dynamic equilibrium could not transform this information into numerical form to state that the concentration of products at the start of a reaction is zero and then to use the equation indicating mole ratios for reaction to determine the equilibrium concentrations.

Significant too was the finding that many candidates who correctly defined Kp as the equilibrium constant for gases then wrote the equilibrium constant for the reaction given as

$$Kc = \frac{[SO_3]^2}{[SO_2]^2\ [O_2]}$$

However, most candidates gave suitable explanations for the low Kp value and gave appropriate suggestions such as recycle and reuse the reactants.

Question 5

Specific Objectives: 9.1 - 9.5, 10.1

Energetics was the topic on which this question was based.

Performance in this question was in general satisfactory. Definitions of enthalpy charge, exothermic and endothermic reactions were good, as was the description of bond making as an exothermic reaction and bond breaking as endothermic.

Candidates experienced some difficulty in balancing the equation

$$N_2\,H_4\,(l) + 2Cl_2\,(g) \longrightarrow N_2\,(g) + 4H\,Cl\,(g)$$

The calculation was in general done well, the most common errors bein (1) incorrect units, for example,

(c) (ii) candidates wrote the answer as 166.7 K J mol $^{-1}$, instead of 166.7 K J.

and (2) a value of +81.4 K J for the conversion $2H_2\ 0 \longrightarrow 2H_2\,0(l)$ instead of - 81.4 K J.

Question 6

Specific Objectives: 1.10 – 1.15

This question was based on addition and condensation polymerization.

Candidates' performance in this question was satisfactory
Definitions were well done. However, candidates experienced some difficulty in

(i) writing the equation to illustrate the repeat unit of a polyester
(ii) illustrating the repeat unit of the addition polymer
(iii) identifying the repeat unit for starch and cellulose from the structures given
(iv) writing displayed formulae.

See Appendix 1 for solution.

Question 7

Specific Objectives: 1.3 – 1.9

Candidates' were expected to demonstrate their knowledge and understanding of organic structure and formulae and to apply their understanding to solve a problem given appropriate data.

Candidates' explanation of structural isomerism were well done, but many were unable to explain stereoisomerism. Candidates also experienced some difficulty in applying knowledge of structural isomerism and geometric isomerism to the examples provided. Responses to Part (c) were satisfactory.

Question 8

Specific Objectives: 1.1 – 1.3

This question was based on uncertainty in measurement.

Candidates were familiar with formulae used to calculate the mean and standard deviation and they easily obtained at least three of the four marks allotted. The most common error was that the formula S.D was

$$\frac{\sqrt{\Sigma\left(x-\bar{x}\right)^2}}{n-1} \quad \sqrt{\frac{\Sigma\left(x-\bar{x}\right)^2}{n-1}}$$

Candidates' performance on the other parts of the question was satisfactory, with appropriate use of concepts of precision and accuracy with reference to replication of sampling and comparison with the true value respectively. Candidates were evidently quite familiar with the relationship between equipment selected and accuracy of results. However, most candidates had either not been exposed to practical laboratory activities to determine the degree of uncertainty in measurements associated with the pipette or they misinterpreted the question. There were responses that gave details on the use of the pipette during volumetric analysis.

Question 9

Specific Objectives: 2.15, 2.17, 3.4

Candidates were expected to demonstrate their understanding of uv/vis spectroscopy and to perform a simple related calculation.

Most candidates stated that substances absorb light and that absorption led to electron promotion. Some common omissions, however, were reference to the wavelength in the uv/vis spectrum, mention of λ max and that the amount of radiant energy given as absorbed at λ max is instead of directly proportional to the concentration of the solution.

Candidate performance on Part (b) was satisfactory. Responses included reference to multiple bonding and the presence of the lone pairs on the N atoms. Candidates were also familiar with the procedure used to obtain a calibration curve.

Some candidates were unable to convert mg dm^{-3} to g dm^{-3} and then to moles dm^{-3} as required in (c) (i). In general, candidates did not include correct units in response to (c) (ii) and (iii).

Unit 2 Paper 01
Detailed Comments

Question 1

Specific Objectives 1.1, 1.3, 1.4

This question was based on reaction rates.

Candidates' responses were for the most part excellent with the modal range of 9-10.

The section of the question that presented most difficulty was (a) (i) in which candidates did not mention that increased surface area resulted in greater frequency of collisions between particles and that catalysts lower the activation energy for the reaction.

Question 2

Specific Objectives 2.1, 3.1

Candidates were assessed on their knowledge and understanding of chemical equilibrium.

Le Chatelier's principle was in general well known. Candidates experienced greatest difficulty in describing the effect of a catalyst on an equilibrium system. Candidates failed to mention that the catalyst speeds up the rate of the forward reaction and the rate of the backward/reverse reaction, which results in no net effect on the equilibrium concentrations/system.

Question 3

Specific Objectives 2.13, 2.14

This question assessed candidates' knowledge and understanding of solubility of sparingly soluble salts and their ability to apply these concepts to a problem requiring calculations. Candidates performed satisfactorily. Parts (a) (i) and (iii) were well done. However, candidates experienced some difficulty as they attempted to explain the term "solubility product" and to calculate the solubility of lead iodide.

Question 4

Specific Objectives 1.4-1.6

The question assessed candidates' understanding of the behaviour of the oxides of the elements of Period 3. The performance on this question was unsatisfactory. . Greater emphasis should be placed on relating the properties and trends in behaviour in terms of structure and bonding.

Question 5

Specific Objectives 3.2- 3.4

This question was based on chemical tests used to identify cations.

Performance on this question was unsatisfactory.

The most common errors in Part (a) of this question were that candidates included the Na^+ and NH_4^+ cations in (a) (i), and in (a) (ii) many candidates did not appreciate that the test does not confirm the presence of a particular ion, rather it reduces the number of possible ions present.

Candidates were unable to explain the chemical principles underlying the precipitation reaction obtained in (a) (i), and the production of the ammonia obtained in (a) (iii). For example, in the latter, candidates were expected to indicate that the stronger base (hydroxide ions) displaced the weaker base.

Candidates also failed to include correct state symbols in writing the ionic equation. It should be written as:

$NH_4^+ (aq) + OH^- (aq) \rightarrow NH_3 (g) + H_2O (l)$

Question 6

Specific Objectives 1.12, 1.14

This question was based on the physical properties of the Group IV elements and bonding of the oxides of these elements.

The performance on this question was generally poor. Candidates were unable to present their responses in terms of structure and bonding relationships and were unable to relate properties to structure and bonding.

In addition, candidates responded to (d) in terms of the stability of the +4 oxidation state relative to the +2 oxidation state, instead of suggesting an explanation for melting point.

Question 7

Specific Objectives 1.6, 1.7, 2.6, 4.4

Candidates were expected to demonstrate their understanding of the industrial manufacture of chlorine.

Candidate performance was satisfactory to good with a modal range of four to six marks.

Candidates experienced most difficulty in (a) (iv) -writing the chemical equation- and in recognizing that the purpose of the pump was to provide a continuous flow of mercury to the electrolysis chamber.

Question 8

Specific Objectives 1.4, 4.2

This question was based on the industrial manufacture and uses of ammonia.

Candidate performance was satisfactory to good with a modal range of four to six marks.

Candidates were familiar with the Haber process. However, many candidates were unable to use the information provided in (b) to write the equation required and to deduce the products of hydrolysis of urea. In addition, candidates were unable to describe the smell of ammonia gas.

Question 9

Specific Objective 2.1

This focus of this question was recycling solid waste.

The quality of candidates' responses to this question was generally poor. Candidates did not distinguish between the terms "recycle" and "reuse."

See Appendix 2 for solution.

Unit 2 Paper 02
Detailed Comments
Section A

Question 1

Specific Objectives 2.10-2.12

This question assessed candidates' ability to apply concepts related to buffer solutions including preparation of buffers in a practical laboratory setting.

Candidate performance on Part (a) was fair. However, most candidates were unable to give a detailed outline of the procedure used to prepare a buffer solution in the laboratory. For example, candidates failed to mention that a known mass of a salt of a weak acid was required and that a solution of known concentration of the weak acid was prepared. It should be noted that laboratory activities assist greatly in helping students to understand difficult or abstract concepts. It seems that candidates are not exposed to laboratory activities of this type. It is recommended that laboratory activities should be an integral part of the teaching/learning experience.

Candidates seemed familiar with the use of the pH meter and/or universal indicator to determine pH.

Question 2

Specific Objectives 1.18-1.10

Candidates were expected to use their knowledge of the physical properties of Group II sulphates and of the chemical reaction between magnesium metal and oxygen to answer this question.

The most common error was that candidates attempted to distinguish among the Group II sulphates by describing chemical reactions. For example, candidates added aqueous sodium hydroxide to solutions. In addition, some candidates who correctly used differences in solubility did not give full details.

It was surprising that in response to Part (b), many candidates were unable to deduce that “dim light” was the environmental condition in which the reaction between magnesium and oxygen would be used. It seems that candidates are not exposed to practical activities, either as demonstrations or as individual/small group work. It was also surprising that some candidates were unable to write the balanced equation:

2Mg (s) + O_2 (g) à 2MgO (s).

Some wrote: Mg (s) + O_2 (g) à MgO (s) or Mg (s) + O_2 (g)à MgO_2 (s)

Question 3

Specific Objectives 1.5, 4.3

This question was based on the production of alcohol by the fermentation process and the consequences of alcohol consumption.

Candidates performed satisfactorily on this question with a mean score of 5 of the 10 marks. Performance on Part (a), which would have been aided by practical experience of fermentation, was disappointing. It was expected that candidates would have mentioned flavour and colour of the product as two differences between the home-made alcoholic beverages. In addition, candidates rarely stated that the percentage of alcohol could be determined by distilling equal volumes of the two beverages to compare the volume of alcohol/distillate obtained. Again, the importance of practical laboratory experience is evident.

Section B

Question 4

Specific Objectives 2.4- 2.6

Candidates were expected to demonstrate their understanding of the Bronsted-Lowry theory of acids and to perform calculations involving the use of pH and K_a.

Generally, the definition of “weak acid” in terms of Bronsted-Lowry theory was widely known. Responses for the classification of niacin as a weak acid were good.

Candidates found some difficulty in performing the calculation. Some failed to subtract the hydrogen ion concentration form the original concentration of niacin and some candidates mentioned that an increase in $[H^+]$ leads to an increase in pH.

Question 5

Specific Objectives 2.18 -2.21, 3.4

This question focused on redox equilibria.

Candidate performance was fair. The most common error was incorrect usage of E values.

APPENDIX I

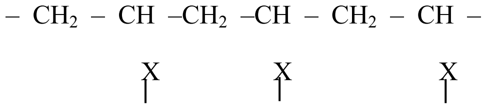
UNIT 01 - PAPER 02

Question 6

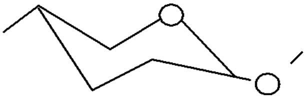
(a) (i) The formation of a large molecule or polymer by the reaction between monomeric molecules with the elimination of a small molecule, for example, H_2O.

(ii) The formation of a large molecule by the addition of unsaturated monomeric molecules.

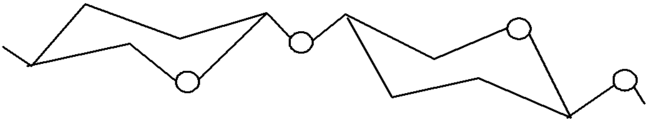
(b) (i) $HO - R - C\ OH + HO\ CO - R^1 - COOH$
$- O - R - O - CO - R^1 - CO - + H_2O$


$$-CH_2 - \underset{X}{\underset{|}{CH}} - CH_2 - \underset{X}{\underset{|}{CH}} - CH_2 - \underset{X}{\underset{|}{CH}} -$$

(c) (i) a)



b)



(ii) The action of amylase causes the breakdown of polymeric starch mocules into its monomeric simple sugars which have a sweet taste.

(d) Sequence: Gly. Leu. His. Ser. Val

(e) (i)


$$[\ N - (CH_2)_6 - \overset{H}{\overset{|}{N}} - \overset{H}{\overset{|}{C}}\ (CH_2)_4 - \overset{O}{\overset{\|}{C}}\ ]$$

(ii) peptide linkage / amide linkage

APPENDIX 2

UNIT 02- PAPER 01

Question 9

(a) (i) Either - Treatment with alkaline solution at elevated temperature

OR - Treatment with enzyme under optimum pH/temperature

(ii) C_2H_5OH

(iii) Reuse of paper in making stationery

(b) (i) To minimize damage to the monomers

(ii) Manufacture of fibres for clothing

OR

Reuse in making new polyester

(iii)
- Decreases mass sent to landfill
- Plastics generally of low biodegradability
- Less toxic fumes released relative to incineration
- Recycling minimises wastage of materials

APPENDIX 3

UNIT 02 - PAPER 02

Question 7

(a) (i)
- H_2O molecules form a complex with the Cu^{2+} ions.
- The coordination of the Cu^{2+} with the H_2O ligands causes a split in the energies of the d-orbitals.
- Electrons in the lower energy orbitals absorb energy in the visible region of the EMR.
- The blue colour is the complement of that absorbed.

(ii)
- The Cl^- ions displace the H_2O molecules in the blue $[Cu(H_2O)_6]^{2+}$ complex.
- The green colour is due to a mixture of the blue and yellow complexes.
- The complex formed $[CuCl_4]^{2-}$ is yellow.

(b) (i)

	Ni	C	N
	36.1/58.7	29.5/12	34.4/14
Moles =	0.615	2.46	2.46
Ratio =	$\frac{0.615}{0.615}$	$\frac{2.46}{0.615}$	$\frac{2.46}{0.615}$

$= 1 : 4 : 4$

Formula NiC_4N_4

$\Rightarrow Ni(CN)_4$

(ii) Shape of X –

(c) (i) - Haemoglobin unit has a central Fe^{2+} ion that coordinates with O_2 molecules for transport to tissue.

- The CO molecules form a complex with a higher K_{stab} and O_2 is displaced.

UNIT 02 - PAPER 02

MARK SCHEME 2005

Question 7 (Cont'd)

Using

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O \quad E^\ominus = +1.33$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O \quad E^\ominus = +1.52$$

Cr is readily reduced from +6 to +3 as indicated by the positive $E^\ominus$ value.

Mn is also readily reduced from +7 to +2

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2006

CHEMISTRY

St Michael Barbados

CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATIONS

MAY/JUNE 2006

DETAILED COMMENTS

Unit 1
Paper 01

Question 1

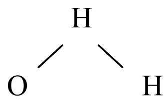
This question sought to test candidate's comprehension of the principles and processes of radioactive decay, the use of mass spectral data and the shapes of atomic orbitals.

Candidates' responses were generally satisfactory. However, a significant number found the representation of a **â** particle and hence the writing of the resulting nuclear equation a distinct challenge. A common mistake involved the writing of the titanium atom as

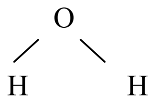
${}^{51}_{23}\text{Ti}$ instead of ${}^{51}_{22}\text{Ti}$.

Question 2

Candidates were required to demonstrate their understanding of the forces of attraction between particles and their influence on the properties of matter.
While many candidates showed an adequate grasp of the information required, a large number found difficulty in describing the relevant aspects of the VSEPR model and its subsequent application to the compounds specified.
Candidates used "crooked" to describe the shape of the H_2S molecule and depicted the water molecule as



instead of



Question 3

This question, which tested the candidates' comprehension of the principles involved in energy changes and the associated calculations, produced inadequate responses. Candidates showed weaknesses in defining the required terms, and in accurately expressing their thoughts. Most candidates were unaware that the enthalpy of solution requires the substance to be dissolved in an excess of solvent.

The calculation in (b)(ii) was poorly done reflecting the difficulty with the energetics of the process of dissolution. (See Appendix A)

Question 4

This question focused on the areas of functional groups and their chemical reactions. The performance of candidates was very weak. While candidates demonstrated little difficulty identifying the esterification reaction as involving ethanol and the carboxyl group, difficulties were evident in the

- differentiating between amide and amine,
- need for the presence of concentrated sulphuric acid as distinct from sulphuric acid in the esterification process,
- the use of $SOCl_2$ in the replacement of –OH by –Cl inorganic molecules.

Question 5

In this question candidates were required to demonstrate an understanding of the structure and formula of organic molecules with particular reference to the concept of isomerism.
The performance of candidates was satisfactory. However, significant difficulty was shown in distinguishing the various forms of structural isomers. Some uncertainty was also shown in the writing of full structural (displayed) formulae as distinct from condensed forms.
Most candidates were able to identify and write the formulae of the optical isomers.

Question 6.

This question tested knowledge of the process of polymerization.

Performance was inconsistent. While some candidates produced good responses, a large number found the question challenging. Difficulty was encountered in the comprehension of the differences between

- hydrolysis and hydration,
- amide and amine groups.

Question 7

Candidates showed commendable performance in answering this question which focused on the notion of primary standards and the calculations based on titrimetric analysis. Some candidates clearly misread Part (b), giving responses relating to the actual titration rather than the preparation of the standard solution.

Question 8

This question, dealing with chromatography as a separating technique, was generally adequately done by the candidates.

The main difficulty encountered involved the difficulty in the explanation of the difference between the terms “stationary” and “mobile” phase.

Question 9

This question sought to test the candidates' understanding of the basic concepts of IR spectroscopy. Candidates' responses indicated that this aspect of the course was not well understood. Candidates were generally unaware that IR activity must involve vibrations that result in a change of dipole moment and of the need to use IR inactive material for the essential components of the IR spectrophotometer.

Unit 1
Paper 02

Question 1

This question centered around the use of combustion analysis for the determining of empirical and molecular formulae.

Candidates showed a commendable level of proficiency in answering this question, handling the calculations with relative ease. However, many candidates disregarded the instructions to describe the observations associated with the tests for water and carbon dioxide. Many candidates responded by simply giving the reagent, "cobalt chloride paper turns pink" instead of "cobalt chloride paper turns from blue to pink", and "anhydrous copper sulphate turns blue" instead of "anhydrous copper sulphate goes from white to blue".

Question 2

In this question candidates were asked to demonstrate their understanding of functional group analysis. While most candidates demonstrated a familiarity with the various reactions of the functional groups, the application of this knowledge in (a)(vi) and (b) (iv) presented some difficulty.

Candidates should be able to demonstrate these skills at this level.

Question 3

This question, which dealt with purification techniques was poorly answered. Most candidates appeared to be unsure in dealing with the flow chart. Filter paper is not considered a piece of laboratory equipment.

Question

There was a general inconsistency in the performance of candidates on this question which focused on the basic ideas of chemical equilibrium.

Candidates were generally comfortable with the description of the characteristic properties of a chemical equilibrium and simple equations as requested in (a)(i) – (iii) and (b)(i).

Candidates, however, surprisingly found the calculations of initial and equilibrium concentrations (which involved manipulations of moles) difficult. Others confused the use of square [ ], and curved ( ) brackets, the latter to be used to express partial pressures.
(seen Appendix B)

Question 5

This question tested the candidates' familiarity with the concepts of redox reactions, their ability to manipulate oxidation numbers and the writing of redox equations.

The general standard of proficiency in this area was weak. The writing of equations continue to be a source of difficulty.

Question 6

Candidate performance on this question was particularly weak.

While the responses regarding homolytic bond fission were good, the areas of identification and explanation of reaction mechanisms presented great difficulty. Most candidates found the use of arrows in this context to be quite bewildering. A common error involved the use of arrows to indicate the movement of charge instead of the movement of a pair of electrons. Candidates also seemed not to be aware that the inductive effect operates through **ó** bonds resulting in a redistribution of charge caused by electronegativity differences.

Question 7

This question was centered around the concept of acidity /alkalinity of organic compounds.

Candidate performance was inconsistent. The main area of difficulty involved the ability to explain concisely the difference in alkalinity of the given molecules. Candidates were generally aware that alkalinity depended on the availability of the lone pair on the nitrogen atom. However, the factors which influenced this availability presented great difficulty.

The subsequent question involving evaluation skills in Part (c) proved to be quite challenging.

Question 8

This question concerned knowledge in the area of the syllabus referring to "Uncertainty in measurement".

Over ninety per cent of the candidates chose this question. Performance was generally satisfactory. Part (b)(ii), instrument calibration, presented a challenge for a number of candidates.

Question 9

This question sought to discover the candidates' understanding of phase separation with respect to distillation and its application.

Responses were weak, although the construction of the boiling point/composition curve produced quite good efforts. Candidates did find parts of the question requiring explanation and application of principles challenging.

Unit 2
Paper 01

Question 1

This question focused on the concepts of solubility product and common ion effect and the associated calculations.
Candidates demonstrated a satisfactory level of comprehension in these areas of knowledge.
Candidates also dealt adequately with Part (b) involving the calculation the of PbCl, most arriving at the correct answer of $0.25\ x\ (0.050) = 0.0000625\, mol^{-3}\ dm^{-9}$.

Question 2

This question tested the candidates' understanding of the various aspects of acid/base equilibria.

Question 3

This question required candidates to demonstrate their knowledge of the principles of redox equilibrium.

Candidates were able to produce a labeled diagram for the determination of the standard electrode potential of the $Zn^{2+}(aq)/Zn(s)$ electrode. However, responses to Part (b)(iii), which dealt with the relationship between cell e.m.f. and concentration, were vague and somewhat confusing.

Question 4

This question sought to test the candidates' knowledge of the chemistry of the Group II elements.

Candidate performance was generally good. Most candidates were able to explain the trends in 1st. ionization energy, write equations for the elements' reaction with water and gain at least two marks in the explanation of the variation of the solubility of the sulphates. Candidates showed little awareness of the fact that

- the 1st. ionization energy involved a gaseous reaction

$$Be(g) \rightarrow Be^+(g) + e^-, \text{ and } K_{sp}$$

- the charge/radius ratio of the Group II cations was vital to the decline in the value of the hydration energy with the resultant reduction of the solubility of their sulphates.

Question 5

Candidates were required to demonstrate a knowledge of the reaction of specific ions.

The performance on this question showed some inconsistency. Candidates demonstrated some knowledge of the reaction of the relevant ions. However, the failure to write the formulae of the ions rather than the symbols of their elements Part (a), and the difficulty in writing ionic equations , Part (b)(iii), gave rise to the above inconsistent performance.

Question 6

A knowledge and understanding of aspects of the chemistry of the transition elements were required for this question.

Candidates produced a commendable performance in this question. Candidates' responses to Parts (a) – (c) were generally good. However, most responses for Part (d) were disappointing. The notion that high charge density of the chromium ion results in the loss of hydrogen ions from the hydrated ion, $[Cr(H_2O)_6]^{3+}$ thus producing acidic solutions was not generally appreciated. The equation showing the dissociation was almost unknown.

$$[Cr(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + [Cr(H_2O)_5OH]^{2+}(s)$$

Question 7

This question focused on the processes involving the production of aluminium from its ore.

Candidates were quite knowledgeable in this area of the course as attested by their responses. This was somewhat spoilt by the laxness in specifying the need for a high *electrical* energy input, while the calculation in Part (c)(i) was a challenge to some candidates. (See Appendix D).

Question 8

This question dealt with the importance of halogen compounds in the form of CFCs and the environmental consequences of their use with reference to ozone interaction.

Candidates' performance was generally good. Some difficulty was encountered in using the relevant equations in responding to the questions asked.

Question 9

This question tested the candidates' understanding of the consequences of altering the concentration of the nitrogen oxides and carbon dioxide on the atmospheric environment.

Candidates demonstrated an adequate knowledge of the effects of the above changes. The responses given for Part (iv) tended to be vague. While candidates appreciated the fact that melting ice results in insufficient ice being present to make a surface crossing of the Artic Ocean, they did not understand the process which causes the ice to melt. Increased use of fossil fuels results in increased levels of CO_2 which absorbs IR radiation, leading to global warming and a melting of the ice caps.

Unit 2

Paper 02

Question 1

This question required candidates to be knowledgeable in the area of reaction kinetics.

Candidates generally demonstrated a poor grasp of the principles involved in this area of the course. Candidates failed to sketch the graph required in Part (b)(i), while the concept of order of reaction and its implications presented an unusually high degree of difficulty.
(See Appendix E).

Question 2

Candidates were tested on their knowledge of the chemistry of Group IV elements.

The performance on this question was inconsistent.
Some deficiencies were observed in the areas involving

- the writing of ionic equations
- the calculation of oxidation numbers (cf. ox. number of chlorine in NH_4ClO_4)

Question 3

This question focused on the manufacture and chemistry of ammonia. Candidates demonstrated some variability in performance, which was caused by the difficulty experienced in following the flow chart.

Question 4

Knowledge of the principles of chemical equilibrium was tested in this question.

Candidate performance was inconsistent. While most candidates were comfortable in the areas of defining and describing of the features and conditions of such systems, the area involving calculations as tested in Part (a)(iv) and (c) provided distinct challenges for most candidates. (See Appendix F)

Question 5

Knowledge of the principles and application of buffer systems and pH were examined in this question.

Candidate performance was rather weak. Candidates demonstrated difficulties in the application of these concepts as seen in their responses to questions dealing with the

- explanation of the role of amino acids as buffers in human blood, Part (c) (i)
- calculation of values of pH and K_a from the data provided, Part (d). (See Appendix G)

Question 6

This question which dealt with the chemistry of the Group IV elements was not popular with candidates.

Performance was rather weak. The best responses were found in Part (b) (ii), where most candidates were able to deduce the reducing property of substance P, and thus its role in the conversion of nitrobenzene to phenylamine.

Candidates demonstrated

- some degree of confusion in trying to explain the trends as indicated in Part (a),
- great difficulty in identifying the substances in (b)(i), although a large number recognized the reducing property of J, PbO_2 and the identity of L as oxygen.

Question 7

This question focused on the structure, bonding and chemistry of the elements in the Period Sodium to Argon as set out in the syllabus.

Candidate performance was satisfactory.
Candidates were able to describe the reaction of the elements specified with water, Part (b). However, deducing the structure and identity of the substances A to E proved to be a challenge .

Question 8

A knowledge of the environmental impact of solid waste as well as the process involved in its recycling were required for the answering of this question.

Candidates' performance was weak.
However, notice was taken of the difficulty experienced by candidates involving the

- confusion between depolymerisation and decomposition,
- suggestion of a suitable solvent for the process outlined in Part (c),
- evaluation of incineration as a method of disposal of PVC material. (This should be noted by teachers as indicating a lack of appreciation of chemical principles to this area of the course.)

Question 9

This question dealt with the refining of crude oil and the importance of its components to the petrochemical industry.

Candidates demonstrated an inadequate grasp of this area of knowledge as seen in the responses provided. Candidates found Part (a) and (b) particularly easy, but experienced some difficulty in Part (d).

INTERNAL ASSESSMENT

The level of performance on the Internal Assessment component of the examination was generally satisfactory.

Marking schemes

In most cases mark schemes were submitted and were very helpful. However, there were too many cases where these schemes were either incomplete or contained activities which were inconsistent with the skill being assessed.

Teachers are reminded that

- mathematical calculations and the writing of equations are to be assessed as Analysis and Interpretation (A&I) ***not*** Observation/ Recording/Reporting (O/R/R)skills
- the awarding of marks for the writing of experimental titles is inappropriate.
- while the assessing of student communication skills in the use of grammar, as mandated by the syllabus is to be commended, this is not to be at the expense of the fundamental O/R/R skills, for example, observations of colours and precipitates, recordings of accurate measurements, the drawing of appropriate graphs and tables.

Assessment of Skills

While most centres did assess each of the skills at least twice, some assessed one or two skills every time a practical exercise was done. This makes moderation extremely difficult as it leaves the moderator with the daunting task of determining which of these practicals were used to produce the data to be moderated.

Planning and Design

This area of assessment continues to present the most challenges.
There still exist the problem of the use of inappropriate activities for the testing of Planning and Design (P&D) skills.

Teachers are reminded that in choosing activities for the assessment of this skill, situations must be presented to students that allow for the formulation of valid hypotheses which will lead to the construction of plans with clear and identifiable variables.

Teachers should also encourage students to refrain from the prediction of actual results. Given the above, certain popular activities will be ruled inadmissible for the testing of this particular skill, such as, the identification of different classes of alcohols as a qualitative analytical exercise.

Appendix A

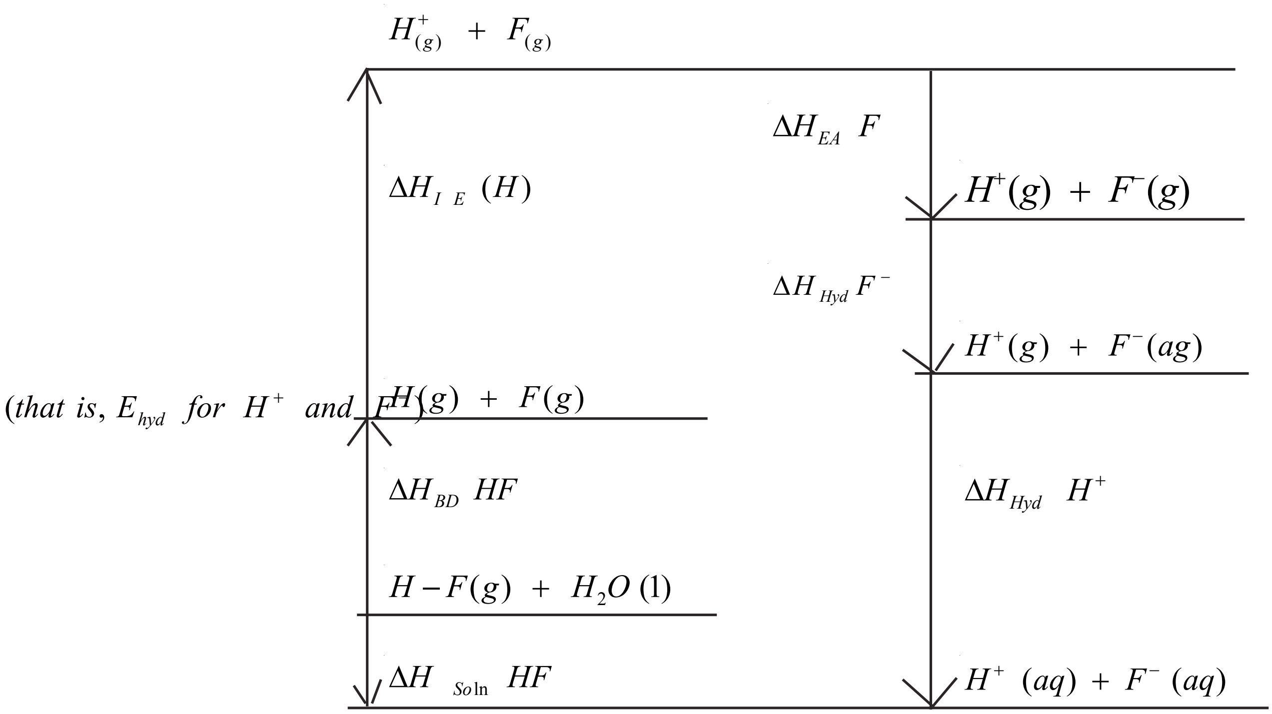
UNIT 1
Paper 01

Question 3

(a) The enthalpy change at 25^{0}C and 1 atm when one mole of solute is dissolved in a large excess of solvent until there is no further change.

(b) (i) Hess' Law: The standard enthalpy change for a reaction is independent of the route taken from reactants to products.

(ii)



$$\Delta H_{so\ln}\ HF = \Delta H_{BD+}\ \Delta H_{IE\,+}\ \Delta H_{EA} + \Delta H_{hyd}F^- + \Delta H_{hyd}H^+$$

= 562 + 1310 - 328 - 506 -1300
= -262 k J mol^{-1}

(iii) Bondmaking: exothermic; bond breaking: endothermic

$\Delta H_{so\ln}\ HF$ is $-ve$ (exothermic)

$\Rightarrow$ E absorbed in bond breaking	$<$	Energy released in bond making

Appendix B

Unit 1 Paper 02

Question 4(a)

(iv) a) No. of moles of hydrogen reacting
= 1 - 0.67
= 0.33

b) Equilibrium Conc. I_2 = 1.67 mol dm^{-3}
HI = 0.66 mol dm^{-3}

(v) $K_p = \dfrac{P^2{}_{HI}}{P_{H_2} P_{I_2}}$

Appendix C

Unit 2 Paper 01

Question 2

(c) pH = 2.4

$$\Rightarrow H^+ = 4\ x\ 10^{-3}\ mol\ dm^{-3}$$

$$\left[H^+\right] = \left[HCOO^-\right]$$

$$K_a = \frac{(4\ x\ 10^{-3})^2}{0.1} \qquad \text{Expression } K_a = \frac{\left[H^+\right]\left[HCOO^-\right]}{HCOOH}$$

$$= \frac{(16\ x\ 10^{-6})}{0.1} \quad \text{mol dm}^{-3}$$

$$= 1.6\ \text{x}\ 10^{-4} \quad \text{mol dm}^{-3}$$

Appendix D

UNIT 2
Paper 01

Question 7

(c) (i) $$Al_2O_3(l) \rightarrow 2Al(l) + \frac{3}{2}O_{2\,(g)}$$

$$(54 \div 102)\ x\ 1900$$
$$= 1006\ \text{kg}$$

(ii) The extraction process is highly efficient

OR

Efficiency of the process is

$$\frac{1000}{1006}\ x\ 100\%$$

$$= 99\%$$

Appendix E

UNIT 2
Paper 02

Question 1

(a) (i) Rate x 2 (doubles)

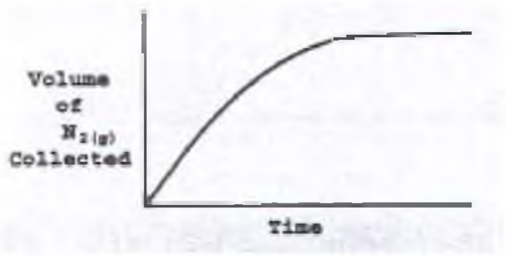
Reaction 1^{st} order w.r.t. $[H_2\ (g)]$

(ii) Rate $x\ \frac{1}{4}$

Reaction 2^{nd} order w.r.t. $[NO\,(g)]$

(iii) Rate x 27

(b) (i)



(ii) Pressure measurement

(iii) 1. Apparatus sealed

2. The volume of gas evolved must not exceed the maximum volume which could be held in the syringe (used for collecting and measuring the volume of gas).

Appendix F

UNIT 2
Paper 02

Question 4

(c) Initial partial pressure of $SO_2\ (g)$ = mole fraction x
Total pressure
=2/3 x 5 = 3.33 atm

Initial partial pressure of O_2 (g) = 1/3 x 5 = 1.67 atm

For P_{so_3} to be 3 atm $\Rightarrow$ 3 atm of SO_2 (g) had reacted and 1.5 atm O_2 (g) had reacted using mole ratios from equation.

Partial pressure of gases at equilibrium:

$= 0.33$ atm

$$P_{0_2} = 1.67 - 1.5$$
$$= 0.17 \text{ atm}$$

$$\therefore K_p = \frac{(3)^2}{(0.33)^2\,(0.17)} = \frac{9}{0.0185} = 486.49\ atm^{-1}$$ or

If serial division done as

$$\frac{9}{0.33} = x;\ \frac{x}{0.33} = y;\ \frac{y}{0.17}$$

accept 486.14 atm^{-1}

Appendix G

UNIT 2
Paper 02

Question 5

(a) A buffer solution resists pH change on addition of small amounts of acid or alkali

(b) (i) To maintain a pH of 7

(ii) CO_3^{2-} reacts with excess H$^+$ ion

HCO_3 reacts with excess OH$^-$ ion

(c) (i) Amino acids contain both acidic and basic groups

- NH_2 group can react with excess H$^+$ ion
- COOH group can react with excess OH^- ion

(ii) food processing

(d) (i) $M_r \; of \; CH_3 \; COONa = 82$

$6.56/82 = 0.08 \; mol \;\; dm^{-3}$

(ii) $K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH \;]}$

$$1.8 \; x \; 10^{-5} = \frac{[H^+] \; x \; 0.08}{0.02}$$

$$[H^+] = \frac{1.8 \; x \; 10^{-5} \;\; x \; 0.02}{0.08} = 4.5 \; x \; 10^{6} \;\; mol\, dm^{-3}$$

$$pH = - \; \log \; 4.5 \; x \; 10^{-6}$$

$$= 5.3$$

Assumption: The concentration of CH_3COO^- ions is equal to the concentration of CH_3COONa

(e) (i) Initial concentration of CH_3COONa = 0.08 mol $dm^{-3.}$
Concentration after adding = 0.08 + .005 NaOH

$$= 0.085\ mol\ dm^{-3}$$

Initial concentration of CH_3COOH = 0.02 mol dm^3
Concentration after adding NaOH
= 0.02 - 0.005
= 0.015 mol dm^{-3}

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
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CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2007

GENERAL COMMENTS

The examination this year marks a transition from the original format to that predicated by the recent syllabus review which saw a realignment of modules and a streamlining of examination papers with the introduction of Multiple Choice papers.

The syllabus review of 2007/2008 resulted in the following changes:

Unit 1
- Module 1 – Fundamentals of Chemistry
- Module 2 – Kinetics and Equilibria
- Module 3 – Chemistry of the Elements

Unit 2
- Module 1 – Chemistry of Carbon Compounds
- Module 2 – Analytical Methods and Separation Techniques
- Module 3 – Industry and the Environment

The examination, therefore, consisted of Paper 01 in both Units being a Multiple Choice paper consisting of 45 items for 90 minutes. Paper 02 of Unit 1 tested candidates on the revised syllabus using an examination of six compulsory questions – half of the questions being of the structured form and the remainder of the structured free response (essay) type. Each question had a maximum mark of 15 – the paper, therefore, having 90 as its maximum mark. Paper 02 of Unit 2 used the original examination format of nine questions testing the original syllabus content.

This year saw a total of 3 575 registered candidates for the Unit 1 – this is an increase of 42.2 percent over the previous year where 2 513 candidates taking the examination. In Unit 2 the figures revealed a 60.5 percent increase – the totals being 1 701 for the present year as compared with 1,060 for the year 2006.

The overall performance showed an exceptional improvement over previous years in both Units.

DETAILED COMMENTS

UNIT 1

PAPER 01

Performance on this paper was good. Candidates were able to answer most of the questions correctly. Candidate performance on four questions could have been better. These questions assessed -

- the values of the bond angles in the displayed formula of the amino acid, glycine;

- factors affecting the solubility product of iron (III) hydroxide;

- the constituents of a standard hydrogen electrode;
- the reagent used to identify a compound, $X^{2+}(aq)$, given the reaction of $X^{2+}(aq)$ with aqueous NaOH, and aqueous NH_3.

PAPER 02

Question 1

Candidates were expected to demonstrate their knowledge of the principles of thermochemistry in the calculation of enthalpy changes, as well as, showing familiarity with simple experimental procedures.

Candidate performance was generally weak. While candidates were able to sketch the relevant energy profile diagrams and show an appreciation of the practical aspects of the subject, quite a few found difficulty with the calculations and the graphical representation of the experimental results as required in Parts (a), (b) (ii) and (b) (iv).

This weakness in the area of mathematical calculations became quite pervasive as the results of the rest of the paper unfolded.

Question 2

This question sought to test the candidates' understanding of some aspects of acid/base equilibrium.

Candidate response was generally satisfactory; marks were lost due to misconceptions such as -

- confusion of pH and pOH in the calculations in Parts (b) (ii) and (b) (iii);
- assumption that [acid] = $[H^+]$ in the case of weak acids – Part (b) (iii);
- use of the equation V = 1/conc. in the calculation in Part (b) (iii);
- confusing the notion of buffering and neutralization in Part (c).

Question 3

This question tested the candidates' knowledge of the chemistry of the Group II elements. Candidates' responses were disappointing with only a satisfactory performance being attained. While a number of candidates gained high marks for Parts (a) and (d), these areas presented challenges for many others.

One area of weakness was noticed in the responses for Part (b), where difficulty was encountered in the use of the correct technical terms to describe the relationships requested. It was disconcerting to note that quite a few candidates wrote Ba(OH), $Ba(OH_2)$ and $CaNO_3$ as the formulae for barium hydroxide and calcium nitrate (V) respectively. Some candidates were also unaware of the alkaline nature of barium oxide and assumed the brown gas in Part (b) to be bromine.

Question 4

This question required candidates to be able to show understanding of the concept of "ideal" and "non ideal" with respect to the theory of gases.

Candidate performance on this question was inconsistent. Marks were lost in the writing of the equation to represent the decomposition of sodium azide, Part (a) (iv), and the factors responsible for gaseous behaviour deviating from ideality, Part (b) (ii).

Question 5

Candidates were asked to demonstrate their competence in answering questions relating to kinetics and the use of initial rates data in deducing properties of reactions.

Candidates' grasp of this part of the syllabus was only satisfactory. The concept of half-life was clearly unknown to candidates and hence its calculation in Part (b) (iii) could not be performed. Challenges encountered by candidates included -

- the notion of "effective collisions" and its vital influence in determining reaction rates, Parts (a) (ii) and (b) (iv);

- the interpretation of equilibrium constant for rate constant with the resultant loss of marks in Part (b) (ii).

Teachers need to pay some attention in teaching the collision theory, and the relation and distinction of equilibrium and rate constants.

Question 6

This question dealt with the roles of oxygen and carbon monoxide as ligands in the complexing of haemoglobin in the human vascular system, as well as, the origin of colour in transition metal complexes.

This question produced only a very modest performance. While candidates were comfortable in identifying the ligands requested in Part (a) (i), and explaining the toxic effects of high concentration of carbon monoxide in Part (b) (ii), most candidates found extreme difficulty in accounting for the colour in transition metal complexes in Part (c), and failed to distinguish between redox and ligand exchange in answering Part (a) (ii).

It is clear that teachers need to review their strategies for teaching the above aspects of transition metal chemistry.

UNIT 2

PAPER 01

Candidate performance on this Multiple Choice paper was good. Areas which provided some challenge to the candidates were:

- indicators which produce a sharp colour change in the titration of a strong acid against a strong base;

- K_{sp};

- the metallic character of Group IV elements;

- a commercial method of alcohol production;
- reactions in catalytic converters;
- nitrogen fertilizers for plant growth;
- formation of photochemical smog.

PAPER 02

It is to be noted that this paper used the original format of the examination – the three compulsory items in Section A, having a maximum mark of 30, while the three questions chosen from the six in Section B had a maximum mark of 60.

Question 1

This question focused on the concept of equilibrium constant, its calculation and an appreciation of the practical details associated with its determination. Candidates' performance on this question was inconsistent. The main difficulties experienced were:

- the writing of the equation in Part (a) (i), where many candidates indicated that bromine was monatomic;
- the writing of the expression for K_c, Part (a) (ii);
- the failure to appreciate that accurate results come from accurate analysis. Most candidates offered the response "closed system" as the answer in Part (b) (ii).

Candidates should be encouraged to use reversible arrows to indicate a chemical equilibrium system.

Question 2

This question centred on some aspects of the chemistry of the sodium halides and elemental chlorine. Candidates' responses were disappointingly weak. While candidates were able to get credit in a few areas, most were unable to show mastery of the content required. Candidates lost marks by their inability to:

- write correct formulae and hence to produce the balanced equation required in Part (c);
- calculate oxidation states (this included failure to recognize the oxidation states of elemental substances to be zero);
- calculate changes in oxidation states;
- identify the foul odor of H_2S in Part (a) (v).

Question 3

This question tested the candidates' knowledge of the effects of industrial pollution and the interpretation and use of calibration curves.

Candidates found this question to be very easy and almost all candidates did very well. The only difficulty encountered involved confusing the process of eutrophication in Part (a) (iii) with an observable outcome, algal bloom, in Part (a) (ii).

Question 4

Candidates' knowledge of buffer systems and, in particular, the control of blood pH by the H_2CO_3/HCO_3 system, along with numerical calculations was the focus of this question.

Candidates showed variable performance levels. Some candidates are to be commended for providing very sound answers. Difficulties were experienced in explaining the working of the buffer system as it related to the effects of strenuous exercise and deep breathing in Part (c). Candidates' responses should have included:

- the equilibrium shifts to produce H_2CO_3;
- H_2CO_3 dissociates to increase H^+ concentration in the blood;
- deep rapid breathing cleans the lungs of $CO_{2(g)}$;
- equilibrium will shift to the left to release CO_2 from the blood;
- H^+ ions reabsorbed as equilibrium shifts to the left.

Question 5

This question probed the candidates' knowledge of reaction kinetics using the alkaline hydrolysis of a halogenoalkane, as well as their understanding of the collision model.

In general, candidates' responses were good with most candidates showing a reasonably satisfactory grasp of the concepts involved.

Some weakness was shown in explaining the mechanism of an S_N2 reaction and the importance of the concept of "effective collisions" as it pertained to reaction rates.

Question 6

Candidate performance was just about satisfactory in this question which dealt with the chemistry of the oxides and chlorides of Period 3. Candidates gained marks in Parts (a), (b) and parts of (c). Areas of weakness included:

- the writing of equations, for example, the reaction of phosphorus (V) chloride and water;

- the lack of awareness of the influence of both covalent and ionic character in $A1C1_3$;

- the difficulty in distinguishing between "intra" and "inter" molecular bonds with the view being expressed that "covalent bonds are weak";

- confusion resulting from a failure to carefully distinguish between structure and bonding in Part (e).

Question 7

This question tested candidates' knowledge of the chemistry of the Group IV elements and was slightly less popular than Question 6.

Performance on this question varied. Candidates were able to describe the trend in electrical conductivities of the elements in relation to their physical structure and were aware of the simple covalent bonding of carbon dioxide. The majority could also classify the acid/base character of the Group IV dioxides.

However, challenges were experienced in the -

- use of standard electrode potentials in commenting on the relative stability of the +2 and +4 oxidation states of the elements in Part (d), and the oxidizing strengths of Sn^{2+} and Pb^{2+} in Part (e);

- failure to recognize the availability of empty "d" orbitals on the silicon atom as the reason for the observations presented in Part (f).

Question 8

This question tested the candidates' knowledge of the crude oil industry and its impact on the environment, and produced a rather weak performance. Candidates could state the name of the process used to separate the crude oil into its various components as well as some of the environmental implications of the use of fossil fuels.

Candidates were, however, very unsure about the underlying basis of the process of fractional distillation (fractions are separated according to boiling point or higher molecular mass fractions at the bottom, lower molecular mass fractions at the top of the fractionating tower).

Candidates again found the writing of equations difficult and were surprisingly unable to explain the source of lead (II) oxide in vehicular exhaust as the result of the reactions produced by the additive tetraethyllead (IV).

Question 9

This question was the overwhelming favourite of this final pair. It required candidates to answer questions concerning the:

- preservation of ozone levels as well as its polluting effects in the environment;

- use and destructive effect of CFCs on the environment.

The performance demonstrated a satisfactory grasp of the knowledge required. The main difficulty revolved around the roles played by stratospheric and tropospheric ozone.

PAPER 03

INTERNAL ASSESSMENT

This year saw an overall improvement in the level of the attainment on this component of the examination. However, giving allowances for the introduction of new Centres, there are some unacceptable trends that seem to have become endemic.

Most Centres submitted the required number of samples with the accompanying mark schemes that were satisfactory. However, quite a number of samples were incomplete or had activities classified incorrectly. Teachers are again reminded that the writing of equations and the performance of calculations are Analysis and Interpretation (A/I), and **not** Observation/Recording/Reporting (O/R/R) skills.

Great difficulty continues to be experienced in the writing of appropriate mark schemes for Planning and Design (P/D) experiments. This is mainly due to the inappropriateness of the activities. Teachers are also encouraged to include the identities of the various unknown substances used in qualitative analysis assignments, as moderation is difficult when the identities of the substances must be deduced.

Syllabus Coverage

The coverage of the syllabus and the number of activities were good. There needs to be an improved attempt to provide a more even spread of the activities over the various topics. An example of the above involves the use of five volumetric or qualitative analyses, one energetics and the absence of an equilibrium activity.

It would be desirable if more creativity was demonstrated in making the volumetric and kinetic experiments more challenging to students at this level.

The Assessment of Skills

Most teachers did assess each of the four skills at least twice as required. However, some Centres assessed one or two skills in every one of, as much as, 17 assignments! While the various skills may be tested on a large number of occasions, teachers must indicate by an asterisk the two or at most three assignments used in the determining of the mark to be submitted for moderation.

Observation/Recording/Reporting (O/R/R)

This skill was assessed in a satisfactory manner in many Centres. In a few, the traditional activities used to assess this skill – observation of colour and formation of precipitates, drawing of graphs, production of tables – were neglected so that the assessment of communication skills could not be made. The assessment of these two areas is to be inclusive in the overall assessment of this skill. More use of graphs needs to be made in the selection of activities. Teachers are reminded that the skills associated with the plotting of points and the drawing of graphs are O/R/R and **not** A/I skills.

Manipulation and Measurement (M/M)

Though not moderated, evidence of the assessment of this skill was examined. Once again indication of at least two assessed experiments must be indicated and the marks noted in the laboratory books. Activities that discriminate adequately between the abilities of candidates should be used.

Analysis and Interpretation (A/I)

Activities used to test this skill need to be more challenging. Many calculations were too easy. Teachers should ensure that calculations should involve between four or five steps so that candidates would be challenged to show the reasoning behind the attainment of the answers (this would also tend to lessen the incidence of cheating).

In the case of qualitative analysis activities, deductions should be based on observations made in a logically progressive manner and well balanced ionic and/or molecular equations required to represent the various reactions involved. Analysis and Interpretation of graphs with the use of results should be encouraged bearing in mind the concluding statement made in the discussion of O/R/R above.

Planning and Design (P/D)

This skill continues to provide the greatest concern to moderators with the inappropriateness of the assignments becoming endemic. Teachers are reminded that acceptable activities for P/D should pose a problem for students to solve using concepts contained in the syllabus. These problems should encourage hypothesis-making, be contextualized in "novel" situations and should not be a repetition of activities previously done or readily available in text books.

Actual results should not be included in the "expected results" component of the reporting.

SUMMARY

The greatly improved candidate performance is noted. Performance can be further improved if teachers devise new strategies or refine present ones to address the following candidate weaknesses:

- difficulty in the use of technical language to describe/explain various chemical phenomena;

- the ability to manipulate mathematical formulae and the working out of calculations with associated units;

- the writing of correct formulae and the balancing of equations, with relevant state symbols, to represent chemical reactions.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2008

CHEMISTRY
(REGION EXCLUDING TRINIDAD AND TOBAGO)

St Michael Barbados

CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2008

THE STRUCTURE OF THE EXAMINATION

A revised CAPE Chemistry syllabus was assessed for the first time for Unit 2 in 2008, and for the second time for Unit 1. The revision included a reorganization of the Modules of the Units, as follows:

Unit 1
Module 1: Fundamentals in Chemistry
Module 2: Kinetics and Equilibria (previously in Unit 2)
Module 3: Chemistry of the Elements (previously in Unit 2)

Unit 2
Module 1: The Chemistry of Carbon Compounds (previously in Unit 1)
Module 2: Analytical Methods and Separation Techniques (previously in Unit 1)
Module 3: Industry and the Environment

The examination for each Unit consisted of two external papers. Paper 01 consisted of 45 Multiple Choice items, 15 from each Module. Paper 02 consisted of six compulsory questions, two from each Module.

The Internal Assessment, Paper 03, involved the continuous assessment of candidates by teachers over the duration of the Unit. Candidates were required to conduct at least 16 laboratory practical exercises. These were assessed by the teachers and comprised the Paper 03 marks for the candidates. Samples of candidates' laboratory books were externally moderated by CXC, and formed the basis of the moderation of all Internal Assessment marks submitted by the teachers.

The contribution of each paper to the overall examination was as follows:

Paper 01 - 40 %
Paper 02 - 40 %
Paper 03 - 20 %

GENERAL COMMENTS

One thousand, seven hundred and two candidates registered for the examination in Unit 1, and 1176 candidates registered for Unit 2.

Unit 1

Overall, candidate performance was satisfactory. Approximately twenty-two per cent (22%) of the candidates achieved Grade I and more that 80 per cent achieved acceptable grades, Grades I-V.

Unit 2

Approximately twelve per cent (12%) of the candidates achieved Grade I, while almost ninety per cent (90%) achieved Grades I-V. This performance is satisfactory, considering that Organic Chemistry (Module 1) and Analytical Methods (Module 2) have been examined for the first time in this Unit.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper comprised 15 items from Module 1, 15 from Module 2, and 15 from Module 3. The mean on Unit 1 Paper 01 was 56 per cent and 49 per cent on Unit 2 Paper 01. For Unit 1, candidates experienced difficulties with the following:

- Polarizing power of elements (Module 1)
- Feasibility of redox reactions given cell diagrams (Module 2)
- Trend in bonding re NaCl, $AlCl_3$, $SiCl_4$, PCl_5 (Module 3)

For Unit 2, candidates experienced difficulties with the following:

- Volatility of organic compounds (Module 1)
- Calculating the concentration of a solution given an absorbance graph (Module 2)
- Fragmentation pattern of CH_2Cl_2 (Module 2)

UNIT 1

Paper 02 – Structured Essay

Question 1

Specific Objectives: 4.1 - 4.3

This question sought to test candidates' understanding of the concept of oxidation/reduction, oxidation number as illustrated in redox reactions and the writing of relevant equations. Candidate performance was modest, giving the distinct impression of superficial comprehension of the above concepts.

There was some confusion surrounding the correct oxidation number change of the two processes.

Particular areas of weaknesses were:

- The balancing of redox equations
- The correct use of chemical terminology. Consistent reference to "clear solution" instead of colourless solution; "insoluble solution", "dirty solution", are clear indicators of the confusion between precipitate and solution.

Question 2

Specific Objective: 6.3 – 6.5

Candidates were required to demonstrate their understanding of the principles involving electrochemical cells and electrode potentials.

Overall candidate performance was rather modest. However, there were some instances when candidates demonstrated a good grasp of the contents presented by the question.

The majority of candidates were able to draw the cell diagram requested in Part (a). However, the identification of the correct electrode reactions with the corresponding E° values and the products of changes required in Part (f) presented quite a challenge.

Question 3

Specific Objectives: 6.1; 6.2; 6.5

This question focused on the chemistry of a number of elements listed in Module 3 of this Unit. Candidates found this question to be difficult, producing a rather poor overall performance. The only section answered with any degree of competence was Part (a), involving the testing for Al^{3+} and Pb^{2+} using alkalis.

The perennial challenge of writing ionic equations and the uncertainty surrounding what constitutes 'observations' and 'inferences' were again quite evident. The best interpretation to be placed on candidates' writing of incorrect formulae was one of carelessness (H_2So_4 for sulphuric acid). It would be quite disappointing to suggest that at this level this presented a basic problem.

Question 4

Specific Objectives: 3.7 – 3.9

This question tested candidates on their knowledge of empirical and molecular formulae and relevant calculations, as well as the practical and mathematical applications of titrimetric analysis.

The majority of candidates were able to calculate the empirical and molecular formulae of caproic acid (Part (a) (ii)).

Candidate weaknesses encountered included:

- Explanations in distinguishing between empirical and molecular formulae (Part (a)(i)). A significant number of candidates used "atom" and "molecule" interchangeably in their attempt to answer this part of the question.
- The lack of appreciation of the fact that the molecular formula describes the ratio of **each** atom in the compound. Some examples used were inappropriate, for example, C_2H_4, C_2H_8.
- The calculation of molar concentration. Candidates were often guilty of relying on the use of the formula $M_1V_1 = M_2V_2$ with its subsequent misuse.

Question 5

Specific Objectives: 2.6; 5.1; 5.2; 5.5

This question focused on the applications and calculations surrounding the concepts of equilibrium and solubility product.

Candidate performance was rather inconsistent with a significant number demonstrating difficulty. The notion of equilibrium, explanations and application of the concept of solubility product presented a challenge for most candidates. However, most candidates were able to define Le Chatelier's Principle (Part (d)), wrote the correct expression for K_c (Part (a) (i)) and deduced the value of K_{sp} (Part (b) (i)).

Question 6

Specific Objective: 4.1; 4.2; 4.5; 1.1

Candidates were tested on their knowledge of the chemistry of the Group VII elements and the variation of ionisation energy across Period 3 of elements in the periodic classification.

Candidates showed a general knowledge of the subject matter, and grades were satisfactory. Candidates found the explanations required in areas represented in Parts (b) (ii), (c) (ii) and (c) (iii) to be challenging.

The above clearly indicates that while candidates were comfortable with questions in the area of "knowledge and comprehension", there was a lack of competence in responding accurately to questions in the area of "use of knowledge".

UNIT 2

Paper 02 – Structured Essay

Question 1

Specific Objectives: 2.4; 2.6 – 2.9

Candidates were required to demonstrate an understanding of the reactions of a number of functional groups with their associated reaction mechanisms.

Candidates' responses indicated a satisfactory grasp of the above concepts. The main deficiency was shown in the responses to Part (b), which required the writing of the reaction mechanism for the conversion of the tertiary bromoalkane to the corresponding alcohol. This deficiency resulted in the incorrect use of arrows, both single and double headed, showing uncertainty in the use of these symbols.

The failure to distinguish between the concepts of "observation" and "deduction" in Part (c) was again seen.

More work needs to be done to assure the removal of these deficiencies.

Question 2

Specific Objectives: 8.1 – 8.4; 8.6

This question tested the candidates' knowledge of chromatographic methods, in particular TLC and GLC.

Candidates' level of performance was somewhat inconsistent. The majority of candidates were familiar with the use of chromatographic methods. They were able to give examples of, and differentiate between, stationary and mobile phases, and to calculate R_f values.

Candidates’ main difficulty stemmed from an inability to adequately explain the function of the two phases and hence to identify polarity as the property of the three compounds in Part (b) (ii).

Candidates also failed in their comparison of R_f values and hence found Parts (b) (iii) (a) and (c) (iii) difficult.

Question 3

Specific Objectives: 8.2; 8.3; 8.5; 8.6

In this question, candidates were asked to show a knowledge of the position of water as a vital compound in the environment; pollution sources and their detection; and purification methods in the provision of potable water.

Candidate performance was disappointingly low and apart from Part (c) (i), the question proved to be difficult.

Candidates showed a lack of knowledge of:

- The test for the presence of Pb^{2+} and NO_3^-
- The concept of eutrophication
- Thermal pollution of the aquatic environment as required in Part (d)

Question 4

Specific Objectives: 2.1; 2.4; 2.6; 2.11; 2.13; 2.17

This question focused on the areas of functional group analysis, their reactions and mechanisms. Candidates showed modest performance in their responses. The pattern of responses in this question mirrored those in the corresponding area as presented in Question 1.

Candidates again had difficulty in explaining the required mechanism and, additionally, found further challenges in the identification of individual groups in the stated reactions.

Candidates, however, had little difficulty in the case of the free radical mechanism.

Question 5

Specific Objectives: 9.1; 9.8

Candidates were asked to respond to questions relating to their knowledge of fractional distillation as a technique of separation.

Candidates were comfortable in answering Parts (c) and (e). However, there was some confusion in distinguishing between “principle” and “process” with respect to fractional distillation, with candidates describing the latter instead (Part (c)).

Many candidates also found the sketching of the boiling point/composition curve to be an area of difficulty.

Generally, candidates only attained a modest mark on this question.

Question 6

Specific Objectives: 4.1; 4.2

This question tested the candidates' knowledge of ammonia production via the Haber Process, and the associated industrial applications.

Candidate performance was again of modest proportions. The majority of candidates were able to write the equation for the Haber Process and to give examples of the use of ammonia, (Part (a) (i)). Candidate difficulty centered around the lack of ability to apply Le Chatelier's principle as required. Thus, candidates were unable to adequately explain the behaviour of the equilibrium mixture (and thus the equilibrium constant, K_{eq}) when the various factors were altered, Part (b).

Internal Assessment

While the general standard of this component of the examination has shown improvements over the years, there are certain areas which continue to be constant. This is cause for concern.

Mark Schemes

These generally were acceptable and served as useful guides for the moderators. There were, however, still quite a few cases where the mark schemes were either incomplete or contained irrelevant skills. For example, a number of mark schemes in assessing Observation, Recording and Reporting (ORR), awarded marks for Analysis and Interpretation (AI).

The construction of mark schemes for Planning and Design (PD) is still presenting great difficulty. This can be traced in part to inappropriate PD assignments.

Mark schemes must be made more informative and 'moderator friendly' by including the identity of unknowns and the observations expected when qualitative analyses are assessed.

Syllabus Coverage; Adequacy and Standard of Activities

This part of the Internal Assessment was very well met and the number of activities was good. Care should be taken to ensure an even spread of activities across topic boundaries. The practice of assigning five volumetric or qualitative analyses, one energetics experiment and an absence of an exercise on equilibrium should be avoided.

Efforts should continue to be made to upgrade the standard of activities so as to provide appropriate challenges for students at this level of competence, especially in the areas of volumetric and qualitative analyses.

Assessment of Skills

Generally each of the four skills was assessed at least twice. Some, however, were assessed in as many as seventeen (17) practical assignments.

Although this is commendable, only two practical assignments should be chosen and **indicated** for the assessment of a particular skill for moderation purposes.

Observation, Recording, Reporting (ORR)

This skill was satisfactorily assessed. This included the assessments of skills and concepts such as communication and correct English grammar. It must be borne in mind, however, that only five (5) marks of the twelve (12) are to be allotted for this purpose.

Candidates should be encouraged to improve their skills in the plotting and drawing of graphs, as well as the inclusion of state symbols in the writing of equations.

Manipulation and Measurement (MM)

Though not moderated, evidence of this skill must be present and indicated in the samples to be presented. Efforts should be made to assess the widest range of skills in this area.

Analysis and Interpretation (AI)

Activities testing this skill needed to be more challenging – calculations should be multi-staged. Deductions from observations/results should be relevant and made in a logical and sequential manner. Analysis of graphs and discussions of results should be encouraged, and it should be borne in mind **that drawing of graphs is an activity related to ORR but not AI.**

Planning and Design (PD)

The assigning and assessment of this skill continues to be the major concern of the whole Internal Assessment component of the examination and in quite a number of cases are unmitigated disasters.

Acceptable activities for PD should pose a problem for candidates to solve, using concepts contained in the syllabus. These problems should encourage hypothesis making, be conceptualized in "novel" situations and should not be activities previously done or readily available in text books.

It must be borne in mind that laboratory practical activities, which are written in the past tense, have no stated hypothesis and are based on common investigations, cannot be accepted for planning and design marks. It must be clear to the moderators that some planning and design was done by the candidates.

Candidates should be instructed not to include actual results in their prediction of results. It is recognized that in places where there is a large turnover of teachers, the need for implementation of strategies in the area of training is vital to the elimination of the above deficiencies in the assessment of this skill. Ministry and School Officials need to lend urgent attention to providing solutions to this critical area.

CONCLUSION

The overall performance of candidates across the region has been satisfactory and the revised syllabus has been effective in relating more closely with the developmental aspect of the candidates' learning processes.

Teachers however, should pay some attention to the:

- Wider use of practical assignments in the teaching of the various topics for example, oxidation/reduction, where candidates can be taught the difference between an observation and the corresponding inference

- Employment of strategies to enable candidates to understand and use the language of chemistry appropriately in descriptive work

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- Writing of equations, both ionic and stoichiometric with the inclusion of state symbols
- Recognition that candidates find certain topics more challenging than others, and, therefore, seek out methods to facilitate comprehension of such; for example, electrochemistry and various analytical techniques
- Insistence that calculations based on the sequential deduction of number of moles contained in a volume of solution be used instead of the parroting of the formula $M_1V_1 = M_2V_2$, which generally leads to muddled thinking.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2009

CHEMISTRY

CHEMISTRY

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2009

GENERAL COMMENTS

Chemistry is a two-unit subject with each Unit consisting of three Modules. This is the second year of examination of both Units based on the revised syllabus and the new examination format. The Modules in the current syllabus are:

Unit 1

- Module 1 - Fundamentals in Chemistry
- Module 2 - Kinetics and Equilibria
- Module 3 - Chemistry of the Elements

Unit 2

- Module 1 - The Chemistry of Carbon Compounds
- Module 2 - Analytical Methods and Separation Techniques
- Module 3 - Industry and the Environment

Both Units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 03 is the Internal Assessment and is examined internally by the teacher and moderated by CXC.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each Module. Each Module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the Unit.

Paper 02 consisted of six compulsory questions, two based on each Module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the Unit.

Paper 03, the Internal Assessment, comprised laboratory exercises and contributed 20 per cent to the Unit.

This year a total of 4039 candidates registered for the Unit 1 examinations compared with 3484 in 2008, an increase of approximately 14 per cent; 2708 registered for Unit 2 compared with 2385 in 2008, an increase of approximately 13 per cent.

DETAILED COMMENTS

Paper 01

The performance on each of these papers was good. In each Unit, candidates were able to answer most of the questions correctly.

The mean score in Unit 1 was 56.9 per cent and standard deviation 8.10.

The mean score in Unit 2 was 61 per cent and standard deviation 7.12.

UNIT 1

Paper 02

Question 1

Specific Objectives: 1.7, 6.6
Mean: 4.06; S.D.: 2.57

This question sought to test candidates' knowledge on the line emission spectrum of hydrogen. Based on the responses of the candidates, this seems to be a neglected area of the syllabus. Many candidates could not give a simple sketch of the converging lines associated with the emission spectrum of hydrogen. In explaining the origin of the lines in the Balmer series, the majority of candidates demonstrated knowledge of electrons becoming excited and moving from lower to higher energy levels but could not give an account of what happens thereafter. Most candidates were aware that the Balmer series is associated with the visible region of the electromagnetic spectrum.

The weaknesses associated with this question were:

(i) Candidates continue to confuse atoms, elements and molecules – using these terms interchangeably.

(ii) In explaining the origin of the Balmer series, candidates had difficulties recognizing that the lines are the result of electrons falling from higher energy levels to the $n = 2$ energy level, giving rise to specific quanta of energy corresponding to the colours observed.

Most candidates were able to identify at least two errors in the apparatus set up to determine the combustion of ethanol.

It is recommended that candidates be prepared for all areas of the syllabus and not concentrate only on those areas from where they believe questions are most likely to come.

Question 2

Specific Objectives: 1.2, 1.3, 1.4
Mean: 9.37; S.D.: 1.76

Candidates were required to demonstrate their understanding of the factors which influence rates of reaction; to express rate data in graphical form, and to deduce order of reaction from the appropriate data.

Overall, candidates' performance was rather good. Part (d) presented the greatest challenge to candidates. Many candidates did not know the steps involved in the experiment to determine the rate of the esterification reaction. Despite the popularity of an esterification reaction as an example illustrating the rates of reaction, it was assumed that because the reagents were organic in nature, this experiment belonged in Unit 2 and cannot be used to highlight aspects of Unit 1.

It is recommended that the different aspects of chemistry be taught in an integrated manner so that candidates will be better able to apply chemical principles to a variety of situations.

Question 3

Specific Objectives: 5.2, 5.4, 5.10
Mean: 5.80; S.D.: 3.58

The objective of this question was to assess candidates' knowledge on the transition elements. Many candidates were inadequately prepared for the objectives tested by this question.

Weaknesses associated with this question are outlined as follows:

(i) Many candidates seemed unfamiliar with orbital diagrams. This was illustrated by the writing of numbers in the boxes provided, rather than drawing arrows.

(ii) Too many candidates were unfamiliar with the anomalies associated with the electronic configurations of chromium and copper.

(iii) The origin of colour in transition metal compounds seemed not to be clear in the minds of some candidates. Common errors included a failure to mention that the electronic transition was a d-d transition; colour was being produced as a consequence of the emission of light when electrons return from high energy to low energy d-orbitals.

Question 4

Specific Objectives: 2.7, 2.8
Mean: 4.03; S.D.: 2.90

This question tested candidates on their knowledge of intermolecular forces, and the origin and prediction of shapes of simple molecules and ions based on Valence Shell Electron Pair Repulsion (VSEPR) theory.

Although many candidates were able to state the basic principle behind VSEPR theory, several described its effect instead. Again, it seems that candidates were unclear about the definition of the terms, valence electrons, ions, atoms and molecules.

It was apparent from the responses to Part (c) (i) that some candidates were not taught dimerization as an example of the effect of hydrogen bonding in molecules.

Some candidates did not see the link between physical properties, such as boiling, and intermolecular forces of attraction between molecules.

Question 5

Specific Objectives: 2.5, 2.6, 2.7, 3.1, 3.3
Mean: 7.55; S.D.:3.91

This question focused on the applications and calculations relating to the concept of dynamic chemical equilibrium, including some aspects of aqueous equilibrium. Candidates were asked to state and apply Le Chatelier's principle and perform basic calculations involving equilibrium constants.

Candidates' performance on this question was satisfactory. The majority of candidates were able to state and apply Le Chatelier's Principle, however, some found it challenging to calculate K_p from the information given.

Some candidates also had problems calculating the pH of a solution of $Ba(OH)_2$. Many of them failed to account for two moles of hydroxide for every mole of $Ba(OH)_2$ in solution.

Question 6

Specific Objectives: 1.1, 1.2, 4.6, 6.5
Mean: 3.40; S.D.: 3.21

Performance on this question was generally poor as many candidates failed to gain marks on the definition of "electronegativity". Their definitions were either poorly or ambiguously worded. In many cases, electron affinity was confused with electronegativity. More practice is needed on precisely worded definitions which fully encapsulate the required terms.

Candidates also had difficulties distinguishing between structure and bonding and frequently confused the two. In addition, several confused the behaviour of the oxides with that of the chlorides. Candidates' responses suggested a piecemeal approach to learning the trends across the periodic table.

It is recommended that candidates practise to relate the properties of the elements to their electronic configuration so that the behaviour patterns of the elements can be cemented in their minds.

Paper 03/2 - (Alternate To Internal Assessment)

Question 1

Mean: 6.23; S.D.: 3.27

This question was designed to test candidates' ability to

(i) use a burette properly
(ii) record burette readings accurately to two decimal places
(iii) use the most consistent readings to perform various calculations
(iv) appreciate the suitability of an indicator.

The majority of candidates were unable to isolate the salient points and therefore failed to earn most of the marks awarded for the question. It was evident that a number of candidates did not possess the required knowledge and experiences to successfully manage the question. In some cases, candidates were unable to write the equation for the reaction.

In general, candidates did not score highly. This was due to failure on their part to

(i) perform molar calculations

(ii) manipulate titrimetric data (finding the average titre volume from the most consistent burette readings)

(iii) perform calculations to determine concentration.

It is recommended that more attention be given to molar calculations, choice of indicator and the correct use of the burette.

Question 2

Mean: 9.58; S.D.: 3.14

This question was designed to test the ability of candidates to

(i) read and record data from a syringe
(ii) plot and label a graph displaying recorded values
(iii) interpret the results illustrated by the graph
(iv) calculate the gradient at several points along a curve.

While the majority of the candidates were able to construct a suitable table to display the data and plot a proper graph, some candidates were confused as to which data were to be displayed on the axes. Some candidates plotted values of 1/t but labelled the axis as t in error. Other errors associated with plotting the graph included using an inappropriate scale and not using the tangent to the curve at particular points to calculate the gradient.

Overall, this question was not well done. Candidates need to pay particular attention to the reading of data from various pieces of apparatus and the recording of values in a table. It is also recommended that the drawing of graphs be practised.

Question 3

Mean: 4.96; S.D.: 2.44

This question investigated the ability of candidates to plan and design an experiment when given a scenario which required a chemical investigation.

Most candidates were able to state clearly a suitable hypothesis and a well defined aim. Most, however, failed to write a clear procedure for the designed experiment and were unsure as to the apparatus to be used. Many of them confused ‘calorimeter’ with ‘colorimeter’.

UNIT 2

Paper 02

Question 1

Specific Objectives: 2.14, 2.15, 2.18, 3.2
Mean: 3.60; S.D.: 3.11

Candidates were required to demonstrate an understanding of the reactions of a number of functional groups and their associated reaction mechanisms.

In Part (a), most candidates correctly identified the intermediate X as nitrobenzene. However, the temperature at which the conversion occurs was not known by many. Candidates need to pay particular attention to the use of concentrated or dilute reagents and to state this information where appropriate in each case.

Question 2

Specific Objectives: 2.1, 2.2, 2.3, 2.4, 2.5
Mean: 4.52; S.D.: 3.09

This question examined the candidates' knowledge of

(i) the difference between end point and equivalence points
(ii) redox titrations and preparation of a standard solution
(iii) calculations associated with a back titration.

Surprisingly, many candidates were unable to define the terms 'equivalence point' and 'end point'. This is perhaps an indication that more care is needed to distinguish between the two as they relate to titrimetric analysis.

Most candidates were able to write the equation for the precipitation of barium ions and calculate the number of moles of $BaCl_2$ used for the reaction. Common errors included the elimination of state symbols which are important when writing an equation to show precipitation. Many candidates also found it difficult to balance the sodium ions in the equation.

The back titration continues to be challenging perhaps because so many candidates continue to find the mole concept to be a difficult area of chemistry. Teachers are encouraged to have mole concept workshops for their student where they can spend extra time to explain the concepts and engage them in adequate exercises to develop their confidence and ability. Too many candidates seemed unfamiliar with the experiment requiring oxalic acid to standardize a solution of potassium permanganate (VII). This may be an indication that some candidates are not exposed to a wide variety of laboratory experiments.

Question 3

Specific Objectives: 2.1, 9.7
Mean: 7.66; S.D.: 2.58

This question addressed the nitrogen cycle and the bauxite process and was attempted by most candidates. Marks were lost mainly through the omission of relevant information or incomplete definitions.

It is recommended that more emphasis be placed on the use of appropriate chemical terms when describing processes, colours, precipitates and other chemically related items.

Question 4

Specific Objectives: 1.8, 1.9, 3.2, 3.3, 4.2, 4.3
Mean: 6.88; S.D.: 3.83

This question focused on isomerism. As with most of the other questions, candidates have a problem with providing precise definitions even when it is clear from the examples given that they have an idea of the concept. Many, for example, were able to identify a chiral centre but were unable to give a definition.

Too many candidates were unclear about displayed structural formulae and condensed structural formulae. Teachers need to remind their students to make the distinctions. Some candidates lost marks for incomplete equations and an inability to name the amide link.

Question 5

Specific Objectives: 6.1, 6.2, 6.4, 9.3
Mean: 6.33; S.D.: 2.98

This question tested candidates' knowledge of the

(i) origin of absorption in IR spectroscopy
(ii) deduction of the functional groups of specific organic compounds based on IR data
(iii) chemical principles, advantages and disadvantages of steam distillation.

The question was poorly done. The principles of IR spectroscopy were not understood. Candidates showed confusion regarding the modes of vibration and the changes that occur within a molecule when subjected to infrared radiation.

Candidates needed more practice in deducing functional groups from IR spectral data.

Question 6

Specific Objectives: 6.1, 6.2, 6.3, 6.4, 7.2
Mean: 5.82; S.D.: 3.96

This question focused on the chlor-alkali industry and the use of sulphur dioxide as a preservative. A few candidates managed to earn full marks on this question but most candidates performed poorly. Yet again, definitions proved to be a big challenge for many candidates. There was a tendency to give examples where categories were requested.

Candidates were unable to give the products of the electrolysis of brine and to write the relevant half equations. Some candidates even confused the terms oxidation and reduction. The role and behaviour of sulphur dioxide in food processing is a mystery for many candidates and is a topic that should be addressed.

Teachers are encouraged to provide ample exercises on redox processes relating to electrolysis.

Paper 03/2 - (Alternate To Internal Assessment)

Question 1

Mean: 10.31; S.D.: 3.77

Most parts of the question were well done. However, there were some areas that were not handled well. In Part (b), while most candidates were able to describe the colour of the heated solid, they demonstrated difficulty in describing its texture.

Candidates also had difficulty in interpreting what was required of them for the column indicated in Part (c), as some proceeded to find the average of the masses involved.

In Part (h), most candidates wrongly calculated the number of moles of anhydrous salt which combined with one mole of water. More attention needs to be placed on calculations relating to the mole concept.

Question 2

Mean: 8.31; S.D.: 3.72

While candidates were able to identify $KMnO_4$ as the indicator in the titration, some had difficulty in recording the colour changes involved in Part (a). It was expected that the colour change recorded would have been colourless to pink. It should also be noted that in many cases, the formula for the manganate ion was written as MnO_4 instead of MnO_4^-. Candidates are once again encouraged to pay more attention to details.

In Part (b), candidates seemed unaware that the oxalic acid solution needs to be heated before titration with $KMnO_4$. This may be an indication of the lack of actual practical experience.

Question 3

Mean: 5.33; S.D.: 2.74

This question related to the planning and design of an experiment. Parts (a), (b) and (c) were handled well by most of the candidates. The writing of aims and hypotheses seemed to be well understood. However, the 'Procedure' presented a bit of difficulty along with Part (h) where candidates were unable to identify source of errors and an assumption. The inability of candidates to write clear procedural instructions for an experiment may be related to a general inability to clearly express themselves. This problem may be addressed by the provision of more writing opportunities for candidates in preparation for the examinations.

Internal Assessment

Submissions

Most schools submitted the laboratory notebooks of five candidates requested for the IA samples. Please note that the computer generated printout **must** also be included with the samples, mark schemes and moderation sheet.

Appropriateness of Mark Schemes

In most cases, mark schemes served as a useful guide to the moderator. There were, however, quite a few cases where the mark schemes were either incomplete or contained irrelevant skills.

It must be noted that Observation/Recording/Reporting marks are classified under Analysis and Interpretation. These include the working out of mathematical problems, identifying sources of error and the writing of equations.

Some teachers are still experiencing great difficulty writing mark schemes for Planning and Design (P and D) experiments. This is partly due to the inappropriate P and D activities chosen – this will be addressed later.

The task of moderation would be made more efficient if teachers included the identities of the unknowns involved and a copy of the table containing the accepted observations and conclusions for the qualitative analysis assignments. Also, where more than one mark is allocated for a particular skill, this should be broken down to indicate where each mark is awarded.

Teachers should be careful to award an appropriate number of marks for each response required, that is, the 'overweighting' of a skill should be avoided, (for example, the awarding of three marks for finding the average of three numbers is unacceptable).

Syllabus Coverage, Adequacy and Standard of Activities.

For most centres, the syllabus coverage and adequacy of number of activities were good. However, more effort should be made to spread the activities more evenly over the topics. For example, exercises in energetics, reaction rates and equilibrium should be included as well as the usually well represented exercises in volumetric and qualitative analysis.

More creativity needs to be exhibited in the assignments involving volumetric analysis so as to make them more challenging and appropriate to the CAPE level.

The Assessment of Skills

Most teachers did assess each of the four skills at least twice. Teachers must select only two of any skill for submission to CXC. These should be clearly indicated on the mark scheme and also in 'The Table of Contents' of candidates' laboratory notebooks. Candidates should be tested in SBAs on practical work with which they are familiar, bearing in mind that the SBA is a form of continuous assessment. Best practice would therefore dictate that candidates have prior experience in the various skills before any assessment is attempted.

Observation/Recording/Reporting (ORR)

Many teachers assessed this skill in a satisfactory manner. While the CXC mandate to assess communication, grammar, spelling and punctuation should be recognized, the testing of the observation of colours and precipitates, and the drawing of proper graphs and tables remain paramount.

More care needs to given to avoid wrong criteria being assessed under this skill, for example, discussion and calculation. Tables should be enclosed and have relevant titles and headings.
There has been an improvement in the number and the standard of graphs that were drawn.

Manipulation and Measurement (MM)

Though not moderated, evidence of this activity was examined in the samples. Evidence of TWO assessed practicals must be included in the candidates' laboratory notebooks. There should be an attempt to ensure variety in the measurements required in the assignments for the testing of this skill. These practicals should be included in the candidates' book and corrected, so that candidates may benefit from the appropriate feedback.

Analysis and Interpretation (A&I)

Activities testing this skill must be more challenging. Many calculations were too easy. In some cases, there was not enough evidence of individual work. Teachers should insist on deductions from observations/results in a progressive manner, and well balanced ionic and/or other equations with state symbols where applicable in the inorganic chemistry/qualitative analysis and physical chemistry. Analysis of graphs and discussion of results should be encouraged. **It is also important for teachers to remember that the drawing of graphs is an ORR activity and not an A&I.**

In volumetric analysis, the calculation of the average titre should involve the use of ONLY the closest values (no more than a difference of +/- 0.10 cm^3).

Planning and Designing (P& D)

The representation of this skill is still problematic. Again, it must be stressed that teachers need to be aware of and be able to apply the appropriate criteria in assigning activities for the testing of these skills. This is imperative in the setting of appropriate P and D exercises and allow for ALL the components of P and D – variables, method, expected results etc. – to be tested.

The assignments should be clearly written in both the candidates' books and mark schemes. Explicit information regarding the aim, method or the apparatus required should not be disclosed as these form an integral part of the planning and design exercise.

Planning and designing activities that can be taken from a text book are unsuitable. Teachers and candidates should resist the temptation to predict ACTUAL RESULTS. It should also be noted that there are some types of practicals that do not lend themselves to P and Ds.

A short excerpt from the Schools Report for the year 2008 is now reproduced to provide a sense of emphasis and urgency:

"Acceptable activities for P and D should pose a problem for candidates to solve using concepts contained in the syllabus. These problems should encourage hypothesis making, be conceptualized in "novel" situations and should not be activities previously done or readily available in text books.

Candidates should be instructed not to include actual results in their prediction of results.

A **sample Mark Scheme** for the assessment of P and D assignments is reproduced for guidance:

1. Statement of hypothesis 3
    - Clearly stated and linked to the problem (2)
    - Clearly stated but partially linked to problem (1)
    - Not clearly stated but related to problem (1)
2. Aim/Title 1
    - Must be relevant to the problem/hypothesis
3. Apparatus and Material 3
    - Essential ones mentioned
4. Method/Procedure 8

    (a) Plan written in logical sequence of steps and in appropriate language (3)

    - All steps written but no order, correct tense (2)
    - All steps written, no order, wrong tense (1)
    - Essential step(s) missing (0)

    (b) Variables (3)

    - Manipulated (1)
    - Controlled (1)
    - Responding (1)

(c) Data to be collected (2)

5. Predicted Results	3

- Correctly linked to problem/hypothesis (3)
- Not properly linked but correct (2)
- Not linked but correct (1)

6. Limitation, Sources of Error and Assumptions	2

- Limitation and sources of error (2)
- Assumptions made (1)

Total	**20**

Conclusion

CAPE Chemistry continues to pose a challenge for too many candidates. This may be the result of several factors. It must be stressed, however, that many candidates are unable to express themselves clearly and to provide appropriate definitions of chemical terms and concepts. Candidates continue to use atoms, molecules, compounds and electrons interchangeably. There is a lack of attention to detail and this is evident especially where definitions of terms are required. In many cases, candidates are able to use the concept to do calculations, for example, to arrive at the appropriate answer, but when asked to define the concepts they are not able to earn the marks because of incorrect terminology and omission of pertinent details. It is suggested that candidates be given more opportunities to express chemical concepts in writing and to prepare adequately for the examination.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2010

CHEMISTRY

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules.

Both units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 03 is the internal assessment and is examined internally by the teacher and moderated by CXC.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 consisted of six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 03, the Internal Assessment, comprised laboratory exercises and contributed 20 per cent to the unit.

This year, a total of 4,810 candidates registered for the Unit 1 examinations compared with 4,039 in 2009, an increase of approximately 19 per cent; 2,960 candidates registered for Unit 2 compared with 2,708 in 2009, an increase of approximately 9 per cent.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

The performance on each of these papers was good. In each unit, candidates were able to answer most of the questions correctly.

The mean score in Unit 1 was 56.5 per cent and standard deviation 16.1.

The mean score in Unit 2 was 64 per cent and standard deviation 15.3.

UNIT 1

Paper 02 – Structured/Essay

Module 1: Fundamentals in Chemistry

Question 1

Specific Objectives: 2.1, 3.4, 3.5, 3.8, 5.1, 5.2
Mean: 6.32
Standard deviation: 3.66

This question sought to assess candidates’ knowledge in the areas of

- bonding
- equations and associated calculations
- kinetic theory of gas
- volumetric analysis and related experimental skills

Candidates' performance was modest. The majority of them were very familiar with the assumptions and conditions associated with kinetic theory and the concept of ideal gases. The main challenges were presented by Parts (b) and (d). Candidates sought to explain how the data collected in Part (d) could be used, however, what was required was a description of the method used to obtain such data. In the case of Part (b), the writing of chemical equations and making correct calculations continue to be perennial weaknesses.

Module 2: Kinetics and Equilibria

Question 2

Specific Objectives: 6.1, 6.3 – 6.5
Mean: 8.25
Standard deviation: 3.18

Candidates were required to demonstrate their understanding of the concepts involved in the area of electrochemical cells and electrode processes.

A satisfactory level of competence was demonstrated in this area, however, some confusion was evident in differentiating among the processes referred to in the question and the principle of electrolysis. The candidates also found writing the concise definitions required in Part (a) to be challenging.

Module 3: Chemistry of the Elements

Question 3

Specific Objectives: 3.3, 3.4, 5.5, 5.9, 5.10
Mean: 4.25
Standard deviation: 3.06

This question which was based mainly on the chemistry of vanadium and copper was poorly answered. All areas presented candidates with challenges. It was surprising that, at this level, candidates found calculating oxidation numbers and recognizing the acidity of the type of oxides in Group IV to be difficult.

It would appear that students were not exposed to the experimental aspect of transition metal chemistry and the principles leading to ligand exchange. Teachers are encouraged to apply appropriate teaching strategies to correct this deficiency.

Module 1: Fundamentals in Chemistry

Question 4

Specific Objectives: 1.2, 1.4, 1.9, 1.10
Mean: 8.84
Standard deviation: 3.26

This question tested candidates' understanding of the principles of

- radioactivity decay
- nuclear stability using the notion of n/p ratio
- atomic orbital structure
- electronic configuration

Candidates were generally comfortable in answering this question with slight difficulty shown in using n/p ratio to comment on the stability of atoms. Candidates had little difficulty in answering Parts (a) and (b) which dealt with the properties of subatomic particles and the identification of the products of nuclear decay and calculation of n/p ratio.

Module 2: Kinetics and Equilibiria

Question 5

Specific Objectives: 3.2, 3.3, 4.1–4.3
Mean: 6.40
Standard deviation: 4.07

The focus of this question was on candidates' understanding of the principles surrounding buffer solutions and pH, and their competence in performing calculations associated with these principles.

Their performance was generally of a modest level. Most candidates had no difficulty in stating the differences between buffer solution and pH, and in writing the expression for the acid dissociation constant (K) as required in Parts (a) and (b) (i). However, most of them encountered challenges in the remaining sections which required them to calculate and manipulate data in order to solve problems relating to concentration and pH.

More attention needs to be paid to the application of knowledge and to calculations involving the relationship between the varying concentrations of the components of buffer systems, pH and their attendant effects.

Module 3: Chemistry of the Elements

Question 6

Specific Objectives: 1.1, 1.3–1.5, 5.6
Mean: 3.42
Standard deviation: 3.30

In this question, candidates were tested on their understanding of the

- trends in Period 3 of the periodic table
- principles relating to the observed acidity of the aqueous solution of aluminum chloride
- difference in melting points of s-block and transition metals
- behaviour of the oxides of phosporpus when reacted with water

They were required to exercise higher-order cognitive skills of application and synthesis.

The performance of candidates was poor, with weaknesses demonstrated in many areas of the question. Some areas in which weaknesses were revealed included the

- relation of effective nuclear charge and electronegativity
- relation of structure to melting point
- concept of carge density and polarization as the factors in hydrolysis (Part (c))
- ability to write appropriate equations (Part (e))
- relation among the number of bonds and strength of bonds, and the melting points of s-block and transition metals

At the level of CAPE, candidates are expected to demonstrate the competency to synthesize and critically assess data as well as communicate results concisely and coherently. Teachers are encouraged to devise strategies to foster and enhance the acquisition of these competencies.

Paper 03/2 - Alternative to Internal Assessment

Range 13–32
Mean: 22.8
Standard deviation: 5.5

Question 1

This question required candidates to perform a number of tests on an unknown substance thereby testing their competence in the practical skills of observation, reporting, recording (ORR) as well as analysis/interpretation (A/I) .

Candidates' responses were weak. They were unable to record their observations accurately. Their exposure to practical activity was clearly inadequate.

Question 2

This question sought to assess candidates' ability to

- assemble correctly the various components of the apparatus for use in the investigation of reaction rates
- report appropriately the information provided from such an investigation
- plot accurately the associated graph
- interpret the information displayed by the graph
- make predictions based on the results

Candidates responded satisfactorily to this question. Most of them obtained the marks for Parts (a), (d) and (e) where they showed their competence in the first two objectives above. Many candidates, however, found the plotting of the graph to be quite challenging. This resulted in very weak interpretive responses as seen in their answers to Parts (b), (c) and (f).

Question 3

This question related to the planning and design of an experiment. Candidates' performance showed some inconsistency. The formulation of hypotheses with corresponding aims presented some difficulty to some candidates while the other aspects of experimental planning and design showed some weaknesses. It appeared that the weaknesses exhibited by candidates stemmed from a weak theoretical understanding of the topic involved.

UNIT 2

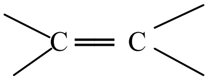
Paper 02 – Structured/Essay

Module 1: The Chemistry of Carbon Compounds

Question 1

Specific Objectives: 2.4, 4.1–4.4
Mean: 6.17
Standard deviation: 3.46

Overall, the achievement of candidates on this question was considered adequate. This question had as its objective the eliciting of responses demonstrating an understanding of the

- reactions of the alkenic group 
- structure and properties of polmers

Candidates were able to state the conditions and/or reagents required in Part (a) and found Part (c) well within their capability. However, Parts (b), (d) and (e) which involved writing displayed formulae and differentiating between the structures of nylon 6.6 and proteins presented significant difficulty.

Once again, candidates showed weakness in applying their knowledge.

Module 2: Analytical Methods and Separation Techniques

Question 2

Specific Objectives: 4.1, 4.2, 5.3
Mean: 4.98
Standard deviation: 2.87

This question required candidates to

- define various spectroscopic terms
- show knowledge of the various areas of the electromagnetic spectrum
- perform calculations based on spectroscopic data

The general performance was weak. Candidates gained most of their marks by stating the definitions required in Part (a) and completing the simple calculations in Parts (b) (i) and (ii). Candidates had challenges in completing the calculation presented in Part (d), with particular reference to the use of units and the manipulation of negative indices. Also presenting a challenge was Part (c) which dealt with the practical skills associated with UV/VIS spectroscopic analysis. A common misconception that was evident concerned the assumption that complexing agents had to be coloured.

In future, more attention needs to be paid to this area of the syllabus — the use of video clips, printed spectra, visits to institutions with relevant hardware (whenever possible) and practice in manipulating data in problem-solving activities would allow for improvement in the performance of candidates.

Module 3: Industry and the Environment

Question 3

Specific Objectives: 8.5, 9.6, 9.7
Mean: 6.89
Standard deviation: 3.11

Candidates were tested on their knowledge of the environment regarding water purity, acid rain and atmospheric gases.

Overall, candidate performance was very modest. Most marks were gained from Parts (a) (i) and (ii) and (d), which dealt with the factors and effects of acid rain. Some marks were lost for the writing of the equation in Part (a) (iii) and the inaccuracies presented in the answers provided for the tests required in Parts (c) (ii) and (iii). Many candidates were of the opinion that 'reagent' referred to a single substance and thus was not aware that acidified potassium manganate (VII), etc., were acceptable answers.

Module 1: The Chemistry of Carbon Compounds

Question 4

Specific Objectives: 1.5, 1.7, 1.8, 2.2, 2.4
Mean: 9.44
Standard deviation: 3.71

This question focused on testing the competence of candidates in the area of structural isomerism and stereoisomerism, and the concept of 'cracking'.

There was good candidate response to this question. Marks were lost due to lack of care in writing the various displayed formulae requested and some inability to clearly and concisely explain the similarities of the structural isomers in Part (a).

Module 2: Analytical Methods and Separation Techniques

Question 5

Specific Objectives: 7.2, 7.3, 8.6
Mean: 5.52
Standard deviation: 3.50

Mass spectroscopy and chromatography were the two analytical methods highlighted in this question.

An Analysis of candidates' performance showed significant weaknesses and revealed deficiencies in their competence. While candidates were generally able to adequately answer the section on chromatography, Part (d), complete the calculation in Part (c) and generally gain some marks for Part (a), the interpretation of the mass spectrum presented in Part (b) proved challenging and accounted for the majority of marks lost.

It is clear that candidates were unprepared in this area of the course. Teachers and students should devote adequate time and resources to this topic.

Module 3: Industry and the Environment

Question 6

Specific Objectives: 4.1, 8.4, 8.6
Mean: 7.92
Standard deviation: 3.98

This question tested an understanding of the manufacture of ammonia and knowledge associated with the source and effects of various pollutants. The overall response of candidates was satisfactory.

The main challenges related to the application of Le Chatelier's principle and the evaluation of conditions used in the Haber Process.

Part (e) dealt with pollutants. Candidates were able to gain at least four of the maximum marks for this part.

Paper 03/2 - Alternative to Internal Assessment

Range 8–30
Mean: 17.9
Standard deviation: 7.0

Question 1

This question focused on the properties of the alcoholic and carbonyl groups. Candidates were required to perform the various tests and record the relevant observations in the tables provided thereby allowing appropriate deductions to be made.

Overall, candidates' performance was weak and inconsistent. Candidates exhibited an unfamiliarity with many of the tests and so wrote unrelated observations. Again, they demonstrated a lack of exposure to practical activities.

Question 2

This question sought to assess candidates'

- knowledge of the principles of volumetric analysis
- exposure to skills associated with the experimental aspect

Most candidates were comfortable with the reading of the burette and the reporting of the resulting observations. The calculations required in Parts (c) — (f) presented great difficulty to the majority of candidates. The question therefore was not very well done.

It should be noted that calculations of this nature present a perennial challenge to candidates, therefore, teachers and students should seek to implement methods in both the experimental and theoretical aspects to reduce the level of such challenges.

Question 3

This question sought to test candidates' level of competence in the various skills associated with the planning and design (PD) of practical investigations.

Candidates obtained marks for determining the necessary reagents and equipment needed. However, the other segments of the exercise presented varying degrees of difficulty. Hypothesis formulation continue to be an area of difficulty, while some confusion was exhibited in the variables involved and a lack of clarity was manifested in the description of the various experimental designs offered.

It is evident that the area of planning and design remains a significant challenge for the majority of private candidates.

Paper 03/1 - Internal Assessment (IA)

The overall level of performance on the Internal Assessment component of the examination was satisfactory; however, some areas continue to raise concerns.

Submissions

Most schools submitted the sample of five laboratory notebooks. It should be noted that the computer generated sample printout **must** also be included with the samples, mark schemes and moderation sheet.

Laboratory notebooks must contain the following in the table of contents:

(i) Name of practical exercise. N.B. All practical exercises done must be included in the table of contents.)
(ii) Skills, if any, assessed for CXC
(iii) Page number
(iv) Date of practical

Appropriateness of Mark Schemes

Generally, mark schemes served as a useful guide to moderators. There were, however, many cases where the mark schemes were either incomplete or contained irrelevant skills. Teachers persist in awarding Observation/Recording/Reporting (ORR) marks for skills that are better classified under Analysis and Interpretation (AI). This might have been the working out of a mathematical problem, identifying sources of error or the writing of equations. Teachers are still experiencing great challenges writing mark schemes for Planning and Design (PD) experiments. This is partly due to the inappropriate PD activities chosen. Mark schemes could be made more informative and useful by including the names of the unknown and observations that are expected when qualitative analyses are tested. Also, where more than one mark is allocated for a particular skill, this should be broken down to indicate where each mark is awarded. Teachers should award an appropriate number of marks for each response required.

Syllabus Coverage, Adequacy and Standard of Activities

The syllabus coverage and adequacy of the number of activities completed from most centres were good. Teachers should, however, seek to spread the activities more evenly over the topics. For example, there should not be five volumetric or qualitative analyses, one energetic experiment and no exercise on rates or equilibrium.

Teachers should seek to ensure that assignments in volumetric analysis are more challenging, for example, exposing students to back titrations, the double indicator method and a variety of iodine/thiosulphate titrations.

Assessment of Skills

Most teachers assessed each of the four skills at least twice. Teachers must select only two assessments of any skill for submission to CXC. These should be clearly indicated on the mark scheme and also in the table of contents in students' books. Students should be tested in IAs on practical work with which they have had experience. Since the IA is formative, it is appropriate to assess the first practical exercise that the students attempt as an IA for submission to CXC.

Observation/Recording/Reporting (ORR)

Many teachers assessed this skill in a satisfactory manner. The majority complied with the CXC mandate to assess communication, grammar, spelling and punctuation; however, the primary skills of observation of colours and precipitates, and the drawing of proper graphs and tables should not be neglected.

The standard of the exercises undertaken for assessing observation skills was, in many cases, lower than expected and was more suitable for CSEC level.

In many instances, there were areas of assessment that were not appropriate for ORR for example:

(i) Inferences
(ii) Interpretation of graphs
(iii) Calculations
(iv) Discussions
(v) Writing equations
(vi) Computer generated graphs

Tables should be enclosed with relevant titles and headings.

Teachers are reminded that in qualitative analysis, 'no reaction', 'soluble', 'insoluble', 'acidic' and 'basic' are not regarded as observations but inferences. Instead the following should be used: 'no observable change/no visible change/no apparent reaction', 'solid/precipitate dissolves'.

Manipulation and Measurement (MM)

Though not moderated, evidence of this activity was examined in the samples. Evidence of two assessed practicals must be included in students' laboratory notebooks for these marks to be accepted. There should be more emphasis on measurement from two different types of practicals. Teachers should correct the entire practical in which the MM skill was tested so that students may benefit from the feedback. In fact, all practical activities must be so marked in order to provide students with relevant feedback.

Analysis and Interpretation (AI)

Activities testing this skill need to be more challenging. Many calculations were too easy. Where applicable in inorganic chemistry/qualitative analysis and physical chemistry, teachers should insist on deductions from observations/results with the level of difficulty increasing in a progressive manner, and well balanced ionic and/or other equations with state symbols.

Analysis of graphs and discussion of results should be encouraged. It is also important for teachers to remember that the drawing of graphs is an ORR activity and not an AI.

In volumetric analysis, the calculation of the average titre should involve the use of **only** the closest values (no more than a difference of +/- 0.10 cm^3). When there are identical values, these should be used to find the average.

Other areas tested under A&I include any type of calculation and answering questions generated by the practical activity.

Planning and Designing (PD)

The representation of this skill is still very, very problematic. Teachers need to acquire a fundamental understanding of this skill relating to scientific research. The problem statement which stimulates critical thinking and inductive reasoning must be able to give rise to a hypothesis and hence a plan that allows for ALL the components of PD — variables, method that demonstrates chemical principles, expected results etc. — to be tested.

Problem statements given to students by teachers should be clearly written in both the students' books and the mark schemes. These statements must not disclose the aim, method or the apparatus required.

In many instances, the hypotheses were either inappropriate or unacceptable. Aims were not linked to hypotheses and it was difficult to identify the chemical principle(s) that were being explored in testing the hypotheses. Mark schemes were not always assessing relevant requirements of the process, for example, marks were awarded for table presentations and discussions that were unrelated to the solving of the problem. There seemed to be confusion over the concepts of limitation and error. It should be noted that although a limitation can be regarded as a source of error, it is really an error that that particular design of experiment cannot reduce or eliminate. Teachers must be reminded that while they are responsible for students' understanding of what is required in this skill, there must be evidence of individual work by the students. There were too many answers which were teacher directed/dictated. Teachers are requested to include more detailed mark schemes for this skill which would indicate the particulars of what is expected from students.

The assignments should be clearly written in both the students' books and mark schemes. Explicit information regarding the aim, method or the apparatus required should not be disclosed as these form an integral part of the planning and design exercise.

Planning and designing activities that can be taken from a textbook are unsuitable. Teachers and students should resist the temptation to predict *actual results*. Teachers should also note that there are some types of practicals that do not lend themselves to PD.

Teachers should set problems that can generate responses that are within the topics of the particular unit being taught and assessed. If not, the PD is deemed unacceptable.

Integrity of Samples

There was adequate evidence to suggest that at a few centres, collaboration between teachers and students and/or students and students was more than desirable as evidenced by:

(i) Laboratory reports being reproduced verbatim.
(ii) Absurd burette readings of greater than 50 cm^3 in all of the students' books and the teachers' mark schemes.
(iii) Burette readings with assumed or estimated accuracy of +/- 0.01 cm^3.
(iv) Planning and design activities where both students and teachers have the identical plan.

In many instances, it was difficult to understand how teachers arrived at marks for students. For example, there were unmarked laboratory reports submitted with mark schemes that were unrelated to any of the practical exercises; however, marks were submitted on moderation sheets.

Summary

The overall performance on Paper 02 of both units was modest and teachers are invited to note the following:

- Candidates' inability to communicate their ideas in a concise and coherent manner continue to be responsible for loss of credit, ultimately leading to a lowering of achievement level.

- Mathematical applications, including the writing of equations, remain sources of challenge for candidates.

- There is need for the development of higher-order cognitive skills so as to equip candidates with the complete array of skills and competencies expected at the CAPE level.

- Paper 03/2 is experimentally based and therefore candidates' preparation *must* include exposure to a broad range of laboratory/practical activities at the required level of the CAPE examination so that relevant skills can be developed hence providing candidates with the opportunity to do well.

- There is an urgent need to improve the quality of the Internal Assessment component of the CAPE Chemistry examination. This need is intensified when trained teachers leave the system and are replaced by untrained counterparts. While CXC provides expertise and some training for teachers, schools are encouraged to organize in-house training for their newer teachers.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2011

CHEMISTRY

St Michael, Barbados

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules.

Both Units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 031 is the School-Based Assessment (SBA) and is examined internally by the teacher and moderated by CXC. Private candidates sit Paper 032 which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031, the School-Based Assessment, comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 is an alternative to the SBA and comprises three compulsory questions focusing on candidate's laboratory experiences.

The number of candidates writing the Unit 1 examination decreased by approximately two per cent from 4,549 in 2010 to 4,421 in 2011. However, the number of candidates writing the Unit 2 examination increased by approximately 12 per cent, from 2,832 to 3,168 in 2011.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. The greatest challenge was with items testing Kinetics and Equilibria (Module 2).The mean score on the paper was 59.7 per cent and the standard deviation 16.0.

Paper 02 – Structured/Essay Questions

Module1: Fundamentals in Chemistry

Question 1

Syllabus Objectives: 1.1, 4.1, 4.2, 4.3
Mean: 5.47; Standard Deviation: 3.50

This question sought to assess candidates' knowledge of

- Daltons's theory of the atom
- the relative reducing properties of zinc and copper and the experimental verification.

Candidate performance was modest. A significant number of candidates had difficulty describing the ideas contained in Dalton's atomic theory.

It was somewhat surprising that candidates experienced difficulty providing answers which would have indicated exposure to a classical experiment to establish the relative reducing abilities of the metals zinc and copper. Difficulty associated with the writing of redox equations was again clearly evident.

Teachers are reminded that the presentation of chemical concepts and theories must be placed in a historical context since science involves the progressive interpretation of empirical data.

Module 2: Kinetics and Equlibria

Question 2

Syllabus Objectives: 5.1, 5.2, 5.3, 5.4, 5.5
Mean: 4.30; Standard Deviation: 2.95

Candidates were required to demonstrate an understanding of

- solubility and solubility product
- common ion effect

They were also required to

- perform associated calculations
- describe the experimental determination of the solubility product of barium hydroxide, $Ba(OH)_2$.

This question was generally not very well answered. A large number of candidates thought that concentration was a factor that influenced solubility, while the crucial notion that the common ion effect involved sparingly soluble salts was not widely appreciated.
The balancing of the equation in Part (c) (i) and the writing of the solubility product expression in Part (c) (ii) were found to be problematic.

The description of an experimental procedure in determining the solubility product for Part (d) was very poorly answered.
The teaching of the concepts above need to be more thorough and students need to be afforded the relevant experimental experience as reinforcement.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives 2.1, 2.3, 2.4, 2.5
Mean: 4.26; Standard Deviation: 2.67

The question required candidates to demonstrate knowledge of the chemistry of the Group II elements and an experimental approach to the comparison of the solubilities of their respective sulphates(VI).

Candidates experienced great difficulty in responding correctly to this question. They were generally able to supply the equation for the formation of the M^{2+} ion, Part (a), and appropriate uses of calcium carbonate, Part (e).

Candidates found it difficult to express coherently the differences in the reactivity of the elements presented. They were able to note the reduction of the value of the second ionization energy as the Group was descended but were unsure of how to apply this information in answering the question.

The inability of candidates to comment correctly on the solubility of the radium sulphate (VI) and to write the equation for the decomposition of its nitrate (V) was surprising. Again, the seeming lack of practical exposure to course materials was seen in the poor responses to Part (d).

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 5.1, 5.3, 6.8, 6.9
Mean: 5.93; Standard Deviation: 2.95

This question required candidates to

- demonstrate knowledge of the kinetic theory as it applies to an ideal gas
- use the ideal gas equation to perform calculations
- provide a definition of Hess's Law
- construct a Born-Haber cycle as illustrating Hess's Law.

Candidates' performance on this question was generally modest. They were able to earn marks from answers to Parts (a), (b) and (c) (i). They encountered difficulty in correctly constructing the Born-Haber cycle for magnesium oxide.

Attention needs to be given to the energy changes involved, especially the bond dissociation energy of gases.

Module 2: Kinetics and Equlibria

Question 5

Syllabus Objectives: 2.1, 2.3, 2.5, 2.6, 2.2, 2.7
Mean: 4.10; Standard Deviation: 3.17

This question was based on aspects of equilibrium and candidates were required to show their understanding of

- dynamic equilibrium and its characteristics
- equilibrium constant, K_c, its applications and associated calculations

This question was poorly answered. Candidates were able generally to gain marks from Parts (a) and (c) (ii). Candidates found it challenging to define the equilibrium constant, K_c, often describing it as the ratio of the concentration of products to reactants as well as neglecting to comment on the significance of its magnitude.

Part (c) (i) provided the greatest challenge. This involved a calculation of the equilibrium concentrations of species involved in the decomposition of dinitrogen tetroxide, N_2O_4. The major challenges encountered were in deducing the number of moles of the gases at equilibrium and that *the small value of K_c allowed the approximation shown below.*

	$N_2O_4(g) \rightleftharpoons$	$2NO_2(g)$
initial	0.800	0
change	$-x$	$+2x$
equil.	$0.800 - x$	$2x$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}, \quad \text{therefore} \quad \frac{(2x)^2}{(0.8-x)} = 4.66 \times 10^{-3}.$$

Since K_c is much less than 1; x is negligible, therefore $0.8 - x = 0.8$.

It was evident from the responses that greater care needs to be taken in the teaching of this topic and that future candidates need much more practice in performing such calculations.

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 3.1, 3.2, 3.3
Mean: 5.40; Standard Deviation: 2.56

This question tested candidates knowledge of the chemistry of the Group (IV) elements. Candidates generally found this question to be challenging. They found Parts (a) and (e) to be easy and the majority gained full marks; however, thereafter the gaining of additional marks was rather difficult.

Candidates provided confusing and sometimes conflicting explanations for explaining the trends asked for in Part (b). The hydrolysis of silicon(IV) chloride by its exposure to the atmosphere was not very well understood – some candidates suggested that the reaction involved oxidation while others opted for displacement.

Candidates also failed to connect volatility with intermolecular forces, while many of them referred to the white fumes as hydrochloric acid.

Paper 032−Alternative to School−Based Assessment

Candidate performance remained fairly stable. The maximum marks available was 48. The mean score was 22.07 (46.07 per cent) and the standard deviation was 11.22.

Question 1

The question tested candidate's ability to execute the process skills associated with the successful completion of an exercise in qualitative volumetric analysis and correctly calculate the solubility product K_{sp} of $Ca(OH)_2$.

Candidate performance on the actual titration was satisfactory; however, some difficulty was experienced in the required calculations.

Question 2

This question utilized the data analysis format. Candidates were asked to

- tabulate data of temperature and time provided
- calculate the enthalpy change of neutralization.

Most of the marks obtained by candidates were for the tabulation and plotting of the resulting graph. Some candidates found it challenging to explain the shape of the graph and calculate the required enthalpy change of neutralization.

Question 3

This question focused on planning and designing an experiment to investigate the variation in the reactivity of the Group VII elements.

The main areas of concern were

- the identification of various variables
- the writing of the appropriate hypotheses.

UNIT 2

Paper 01−Multiple Choice

Performance on this paper was good. Candidates answered most questions correctly.
Of the three Modules, the greatest challenge for candidates was with items testing Industry and the Environment (Module 3). The mean score was 65.5 per cent and the standard deviation 16.2.

Paper 02−Structured/Essay

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 2.4, 2.6, 2.9
Mean: 6.12; Standard Deviation: 4.16

Candidate performance was moderate. This question required candidates to demonstrate their competence in the area of group analysis and the mechanisms associated with nucleophilic substitution.

Responses to Parts (a), (b) (i) and (c) (ii) were generally satisfactory. The main challenge was in explaining the mechanism of the reaction in Part (b) (i) using curved arrows. Candidates are still not clear about the direction of electron movement as indicated by the arrows. They also need to be more careful in describing the conditions under which organic reactions occur.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 1.1, 1.2, 1.3
Mean: 5.78; Standard Deviation: 2.45

Candidates were required to supply responses in the areas involving

- knowledge of concepts of precision and accuracy
- the calculation of standard deviation and its implications
- an experimental knowledge of the calibration of a pipette.

Candidates showed a satisfactory understanding of the concepts above, in Parts (a) and (b), as well as in the calculation of standard deviation in Part (c) (i). Again, weakness was evident in the inability to outline experimental procedures that were required in Part (d).

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 3.1, 3.2, 5.1
Mean:8.38; Standard Deviation: 3.14

This question focused on the distillation of crude oil and the process of fermentation.

Candidate performance was generally good except for some difficulty with the concept of reforming in Part (b) and some aspects of fermentation in Part (e).

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 3.1, 1.4, 1.7
Mean: 5.00; Standard Deviation: 3.00

The topics tested in this question were

- structural isomerism
- combustion analysis
- acidity of organic compounds.

Overall, candidate performance was rather weak. Candidates were able to submit correct answers to questions relating to structural isomerism, Part (a), but performed poorly in their attempts at answering Parts (b) and (c) which related to the other two topics. Candidates seemed to be surprised by the question on combustion analysis while the explanation concerning the acidity of the given organic compounds demonstrated inadequate understanding of the principles involved.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 5.1, 5.2, 5.4, 5.5
Mean: 4.67; Standard Deviation: 3.83

This question tested the theory and simple applications of UV/VIS spectroscopy.
Responses from candidates indicated a weak understanding of this analytical technique.
This weakness was evident in the majority of the sections of the question. These included the

- concept of chromophore
- use of the Beer Lambert equation
- significance of calibration curves and standard solutions as they apply to UV/VIS spectroscopy.

It is evident that more attention needs to be given to these areas in the completion of the syllabus.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 9.7, 9.1
Mean: 6.71; Standard Deviation3.64

Candidates were tested concerning their knowledge of the nitrogen and carbon cycles and the preservation of the levels of stratospheric ozone.

Candidate performance was satisfactory. Candidates were able to gain at least two marks in identifying the components of the nitrogen cycle as well as supplying acceptable answers to the disturbing of the balance of the two cycles by human activity.

The responses regarding the preservation of ozone levels proved to be a challenge for the majority of candidates especially in writing appropriate equations.

Paper 032 – Alternative to School−Based Assessment (SBA)

Candidate performance on Paper 032 showed modest improvement.

The maximum marks available was 48. The mean score was 19.25 (40.1 per cent) and the standard deviation was 6.94.

Question 1

This question involved the testing of organic compounds to determine their relevant functional groups. Candidates generally manifested good manipulative skills and were also able to correctly identify the relevant functional groups.

Question 2

The application of the concepts *equivalence point* and *strength of acid* were challenging areas for the majority of candidates.

Question 3

The questions on planning and designing were inconsistently answered. The main area of concern for candidates were

- the identification of the various variables
- the writing of appropriate hypotheses.

Paper 03/1 – School−Based Assessment (SBA)

Submissions

Most centres submitted the requested five samples, however there were a few whose samples did not correspond with the computer−generated sample printout as issued by the Council. It is to be noted that this is a requirement stipulated by the Council and as such teachers and students are expected to comply with this instruction.

In the case of the laboratory books, they are required to contain

- a table of contents indicating the skills assessed, page number and date of the practical exercise
- the practical exercises for which assessment was done (these must be clearly marked
- the names of the practical exercises at the beginning of the respective reports.

Mark Schemes

Generally, the mark schemes submitted were appropriate for most skills. In a few instances, the mark schemes were not detailed enough and this made moderation challenging.

Mark schemes are required to provide the following:

- A clear indication for the awarding of *each* mark–this is especially important where multiple marks are awarded for a particular question or part thereof
- Names of unknown compounds and ions used in qualitative and quantitative analysis assignments
- Expected observations and inferences in qualitative analysis assignments
- Marks awarded for calculations and equations
- Criteria for Manipulations and Measurement (MN) assignments
- Problem statements for Planning and Designing (PD) activities

Syllabus Coverage

This aspect was well done and teachers are to be commended for seeking to include activities from most areas of the syllabus.

Assessment of Skills

While it is heartening to note that some skills were assessed more than twice, it must be borne in mind that only *two* assessments for each skill should be selected and submitted for moderation. These should be clearly indicated in the table of contents at the front of the laboratory book.

Observation/Recording/Reporting (O/R/R)

There has been some improvement in the assessment of this particular skill, however, the following should be noted:

In reporting in the area of qualitative analysis, ‘no reaction’, ‘insoluble’, ‘soluble’, ‘acidic’ and *‘basic’* are not regarded as observations but inferences. Instead the following should be used: *‘no observable change/no visible change/no apparent reaction’, ‘solid/precipitate dissolves’.*

Analysis and Interpretation (AI)

The assignments used to test this skill need to be more challenging, for example, calculations based on volumetric analysis should come primarily from areas of the syllabus which do not overlap with the CSEC syllabus, that is, these should be at the advanced proficiency level. The award of marks for analysis of graphs and discussions based on observations or results of practical activity is encouraged. However, the use of questions based solely on theory is unacceptable for assessing this skill as it provides no measure of analysis or interpretation.

Planning and Designing (PD)

Although there has been some improvement in the assessing of this skill, teachers still exhibit great difficulty in formulating problem statements capable of generating hypotheses with appropriate variables. In many instances, problem statements were unacceptable either because no viable hypothesis was possible or all that was required of the student was the 'lifting' of the material directly from a text book. A popular unacceptable assignment involved the experiment to determine the order of the iodine/propanone reaction.

Teachers are reminded that acceptable PD assignments should *pose a problem for candidates to solve using concepts contained in the syllabus. These problems should encourage hypothesis making, be conceptualized in 'novel' situations and should not be activities previously done or readily available in textbooks.*

Summary

- Teachers are reminded that credit is to be given for the individual work of students, especially for discussions, calculations and PD activities.
- There was evidence of increasing collaboration between teacher/student and student/student in a number of centres in the presentation of student responses.

- Care must be taken to ensure the accuracy of content communicated. Instances were found where inaccurate information formed the basis for the awarding of marks thereby placing students at a disadvantage.
- The integrity of some of the SBA samples submitted continue to be of grave concern.

There is evidence to indicate that teachers are using practices that undermine the pedagogical philosophy of the SBA component of the syllabus. The SBA component has been designed to form part of the continuous assessment of students in the area of the development of their practical and problem-solving skills.

The following quotation from the CAPE Chemistry Syllabus, May/June 2007/2008 is of particular relevance.

> *Internal Assessment 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 associated with the subject. The activities for the Internal Assessment are linked to the syllabus and should form part of the learning activities to enable the student to achieve the objectives of the syllabus.*

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2012

CHEMISTRY

St Michael, Barbados

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules. Both units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 031 the School-Based Assessment (SBA), is examined internally by teachers and moderated by CXC. Private candidates write Paper 032 which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031, the School-Based Assessment, comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 is an alternative to the SBA and comprised three compulsory questions focusing on candidate's laboratory experiences.

The number of candidates writing the Unit 1 examination increased by approximately eight per cent from 4,421 in 2011 to 4,772 in 2012. However, the number of candidates writing the Unit 2 examination decreased by approximately 16 per cent, from 3,168 to 3,012 in 2012.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly.
The greatest challenge continues to be with items testing Kinetics and Equilibria (Module 2).

Paper 02 – Structured/Essay Questions

Module1: Fundamentals in Chemistry

Section A

Question 1

Syllabus Objectives: 2.5, 2.6, 2.7.
Mean: 5.01; S.D: 2.62

This question sought to test the candidates' knowledge of the types of bonding and intermolecular forces of attraction.

Candidate performance was very poor, with correct answers coming mainly from Part (a). Candidates exhibited great difficulty in describing the origins of the various intermolecular forces of attraction as well as identifying their individual presence in given compounds. It was also surprising to observe that the majority of candidates were unable to associate bonding types with corresponding solubility patterns.

It seemed that teachers may have assumed that students were familiar with this part of the course. The above performance belies this assumption and thus relevant review instruction should be provided.

Module 2: Kinetics and Equlibria

Question 2

Syllabus Objectives: 5.1, 5.2, 5.3, 5.4.
Mean: 3.70; S. D: 3.52.

The focus of this question was on candidates' understanding of the

- principles surrounding solubility product
- details of its experimental determination
- application of principles to problem solving.

The overall performance of candidates was poor. Candidates experienced significant difficulty in

- describing the experimental process involved
- defining and writing the appropriate expression
- calculating values from data provided.

It was evident that candidates were unfamiliar with the practical aspects of this part of the course and their inability to solve problems involving calculations continues to be a serious concern. Teachers need to invest more time in practical activities as well as to devise strategies to overcome the apparent fear of the mathematics involved in problem solving.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 4.3, 4.4, 4.5.
Mean: 5.16; S. D: 3.11

This question which was based mainly on the chemistry of the halogens was answered unsatisfactorily.

Candidates were generally able to

- correctly describe the reactions of hydrogen with the halogens indicated
- identify the gases observed in Part (b) (i)
- describe the observations with silver nitrate as presented in Part (d).

Candidates demonstrated weaknesses in

- writing balanced equations
- presenting reasoned explanations for the trends observed in Part (b)
- describing the reaction of concentrated sulphuric acid with halides as in Part (c).

The above weaknesses can be corrected by meaningful instruction with constant review activities as well as relevant experimental experiences.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 1.10, 1.11, 1.12, 1.13, 1.14
Mean: 7.13; S. D: 3.27

This question tested candidates' understanding of the principles of electronic configuration, ionization energy and its relevance to electronic structure. The responses in this case were modest with most marks being awarded for answers to Parts (a), (b) and (d) (i),(ii).

Again candidates exhibited difficulty in adequately explaining the relevant concepts and writing balanced equations with associated state symbols.

Greater attention must be given to the inclusion of state symbols in the writing of chemical equations.

Module 2: Kinetics and Equlibria

Question 5

Syllabus Objectives: 2.2, 2.3, 2.5, 2.7
Mean: 7.40; S. D: 3.72

This question sought to assess candidates' understanding of the

- concept of chemical equilibrium
- equilibrium constant
- position of equilibrium
- use of calculations in problem solving.

Candidates' level of performance was generally satisfactory. Candidates responded well to Parts (a) and (b); however, they struggled with Parts (c) and (d).

Performance on this question exemplifies the systemic weakness of candidates to respond adequately to questions requiring reasoned explanations and problem solving.

Teachers must note these weaknesses and must seek to implement the necessary strategies to overcome them.

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 1.1, 1.2, 1.3.
Mean: 6.88; S.D: 3.10

Candidates were assessed on their understanding of the trends in Period 3 of the Periodic Table relating to

- atomic radius
- melting points
- structure and bonding
- electrical conductivity.

Their understanding of the reaction of chlorine with the second member of the Period was also examined.

Candidates performed modestly on this question. Parts (a) and (b) were answered satisfactorily. Candidates, however, encountered difficulties in

- sketching a diagram to illustrate the variation in electrical conductivity
- providing adequate explanations for variations in melting points and electrical conductivity based on structure and bonding
- writing equations with appropriate state symbols.

Candidates exhibited superficial acquaintance with the principles involved in the above trends. However, application of these principles in presenting cogent explanations for these trends was lacking. While candidates knew that delocalized electrons were responsible for electrical conductivity in metals, they failed to appreciate that the *number* of such would be responsible for the *increase* in conductivity from sodium to aluminium. Similar examples were observed with respect to the other trends. Many candidates were unfamiliar with the reaction and associated equation (with state symbols) for the reaction of chlorine and magnesium.

Paper 032 − Alternative to School Based Assessment

Syllabus Objectives: 1.2, 1.3, 1.6. 3.8, 3.9
Mean: 22.82; S.D: 9.10

Question 1

Candidates were required to perform a practical exercise to demonstrate their competence in

- manipulating various laboratory measuring apparatus and timing devices
- drawing an appropriate graph using the information collected
- making relevant deductions from the graphical display of information.

Candidates performed at varying level on this question. Some of them seemingly had difficulty with the level of manipulation required which lead to large variations in observed times, (t). Other candidates were unsure about the notion of decimal places in calculations.

Most candidates were comfortable with the plotting of the required graph.

Question 2

This question sought to assess candidates'

- knowledge of the principles of volumetric analysis and associated calculations
- exposure to skills associated with data collection and reporting.

Most candidates were able to correctly read the burette and record the resultant data in the appropriate manner. The associated calculations showed great variation among the candidate population with Parts (f)–(i) presenting the greatest challenge. Some candidates found difficulty in writing the required ionic equation while most candidates were able to suggest an appropriate indicator.

Overall, the level of performance was varied and below expectation.

Question 3

This question sought to test the candidates' level of competence in the various skills associated with the planning and design (PD) of practical investigations. Candidates obtained marks for suggesting the aim of the experiment and determining the necessary reagents and equipment needed; however, the other segments of the exercise presented varying degrees of difficulty.

Hypothesis formulation continues to be an area of weakness, while some confusion was present in the identification of the variables involved.

It is clear that the area of planning and design continues to pose significant challenges for these candidates.

UNIT 2

Paper 01−Multiple Choice

Performance on this paper was good. Candidates answered the majority of questions correctly. The greatest challenge continues to be with questions testing Industry and the Environment (Module 3).

Paper 02−Structured/Essay Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 1.5, 1.6, 1.7, 2.6.
Mean: 9.20; S. D: 3.58

Most candidates had few challenges in answering this question which sought to assess their competence in

- writing displayed formulae
- applying correct chemical nomenclature
- identifying isomeric compounds
- explaining the reaction of oxidizing agents with alcohols.

A few candidates showed some confusion in the application of the correct nomenclature as it related to the isomeric alcohols.

Generally this question was very well answered. However, teachers should insist on the use of the correct IUPAC name and avoid traditional or common names, for example, Butan-1-ol instead of butanol, and 2-methyl propan-1-ol instead of 2, methylpropanol.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 8.3, 8.4, 8.5, 8.6.
Mean: 5.6; S. D: 3.16

This question sought to assess candidates' knowledge of the principles and the operation of the thin-layer chromatography technique. Candidates' responses indicated a very weak understanding of both the principles and the practical details involved in this separation technique. The only part of the question that was handled well involved the calculation of R_f values.

Candidates should be given significantly more exposure to both the principles relating to the theoretical basis of chromatography and the practical processes involved.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 8.3, 8.4, 8.5, 8.6.
Mean: 5.47; S. D: 3.20

The focus of this question was on the

- concepts of *reuse, recycle* and *reduce* in solid waste management
- chemistry associated with the fermentation of sucrose.

Candidates' responses were surprisingly weak.

Candidates seemed confused about some concepts of solid waste management, for example, *reduce* and *reuse* were used interchangeably and *recycle* was mistaken for *reuse*.

Candidates demonstrated a superficial understanding of the fermentation process and many of them were unable to name one compound responsible for the sharp smell resulting from the *souring* of beer.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 1.8, 2.4, 2.5
Mean: 5.06; S. D: 4.02

This question sought to assess candidates' knowledge of the chemical properties of alkenes including the use of arrows in the explanation of reaction mechanisms. Candidates earned most of the marks from Parts (a) (ii-iv), (d) and (e).

The majority of candidates failed to appreciate that the reaction of aqueous bromine involved the addition of BrOH; while the use of curved arrows to explain the mechanism in Part (d) presented a serious challenge although the formula of the product was known.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 3.2, 9.4.
Mean: 2.6; S.D: 2.97

This question required candidates to

- identify some of the apparatus needed to carry out separation by filtration
- define the partition or distribution coefficient
- explain the principles associated with solvent extraction
- perform calculations leading to the determination of the partition coefficient.

Candidates' performance on this question was poor. It seemed that little or no time was given to the teaching of this part of the course. They were clearly unfamiliar with and therefore unable to identify the pieces of apparatus presented in Part (a). These were images of a sintered glass crucible and a Buchner funnel respectively.

The attempts to explain the process of solvent extraction showed little or no understanding of the principles involved and the calculation in Part (b) (iv) only fared slightly better.

Teachers are encouraged to provide adequate laboratory experiments for students.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 1.1, 1.2, 9.6.
Mean: 6.65; S. D: 2.67.

This question focused on the impact of industry on the environment.

Most candidates were able to

- list the influential factors involved in the siting of industrial plants (Part (a))
- write an equation to support the production of acid rain by sulfur dioxide
- provide a reason for the classification of sulfur dioxide as a pollutant (Part (d)).

Candidates demonstrated weaknesses in the identification of relevant safety concerns and the chemistry associated with the operation of vehicular catalytic converters. Generally, candidates performed satisfactorily.

Paper 032 – Alternative to School Based Assessment (SBA)

Syllabus Objectives: Module 1 - 2.4, 2.8; Module 2 - 2.4, 2.6, 2.9, 2.7, 3.1; Module 3 - 2.4, 2.5
Mean: 18.60; S. D: 11.30

Question 1

This question required candidates to perform a volumetric analysis using the technique of back titration to determine the concentration of barium ions, Ba^{2+}, in a solution.
Candidate s' performance was generally poor. The concept of back titration was unfamiliar and hence the calculations required posed serious challenges.

Question 2

This question tested candidates' knowledge of the chemical properties of various organic functional groups.

They were required to describe test-tube tests to differentiate between pairs of compounds while suggesting a further compound that would yield a positive test.

Candidates' responses exhibited a weak grasp of the knowledge required and thus were generally unable to provide correct suggestions as requested.

As seen in the answers to Paper 02 in the two units, there is a lack of exposure of candidates to experimental activities. This is a serious deficiency in the instructional strategy in the preparation for these courses.

Question 3

This question sought to assess the creativity and problem-solving ability of candidates in the planning and design of an appropriate experiment.

Candidates seemed to lack the depth of knowledge to enable them to produce credible experiments to solve the problem presented. This, along with the perennial challenges of hypothesizing, and identification of various variables, resulted in a candidate performance that can only be described as poor.

Paper 031 – School Based Assessment (SBA)

The overall level of execution and management of this aspect of the examination continues to see incremental improvement. This is evident in the areas involving

- submission of samples
- use of appropriate laboratory books
- the provision of relevant mark schemes
- the attempts at increased syllabus coverage
- skills assessment.

While it is heartening to note that some skills were assessed more than twice, it must be borne in mind that only *two* assessments for each skill should be selected and submitted for moderation. These should be clearly indicated in the table of contents at the front of the laboratory book.

Finally, it must be noted that in some schools teachers are engaged in practices that undermine the pedagogical philosophy of the SBA component of the syllabus. This philosophy is captured by the following excerpt from the current syllabus (CXC A11/U2/06):

> *Internal Assessment 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 associated with the subject. The activities for the Internal Assessment are linked to the syllabus and should form part of the learning activities to enable the student to achieve the objectives of the syllabus.(p. 54)*

In the following report an attempt will be made to deal with specific matters involving the assessment of the various skills and to provide reminders and examples where possible to facilitate a greater level of security and efficiency in the management and operation of this component of this the CAPE course.

Assessment of Skills

Observation/Recording/Reporting (O/R/R)

Teachers are reminded of the following:

(a) Activities NOT to be assessed under *O/R/R* but as ANALYSIS AND INTERPRETATION (A/I) include:
- The interpretation of graphs
- All types of calculations
- The writing of all equations

(b) In qualitative analysis, the response *'no reaction'* is unacceptable as an observation and should be marked accordingly, students must respond by recording *no observable change/no apparent reaction/no visible change.*

Suggested Mark Schemes

(a) Graphs:

•	Labelled axes	2 marks
•	Units on both axes	1
•	Appropriate title	1
•	Scale (at least ¾ of the graph paper should be used)	1
•	Best straight line/smooth curve	2

(b) Tables

•	Column headings	2
•	Units in column headings	2
•	Neat	1

(c) Main components of a report

•	Aim	2
•	Apparatus and Materials	4
•	Method	
−	past tense	1
−	no pronouns	1
−	grammar	2
−	observations	?

(mark to be awarded based on the type of activity)

Analysis and Interpretation (AI)

Additional criteria that can be assessed under this skill are discussions and conclusions resulting from observations made.

The above criteria are provided in the hope that teachers will include them in their assessment and not continue to limit themselves to the assessment of calculations.

It is further suggested that
- questions are asked of students that are directly related to observations made and not to general theory
- 'unknowns' be identified on the mark scheme for accurate moderation.

Planning and Design (PD)

This skill still presents the greatest challenge with some teachers demonstrating a lack of clarity concerning what constitutes an acceptable assignment for assessment. A planning and design activity is deemed appropriate if it can generate a hypothesis and variables as outlined in the statement below:

> *……. assignments should pose a problem for candidates to solve using concepts contained in the syllabus. These problems should encourage hypothesis making, be conceptualized in 'novel' situations and should not be activities previously done or readily available in textbooks.*

The following points are to be noted.

- Students given a problem requiring them to distinguish between unknowns, must identify each unknown in the hypothesis (for example, A is a simple covalent compound, B is a metal and C is an ionic compound).
- Problems which can be easily solved by lifting the answer from a textbook are to be avoided as these would be deemed to be inappropriate and unacceptable. Teachers therefore run the risk of their students being marked down as a result of moderation.
- *Expected Results* and *Treatment of Results* are two different criteria. In the latter criterion, students must describe how they will use the results obtained to solve the problem.
- Teachers should impress upon students the need to avoid using the term 'amount' when describing variables. Specific terms such as volume, concentration, and mass should be used.

Typical Mark Scheme for Planning and Design

• (a)	Hypothesis (must be testable)	2
• (b)	Aim (must be related to the hypothesis)	1
• (c)	Apparatus and Materials	3
• (d)	Method	
	- Logical sequence	2
	- Language (tense, no pronouns)	2
• (e)	Variables	3
• (f)	Treatment of Results	3
• (g)	Expected Results	2
• (h)	Sources of Error/Limitations	1
• (i)	Assumptions	1
	Total	**20 marks**

Samples of Planning and Design Assignments

(a) Mark and Tim decided that they would produce biodiesel using different waste oils from Grandma’s kitchen. Mark argues that coconut oil makes the better quality biodiesel than soya bean oil. Plan and design an experiment that proves or disproves this statement.

(b) Jimmy was bitten by some large red ants when he climbed his neighbour’s tree. He states that these ant stings were more potent than the small black ant stings. Plan and design an experiment to test the accuracy of this statement.

(c) A local fish farmer noticed that as plant life thrived in the surrounding stream the fish began to die. They blamed a local soap and detergent plant located upstream from the farm for this occurrence. Plan and design an experiment to support or refute this claim.

(d) Mr McGann tells his staff to pack the white eggs in styrofoam trays and the brown eggs in plastic trays because brown eggs have stronger shells than white eggs. Plan and design an experiment to test the validity of this statement.

(e) Garlic contains the active ingredient Alicin. Some chefs use fresh garlic, others use ground, refrigerated, or processed garlic. Plan and design an experiment to determine which type of garlic is most potent, that is, has the greatest concentration of Alicin.

(f) A limestone factory is located near a river between Villages A and B. Residents in Village B complain that since the factory has moved in the area, they were using much more soap in their laundry than before. They think that this is due to the factory affecting the quality of the river water. Plan and design an experiment to test this hypothesis.

Manipulation and Measurement

This skill is not moderated, however, criteria used to assess this skill should be recorded in the mark scheme. Criteria must include appropriate use of laboratory equipment.

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MAY/JUNE 2013

CHEMISTRY

St Michael, Barbados

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Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031, comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 comprised three compulsory questions focusing on candidates' laboratory experiences.

Overall, performance in 2013 declined when compared with 2012.

Performance across the two papers in both units showed a vast disparity, with candidates doing very well on Paper 01 while performing poorly on Paper 02.

Some of the underlying causes for the poor performance on Paper 02 included

- the inability of candidates to operate above the basic level of comprehension
- challenges with questions involving the use of application, analysis and synthesis
- severe limitation of the use of technical language to explain chemical concepts
- inadequate exposure to practical activities.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. The greatest challenge continues to be with items testing Kinetics and Equilibria as well as qualitative and quantitative treatment of first-order equations (Module 2).

Paper 02 – Structured/Essay Questions

Module1: Fundamentals in Chemistry

Section A

Question 1

Syllabus Objectives: 4.1, 4.2, 4.3
Mean: 4.52; Standard Deviation: 2.43

This question tested candidates' understanding of the concepts of oxidation/reduction, the use of equations in representing such reactions and the application with respect to the halogens.

Candidate performance was very weak. Most candidates were able to define these concepts in terms of electron transfer and/or oxidation numbers, however, a minority opted to use oxygen as the basis for their definition. It should be noted that the last approach represents a very narrow perspective and explanations involving the two former notions should be adopted. There was some compensation as candidates gained additional marks from Parts (b) (i) and (iii).

Candidates had great difficulty writing the relevant half equations and demonstrated a lack of awareness of the experimental application of these concepts in the understanding of the chemistry of the halogens.

Module 2: Kinetics and Equilibria

Question 2

Syllabus Objectives: 4.1, 4.2, 4.3, 4.4
Mean: 3.42; Standard Deviation: 2.58

This question focused on buffer solutions (their operation and the associated experimental and mathematical applications) and was very poorly answered. The area of definition was the only component of the question with which candidates showed any measure of competence.

The answers involving the operation of buffers showed either an incomplete or a confusing comprehension of the concepts involved. Candidates also found it challenging to manipulate the information provided to make the calculations requested, while familiarity with the practical details of the determination of the pH of such solutions was glaringly absent.

It would appear from responses submitted by candidates that they were inadequately prepared for this topic. Teachers should therefore seek to address these deficiencies by providing appropriate learning activities in the areas of chemical equilibrium, acidity, and associated concepts, both experimental and theoretical.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 5.8, 6.1, 6.2, 6.5, 6.6
Mean: 3.95; Standard Deviation: 2.66

This question assessed candidates' competence in the area relating to the identification of both anions and cations.

Candidate performance was poor considering the significant overlap in this area with the CSEC syllabus.

The unsatisfactory level of responses in the completion of the laboratory report in Part (b) pointed to gaps in this area of knowledge. The majority of candidates found great difficulty in deducing the presence of the sulfate (IV) ion, $SO_3{}^{2-}$, which lead to the loss of marks in the writing of the subsequent equations.

The majority of candidates was awarded marks for answers to Part (a) which was handled satisfactorily.

Performance on this question continues to confirm the observation that the level of exposure to activities of an experimental nature is undesirably low.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 6.1, 6.2, 6.3, 6.9
Mean: 5.76; Standard Deviation: 3.87

This question tested candidates' comprehension of a number of concepts under the topic Energetics. These included:

- Standard enthalpy of formation
- Exothermic and endothermic changes in enthalpy
- Construction of Born–Haber cycle

Candidate responses were inconsistent, resulting in an overall weak performance. Marks were obtained across the various sections of the questions; however, these were not sufficient to produce an acceptable level of performance.

The following presented candidates with significant challenges:

- The relationship between the electron affinity of the oxygen atom in the production of the oxide ion, O^{2-}
- The lattice energy and the enthalpy change of formation of CaO(s) in the construction of the Born–Haber cycle

- The distinction between *exothermic enthalpy change* and *endothermic enthalpy change* (Attempts generally resulted in confusing presentations.)
- Calculations using information provided by the Born–Haber cycle

Candidates need to engage in more activities surrounding the construction of a number of Born–Haber cycles for different compounds along with the relevant calculations. This would assist in improving performance in this area.

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 1.3, 1.4, 1.6, 1.8
Mean: 5.21; Standard Deviation: 4.05

Candidates were tested in this question on their

- understanding of the effects of temperature and catalysts on reaction rates
- ability to perform calculations using information about initial rates.

While the general level of performance was weak, some candidates demonstrated a satisfactory level of competence in these areas.

Candidates showed a general acquaintance with the subject matter in the first area of testing. However, the absence of an accurate and complete understanding was noted in the frequent interchange of distribution curves with respect to the relevant temperatures (T_1, T_2) and the failure to clearly explain the relevant effects.

In the second area of testing, there was confusion evident in the choice of information made to deduce the rate equation and the overall order of the reaction.
The importance of units in the various calculations should be emphasized.

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 5.2, 5.3, 5.4, 5.7
Mean: 4.69; Standard Deviation: 3.80

This question focused on the chemistry of the first row of transition elements. The majority of candidates obtained marks in Part (c) for identifying the shapes of the complex ions.

Candidates had difficulty answering questions which required explanations and/or applications of chemical principles. This was exemplified by the

- inadequate explanation of d-orbital splitting as well as the relationship between absorption and emission of light in the formation of coloured ions in transition elements

- unsatisfactory application of electronic configuration in accounting for the stability of iron(III) with respect to iron(II).

Candidates were challenged in accounting for the gradual decrease in atomic radius across the first row of transition elements.

It would appear that this section of the syllabus would benefit from more careful attention by teachers in planning their overall teaching strategy.

Paper 032 – Alternative to School-Based Assessment

Syllabus Objectives: Module 3: 6.5.
Mean: 19:71: Standard Deviation: 7.44

Question 1

In this question, candidates were required to perform a practical exercise to test their competence in the identification of anions using the method of simple qualitative analysis.

An inadequate knowledge of the concepts underlying the tests required resulted in weak candidate performance. The lack of adequate practical activities was evident in the recurring unsatisfactory level of reporting/recording of observations.

Some of the inadequate/inaccurate reporting included expressions such as

- '*insoluble* precipitate formed'
- 'a *clear* solution was seen'/precipitate dissolves to form a *clear* solution'
- 'a *cloudy* solution formed'
- '*bubbles/fizzing* seen'
- '*white* solution formed'.

Teachers should seek to redress this deficiency in the preparation of students by affording students various opportunities to conduct practical assignments and practise the use of the appropriate language for chemical reporting.

Question 2

This question assessed candidates' ability to

- manipulate data pertaining to reaction rates
- interpret information presented in a graphical format
- display the skills associated with data collection and reporting.

Most candidates were able to correctly read the gas syringe, record the resultant data in the appropriate manner and draw the resultant graph. Candidates who correctly deduced the rates of reaction at the relevant times from the graph performed well. Generally, candidates faltered in their responses to Parts (d) — (g). The level of performance was inconsistent.

Question 3

This question tested candidates’ level of competence in the various skills associated with the planning and designing (PD) of practical investigations.

Candidate performance was weakest on this question. In addition to the general inadequacies associated with this area, the lack of knowledge of the content relating to the question resulted in a low level of performance.

UNIT 2

Paper 01 − Multiple Choice

Performance on this paper was very good. Candidates answered the majority of questions correctly. The greatest challenge continues to be with questions testing Industry and the Environment, for example, free radical reactions in the upper atmosphere (Module 3).

Paper 02 − Structured/Essay Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 2.9, 2.10, 2.12.
Mean: 3.47; Standard Deviation: 2.67

This question tested candidates’ knowledge of the chemistry of the functional groups of esters and carbonyl compounds. It was poorly done.

The question highlighted the dependence on rote learning by candidates and the consequent inability to respond to instances where application of knowledge is required. It is critical that teachers re-examine present teaching methodology to include opportunities to develop the critical thinking skills of prospective candidates.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 6.1, 6.2, 6.4, 6.5
Mean: 6.48; Standard Deviation: 3.70

This question focused on infrared spectroscopy and its use as an analytical method. Candidate performance was modest.

Generally, candidates were able to

- cite examples of the use of this method
- interpret the information provided by spectrographs. (Parts (a) ─ (c))

Candidates, however, found challenging the

- description of the practical preparation for sample analysis
- identification of the characteristic properties of molecules that are IR responsive.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 8.2 – 8.5
Mean: 7.33; Standard Deviation: 3.11

This question tested candidates' knowledge on aspects of the environment. These included

- processes which result in pollutants and oxygen entering waterways
- tests for the identification of such pollutants
- relation of eutrophication and water quality
- processes used for the treatment of water.

While some inconsistency in correct responses was observed, there was an overall satisfactory level of performance.

Candidates were able to obtain marks across the various components of the question.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 2.15, 2.16, 2.17
Mean: 4.68; Standard Deviation: 3.29

Candidates were required to respond to questions relating to the

- chemistry of phenols
- introduction of various species into the benzene molecule
- effect of such species on the reactivity of subsequent substituted molecules.

Candidate response to this question was weak.

The concepts surrounding substitution in the benzene molecule and the resulting explanation of the effect of such substituents on the electron availability within the benzene molecule presented a major challenge for candidates.

A significant number of candidates were unsure about the experimental conditions associated with many of the reactions as indicated.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 9.1, 9.4, 9.5
Mean: 3.40; Standard Deviation: 3.08

This question tested candidates' knowledge on a number of separation techniques and in particular the

- principle and application of partition coefficient in solvent extraction
- explanation of boiling point/composition curves related to the process of distillation of ideal liquid mixtures.

Candidates were generally able to define *partition coefficient* and earned marks in the identification of appropriate methods of separation in specific cases. However, severe deficiencies were exposed when attempts were made to perform the required calculation and interpret the boiling point/composition curve as presented.

Once again, candidates showed their incomplete apprehension of relevant concepts and limited mathematical skills, which at this level can be described as simple operations.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 2.1, 2.3
Mean: 5.93; Standard Deviation: 3.39

This question centred around the extraction and purification of aluminum oxide from its bauxite ore and its subsequent electrolysis leading to the production of the metal.

Given the prior introduction to this topic at the CSEC level, it was surprising that the level of performance was so weak.

Most candidates were able to identify the polluting by-product of the extraction of the oxide as well as the resulting environmental consequence. However, the writing of the relevant equations involved in the processes, both chemical and electrolytic, presented a challenge. Candidates demonstrated limited awareness of the benefits of the recycling of the metal.

Paper 032 – Alternative to School-Based Assessment (SBA)

Mean: 22.32
Standard Deviation: 9.41

Question 1

This question required candidates to perform a volumetric analysis involving a redox reaction. Candidates were required to standardize a solution of oxalate ions using a standard potassium manganate(VII) solution.

Candidates' performance was inconsistent. Many candidates were able to calculate the number of moles of manganite (VII) ions used in the titration. However, the subsequent calculations presented serious challenges.

Some observations that should be noted by teachers and candidates are:

- Titres should be recorded to two decimal places.
- Consistent results are achieved when two titres agree to within 0.10 cm^3.
- Volume to be used in calculations is the mean value of the consistent results.

Question 2

This question assessed candidates'

- knowledge of the principles of gravimetric analysis
- ability to perform calculations to determine the number of molecules of water of crystallization
- exposure to skills associated with data collection and reporting.

Candidates were able to tabulate the data provided. Parts (b)–(e) were answered with varying levels of success. However, the lack of competence in performing the necessary calculations continues to be a problem for candidates. A concerted effort needs to be made to address this deficiency.

Question 3

This question focused on candidates' level of competence in the various skills associated with the planning and design (PD) of practical investigations.

Candidates obtained marks for suggesting an appropriate hypothesis, however, some found it difficult to produce a corresponding aim of the experiment. Generally, the lists of reagents and equipment were satisfactorily presented. However, the description of a concise procedure (indicating the need for control of variables) was inadequate. Overall, candidates showed limited familiarity with experimental reporting and performance.

Paper 031 – School-Based Assessment (SBA)

Most centres complied with the guidelines for the submission of samples for moderation: however, teachers are reminded of the following:

- Samples submitted should correspond to those on the list that was computer generated by the Council.
- Laboratory books must contain a table of contents with the date of the practical, the page number and the skills assessed. Where more than two practicals are assessed for the same skills, the two to be moderated must be clearly identified.
- Mark schemes should be detailed so as to facilitate the smooth and accurate process of moderation. This should include the names of unknown compounds and ions, observations and corresponding inferences used in qualitative and/or quantitative analyses.
- Marks awarded for calculations, writing of equations and discussions should be clearly indicated.
- Problem statements for planning and design (P/D) activities must be included as part of the mark scheme.
- Criteria for manipulation and measurement must also be submitted.

Observation/Recording/Reporting (O/R/R)

There has been improvement in the assessment of this particular skill and teachers are to be commended. The following points, however, need attention:

- In the reporting of qualitative analysis, ‘no reaction’, ‘insoluble’, ‘soluble’, ‘acidic’ and ‘basic’ are not regarded as observations but inferences.
  The following should be used instead: *no observable change, no visible change, no apparent reaction, solid/precipitate dissolves.*
- Discussions and conclusions, calculations and information obtained from graphs are all to be assessed as analysis and interpretation (A/I).

Analysis and Interpretation (A/I)

The criteria testing this skill need to be more challenging. Calculations based on volumetric analysis should go beyond acid/base and include redox and back titrations. The use of questions based solely on theory is unacceptable for assessing this skill as it provides no measure of analysis or interpretation.

Planning and Design (P/D)

Although there has been some improvement in the assessment of this skill, teachers still have great difficulty formulating problem statements capable of generating hypotheses and variables.

Care must be taken to ensure that problem statements do not lead to students reproducing material directly from textbooks, for example, requiring students to plan and design an experiment to determine the order of reaction between iodine and propanone. This type of assignment will be deemed unacceptable.

Problem statements should allow for multiple hypotheses and methods. Many mark schemes tend to be extremely rigid and students are expected to use only one particular method — this tends to limit creativity.

Assumptions, limitations and sources of error should not be assessed as one criterion. Students should be taught to appreciate the differences and be assessed appropriately.

Care must also be taken to ensure that the various activities relate to relevant areas of the CAPE syllabus. Activities involving objectives presented in Unit 1 should not be used as a Unit 2 assignment.

Integrity of Samples

There was an increase in the number of centres where teacher/student collaboration was evident.
Teachers are reminded that

- students are to engage in individual work, especially for discussion, calculation and planning and design (P/D) activities
- the SBA component of the CAPE course is intended to be developmental, involving continuous assessment of student skills and attitudes concerning a vital aspect of a chemist's work — experimentation. Teachers should therefore refrain from using the SBA as a form of summative assessment.

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Paper 031 comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 comprised three compulsory questions focusing on candidates' laboratory experiences.

Overall, some improvement was noted in performance in 2014 when compared with 2013. However, in both units, performance across the two papers continues to be disparate with the means on Paper 02 significantly lower than those on Paper 01.

As identified in 2013, some of the underlying causes for the poor performance on Paper 02 include

- the general absence of critical thinking skills
- the inability of candidates to operate beyond the basic level of comprehension
- challenges with questions involving the use of application, analysis and synthesis
- severe limitation in the use of technical language to explain chemical concepts and phenomena
- inadequate exposure to practical activities.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. However, Kinetics and Equilibria as well as qualitative and quantitative treatment of first-order equations (Module 2) continue to present challenges to too many candidates.

Paper 02 – Structured Essay Questions

Section A

Module 1: Fundamentals in Chemistry

Question 1

Syllabus Objectives: 3.1–3.9
Mean: 4.39; Standard Deviation: 3.44

This question sought to assess candidates' understanding of the mole concept, associated calculations and practical applications.

Overall, candidate performance was surprisingly weak. Many candidates were unable to define the term *mole*, limiting the term to atoms only. In the case of *molar mass*, the majority of candidates was able to define the term. However, there is concern that too many candidates found it challenging to provide a simple definition and to state the associated unit of g mol^{-1}.

The majority of candidates was also unable to correctly perform the calculation for Part (b), and very few candidates were able to obtain the five marks allocated to Part (c).

Expected Responses:

(b) (i) a) The number of moles M_2CO_3:
Number of moles HCl:

1000 cm^3 contain 0.150 mole

$\therefore$ 23.6 cm^3 HCl contain $\frac{0.150 \text{ moles x } 23.6 \text{ cm}^3}{1000 \text{ cm}^3}$

= 0.00354 mole

Moles M_2CO_3 = ½ x 0.00354 mole
= 0.00177 mole

(i) b) The relative molecular mass of M_2CO_3:

1000 cm^3 of M_2CO_3 contain 6.125 g
$\therefore$ 40 cm^3 of M_2CO_3 contain 0.245 g
So, 0.00177 mole of M_2CO_3 weighs 0.245 g

$\therefore$1 mole of M_2CO_3 weighs $\frac{0.245 \text{ g x 1 mole}}{0.00177 \text{ mole}}$

= 138.418 g

(ii) M_2CO_3 = 138.42 g
M_2 + 60 g = 138.42 g
M_2 = (138.42 – 60)g = 78.42 g
M = 39.21
M is potassium, K.

(c) 6.125 g of M_2CO_3 are weighed on an analytical balance and made up to 1 dm^3 in a volumetric flask.
Two 20 cm^3 portions are pipetted into a conical flask and methyl orange is added.
The mixture is titrated with the hydrochloric acid until the yellow indicator changes to pale pink.
The volume of acid used is noted.

It is recommended that teachers

- impress upon students that the mole is a *universal unit* describing the 'amount of substance' containing the Avogadro Number of particles
- provide students with adequate practice in the use of relevant concepts in solving mathematical problems
- ensure students' *continued* exposure to performing titration exercises which would allow them to describe in detail the use of a pipette, burette and associated apparatus.

Module 2: Kinetics and Equilibria

Question 2

Syllabus Objectives: 1.5-1.7; 3.1-3.7
Mean: 5.75; Standard Deviation: 2.93

This question tested candidates' understanding of the

- Bronsted-Lowry concept of acids and bases
- use of the initial rate method in determining the order of reaction and applied deductions
- experimental description of determining rate of reaction.

The majority of candidates' responses was weak and inadequate. Candidates obtained marks from responses to Part (a) relating to the theory of acids and bases, as well to Part (c) dealing with calculations based on information involving initial reaction rates.

In Part (b), most candidates were unable to provide a correct sketch to show the changes taking place during the titration of equimolar solutions of hydrochloric acid and aqueous ammonia. Candidates were expected to indicate the volume at which the rapid change of pH occurs and to recognize that aqueous ammonia is a weak base hence the end/equivalence point would be at a pH less than seven.

Most responses to Part (d) were very poor. Very few candidates were able to describe an alternate method for determining the rate of reaction requested.

Once more, there is an obvious lack of familiarity with the practical application of chemical concepts. Teachers are reminded that investigation is a vital part of the subject and are encouraged to reflect this in their teaching.

Additionally, corrective measures need to be implemented to help students fully grasp the concepts underlining the changes in pH during titrations including the effects produced by a consideration of the strengths of both acid and base.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 5.1, 5.2. 5.7, 5.10
Mean: 4.72; Standard Deviation: 2.58

This question focused on transition elements – their definition, electronic configuration and implications, compounds, ligand replacement reactions and shapes of complexes.

Candidates demonstrated great difficulty in answering this question. Most candidates were able to obtain marks for Parts (b) and (c) (i).

Candidates found it very challenging to give an adequate definition of *transition element*. The fact that the definition must include the notion of the formation of one or more ions with an incomplete d sub-shell was not appreciated leading to definitions which included the elements scandium and zinc!

Again, candidates' lack of practical experience was evident as the majority was unable to correctly identify the colour changes — pink, brown and blue — involved in the reaction of aqueous cobalt(II) compounds in environments of ammonia and chloride ions respectively.

The chemistry of the transition elements forms a relevant part of study in the present world system and teachers need to present this topic so as to highlight the many applications of these elements and their compounds in critical areas of life in the 21st century. An experimentally based approach offers a sound way of encouraging curiosity and interest in the various areas of

- defining concepts and terms
- applying chemical terms, electronic configuration to some chemical properties, for example, stability of varying oxidation states – Mn^{2+}/Mn^{3+} and Fe^{2+}/Fe^{3+}
- writing structures of complex ions and paying attention to bonds formed with coordination atoms of ligands involved
- deducing possible shapes of complexes with respect to the number of coordinating ligands.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 2.9, 2.10, 5.1-5.4
Mean: 6.20; Standard Deviation: 3.37

This question tested candidates' appreciation of the

- concept of hybridization in the tetravalent carbon atom,
- use of the VSEPR theory in explaining the bonding arrangements in molecules,
- ideal gases as described by kinetic theory with mathematical applications using the ideal gas equation.

Candidates’ performance was satisfactory in Parts (a), (b) (i) and (b) (ii). Candidates were able to obtain marks in the areas which required simple recall — electronic configuration of the carbon atom, assumptions of kinetic theory for ideal gases and the conditions under which gaseous behavior becomes non-ideal.

However, candidates showed great difficulty in clearly explaining the process by which the carbon atom showed tetravelency in the ethane molecule, as well as deducing the types of orbitals used and the arrangement of bonds formed as provided by the VSEPR theory.

Expected Response:

Each carbon atom has four bonded pairs. The extent of the repulsion between the bonding pairs result in a tetrahedral arrangement around each carbon atom with four equal bond angles of 109.5°.

Candidates also lost marks in the calculation by failing to convert the given information into appropriate units.

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 1.8, 5.1, 5.5
Mean: 4.89; Standard Deviation: 3.54

This question sought to assess candidates’ understanding of the concepts of solubility, solubility product with mathematical applications and the use of the distribution of energies of a gas to explain the relationship between temperature and reaction rates.

Again, candidate performance was weak. Several candidates lost marks for incomplete or partial definitions. On the other hand, candidates earned marks for the expression of the solubility product and sketches involving the distribution of energies of particles in a gas.

Candidates’ performance indicated superficial acquaintance with the subject matter in Part (b), However, a full comprehension of the concepts involved and the deductive reasoning skills required to correctly solve mathematical problems were not evident.

Expected Responses:

(b) (i) Solubility of lead (II) azide:

Molar mass $Pb(N_3)_2$
$= 207 + 2 \times (14 \times 3)$
$= 291$

$0.025\ g / 291\ g\ mol^{-1} = 8.59 \times 10^{-5}$

In 1000 cm^3:
$8.59 \times 10^{-5} \times 10 = 8.59 \times 10^{-4}$

(ii) Solubility product of lead (II) azide:
$K_{sp} = [Pb^{2+}]\ [N_3^-]^2$

(b) (iii) K_{sp} of $Pb(N_3)_2$

Let sol be s

$[Pb^{2+}]$ = s

$[N_3^-]$ = 2s

$s \times 4s^2$ = $4s^3$

$4 \times (8.59 \times 10^{-4})^3 = 2.54 \times 10^{-9}$ $mol^3\ dm^{-9}$

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 1.1, 1.4, 4.2
Mean: 2.95; Standard Deviation: 2.84

The focus of this question was the concept of polarization and its implication for the difference in pH of the aqueous solutions of the chlorides of sodium and aluminium, and the response required for the successful identification of the halide ion in the data analysis.

Part (b) was poorly answered. Candidates were unsure of the term *polarization* and as a result faced severe challenges in explaining the differences in pH between aqueous solutions of NaCl and $AlCl_3$.

Expected Responses:

(b) (i) Ionic size decreases from Na → Al.

(ii) An aqueous solution of sodium chloride contains hydrated ions producing a neutral solution (pH 7).

$NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$ **(1)**

The high charge/radius ratio of aluminium ion removes protons from water molecules producing an acid solution (pH 3).

$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightarrow [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

OR

$AlCl_3 + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3HC1(aq)$

Generally, candidates were unable to deduce the identity of the halide ion in Part (c). Candidates failed to appreciate the difference between the terms halogen and halide ion, referring repeatedly to iodide and bromide ions as iodine and bromine. Candidates, even at this level of study, continue to find difficulty writing balanced equations (both ionic and formula).

Expected Responses:

(c) (i) Iodide

(ii) $2\ RbI(aq) + Cl_2(aq) \rightarrow 2\ RbCl(aq) + I_2(aq)$

(iii) Add $Pb(NO_3)_2(aq)$ to solution of halide ion – a yellow precipitate will form.

Teachers need to

- devise strategies to explain clearly the concept of polarization as the distortion of an electric cloud by an adjacent ion or dipole — this in the context of electronegativity and polarity.
- foster the critical thinking skills of students so as to foster competence in problem solving.

Paper 032 – Alternate to School-Based Assessment (SBA)

Syllabus Objectives:
Mean: 20.46; Standard Deviation: 5.85

Question 1

This question required candidates to perform a volumetric analysis exercise involving a redox reaction. Candidates were asked to titrate stated volumes of a standard solution of thiosulfate ions with standard aqueous solution of iodate ions. They were then asked to determine the ratio of iodate to iodide ions and thus write the balanced equation between thiosulfate ions and iodine.

Expected Responses:

(c) Starch combines with the iodine in solution to form a blue – black complex which becomes colourless at the end point of titration.

(d) $I_2 + 2e^- \rightleftharpoons 2I^-$

(e) $2S_2O_3^{2-}(aq) + I_2(aq) \rightleftharpoons S_4O_6^{2-}(aq) + 2I^-(aq)$

Candidate performance was inconsistent. In the case of the actual titration, most candidates were able to obtain at least three out of the possible six marks; marks were lost for accuracy and failure to obtain consistent results. Candidates are reminded that volume observations must be recorded to two decimal places. Most candidates found the calculations a challenge and as a result not many marks were obtained. This is a weak area in candidates' knowledge and needs better preparation.

Expected Response:

(f) (i) 1000 cm^3 of thiosulfate contain 0.10 mole, V cm^3 of thiosulfate contain

$$\frac{0.10 \text{ mole x V cm}^3}{1000 \text{ cm}^3}$$

(ii) Based on the equation in (e) the number of moles of iodine produced is

$$\frac{\frac{1}{2} \text{ x } 0.10 \text{ moles x V cm}^3}{1000 \text{ cm}^3}$$

(f) (iii) Mole iodate ion present in 20.0 cm^3:

KIO_3 = 39 + 127 + 48 = 214 g
3.00 g = 3.00 g/214 g/mol^{-1}
= 0.014 mole
1000 cm^3 of iodate solution contain 0.014 mole

20.0 cm^3 of iodate solution contain

$$\frac{0.014\ \text{moles}\ \text{x}\ 20\ \text{cm}^3}{1000\ \text{cm}^3}$$

= 0.00028 mole

Number of moles iodine formed from one mole iodate:

0.00028 moles KIO_3 produce

$$\frac{\frac{1}{2}\ \text{x}\ 0.10\ \text{x}\ V}{1000}\ \text{mole}\ I_2$$

∴ 1 mole KIO_3 produce

$$\frac{\frac{1}{2}\ \text{x}\ 0.1\ \text{x}\ V}{1000\ \text{x}\ 0.00028}\ I_2$$

Question 2

This data analysis question tested the candidates' ability to

- read accurately volumes from a graduated gas syringe
- design a table to present the information obtained
- plot a graph of volume against time
- respond to queries about the rate of the reaction.

This question was answered satisfactorily. Candidates showed a reasonable level of competence in responding to the first three of the above objectives, which carried a total of nine marks. However, the response to the final objective, which included the calculation of rates and the effects of the various conditions on reaction rates, presented serious challenges.

Question 3

This question assessed candidates' level of competence in the skills associated with the planning and design (PD) of practical investigations. Candidates were asked to design an experiment to investigate the difference between the hardness of water in urban as distinct to rural environments.

Candidates' overall performance was very weak. While they were generally able to formulate appropriate hypotheses, producing corresponding aims presented some challenge. Candidates appeared to lack the relevant background knowledge to provide credible methods as the basis for providing answers to the questions of reagents and apparatus and procedures which involved the relevant variables.

This is an area which requires greater attention in developing the skills needed for candidates to acquire the competence to answer such questions satisfactorily.

UNIT 2

Paper 01 – Multiple Choice

Performance on this paper was very good — candidates responded to the majority of questions correctly. Candidates seemed to experience the greatest challenge with questions focusing on some aspects of spectroscopy (Module 2) and on free radical reactions on the upper atmosphere (Module 3).

Paper 02 - Structured/Essay Questions

Section A

Module1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 2.2, 2.4, 2.7, 2.13, 2.17, 3.2
Mean: 4.92; Standard Deviation: 2.84

This question assessed candidate competence in the areas of

- substitution in alkanes via chain reaction and the associated steps of initiation, propagation and termination,
- the source of the basic character of amines, their measurement in terms of K_b and pK_b
- the differences in basic strengths between aliphatic and aromatic amines (ethylamine/phenylamine) and amides (ethanamide).

Candidate performance was very inadequate. Candidates generally earned marks for

- stating the role of UV radiation in the above reaction in Part (a) (i)
- writing the expression for the dissociation constant of the amine RNH_2
- identifying ethylamine as a stronger base than phenylamine by virtue of their pK_b values.

Many candidates found it challenging to write equations which explain the propagation stage of the stated reaction, the difference in pK_b values of the above amines and the reduction in basic character of ethanamide.

Several candidates did not

- understand the relationship between basic strength and pK_b value with many failing to recognize that 'the greater the pK_b value, the lower the basic strength'.
- appreciate that the strength of aliphatic amines is enhanced by electron-donating groups in increasing electron availability at the nitrogen atom while the delocalization of the lone pair on nitrogen in the aromatic amines results in the opposite response.

Again, many candidates were ignorant of the reactions of the functional groups presented in Part (d). This recurring lapse underlines the absence of appropriate practical learning experiences.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 3.2, 3.3, 3.4, 3.5, 4.1, 4.2
Mean: 7.73; S.D.: 3.21

This question centered around the electromagnetic spectrum, and the relationship of frequency and wavelength. It also focused on the use of the gravimetric method in chemical analysis.

Candidates' responses to the various sections of the question were satisfactory. Many candidates showed familiarity with the different parts of the electromagnetic spectrum and were able to do the calculation requested.

In the case of the use of the gravimetric method, candidates were generally able to state the purpose behind the various stages of the procedure and the apparatus required.

Some candidates seemed to be confused about the relationship between wavelength, frequency and energy that was required in Part (b). In Part (c), the majority of candidates could not identify a use of gravimetric analysis in quality control.

Expected Responses:

(b) Using $C = \nu\lambda$

$\Rightarrow 3.0 \text{ x } 10^8 = 4.5 \text{ x } 10^{15}\lambda$

$\Rightarrow \frac{30 \text{ x } 10^8}{4.5 \text{ x } 10^{15}} = \lambda = 6.7 \text{ x } 10^{-8}$ m.

(c) Use of gravimetric analysis in quality control:
Air quality (detecting pollutants in air)
Assaying of minerals (determining composition of minerals) any other relevant use.

Many candidates were able to determine correctly the formula of $Na_2SO_4 . xH_2O$ using a number of differing approaches. The manipulation of the information using moles was good.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 1.1, 1.2, 4.1, 4.2, 4.3
Mean: 7.20; Standard Deviation: 3.81

This question tested candidates' knowledge of the Haber process and the application of Le Chatelier's principle in explaining the various conditions affecting the yield of the compound and the identification of the different steps in the production process.

Given the fact that this topic is a continuing one from CSEC, the overall performance was just satisfactory. Candidates were generally able to obtain marks for writing the relevant equation, stating the working conditions and suggesting factors influencing the siting of the plant.

However, marks were lost in the use of Le Chatelier's principle to explain the effect on yield with many responses presenting convoluting and contradictory statements. Candidates also failed to gain marks in the identification of the steps in the flow diagram of the manufacturing process.

Expected Responses:

(b) (i) The process is an exothermic process in the forward reaction to produce ammonia. An increase in temperature will result in the equilibrium position shifting to the left and a decrease in the yield of ammonia.

(ii) The forward reaction favours an increase in pressure due to lowering of the total number of molecules. There should be a higher yield of ammonia.

(c) (i) The processes are:
A – Steam reforming
B – Dissolving of CO_2 in water/caustic soda
D – Condensation

(ii) A catalyst (finely divided iron) is required.

(iii) Liquid (ammonia)

Teachers need to carefully review the teaching of the concept of chemical equilibrium which would allow students to clearly describe the effects of the various conditions affecting such equilibria which is at the core of the Le Chatelier's principle.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 1.6, 1.8, 2.7, 2.8
Mean: 4.77; Standard Deviation: 3.39

This question focused on the chemistry of halogenoalkanes — the three types, isomerism, and substitution reaction among others.

Generally, candidates were able to distinguish between primary, secondary and tertiary halogenoalkanes as well as to describe the result of the silver nitrate test. However, the other parts were very poorly done.

In Part (b), the majority of candidates misinterpreted the question as stated and hence deduced the isomerism as positional.

The question stated that 'Compound A was *one* of two…… bromoalkanes', hence this *one* compound existed in two isomeric forms. This would indicate that there were two compounds with the *same* molecular mass; the isomerism then would be optical and the Compound A would be 2-bromobutane.

Candidates were given credit for the positional isomerism response and provided that further responses were consistent, marks could be obtained. However, at this level, candidates should have been able to carefully read and interpret the statement as written.

In Part (c), the majority of candidates was unable to explain the mechanism involving the reaction with aqueous sodium hydroxide. The use of arrows to indicate the movement of electrons proved to be very challenging for candidates.

The above deficiencies need to be addressed by teachers and students preparing for this part of the course.

In Part (d), candidates were expected to indicate that a creamy yellow precipitate would be formed between a solution of D and aqueous silver nitrate represented by the following equation.

$$NaBr\ (aq) + AgNo_3\ (aq) \rightarrow NaNO_3\ (aq) + AgBr\ (s)$$

OR $$Br\ (aq) + Ag^+\ (aq) \rightarrow AgBr\ (s)$$

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 7.1, 7.2, 7.3
Mean: 5.51; 3.64

This question centered on mass spectrometry as an analytical tool and candidates were required to explain the various components of the mass spectrometer and the identification of the various fragments provided by the mass spectrum of a compound leading to the writing of its structural formula.

Generally, candidate performance was weak. There were inconsistent responses to the various sections of the question. Candidates were able to obtain at least two marks for describing the workings of the various parts of the spectrometer. Marks were also gained for recognizing that the (M+1) peak was related to the number of carbon atoms present in the compound and identifying some of the fragments involved.

In Part (c), candidates showed very weak deductive skills in answering the various parts of the question; they should be encouraged to identify the different fragments by writing their correct formulae.

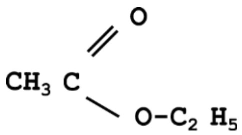
Expected Responses:

(c) (i) 88

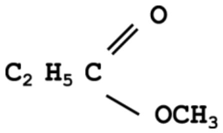
(ii) 43

(iii) $(CH_3.)+$
$(C_2H_5.)+$
$(CH_3CO.)+$

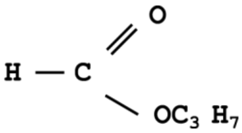
(iv)



(d)



or



Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 5.1, 5.4, 9.1-9.8
Mean: 6.82; S.D.: 3.34

This question tested candidates' understanding of the processes involved in the maintenance of the level of stratospheric ozone, the resulting effect on human life by its depletion, the fermentation process and its economic value to Caribbean countries.

Responses to Part (a) were quite modest. Candidates showed a superficial grasp of the processes of destruction of stratospheric ozone and hence were severely handicapped in the writing of the relevant equations. Part (a) (i) carried five marks and on average, candidates were only able to obtain about two of these marks. For Part (a) (iii), candidates were generally able to cite two effects of ozone depletion on human life.

For Part (b), it was surprising how many candidates found difficulty explaining the fermentation process and writing the equation for the production of alcohol.

Part (c) focused on the importance of the fermentation industry to Caribbean economies. Most candidates were able to obtain the three marks for commenting on this.

It should be noted that for CXC purposes, the term *comment* requires students to state an opinion or view and support it with appropriate reasons.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus Objectives: Mod 1-2.4; Mod 2-2.3, 2.4, 2.5
Mean: 21.00; S.D.: 7.39

Question 1

In this question candidates were asked to carry out a thermometric titration leading to the standardization of an aqueous solution of ethanoic acid.

Candidates' performance was satisfactory with candidates receiving most of their marks for the recording of observations of temperature and the plotting of the associated graph.

These two components carried a maximum of 11 marks out of a total of 18. The remaining components which involved knowledge of the theoretical basis of the investigation proved problematic and very few marks were obtained.

Question 2

This data analysis question concerned the accurate reading of burette readings in a volumetric analysis involving the titration of manganite(VII) and iron(II) ions leading to the determining of the percentage purity of an iron(II) compound.

General performance was weak. As in the corresponding question in Unit 1, most marks were gained in the reading of the specific instrument and the presentation of the acquired information. Most candidates were unable to carry out the required calculations, suggest the colour change at the end-point and describe the steps in making the standard solution of the iron(II) salt.

It is clear that candidates are not given adequate practical experiences and as such lack both the theoretical and practical competence to adequately deal with questions such as this one.

Expected Responses:

(a) (iii) $\frac{10.5 + 10.6}{2} = 10.55 \text{ cm}^3$

(iv) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$

(v) Concentration of $MnO_4^-(aq)$ = 0.02 mol dm^{-3}
Number of moles of MnO_4^- = $(10.55 \times 0.02 \times 10^{-3})$
Number of moles of $Fe^{2+}(aq)$ = $(5 \times 10.55 \times 0.02 \times 10^{-3})$

Number of moles of $Fe^{2+}(aq)$ in 1 dm^3

$$= \frac{5 \text{ x } 10.55 \text{ x } 0.02 \text{ x } 10^{-3}}{20}$$

$$= 5.275 \text{ x } 10^{-2} \text{ mol dm}^{-3}$$

Concentration of Fe^{2+} = $(5.275 \times 10^{-2} \times 56)$

= 2.95 g dm^{-3}

(vi) % Purity = $\left(\frac{2.95}{10} \text{ x } 100\right) = 29.5\%$

(b) Steps to prepare iron (II) sulfate solution:

- Dissolve the 10 g of $FeSO_4$ in minimum volume of H_2SO_4 in a beaker.
- Transfer quantitatively to a 1 dm^3 volumetric flask.
- Make up to mark with distilled water.
- Stopper and shake/invert to ensure thorough mixing.

Question 3

This question tested candidates' level of competence in the planning and designing of a practical investigation.

This question was poorly done by the majority of candidates. Most of them received marks for stating a hypothesis but thereafter, responses were very inconsistent resulting in an overall small number of marks.

Paper 031 – School-Based Assessment (SBA)

General Remarks

The overall level of compliance with the guidelines for the submission of samples for moderation continues to improve. However, as a reminder to teachers the following are to be noted:

- Samples submitted should correspond to those computer generated by the Council.
- Activities should be aligned to the syllabus objectives.
- Laboratory books must contain a table of contents with the date of the practical, the page number and the skills assessed. Where more than two practicals are assessed for the same skills, *the two to be moderated must be clearly identified.*
- Mark schemes should be detailed so as to facilitate the smooth and accurate process of moderation. This should include the names of unknown compounds and ions, observations and corresponding inferences used in qualitative and/or quantitative analysis.
- Marks awarded for calculations, writing of equations and discussions should be clearly indicated,
- Problem statements for Planning and Design (P/D) activities must be included as part of the mark scheme.
- Criteria for Manipulation and Measurement must also be submitted.
- Titles stating what is happening either in tables or graphs must be clearly written.
- Expected results and the marks awarded must be clearly stated in the mark scheme and indicated in the laboratory books as well.

Observation/Recording/Reporting, (O/R/R)

There continues to be improvement in the assessment of this particular skill and teachers are to be commended. The following points, however, needs repetition:

- In the reporting of qualitative analysis, the terms *no reaction*, *insoluble, soluble, acidic* and *basic* are not regarded as observations but inferences. The following should be used instead: *no observable change, no visible change, no apparent reaction, solid/precipitate dissolves.* In the case of *acidic* and *basic, the observations* resulting from the appropriate tests should be recorded.
- Discussions and conclusions, calculations and information obtained from graphs are all assessed as Analysis and Interpretation (A/I) and not as ORR.

Analysis and Interpretation (A/I)

The criteria testing this skill need to be more challenging — calculations based on volumetric analysis should go beyond simple acid/base and include redox and back titrations.

The use of questions based solely on theory is unacceptable for assessing this skill as it provides no measure of analysis or interpretation.

All calculations including units are to be checked carefully for each candidate.

Inferences must match the observations for the marks to be awarded.

Planning and Design (P/D)

Teachers continue to show improvement in the assessment of this skill, however, great difficulty is still being shown in the formulation of problem statements capable of generating hypotheses and variables.

Care must be taken to ensure that problem statements do not lead to students reproducing material directly from textbooks, for example, requiring students to plan and design an experiment to determine the order of reaction between iodine and propanone. This type of assignment will be deemed unacceptable.

Problem statements should allow for multiple hypotheses and methods and should consist of scenarios from which hypotheses and variables may be generated.

Many mark schemes tend to be extremely rigid and students are expected to use only one particular method; this tends to limit creativity.

Too much information is given to the students in the problem statements leading them to a particular solution.

Hypothesis should be clearly stated and substance(s) being measured must be quantified, that is, mass/concentration and so on, must be identified in the hypothesis as criteria being analyzed.

Expected results should explain how the data gathered can be used to refute or prove the hypothesis. Assumptions, Limitations and Sources of Error should not be assessed as one criterion; students should be taught to appreciate the differences and be assessed accordingly.

Care must also be taken to ensure that the various activities relate to relevant areas of the CAPE syllabus; activities involving objectives presented in Unit 1 should not be used as a Unit 2 assignment. For example, an assignment whose underlying theoretical basis centres on the identification of the alkene group is unacceptable for use as a Unit 1 exercise.

An example of an inappropriate PD problem statement is: “Jelees and Rhenez are in disagreement over the order of reaction of iodine in a reaction between iodine and propanone. Jelees thinks that the order of reaction with respect to iodine is first order, whereas Rhenez believes that the order of reaction with respect to iodine is second order. Plan and design an experiment to help them to settle this disagreement”. This problem statement is unacceptable since the scenario is not new/novel and requires no creativity on the part of the student as the answer can be lifted from a textbook.

Integrity of Samples

There was an unfortunate increase in the number of centres where teacher/student collaboration was evident. Teachers are therefore reminded that

- students are to engage in individual work, especially for discussion, calculation and P/D activities
- the SBA component of the CAPE course is intended to be developmental, involving continuous assessment of student skills and attitudes concerning a vital aspect of a chemist’s work – experimentation. *Teachers should therefore refrain from using the SBA as a summative assessment.*

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE
CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2015

CHEMISTRY

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules. For Unit 1, these are:

Module 1 – Fundamentals in Chemistry
Module 2 – Kinetics and Equilibria
Module 3 – Chemistry of the Elements

For Unit 2 the modules are:

Module 1 – The Chemistry of Carbon Compounds
Module 2 – Analytical Methods and Separation Techniques
Module 3 – Industry and the Environment

Both units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 031, the School-Based Assessment (SBA) is examined internally by teachers and moderated by CXC. Private candidates write Paper 032 which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031 comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 comprised three compulsory questions focusing on candidates' laboratory experiences.

The number of candidates who wrote the examinations was 5426 for Unit 1 and 3628 for Unit 2. Most candidates performed at an acceptable standard. Eighty-five per cent of candidates earned acceptable grades, Grades I-V for Unit 1, while 93 per cent earned acceptable grades for Unit 2. Too many candidates demonstrated a lack of facility with the appropriate technical language in their responses to questions, thus revealing a weak grasp of concepts and principles. Several candidates performed unsatisfactorily on questions which focused on experimental skills and practical experiences required by the syllabus, experiences which are expected to be garnered through consistent engagement with practical/laboratory exercises.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. Questions focusing on chemistry of the elements presented challenges for some candidates. The mean performance was 63 per cent with a standard deviation of 8.

Paper 02 – Structured/Essay Questions

Section A

Module 1: Fundamentals in Chemistry

Question 1

Syllabus Objectives: 6.3, 6.4, 6.5, 6.6, 6.9. Mean: 5.67 Standard Deviation: 2.95

This question sought to assess candidates' understanding of bond energy, associated calculations and practical applications.

Candidates' performance was weak. For Part (a) (i), most candidates were familiar with the term *bond energy* but there was the omission of *one mole* in the stated definitions. In Part (a) (ii), candidates related bond length to bond energy instead of the relationship between bond strength and its bond length.

For Part (b) (i), most candidates gave the correct balanced equation with state symbols. A number of candidates, in Part (b) (ii), thought that the enthalpy change of reaction should be calculated by using the expression $H_{products} - H_{reactants}$.

Expected Responses

(b) (ii) $\Delta H_{rxn} = \sum \Delta \text{ (bond breaking)} - \sum \Delta \text{ (bond forming)}$

$= (410 + 244) \text{ kJ mol}^{-1} - (340 + 431) \text{ kJ mol}^{-1}$

$= 654 \text{ kJ mol}^{-1} - 771 \text{ kJ mol}^{-1}$

$= -117 \text{ kJ mol}^{-1}$

OR

$(4 \times 410 + 244) \text{ kJ mol}^{-1} - (3 \times 410 + 340 + 431) \text{ kJ mol}^{-1}$

$= 1884 \text{ kJ mol}^{-1} - 2001 \text{ kJ mol}^{-1}$

$= -117 \text{ kJ mol}^{-1}$.

Very few candidates confused the terms *endothermic* and *exothermic* in Part (b) (iii). Most candidates had difficulty drawing the labelled energy profile diagrams in Part (b) (iv). Part (c) was the most challenging part of the question with most candidates earning one or two marks.

Candidates should

- practise to draw correctly labelled energy profile diagrams
- be exposed to practical activities involving thermochemical determinations
- be familiar with how to use the thermochemical data to perform calculations in the determination of enthalpy changes.

Module 2: Kinetics and Equlibria

Question 2

Syllabus Objectives: 6.1, 6.3, 6.4, 6.5. Mean: 6.10 Standard Deviation: 3.90

This question tested candidates' knowledge of the standard electrode potential and standard cell potential. Candidates' understanding of the structure and conditions of the operation of an electrochemical cell were also assessed as well as calculations to determine standard cell potentials.

Some candidates had a fair grasp of this topic. A few candidates wrote similar definitions for the standard electrode potential and the standard cell potential in Parts (a) (i) and (ii).

Some responses in Part (b) (i) lacked state symbols and very few candidates were able to write the correct cell diagram in Part (b) (ii). Most responses in Part (b) (iii) were correct with a few candidates omitting the concentrations of the solutions and the temperature. Most candidates identified the cell equations and did the calculations fairly well.

It is recommended that teachers

- highlight the differences between the standard electrode potential of a half cell and the standard cell potential of an electrochemical cell
- emphasize the importance of state symbols of the substances for the reaction taking place in an electrochemical cell
- explain the importance of the standard conditions required for the reaction in an electrochemical cell.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 3.3, 3.4, 6.2, 6.3. Mean: 4.07 Standard Deviation: 3.00

This question focused on the acid/base nature, thermal stability and the relative stabilities of the +2 oxidation state of the oxides of the Group IV elements. Candidates were also expected to write observations for the reactions of the Pb^{4+} and Pb^{2+} ions in aqueous solution with certain reagents.

A few candidates were able to answer Part (a) fairly well, but candidates demonstrated great difficulty in answering Parts (b) and (c).

Candidates demonstrated their confusion in the responses related to the acid/base nature of the oxides of Group IV elements. Part (b) was very challenging for most candidates. Although candidates were able to state that lead (II) was more stable than carbon (II), they were unable to provide acceptable reasons.

Candidates demonstrated that they had little experimental knowledge of the reactions given in Parts (c) (i) and (ii), but some candidates were able to describe the reaction in Part (c) (iii).

Again, this question demonstrated that students are not being exposed to practical activities which are outlined in the syllabus. Teachers should realize that if students are not involved in regular practical activities with practical discussion and reporting, then performance will continue to be poor for questions demanding practical knowledge.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 1.4, 1.8, 1.9. Mean: 6.87 Standard Deviation: 2.56

This question examined
- the phenomenon of radioactivity – the types and symbols of radiation
- the writing of equations representing nuclear reactions
- candidates' understanding of atomic orbitals – their shapes and orientation
- candidates' understanding of the arrangement of electrons in K, Sc and Zn^{2+}

Most candidates performed satisfactorily on Part (a) (i). However, candidates still had difficulty writing the correct nuclear equations in Part (a) (ii). Candidates were not able to draw the s and p orbitals with the appropriate axes in Part (b) (i).

Part (b) (ii), which required candidates to comment on the similarity and difference in the electronic configurations for K, Sc and Zn^{2+}, proved to be challenging for candidates.

The weaknesses demonstrated in this question shows that students are not given sufficient practice in writing nuclear equations and drawing the s and p orbitals as required in the syllabus. Teachers should ensure that students are given the required practice exposure in these areas.

Candidates also seemed unfamiliar with the word *comment*. Teachers should provide students with experiences which require statements of opinion with supporting reasons.

Expected Responses

(b) (ii) Similarity
- Identical arrangement for the first 18 electrons in each species.

Difference
- The single electron in the valence shell of K is in a 4s orbital, whilst the single electron for Sc resides in the 3d orbital.

Comments (any three)
- After 18 electrons, the electrons which follow fill the 4s before the 3d.
- Once the 3d are filled, 4s electrons are removed before the 3d, hence the Zn2+ arrangement.
- All three species have identical filled orbitals up to 3p6.
- $Zn2^{+}$ has no 4s electrons (due to their loss in the formation of Zn^{2+}).

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 4.1, 4.2, 4.3, 4.5. Mean: 3.41 Standard Deviation: 3.23

This question assessed candidates' understanding of the operation of buffer solutions, associated calculations to determine the pH and the practical applications of buffers.

Candidates' performance was very poor on this question. Candidates were unable to gain the six marks in Part (a) because they were unfamiliar with the hydrogen phosphate buffer and had difficulty explaining how the buffer maintains a constant pH if acid or base is added.

Some candidates were able to do parts of the calculations in Part (b). However, in Part (c), candidates again exhibited their lack of knowledge and understanding of biological buffers and how they work. Instead, candidates wrote irrelevant biological information.

Students continue to have difficulty explaining the nature and operations of buffers. Teachers should use the simple examples of buffers with the relevant equations and allow students to apply the principles of chemical equilibrium. Then actual examples of buffers in the body and those in industrial areas should be discussed.

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 2.1, 2.3, 2.4. Mean: 4.00 Standard Deviation: 2.91

This question sought to test candidates' knowledge and understanding of the trend of the physical and chemical properties of the Group II elements.

Candidates had some difficulty with the parts of this question. A few candidates exhibited a good grasp of the atomic and ionic radii in Part (a) and gave adequate explanations.

Candidates stated the trend in the variation of melting points of the Group II elements in Part (b) but did not give acceptable explanations. Candidates' responses for Part (c) and (d) were weak and inadequate.

Teachers should highlight those factors (for example, atomic radii, ionic radii, lattice energy, hydration energy polarization) which affect the solubility of the sulfates and the ease of decomposition of the nitrates.

Expected Responses

(c) Trend:

- The solubility of the sulfates decreases down the group.
- The large size of the sulfate anion and the slight increase in the size of the cations results in small decrease in lattice energy.
- The change in density of the cations decreases due to slight increase in the size of cations, and hydration energy decreases.
- The decrease in hydration energy becomes more significant than the decrease in lattice energy and the solubility of the metal sulfates decrease down the group.

(d) Metal nitrates become more thermally stable going down the group OR ease of decomposition decreases.

- Size of cations increases.
- As the size of cations increase, the large cations cannot polarize the large NO_3^- ion to break the bonds to form stable oxide compounds.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus Objectives: Module 1: 6.6, 6.9 Module 2: 1.3, 1.4, 1.5. Mean: 17.43
Standard Deviation: 7.30

Question 1

This question required candidates to determine the molar heat of solution of potassium nitrate. Candidates were asked to use a calorimeter to determine the temperature change when a given mass of potassium nitrate was dissolved in 50 cm^3 of water. Hence, they were to determine if the reaction was endothermic or exothermic, with the expected answer being endothermic.

Most candidates were not able to do the calculations in Parts (c), (d), (e) and (f) nor indicate that the reaction was endothermic in Part (b). Candidates demonstrated limited practical knowledge in responding to Part (g).

Expected Responses

(c) $Q = 54.75 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ C}^{-1} \times 9 \text{ }^{o}\text{C}$
$= + 2059.69 \text{ J}$

(d) $\triangle H_{rxn} = \frac{2059.69 \text{ J}}{4.75 \text{ g } KNO_3} = 433.61 \text{ J g}^{-1} \text{ } KNO_3$

(e) No. of moles of KNO_3
Molar mass of $KNO_3 = (39.10 + 14.01 + 48)$ g
$= 101.11$ g

$$\text{Moles of } KNO_3 = \frac{\text{Mass of } KNO_3 \text{ (g)}}{\text{Molar mass of } KNO_3 \text{ g mol}^{-1}}$$

$$\text{No. of moles of } KNO_3 = \frac{4.75 \text{ g}}{101.11 \text{ g mol}^{-1}}$$
$$= 0.0469 \text{ moles}$$

(f) Molar heat solution for KNO_3

$$= \frac{2059.69 \text{ J}}{0.0469 \text{ moles}} = 43916.63 \text{ J mol}^{-1}$$
$$= 43916.63 \text{ J mol}^{-1}$$

$$= 43.91 \text{ k J mol}^{-1}$$

(g) Any three

- Grind potassium nitrate to allow for faster dissolution to minimize heat loss.
- Use an electronic thermometer for more accurate temperature readings.
- Use heat capacity for solution of potassium nitrate.
- Weigh KNO_3 directly into the calorimeter to minimize error in mass of salt due to transfer.
- Experiment carried out in calorimeter.

Question 2

This data analysis question tested candidates' ability to perform the following:

- Design a table to present the information given
- Calculate ln of given values
- Plot a graph of ln P against time
- Respond to queries about the rate of the reaction.

This question was not answered satisfactorily. Some candidates were not able to calculate ln P and gave no value of ln P. The plots were therefore inaccurate. The responses to the other parts of the question, which included the calculation of rate constant, alternative method and safety precautions, presented serious challenges.

Expected Responses

(d) Rate constant k = − slope

$$\text{Slope} = \frac{\Delta Y}{\Delta X}\left[\frac{y_2 - y_1}{x_2 - x_1}\right]$$

$$\frac{\Delta Y}{\Delta X} = \frac{5.26 - 5.39}{150 - 100} = \frac{-0.13}{50\ (s)}$$

$= -2.6 \times 10^{-3}\ s^{-1}$

:. Rate constant $k = 2.6 \times 10^{-3} s^{-1}$

(e) One alternative method

- The partial pressure of C_2H_6 could have been monitored

  OR

- The partial pressure of N_2 could have been monitored.

(f) The pressure of the system must be monitored to prevent explosions.

Question 3

This question sought to assess candidates' ability to utilize the skills associated with the planning and design (PD) of practical investigations. Candidates were asked to design an experiment to investigate the acid/base nature of the oxides of Period 3 elements.

Candidates' overall performance was weak. They were able to formulate the appropriate hypothesis, but had difficulty writing the corresponding aim in Part (b). Candidates lacked the relevant practical knowledge to provide acceptable answers to the questions of reagents and apparatus, experimental procedures, the manipulated variables and to state the expected results.

Teachers should ensure that students are exposed to suitable planning and design exercises to develop those skills necessary to answer these questions satisfactorily.

UNIT 2

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. Some candidates continue to have difficulty with questions on mechanisms associated with the chemistry of carbon compounds and spectroscopy. The mean performance was 65 per cent with a standard deviation of 7.

Paper 02 – Structured/Essay Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 1.1, 2.2, 2.3, 2.4, 2.5. Mean: 5. 68 Standard Deviation: 3.18

This question sought to examine candidates' knowledge and understanding of
- some chemical reactions involving alkanes/alkenes
- hybridization
- free radical substitution mechanism of alkanes
- electrophilic addition mechanism involving alkenes including movement of electrons that are indicated by curved arrows and fish hook notation.

Candidates had difficulty answering this question. Candidates were able to identify the type of process, 'cracking' in Part (a) (i) but had difficulty stating the condition of the process in Part (a) (ii). It was clear that candidates had a challenge with writing condensed formula in Part (a) (iii) as most of them wrote the molecular formula instead. It was also challenging for candidates to explain the concept of hybridization in accounting for the tetravalency of carbon.

It was evident that the candidates had some knowledge/understanding of writing the mechanisms for free radical substitution and electrophilic addition in Part (b) (ii). Common errors included full arrows being used instead of fish hooks, and some carbon atoms given five bonds. The propagation step in the free radical substitution mechanism seemed most difficult for candidates.

The names of mechanism in Part (b) (iii) were incorrectly given as 'radicle substitution', nucleophic addition/nucleophilic substitution or 'halogenation'.

For Part (c), candidates were not able to describe the colour changes of the reactions outlined.

Teachers should ensure that
- students have adequate practice in writing organic mechanisms with the appropriate arrows
- the phenomenon of hybridization is emphasized to account for the tetravalency of carbon
- students are exposed to appropriate practical exercises to observe the reaction changes.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 1.1., 2.2., 2.3, 2.4, 2.5. Mean: 6.85 Standard Deviation: 2.52

This question focused on

- the effect of practical operations on accuracy and precision
- the characteristics of primary standards
- the use of data from thermometric titration to determine the end point graphically
- experimental steps in a thermometric titration.

Candidates performed fairly well on this question — Parts (a) (i) and (ii) were the least known. They were able to state two characteristics of primary standards in Part (b) and were also able to plot the graph and determine the end point in Part (c). Some candidates were able to describe the experimental steps for the thermometric titration in Part (d).

It is obvious that candidates have been exposed to the thermometric method for titration but have little knowledge about the factors which can affect accuracy and precision. Teachers need to address this deficiency.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 1.2, 7.1, 7.2, 7.3. Mean: 6.32 Standard Deviation: 3.54

This question sought to test candidates’ knowledge of the contact process and the application of Le Chatelier’s Principle in explaining the conditions for the yield of sulfuric acid as well as safety considerations.

Candidates’ responses were adequate but disappointing. For Part (a), candidates’ responses were acceptable. However, some candidates said that the rate of production of SO_3 could be improved by an increase in the temperature.

Candidates were able to state Le Chatelier’s Principle and the general conditions of temperature and pressure for Parts (b) (i) and (ii).

A number of candidates did not indicate that the SO_3 was added to concentrated sulfuric acid in Part (b) (iii) and many candidates lost marks for incorrect state symbols in Part (b) (iv). Part (b) (v) was misinterpreted and was poorly done.

In teaching the concept of chemical equilibrium, teachers should emphasize the conditions of temperature and pressure, and the effect of a catalyst necessary for maximum yield of the main product in industrial processes. Other conditions should also be considered on the chemical equilibrium of the industrial system.

Expected Responses

(a)

- Increased pressure
- Increased concentration of reactants
- Increased temperature
- Use of a catalyst

(b) (i) Le Chatelier's Principle: If one or more factors that affect an equilibrium are changed, the position of equilibrium shifts in the direction which opposes the change.

(b) (ii)

- Low temperature
- High pressure

(b) (iii)

- The sulfur trioxide is dissolved in concentrated sulfuric acid to form oleum.
- The oleum is diluted with water to form concentrated sulfuric acid.

(b) (iv)

$H_2SO_{4\,(l)} + SO_{3\,(g)} \rightarrow H_2S_2O_{7\,(l)}$

$H_2S_2O_{7\,(l)} + H_2\,O_{(l)} \rightarrow 2H_2SO_{4\,(l)}$

(b) (v) Safety considerations:

- Reaction between SO3 and water is highly exothermic.
- Clouds of sulfuric acid are produced.
- Sulfuric acid can cause burns to the skin/flesh.
- Sulfuric acid can also cause blindness if it gets into eyes.
- Appropriate use of protective gear.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6. Mean: 5.54 Standard Deviation: 3.28

This question focused on addition and condensation polymerization as well as the deduction of the monomers for a given polymer. Candidates had difficulty answering parts of this question.

Candidates showed a lack of understanding in their responses to the differences between the two types of polymerization in Part (a).

Candidates' knowledge of naturally occurring polymers was limited and included inappropriate examples for Part (b).

Candidates had great difficulty drawing the structures for monomers and polymers in Part (c). It was also very difficult for candidates to decide the structural formulae of the monomers for the repeating unit of the polymeric substance in Part (d).

It is obvious that students are not exposed to sufficient practice in drawing the structural formulae for these molecules. Teachers should ensure that students have adequate practice in drawing the displayed structural formulae of these molecules.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 8.1, 8.2, 8.3, 8.4, 8.5, 8.6. Mean: 5.85 Standard Deviation: 3.36

This question assessed candidates' understanding of chromatography, associated calculations, of thin and column chromatography.

Overall, candidates' performance was unsatisfactory. They performed fairly well on the calculations in Part (b) (ii) and stated the reasons for the differences in the answers in Part (b) (iii). However, their understanding of the process of chromatography was limited in Part (a) and candidates also had great difficulty answering Part (c).

Students exhibited their unfamiliarity with the term *assess* and teachers again need to provide appropriate questions using these terms so that students are better able to interpret exactly what is expected.

Assess means comparing the advantages or disadvantages or the merits or demerits of a particular structure, relationship or process (CAPE Syllabus, 2006).

Expected Responses

(c) Thin layer chromatography:
Separates small amounts of compounds (dyes, amino acids, plant pigments).

- Less useful if quantification of large amounts are required.
- Cannot separate compounds of similar R_f values.
- Samples can be removed from analysis.

Column chromatography:

- Large amounts of material can be separated and collected.
- Large columns can be used for purification.
- Can be used to prepare compounds.
- Fractions can be collected for analysis.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 6.1, 6.4, 9.2, 3.3. Mean: 7.26Standard Deviation: 4.10

This question tested candidates' ability to

- describe the production of chlorine by drawing an annotated diagram of the diaphragm cell
- explain the health concerns associated with the disposal of the diaphragm cell
- assess the impact of CFCs and CO_2 on the environment.

Overall, the performance of candidates was not satisfactory.

Response to Part (a) was quite limited. Candidates showed superficial knowledge of the structure of the diaphragm cell which was also reflected in their labelling of the cell. However, most candidates were able to provide acceptable responses to Parts (b), (c) (i) and (ii).

Teachers are urged to encourage students to draw and label simple industrial apparatus/equipment for industrial processes.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus Objectives; Module 1: 2.6, 2.9 Module 2: 2.1, 2.2, 2.4. Mean: 14.50
Standard Deviation: 5.95

Question 1

Candidates were asked to carry out a series of tests on three unknown substances A, B, and C — a ketone, an aldehyde and an alcohol respectively.

Performance was satisfactory with candidates receiving most of their marks for the observations with the different reagents. The remaining components which involved identification of samples and reasons for deductions proved to be difficult for candidates, and very few marks were obtained.

Question 2

This data analysis question involved the accurate reading of burette readings in the titration of manganate (VII) and sodium oxalate for the standardization of the potassium manganate (VII) solution. In general, performance was weak. Most marks were gained in the recording of the burette readings and the presentation of these readings.

Most candidates were unable to suggest the reason for using sodium oxalate as a standard, carry out the required calculations, suggest the colour change at the endpoint and describe the steps in the titration process. It is clear that candidates are not given adequate practical exposure and as such lack both the theoretical and practical knowledge to adequately deal with the question.

Expected Responses

(a) (ii) Sodium oxalate is used as a primary standard because
- of its high state of purity or
- of its stability in the atmosphere or
- it is unaffected by light.

(d) 1 Mole $Na_2C_2O_4$ = 23 x 2 + 12 x 2 + 4 x 16
= 46 + 24 + 6
= 134 g mol^{-1}

$$\text{Moles oxalate} = \frac{1.65\,g}{134\quad g\,mol^{-1}}$$
= 0.0123 moles

250 cm^3 of oxalate contain 0.0123 moles
1000 cm^3 contain (0.0123 × 4) moles
= 0.0492 moles

(e) $5C_2O_4^{2-}(aq) + 2MnO_4^{-}(aq) + 16H^{+}(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O_{(l)}$

(f) 25 cm^3 oxalate contain $0.492\ \frac{\times 25}{1000}$
= 0.00123 moles

:. Moles MnO_{4^-} = 2/5 x 0.00123 moles

25.45 cm^3 of MnO^{4-} contain 0.000492 moles

:. 1000 cm^3 contain 0.0193 mol dm^{-3}

Concentration is 0.0193 mol dm^{-3}.

Question 3

This question tested candidates' level of competence in the planning and design (PD) of a practical investigation.

Candidates' performance on this question was poor. Marks were obtained for stating a hypothesis, but responses thereafter were limited and inadequate.

Again, the poor performance on this question is due to limited practical activities. Improvements will only be possible with regular practical activities as assigned in the syllabus.

Paper 031 – School-Based Assessment (SBA)

One hundred and ninety centres were moderated for Unit 1 and 182 for Unit 2.

Most centres complied with the guidelines for the submission of samples and mark schemes for moderation. The samples submitted were those generated by the online registration system (ORS) of the Council. Nevertheless, teachers are reminded of the following:

- Activities should be aligned to the syllabus objectives for the specific unit and aimed at the CAPE level.
- Laboratory books must contain a table of contents with the date of the practical, the page number and the skills assessed. Where more than two practicals are assessed for the same skills, the two to be moderated must be clearly identified.
- Mark schemes should be detailed so as to facilitate a smooth moderation process. They should include the names of unknown compounds and ions, observations and corresponding inferences used in qualitative and/or quantitative analysis.
- Marks awarded for calculations, writing of equations and discussions should be clearly indicated.
- Problem statements for planning and design (P/D) activities must be included as part of the mark scheme.
- Criteria for manipulation and measurement must also be submitted.
- Titles stating what is happening either in tables or graphs must be clearly written and self-explanatory.
- Expected results and the marks awarded must be clearly stated in mark schemes and indicated in the laboratory books as well.
- The criteria must vary for each skill that is being assessed.
- The conclusion is not to be marked as part of ORR.
- A discussion should not be included as part of PD.
- The theoretical aspect of the syllabus should not be assessed in laboratory activities unless it relates specifically to the observations recorded.
- Where there is more than one teacher for a particular centre, there needs to be greater collaboration. Students should all be doing the same practical activities and a common mark scheme for the centre should be submitted.

Observation/Recoding/Reporting (ORR)

There has been improvement in the assessment of this particular skill and teachers are to be commended. The following points, however, need attention:

- In the reporting of qualitative analysis, *no reaction, insoluble, soluble, acidic and basic* are not regarded as observations but inferences.

The following should be used instead: *no observable change/no visible change/no apparent reaction, solid/precipitate dissolves.*

- Discussions, conclusions, calculations, writing chemical equations and information obtained from graphs are all assessed as analysis and interpretation (A/I) and not as ORR.
- Appropriate mark schemes should be confined to approximately 20 marks to be prorated.
- Expected observations are to be included in the mark scheme and the marks awarded for each observation clearly indicated in the mark scheme.
- The recommendation is for each skill to be assessed by three laboratory activities (ideally two).

Analysis and Interpretation (A/I)

- The criteria testing this skill need to be more challenging — calculations based on volumetric analysis should go beyond acid/base and include redox and back titrations.
- The use of questions based solely on theory is unacceptable for assessing this skill as it provides no measure of analysis or interpretation.
- All calculations including units are to be checked carefully for each student.
- Inferences must match the observations for the marks to be awarded.
- The criteria for each A/I assessed must be varied rather than all being solely based on calculations; interpretations of graphs and inferences should be included as part of the assessment.

Planning and Design (P/D)

- Although there has been some improvement in the assessment of this skill, teachers still have great difficulty in formulating problem statements capable of generating hypotheses and variables.
- Care must be taken to ensure that problem statements do not lead to students reproducing material directly from textbooks, for example, requiring students to plan and design an experiment to determine the order of reaction between iodine and propanone. These type of assignments will be deemed unacceptable.
- Problem statements should allow multiple hypotheses and methods, and should consist of scenarios from which hypotheses and variables may be generated. Many mark schemes tend to be extremely rigid and students are expected to use only one particular method — this tends to limit creativity.
- Too much information is given to the students in the problem statements; leading them to a particular solution.
- Hypotheses were *not* clearly stated (substance(s) being measured must be quantified, that is, mass/concentration etc. must be identified in hypotheses as criteria being analysed).
- Discussion and conclusions are not to be included.
- Expected results should explain how the data that would be gathered can be used to refute or prove the hypothesis.
- Assumptions, limitations and sources of error should not be assessed as one criterion; students should be taught to appreciate the differences and be assessed appropriately.
- Students should not include data in tables for this skill.

- Care must also be taken to ensure that the various activities relate to relevant areas of the CAPE syllabus — activities involving objectives presented in Unit 1 should not be used as a Unit 2 assignment.
- An example of an inappropriate PD statement is:

  Jelees and Rhenez are in disagreement over the order of reaction of iodine in a reaction between iodine and propanone. Jelees thinks that the order of reaction with respect to iodine is first order whereas Rhenez believes that the order of reaction with respect to iodine is second order. Plan and design an experiment to help them to settle this disagreement.

  The problem statement is bad since the answer can be lifted from a textbook.

Integrity of Samples

Teachers are reminded that the SBA component of the CAPE course is intended to be developmental, involving continuous assessment of student skills and attitudes concerning a vital aspect of a chemist's work — experimentation. They should therefore refrain from using the SBA as a form of summative assessment.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATIONS

MAY/JUNE 2016

CHEMISTRY

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules. For Unit 1, these are:

Module 1 – Fundamentals in Chemistry
Module 2 – Kinetics and Equilibria
Module 3 – Chemistry of the Elements

For Unit 2, the modules are:

Module 1 – The Chemistry of Carbon Compounds
Module 2 – Analytical Methods and Separation Techniques
Module 3 – Industry and the Environment

Both units are examined by three papers. Paper 01 and 02 are external examinations while Paper 031, the School Based Assessment (SBA), is examined internally by teachers and moderated by CXC. Private candidates write Paper 032, which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to candidates’ grades on the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to candidates’ grades on the unit.

Paper 031 comprised laboratory exercises and contributed 20 per cent to grades on this unit. Paper 032 comprised three compulsory questions focusing on candidates’ laboratory experiences.

The number of candidates who wrote the examinations was 4897 for Unit 1 and 3677 for Unit 2. Eighty per cent of the candidates earned acceptable grades (Grades I – V) for Unit 1, while 86 per cent earned acceptable grades for Unit 2.

Candidates’ responses in some modules demonstrated limited development of certain knowledge, critical skills and abilities that are emphasized by this CAPE subject. Several candidates demonstrated limited experimental knowledge and skills on questions which required practical knowledge and experiences as outlined in the syllabus.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. However, questions focusing on fundamentals of chemistry presented challenges for some candidates. The mean score on this paper was 63 per cent with a standard deviation of 9.

Paper 02 – Structured Essay Questions

Section A

Module 1: Fundamentals in Chemistry

Question 1

Syllabus Objectives: 1.1, 4.1, 4.2, 4.3; Mean: 5.29; Standard Deviation: 2.87

This question tested the candidates' knowledge and understanding in the content areas of atomic theory, redox reactions and the oxidizing ability of the halide ions.

Candidates demonstrated a fair grasp of these content areas. A number of candidates were able to obtain the maximum scores in Part (a) (i) and Part (a) (ii). However, many candidates lost marks due to their incomplete expressions of the postulates of Dalton's Atomic Theory. For example, candidates omitted descriptive terms such as 'same' when writing that *atoms of the same element are identical in mass and properties*, and the term 'different' when writing that *different atoms combine in simple whole number ratios to form compounds*.

In Part (b) (i), while many candidates were able to correctly identify the Cr^{3+} ion, very few candidates were able to correctly deduce the overall balanced equation for the redox reactions.

Part (c) was answered well. Some candidates wrote the name of the white precipitate given in Part (c) (i) and Part (c) (ii) instead of giving the inference deduced from the presence of the precipitates observed.

- Teachers are encouraged to emphasize the importance of all relevant terms in the discussion of chemical theories, as the omission of just one critical term can change the meaning of a statement and make the answer either incomplete or incorrect.
- Candidates should carefully read the stem of questions, which usually provides many clues to the correct answer. Half the reaction for the dichromate (VI) ion was already provided in Part (b), while the stem of Part (b) of the question contained many clues as to how the sulfate (IV) ion would react.

Module 2: Kinetics and Equilibria

Question 2

Syllabus Objectives: 3.1, 3.2, 3.3, 3.6; Mean: 5.98; Standard Deviation: 3.76

This question sought to assess candidates' knowledge and understanding of weak acids, the equilibrium constants associated with acids, as well as calculations of the pH of a weak acid. The question also tested the candidates' practical knowledge of how to determine the acid content of a named drink.

Some candidates had a fair grasp of this topic. The majority of candidates were able to write the correct definitions required for Parts (a) (i) and (ii).

Most candidates wrote the correct balanced equation required for Part (b) (i). However, some candidates wrote the formula for the carbonate ion as one of the products, although the question stated that the hydrogen carbonate ion was produced. Candidates were also able to write the correct K_a expression for Part (b) (ii). A few candidates were unable to calculate the hydrogen ion concentration.

Part (c) was challenging for most candidates. Candidates were unable to outline the appropriate experimental steps required for the titrimetric analysis of the club soda. The candidates demonstrated that they had little experimental knowledge of titrations and the selection and colour changes of appropriate indicators based on the nature of the strengths of the acid/base combination.

It is recommended that teachers:

- provide practical exercises which allow candidates to identify the effectiveness of different indicators as related to the pH changes which occur during titration.
- emphasize the basis for the selection and colour changes of acid-based indicators for use in titrations.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 1.1, 1.4, 1.5; Mean: 4.05; Standard Deviation: 3.35

This question focused on the chemistry of the Period 3 elements. Candidates were expected to show their understanding of the relationship between the melting points of the elements and the elements' structure and bonding. Candidates were also expected to describe, with appropriate equations, the reactions of the oxides and chlorides of some of the elements of Period 3.

The performance of the candidates on this question was poor. Candidates were unable to give complete explanations for the various phenomena described in Parts (a) (i) to (a) (iii). This revealed a lack of knowledge of the reasons for the observed properties of the elements of Period 3.

In Part (b), candidates either did not describe appropriately the type of reaction obtained between the oxides and water or they did not know the pH of the resulting solution. Candidates gave very few correct responses detailing the balanced equations for these reactions.

Candidates were unable to correctly write the balanced equations for the reactions of the chlorides with water in Part (c). Not many candidates obtained full marks in this part of the question.

Teachers should:

- provide practical exercises which demonstrate the reactions of the oxides and chlorides of the elements of Period 3.
- allow candidates to write observations and balanced equations for these reactions.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.11; Mean: 3.67; Standard Deviation: 2.88

This question examined the concepts of:

- ionic and covalent bonding
- the differences in physical properties in ionic and covalent species
- the origin of intermolecular forces as well as the shapes of molecules.

Candidates did not perform well on this question. In Part (a) (i) and Part (a) (ii), only a few candidates were able to achieve full marks. Some of the challenges revealed by candidates' responses were:

- inability to indicate that loss of electrons led to positive ions and gain of electrons led to negative ions
- lack of recognition that covalent bonding will not exist between a nonmetal and a metal
- difficulty in explaining the ionic bond as the electrostatic attraction between oppositely charged ions
- lack of knowledge of the number of pairs of electrons being shared between the two iodine atoms
- confusion as to what exactly are van der Waals forces
- inability to identify the properties of ionic and molecular species.

In Part (b), only a few of the candidates produced correct responses. Candidates appeared to be very confused as to what feature of the molecules was truly responsible for the observed phenomenon in Part (b) (i). Candidates demonstrated a weak understanding of the hydrogen bond. For Part (b) (ii), candidates' knowledge of the dative covalent bond responsible for the formation of H_3NAlF_3 was also very weak. Many candidates failed to earn full marks due to the omission of the lone pairs of electrons present on the nitrogen in their formula of NH_3.

Part (c) was generally answered very well.

Expected Response:

(a) (i) Potassium Chloride

- Each potassium atom donates an electron to each chloride atom, forming potassium and chloride ions.
- The oppositely charged ions are held together by strong electrostatic forces called ionic bonds.

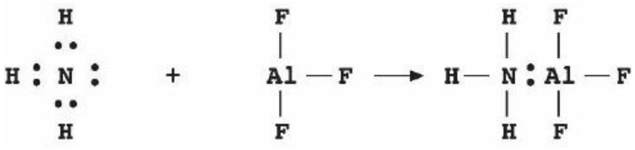
Iodine

- Two iodine atoms share a pair of electrons to form a covalent bond.
- The iodine molecules formed are held by intermolecular forces/van der Waals forces.

(b) (i) The oxygen atom is more electronegative than the sulfur atom.

- The dipole – dipole attractions/hydrogen bonds between the molecules are stronger in water than in hydrogen sulfide.
- The stronger hydrogen bonds in water result in higher boiling temperatures.

(b) (ii) The lone pair of electrons on the nitrogen atom of the ammonia molecule allows for the dative covalent bonding of the nitrogen atom in ammonia to bond to aluminum fluoride.



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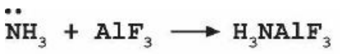


$$\overset{\bullet\bullet}{N}H_3 + AlF_3 \longrightarrow H_3NAlF_3$$

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7; Mean: 4.84; Standard Deviation: 3.56

This question sought to assess candidates' comprehension of a number of concepts related to the topic of chemical equilibrium. These included:

- the characteristics of a reaction in dynamic equilibrium
- the equilibrium constant expression, K_p
- the factors which affect a reaction in equilibrium
- the effect of temperature changes on the equilibrium of a reaction and its K_p value
- calculations involving K_p.

Most candidates showed limited understanding of the concepts examined and this resulted in an overall weak performance. Only a few candidates were able to give four correct characteristics of a reaction in a state of dynamic equilibrium in Part (a) (i).

Candidates had difficulty writing the correct equilibrium constant expression for Part (a) (ii). Candidates sometimes used square brackets with the partial pressure notation. The majority of the candidates were able to state only one correct factor, which does not affect equilibrium.

Parts (b) (i) and (ii) proved to be challenging for the candidates. The responses showed that candidates were having difficulty with the application of Le Chatelier's Principle.

Candidates also had difficulty with the calculations in Part (c). Most candidates either did not attempt to perform the calculations, or when done, the calculations of the equilibrium concentrations or equilibrium partial pressures were incorrect. It is evident that more time and practice are required in this topic.

Expected Responses

(c) P = total pressure = 1 atm

$$H_{2\,(g)} + I_{2(g)} \rightleftharpoons 2HI_{\,(g)}$$

	$H_{2\,(g)}$	$I_{2(g)}$	$2HI_{\,(g)}$
Initial	0.5 mol	0.5 mol	0 mol
Equil $^{n/}$	0.11 mol	0.11 mol	0.78 mol

Equilibrium partial pressures

Mole fraction x total pressure

$$H_2 = \frac{0.11}{1} P = 0.11$$

$$I_2 = \frac{0.11}{1} P = 0.11$$

$$HI = \frac{0.78}{1} P = 0.11$$

$$Kp = \frac{(0.78)^2}{(0.11)^2} = \frac{0.6084}{0.0121} = 50$$

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 5.1, 5.2, 5.4, 5.9, 5.10; Mean: 3.90; Standard Deviation: 3.19

This question tested the candidates' knowledge of:

- the characteristics and electronic configuration of the first row transition metals
- the formation of coloured ions by transition metals
- the principle of ligand exchange and the description of a reaction illustrating ligand exchange.

The majority of candidates did not have a good grasp of this topic. However, a few candidates demonstrated a satisfactory level of comprehension in this content area. Most of the candidates were able to list four correct properties of transition elements in Part (a).

Some candidates had difficulty writing the correct electronic configuration for the Ti^{3+} ion in Part (b) (i). Teachers should ensure that their students understand how the electrons in the atoms of elements fill the increasing energy levels for the elements in Periods 1 to 4.

Although most candidates were able to indicate the splitting of the d-d orbitals in Part (b) (ii), there was no mention that the splitting of the d orbitals was caused by the water ligand attached to the Ti^{3+} ion. Some candidates correctly explained that the colour observed was due to the absorption of energy from the visible region, which resulted in the colour seen. However, other candidates explained that the colour seen was due to the emission of energy. Candidates' responses indicated confusion in this area.

A full description of the colour changes when concentrated hydrochloric acid is added to aqueous Co^{2+} was not forthcoming in Part (c) (i). The common errors in Part (c) (ii) in writing the equation for the reaction in Part (c) (i) were

- incorrect formulae
- unbalanced equation
- no physical states included.

For Part (c) (iii), most candidates could not use the stability constant to explain the changes which occurred when concentrated hydrochloric acid was added to the aqueous Co^{3+} ion. Candidates were not familiar with this concept and had difficulty applying the concept to the changes in the reaction.

Summary

Candidates' responses to the questions in Unit 1 revealed that there are some fundamental concepts which have not been adequately grasped, resulting in an overall weak performance. Candidates continue to have difficulty:

- writing balanced chemical equations with the appropriate physical states
- using chemical/technical language related to various topics
- demonstrating adequate practical knowledge and experience.

It is obvious that candidates have limited practical knowledge and experience of experiments which should have been done in the school-based assessment section for this Unit.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus Objectives: Module 1: 3.8, 3.9; Module 2: 1.3, 1.4, 1.5, 1.7;

Mean: 19.37; Standard Deviation: 8.45

Question 1

This question tested candidates' ability to execute the process skills associated with the successful completion of an exercise in volumetric analysis to determine the concentration and the percentage purity of a solution of iron (II) sulfate heptahydrate.

Candidates' performance on the actual titration was satisfactory; however, some difficulties were experienced in the required calculations. Despite clear instructions to candidates that all values (weights as well as titration volumes) were to be recorded to two decimal places, a significant number of candidates still reported values to only one decimal place. The majority of candidates were unable to correctly perform the calculations required in Parts (d) through (g).

Question 2

This question utilized the data analysis format and investigated the disintegration of photogenerated complex, A, and tested the candidates' ability to

- tabulate data of concentration and time provided
- plot a graph of concentration vs time
- determine, from the graph, the times for various concentrations of A
- deduce the order of the reaction and the units for the rate constant
- write an expression for the rate law for the disintegration of A.

Most candidates were able to correctly tabulate the data provided; however, a significant number of candidates exhibited difficulty in drawing the required graph – particularly in the areas of choosing an appropriate scale and labelling the axes. Very few candidates were able to correctly deduce the order of the reaction and hence write the correct expression of the rate law.

Question 3

This question focused on the planning and designing of an experiment to investigate the variation in the catalytic activity of two oxides, namely manganese (IV) oxide and copper (II) oxide. The main areas of concern were the writing of the appropriate hypothesis in Part (a), the identification of the various variables in Parts (e) (i), (ii) and (iii) and the writing of an appropriate procedure in Part (d).

UNIT 2

Paper 01 – Multiple Choice

Performance on this paper was fairly good. Some candidates were able to answer most of the questions correctly. Candidates continue to have difficulty with questions on the chemistry of carbon compounds and analytical methods and separation techniques. The mean score was 61 per cent with a standard deviation of 7.27.

Paper 02 – Structured/Essay Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 1.4, 1.5, 1.6, 1.9; Mean: 4.01; Standard Deviation: 3.14

In this question, candidates were expected to demonstrate their knowledge and understanding of the general topic of the chemistry of carbon compounds, with specific emphasis in the areas of isomerism, determination of chemical formulae from experimental data, and selected reactions of alcohols.

The performance of the candidates on this question was weak. The majority of candidates, nevertheless, were able to correctly answer Part (a).

However, a substantial number of candidates were unable to correctly determine the formula of the hydrocarbon from the experimental data provided in Part (b) (i). The main problem was the candidates' inability to determine the correct volume of carbon dioxide produced in the reaction and this led to an incorrect ratio of reactants to products. Some of the candidates correctly determined the formula, but were unable to earn marks in Part (b) (ii) as they drew the condensed formula and not the displayed formula as requested.

A fair number of candidates were able to correctly draw and name the requested isomers of Parts (c) (i) and (c) (ii). However, a substantial number of candidates exhibited difficulty in distinguishing between the cis and trans isomers as requested in Part (c) (ii).

Candidates generally found Part (d) to be very challenging. Part (d) required candidates to demonstrate practical knowledge of the types of alcohol by writing appropriate tests and the required observations of the reactions. It was obvious of the candidates had very limited knowledge about the content tested in this part of the question.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 6.1, 6.2, 6.3, 6.4; Mean: 4.78; Standard Deviation: 3.35

This question focused on

- the origin of absorption in infrared (IR) spectroscopy
- the properties of compounds which absorb IR radiation
- the use of IR spectra to deduce the functional groups present in organic compounds
- the basic steps involved in analysing samples by IR spectroscopy
- the limitations associated with the use of IR spectroscopy.

A few candidates demonstrated a good grasp of this topic. In Part (a), most candidates were able to explain the origin of IR absorption by compounds.

For Part (b), most candidates were able to state that the compounds must have a dipole, but were unable to state the other property which indicates that there must be a change in the dipole.

The majority of candidates were able to identify the group associated with the values given in Part (c) (i). However, for Part (c) (ii) only a few candidates were able to accurately name the compound Y- and draw its displayed formula.

A fair number of candidates were able to describe the steps in the preparation of the sample for analysis in Part (d). Only a few candidates, however, could indicate a limitation of IR spectroscopy in Part (e).

Teachers should ensure that students

- understand the differences between displayed and condensed formula
- have adequate practice in writing the displayed and condensed formula for organic compounds.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 7.3, 8.3, 8.4, 8.5, 8.6; Mean: 6.40; Standard Deviation: 3.42

This question sought to assess candidates’ knowledge of the issues related to water pollution, namely the sources of water pollution and the effects of these pollutants on aquatic life. Candidates were also required to write chemical equations detailing the formation of sulfuric acid (in acid rain).

Candidates’ performance on this question was acceptable. Most candidates were able to gain the majority of marks for Parts (a), (b), (c) (i), and (c) (ii).

However, a substantial number of candidates exhibited difficulty detailing the laboratory tests to confirm the presence of Pb^{2+} and NO^{3-} ions in a sample of water as requested in Part (d).

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 2.15, 2.16, 2.17, 2.18; Mean: 3.19; Standard Deviation: 3.12

In this question, candidates were asked to

- demonstrate their knowledge of selected reactions of benzene and methylbenzene
- explain the steps involved in the bromination of methylbenzene
- write structural formulae of products for selected reactions of phenol.

The question was very poorly answered. Candidates' difficulty with the question was seen in all parts of the question, with candidates exhibiting an extremely low level of knowledge and understanding of the organic chemistry topics being examined.

In Part (a), candidates were unable to provide the names of the types of reaction. For Parts (b), (c) and (d) candidates were unable to list the reagent and conditions for the selected reactions of benzene, draw the displayed formula for compound X, and outline the mechanics for selected reactions of methylbenzene.

The majority of candidates were also not able to determine the correct structural formulae of the compounds produced when phenol reacted with certain reagents in Part (e).

Teachers need to provide

- practical organic exercises on which candidates can develop those critical skills and abilities which are emphasized by the CAPE Chemistry syllabus
- appropriate questions to allow candidates to practise writing chemical formulae (displayed/condensed structural formulae) and chemical equations of the many organic reactions.

Expected Responses

(a) Reaction I – Electrophilic substitution
Reaction IV – Diazotization/ Diazonium salt formation

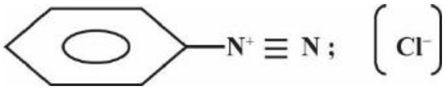
(b) Step II:

Conc H_2SO_4 + HNO_3; temp 55-60 °C OR $H_2SO_4(l)$ + $HNO_3(l)$ Temp 50 -60°C

Step IV:

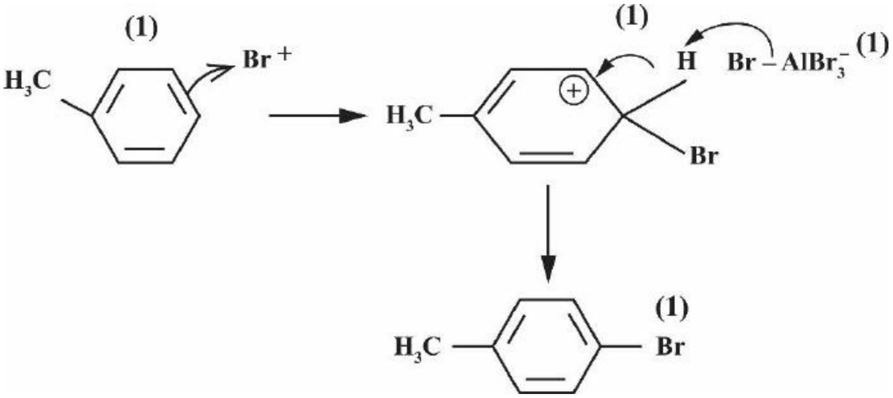
$NaNO_2(aq)$ / $HCl(aq)$; temp -5 °C (<0 °C)
Accept ($HNO_2(aq)$)

(c)



(optional to have the Cl⁻)

(d)



Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 9.1, 9.4; Mean: 1.12; Standard Deviation: 1.76

This question was centred on phase separations in which candidates were assessed on their ability to

- state Raoult's law of an ideal mixture of two liquids
- list the characteristics of an ideal solution
- explain the characteristics of azeotropic mixtures
- use boiling point curves to explain the separation of an azeotropic mixture
- perform calculations associated with solvent extraction.

The candidates' responses to this question revealed that they had little or no knowledge of the concepts associated with this topic. The performance on this question was the weakest on this paper and demonstrated that candidates were ill prepared in the area of phase equilibrium and separations.

The majority of candidates were unable to answer Parts (a) (i) to (iii) correctly.

A few candidates were able to define the term 'azeotropic mixture' in Part (b) (i) but most candidates could not answer Part (b) (ii). For Part (b) (iii), the use of the graph to explain the distillation of the mixture, X, proved to be very difficult for the majority of candidates. However, a few candidates were able to perform the calculations on solvent extraction in Part (c) correctly.

Expected Response

(a) (i) Raoult's Law:

The vapour pressure of a component of an ideal solution is equal to the vapour pressure of the pure component multiplied by the mole fraction of the component.

OR

$P_A = P^o_A \times x_A$

OR

Any other similar statement.

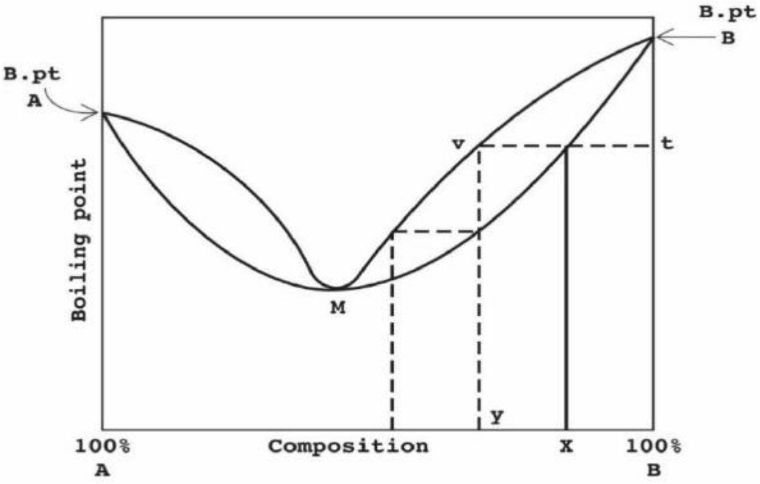
(ii) Mixture occurs with zero heat change.

Mixture occurs with zero volume change.

(b) (i) An azeotropic mixture is one that boils at a fixed temperature.

(ii) Their composition changes with pressure.

(iii)



- Liquid of composition X boils at temp t.
- Vapour of composition Y indicated at V.
- Vapour has higher composition of A.
- As distillation continues vapour produces azeotrope M.
- Temperature of residue rises producing pure B.

(c) Let mass of compound in organic solvent = x g.
Let mass of compound in water = (5.0 – x) g.

$$\frac{[\text{Compound}]\ \text{organic solvent}}{[\text{Compound}]\ \text{water}} = \frac{1}{0.200} = \frac{x/25}{(5-x)/100}$$

$$X = 2.8$$

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 1.1, 2.1, 2.2, 2.3, 10.1, 10.2, 10.3; Mean: 6.13; Standard Deviation: 2.50

This question focused on the extraction of aluminum from alumina, the effect of oxygen on the process, the factors which influence the location of a bauxite plant and the recycling process of aluminum.

Some candidates demonstrated a satisfactory level of performance. However, a significant number of candidates experienced some difficulty with detailed processes and the writing of chemical equations.

Part (a) (i) proved to be difficult for most candidates. This was very surprising as this is a topic in the CSEC syllabus. The responses of candidates included a description of the process of obtaining alumina from the bauxite ore and many candidates excluded the aluminum fluoride/calcium fluoride as necessary components in the extraction process. Some candidates also had difficulty writing the electrode reaction equations. Most candidates were able to answer Parts (a) (ii) and (iii) correctly.

Although most candidates were able to state the correct factors for the location of the bauxite plant, some factors they stated were not relevant to the industry in Part (b).

For Part (c) (i), some candidates had challenges defining the term ‘recycling’, and describing the process of recycling aluminum in Part (c) (ii).

Part (d) was answered quite well by most candidates. Candidates scored well on this part of the question.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus Objectives: Module 1: 2.6, 2.11, 2.13; Module 2: 2.4, 2.5;

Mean: 19.90; Standard Deviation: 8.16

Question 1

This question involved the testing of two organic liquids, R and S, to determine their relevant functional groups. Candidates were also expected to give details of colour changes as well as the names of gases evolved. A significant number of candidates were unable to correctly infer from their observations the functional groups present in the organic compounds.

Question 2

This question utilized the data analysis format. Candidates were asked to

- tabulate data of titration volumes through accurate interpretation of burette readings
- calculate the solubility of ammonium chloride in water in gdm^{-3} at room temperature.

Most candidates were able to correctly tabulate the data provided. However, a significant number of candidates exhibited difficulty in carrying out the required calculations. The candidates demonstrated very poor knowledge of the theory and concepts of back titration.

Question 3

This question focused on planning and designing an experiment to investigate the validity of the assertion that "the acid leached from the fertilizers applied to the plot had, over time, resulted in increased acidity of the river and hence damage to the villagers' clothing."

Candidates' responses indicated difficulties with certain parts of this question. The main areas of concern were

- the identification of the various variables
- the writing of appropriate hypotheses.

Summary

The theory and concepts of the modules in Unit 2 continue to be challenging for a significant number of candidates. Every effort should be pursued to ensure that adequate time and practice are provided to help candidates understand the concepts. Candidates should also be provided with appropriate exercises in the school-based assessment and otherwise to help them in their development of higher-order cognitive skills such as analysis, synthesis and evaluation.

Paper 031 – School-Based Assessment (SBA)

All centres submitted the five samples requested or if there were fewer than five candidates in the class, the number requested by CXC. The computer-generated printout was also included with the samples, mark schemes (most times) and moderation sheets. Teachers are reminded that practical books must contain in the table of contents the following information:

- Name and number of practical exercises. (N.B. All practical exercises done must be included in the table of contents.)
- Skills, if any, assessed for CXC
- Page number
- Date of practical

Appropriateness of Mark Schemes

In many cases mark schemes served as a useful guide to the moderators. There were, however, many cases also where the mark schemes were either incomplete or contained irrelevant skills. Teachers persist in awarding Observation/Recording/Reporting marks for skills that are better classified under Analysis and Interpretation, such as those skills that might have been demonstrated in the working out of a mathematical problem, identifying sources of error or the writing of equations. Teachers are still experiencing great difficulty writing mark schemes for Planning and Design (P&D) experiments. This was partly due to the inappropriate P&D activities chosen.

Teachers are reminded of the following:

- Mark schemes could be made more informative and hence more useful by including the names of the unknowns and observations that are expected when qualitative analyses are tested.
- Where more than one mark is allocated for a particular skill this should be broken down to indicate where each mark is awarded.
- Award an appropriate number of marks for each response required.
- Avoid ‘overweighting’ a skill. For example, awarding 3 marks for finding the average of three numbers is unacceptable. Also, awarding 6 marks for six points in a skill and then upgrading these marks to a total of 12 marks, means that if a candidate gets one point wrong, 2 marks are lost. This is not recommended by measurement and evaluation practitioners. It is more acceptable to mark an exercise out of 12 marks, or at most out of 24 marks and then convert to the nearest whole number out of 12.

Syllabus coverage, adequacy and standard of activities

The samples received from most centres showed evidence of good syllabus coverage and adequacy of the number of activities completed. Teachers should however, note the following:

- Activities should be spread more evenly over the topics. For example, there should not be five volumetric or qualitative analyses, one energetics experiment and no exercise on rates or equilibrium.
- The standard of the volumetric analyses still needs to reach beyond the CSEC level into that of Chemistry at a more advanced level.
- Candidates should be exposed to back titrations, the double indicator method and a variety of redox and iodine – thiosulfate titrations.

The assessment of skills

Most teachers did assess each of the four skills at least twice.

- Teachers must select only two in any skill for submission to CXC. These should be clearly indicated on the mark scheme and also in the candidates’ books.
- Candidates should be tested in SBAs on practical work with which they have had experience.
- For school-based assessment it is not good practice to assess the first practical exercise that the candidates attempt.

Observation/Recording/Reporting (ORR)

Many teachers assessed this skill in a satisfactory manner. A few took advantage of the CXC mandate to assess communication, grammar, spelling and punctuation and seemed to be focused only on these, while neglecting the observation of colours and precipitates, and the drawing of proper graphs and tables.

The standard of exercises given for assessing observation skills was, in many cases, lower than expected and was more suitable for CSEC level.

In many instances, there were areas of assessment that were not appropriate for ORR, for example:

i. Inferences
ii. Interpretation of graphs
iii. Calculations
iv. Discussions
v. Writing equations

Tables should be enclosed with relevant titles and headings.

Teachers are reminded that in qualitative analyses, ‘no reaction’, ‘soluble’, ‘insoluble’, ‘acidic’ and ‘basic’ are regarded not as observations but as inferences. Instead, terms such as the following should be used – ‘no observable change/no visible change/no apparent reaction’, ‘solid/precipitate disappears’, solid/precipitate decreases in quantity/remains unchanged.

Manipulation and Measurement (M&M)

Though not moderated, evidence of this activity was examined in the samples.

- Evidence of TWO assessed practicals must be placed in the candidates’ lab books for these marks to be accepted.
- There should be more emphasis on measurement from two different types of practicals.

- In many cases the criteria for assessing manipulation/measurement were too basic and more appropriate for a Fourth Form/Grade 10 practical.
- Teachers should assess the entire practical in which the MM skill was tested so that candidates may benefit from the feedback. In fact, all practical activities must be marked and feedback provided to the candidates.
- There should also be a breakdown of how marks are awarded for the skill. Teachers may consider the recommendation that accuracy and precision be marked for titrations rather than correct execution of each part of the activity.

Analysis and Interpretations (A&I)

- Activities testing this skill must be more challenging.
- Many calculations were too easy.
- Teachers should insist on deductions from observations/results in a progressive manner, and well-balanced ionic and/or other equations, with state symbols where applicable, in the inorganic chemistry/qualitative analysis and physical chemistry.

- Analysis of graphs and discussion of results should be encouraged. It is also important for teachers to remember that the drawing of graphs is an ORR activity and not an A&I.
- In volumetric analysis, the calculation of the average titre should involve the use of ONLY the closest values (no more than a difference of +/- 0.10 cm^3). When there are identical values, these should be used to find the average.
- Other areas tested under A&I should include any type of calculation and answering of questions generated by the practical activity.

Planning and Designing (P&D)

After eighteen years of this examination, the representation of this skill is still extremely problematic. Well over 75 per cent of the situations/problem statements that teachers gave candidates were inappropriate. It is the belief of the examiners and assistant examiners that this is an area where there is need to develop greater teacher capacity. The basis and basics of scientific research are still misunderstood.

- Teachers need to acquire a fundamental understanding of this skill.
- The situation or problem statement which stimulates critical thinking and deductive reasoning, must be able to give rise to a hypothesis from which variables can be generated. Hence a plan should allow for assessment of **all** the components of a P&D, such as variables and methods that demonstrate **chemical principles**, (testable in a typical high school chemistry laboratory), expected results, etc.
- Situations and problem statements given to candidates by teachers should be clearly written in the candidates' books and in the mark schemes. These statements must not disclose the aim, method or the apparatus required.

A P&D activity was deemed to be inappropriate when

i. solving the problem did not fall under a syllabus objective
ii. solving the problem was not from the appropriate unit
iii. the solution could be taken directly from a textbook
iv. the hypothesis was not testable and/or no variables could be generated.

- In some cases, aims were not linked to hypotheses and it was difficult to identify the chemical principles that were being explored in testing the hypotheses.
- Mark schemes did not always assess relevant requirements of the process. For example, marks were awarded for table presentations and discussions that were unrelated to the solving of the problem.
- There is no need for marks to be given to each 'limitation', 'source of error', 'assumption' and 'precaution' stated. Any two given are sufficient, since in many cases a precaution can prevent a source or error and an assumption may be the flip side of a limitation.
- Teachers must also be reminded that while they are responsible for candidates' understanding what is required in this skill, there must be evidence of individual work by the candidates. Teachers are requested to send more detailed mark schemes for this skill, which demonstrate or are a guide to the particulars of what they are expecting from the candidates.
- It is recommended that workshops be conducted for teachers in all the countries/islands so that there can be marked improvement in the performance of this skill in 2017.

Integrity of Samples

There was adequate evidence to suggest that in some cases the collaboration between teachers and candidates and peer collaboration between candidates went beyond that which was desirable or appropriate, as evidenced by laboratory reports being reproduced verbatim even with identical spelling/grammar mistakes. This is a violation of examination regulations and candidates and centres are liable to sanctions when this is discovered at moderation.

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2018

CHEMISTRY

St Michael, Barbados

GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules. Unit 1 has the following modules

- Module 1 – Fundamentals in Chemistry
- Module 2 – Kinetics and Equilibria
- Module 3 – Chemistry of the Elements

Unit 2 has the following modules

- Module 1 – The Chemistry of Carbon Compounds
- Module 2 – Analytical Methods and Separation Techniques
- Module 3 – Industry and the Environment

Both units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 031, the School-Based Assessment (SBA) is examined internally by teachers and moderated by CXC. Private candidates write Paper 032 which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031 comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 comprised three compulsory questions focusing on candidates' laboratory experiences.

The number of candidates who wrote the examinations was 4627 in Unit 1 and 3475 in Unit 2. Ninety-one per cent of candidates earned acceptable grades, Grades I–V for Unit 1 while 96 per cent earned acceptable grades for Unit 2.

There was improvement in the overall performance of candidates in 2018 compared with performance in 2017 and 2016. There was improvement in candidates' performance in Modules 1, 2 and 3 in Unit 1. However, candidates' performance in Modules 1, 2 and 3 in Unit 2 showed a decline in 2018 compared with 2017.

Candidates' responses on Paper 02 in some modules demonstrated limited development of certain knowledge, skills and abilities that are emphasized by this CAPE subject. Several candidates continue to demonstrate limited experimental knowledge and skills on questions which require practical knowledge and experiences as outlined in the syllabus.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

Paper 01 consisted of 45 multiple-choice items. It was designed to provide adequate coverage of the syllabus content with items taken from sections of the three modules of the syllabus. Approximately 94 per cent of the candidates earned acceptable grades on this paper. The mean score was 33.17 out of 45 marks.

Paper 02 – Structured Essay Questions

Section A

Module 1: Fundamentals in Chemistry

Question 1

Syllabus Objectives: 6.6, 6.7, 6.8, 6.9
Mean: 4.93 Standard Deviation: 3.03

This question sought to assess candidates' knowledge and understanding of

- Hess' law
- Born–Haber cycle
- Lattice energy calculations
- Relationship of theoretical/experimental values to types of bonding
- Experimental steps required for the determination of the enthalpy of neutralization between an acid and a base.

Candidates' performance on this question was weak. Many candidates were unable to state a concise definition of Hess' law in Part (a). Most of the marks were earned in Parts (b) (i) and (b) (ii) as candidates identified the types of enthalpy changes seen in the Born–Haber cycle for potassium fluoride. Candidates were able to perform correct calculations of the lattice energy.

However, a number of candidates had difficulty relating the theoretical and experimental values of the lattice energy to the type of bonding in potassium fluoride with a suitable reason in Part (b) (iii). Part (c) proved to be challenging for most candidates as their responses showed limited knowledge of the experimental steps required in the determination of the enthalpy of neutralization between hydrochloric acid and potassium hydroxide.

Teachers are reminded to introduce their students to the appropriate apparatus and methods required for the determination of the enthalpy of neutralization of an acid and a base.

Module 2: Kinetics and Equlibria

Question 2

Syllabus Objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6
Mean: 5.66 Standard Deviation: 2.55

This question examined candidates' knowledge of the factors that affect the rate of reaction and the term *reaction rate*. Candidates' understanding of deducing the order of reaction and the rate law from given data were also assessed as well as their ability to perform calculations to determine the rate constant. Candidates were also expected to outline the experimental steps required for the investigation of the effect of concentration on the rate of reaction between aqueous bromine and methanoic acid.

Candidates' performance on this question was fair. Most candidates were able to state two factors that affect the rate of reaction in Part (a). But only a few candidates were able to define the reaction rate in terms of the production of nitrogen in Part (b) (i).

A number of candidates were able to provide the appropriate responses for Parts (b) (ii) to (b) (iv). However, candidates' responses for Parts (c) (i) and (c) (ii) were inadequate and showed a lack of knowledge and understanding as to the investigation of the rate of reaction of gaseous reactions and the rate of reaction between aqueous bromine and methanoic acid.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 3.3, 3.4
Mean: 3.88 Standard Deviation: 2.66

This question focused on the chemistry of the Group IV elements. Candidates were expected to describe the thermal stability of the oxides of some of the Group IV elements, account for the type of structure and bonding of the oxides of carbon, silicon and lead in the +4 oxidation state, explain the relative stabilities of the oxides of carbon, silicon and lead in the +2 and +4 oxidation state and provide observations for the reaction of lead (IV) oxide with certain reagents.

Candidates demonstrated limited knowledge and understanding of the Group IV elements and overall performance was therefore very weak. Many candidates described the thermal stabilities of the oxides of some of the Group IV elements correctly in Part (a).

Candidates demonstrated limited understanding in relating the structure and bonding of the oxides of carbon, silicon and lead in the +4 state to the melting points of the compounds as well as in explaining the trend in the relative stabilities of the Group IV elements carbon, silicon and lead in the +2 and +4 oxidation stated for Parts (b) and (c) respectively.

The responses for Part (d) showed that candidates had limited knowledge of the reaction of lead IV oxides with stated reagents.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 5.1, 5.2, 5.3, 5.4
Mean: 5.23 Standard Deviation: 3.18

This question tested candidates' knowledge and understanding of kinetic theory. The following areas were examined:

- The basic assumption of kinetic theory
- The assumptions of the kinetic theory of gases based on conditions of temperature and pressure
- Graphical representation to illustrate the deviation of a real gas from ideal gas behaviour
- Description of the liquid state in terms of arrangement and motion of particles
- Calculation of the molar mass of a volatile liquid

The performance of candidates on this question was modest. Most of the marks were earned in Parts (a) and (b) (i) as candidates stated four basic assumptions of the kinetics theory of gases which do not hold under certain conditions of temperature and pressure.

However, Parts (b) (ii) and (c) (i) proved to be challenging for many candidates. A few candidates were able to calculate the molar mass of the volatile liquid correctly in Part (c) (ii).The errors in Part (c) (ii) were due to candidates' inability to convert certain quantities to the appropriate units to calculate the molar mass of the volatile liquid.

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7
Mean: 4.63 Standard Deviation: 3.53

This question sought to assess candidates' knowledge and understanding of the following:

- The definition of the standard electrode potential of a half-cell
- A labelled diagram to illustrate how the standard electrode potential of the $Fe^{3+}aq/Fe^{2+}(aq)$ half-cell can be measured
- The calculation of standard cell potential
- The conditions for feasibility of a reaction
- The effect of an increase in the concentration of ions on the standard cell potential

Generally, this question was not answered very well. Some candidates stated the definition of the standard electrode potential of a half-cell correctly and were able to draw the labelled diagram to illustrate how to measure the standard electrode potential of the $Fe^{3+}(aq)/Fe^{2+}(aq)$ half-cell in parts (a)(i) and (a)(ii). Only a few candidates were able to state two uses of standard electrode potentials.

Parts (b) (i) and (b) (ii) showed that many candidates had difficulty writing balanced equations with the required state symbols. The calculation of the standard cell potential proved to be challenging for candidates.

Although many candidates were able to correctly assess the feasibility of the reaction in Part (b) (ii), the responses of candidates for Part (b) (iv) demonstrated that Le Chatelier’s Principle was unrelated to the effect of an increase in the concentration of silver ions on the standard cell potential. Only a few candidates’ responses showed the relationship to Le Chatelier’s Principle using the appropriate terminology.

Expected Response (Part 5 (b) (iv))

If the concentration of silver ions increases, according to Le Chatelier’s Principle, the equilibrium will shift to the right and the cell potential will become more positive.

Module 3: Chemistry of the Elements

<u>Question 6</u>

Syllabus Objectives: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6
Mean: 3.51 Standard Deviation: 2.63

This question focused on the physical and chemical properties of the halogens. Candidates were expected to

- explain the trend in volatility of the halogens down the group
- explain the relative reactivities of the halogens as oxidizing agents using E^{o} values and the reagent sodium thiosulfate
- describe the reactions of the halogens with hydrogen
- explain the trend in the relative stabilities of the hydrides.

The performance of candidates on this question was very weak. Although candidates were able to state the trend in Part (a), many candidates were unable to explain the reasons for the trend.

Part (b) proved to be very challenging for candidates. Many candidates’ responses revealed a lack of knowledge and understanding in relating the E^{o} values and the reaction with sodium thiosulfate to explain the oxidizing ability of halogens.

Candidates also demonstrated their lack of knowledge in describing the reactions of the halogens with hydrogen in Part (c) (i). Some candidates stated the trend in the relative stabilities of the hydrides but again were unable to suggest the reasons for the trend in Part (c) (ii).

Many candidates were able to write a balanced equation with the appropriate state symbols in Part (c) (iii).

Recommendations

Teachers are reminded of the following

- Provide practical exercises as outlined in the syllabus and allow students to write an outline of the experimental steps as well as use the data to arrive at conclusions.

- Encourage class discussions which can develop and enhance the critical thinking skills so necessary in explaining trends, concepts et cetera, using the appropriate chemical language.

Paper 032 – Alternative to School-Based Assessment

Syllabus Objectives: Module 1: 6.9
Module 2: 3.8

Candidate performance was fair. The maximum mark available was 48. The mean score was 15.76 with a standard deviation of 6.41. The highest score obtained was 36 with the lowest score obtained being five.

Question 1

This question asked candidates to determine the enthalpy of hydration of the salt copper (II) sulphate after recording temperature changes observed during the dissolution of anhydrous copper (II) sulphate and copper (II) sulphate pentahydrate, in water. These temperature changes were then to be used to determine the enthalpy of solution of the aforementioned salts. With these values, using Hess' law, candidates were then asked to determine the enthalpy of hydration of copper (II) sulphate.

The question was answered very poorly. Although most candidates were able to accurately carry out the initial temperature measurements, very few were able to follow through with accurate calculations. Basic calculations involving finding the number of moles of the salts were either left out entirely or done incorrectly. The error was followed by inaccurate application of the equation, $E = mc\Delta T$, which was needed to determine the enthalpies of solution. The majority of candidates was not able to accurately determine the relationship between the enthalpy of solutions and the enthalpy of hydration of the copper (II) sulphate. Overall, this was the question most poorly answered in the paper.

Question 2

This question utilized the data analysis format to calculate the concentration of iron (II) ions in a solution of iron (II) sulphate tirated against potassium permanganate solution. Candidates were asked to

- tabulate data of the titration initial and final burette readings, as well as the volume of $KMnO_4/H^+$ used
- state the volume of $KMnO_4/H^+$ that would be used in the calculations
- write an ionic equation to represent the reaction taking place during titration
- determine the concentration of iron (II) ions in mol/dm^3 followed by g/dm^3.

Whilst most candidates were able to accurately read the burette reading for the initial and final volumes of the titration trials, they still did not record their values to two decimal places. Another area of weakness was candidates' inability to correctly determine the volume of $KMnO_4/H^+$ that would be used in their calculations. Titre volumes with differences greater than 0.05 cm^3 were used. Lastly, most candidates were unable to correctly write the ionic equation which represented the reaction taking place during the titration. Without the correct molar ratio of reactants, candidates were then unable to correctly calculate the molar concentration as required. This area of titrations, and subsequent recordings and calculations, seems to be an area of weakness for most candidates.

Question 3

This question focused on the planning and design of an experiment to determine the presence of lead, aluminium and zinc ions present in unlabelled containers of these ions.

This question was answered with a fair degree of accuracy. Many candidates were able to correctly state the qualitative tests used to identify the presence of the ions. However, candidates fell short in being able to identify the use of potassium iodide to definitively identify the presence of the lead ion.

Unit 2

Paper 01 – Multiple Choice

Performance on this paper was fair. The paper was designed to provide adequate coverage of the content with items taken from sections of the three modules of the syllabus. Approximately 97 per cent of the candidates earned acceptable grades on this paper. The mean score was 30.75 out of 90 marks.

Paper 02 – Structured Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 2.4, 2.5, 2.6, 2.7, 2.8, 2.17
Mean: 6.06 Standard Deviation: 4.34

This question sought to assess candidates’ knowledge of

- the reaction of an alkene and halogenoalkane
- the mechanism of electrophilic addition involving the alkene
- the laboratory test to distinguish between types of alcohol
- the observations of some reactions of phenol.

Candidates performed fairly well on this question. Many candidates were able to identify the reaction mechanisms leading to the compounds indicated in Part (a).

A number of candidates were able to draw the displayed formulae of the products of electrophilic addition and nucleophilic substitution in Part (b). Only a few candidates were able to gain full marks in writing the electrophilic addition mechanism for the conversion of the alkene to a halogenoalkane in Part (c).

For Parts (d) and (e), candidates exhibited limited knowledge of the laboratory tests for alcohols and the reactions of phenol.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 3.1, 3.2, 3.3, 3.4, 3.5, 5.1–5.5
Mean: 4.39   Standard Deviation: 3.08

This question examined candidates' knowledge and understanding of the function of some pieces of apparatus used in gravimetric analysis and the use of data in gravimetric analysis to perform calculations. The identification of some components of a UV spectrophotometer, and the use of Beer–Lambert's law in calculating the concentration of a stated solution were also examined.

Candidates performed fairly well on some parts of this question but did poorly on other parts.

Many candidates exhibited limited knowledge of the function of the pieces of apparatus used in gravimetric analysis in Part (a). However, performance on Part (b) was good for many candidates. Only a few candidates were able to state one example of the use of gravimetric analysis in quality control in Part (c). Also, the responses for Part (d) showed limited knowledge of the components of a UV spectrophotometer.

A number of candidates performed well on Part (e).

Section B

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 1.2, 6.1, 6.2, 6.3, 6.4
Mean: 5.44   Standard Deviation: 3.67

This question focused on the production of chlorine using the diaphragm cell, the structure of the cell and the chemical process involved. The use of chlorine and the impact of chlorine production in close proximity to a neighbourhood were also tested.

Candidates' performance on this question was modest. Many candidates were able to identify the products and components in Part (a) (i). Parts (a) (ii) and (a) (iii) proved to be challenging for a number of candidates who exhibited limited knowledge and understanding in writing balanced chemical equations for the process involved.

Parts (b) and (c) showed that candidates had the knowledge and understanding of the uses of chlorine and the impact of chlorine in close proximity to a neighbourhood.

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus objectives: 1.1–1.9, 4.1–4.2
Mean: 7.51 Standard Deviation: 3.49

This question tested candidates' knowledge and understanding of the

- displayed formulae of isomers of butene
- displayed formulae of 2–butanol
- type of isomerism 2–butanol is expected to exhibit
- process of condensation in the formation of Nylon 6.6 demonstrated with a structural equation.

Generally, candidates performed very well on this question. Many candidates responded very well to Part (a) (i), stating three isomers of butane including the cis-trans isomers with the appropriate displayed formulae. The responses from candidates for Part (a) (ii) were also correctly displayed.

Some candidates correctly identified that 2-butanol exhibited optical isomerism with the appropriate reasons in Part (a) (iii). However, a number of candidates indicated that 2-butanol exhibited positional isomerism which was incorrect.

Candidates who earned high marks for Part (b) were able to correctly write the displayed formulae in an equation to describe the process of condensation in the production of Nylon 6.6. However, many candidates were unable to write a correct structural equation for this process.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 7.3, 9.1
Mean: 4.14 Standard Deviation: 3.54

This question examined mass spectrometry, in particular, identifying the fragment responsible for the base peak from the mass spectrum of a haloalkane, deducing the halogens present and providing a reason for the two peaks at m/2 108, 110 having the same intensity. The question also tested candidate's knowledge and understanding of Raoult's law, the positive deviation from Raoult's law exhibited by a mixture of ethanol and cyclohexane as well as the depiction of a fully labelled boiling point–composition curve for the mixture of ethanol and cyclohexane.

Generally, this question was not answered very well. Only a few candidates were able to provide correct responses to Parts (a) (i), (a) (ii) and (a) (iii).

A number of candidates were able to define Raoult's law as applied to miscible liquids in Part (b) (i), but only a few candidates were able to explain the positive deviation from Raoult's law exhibited by a mixture of ethanol and cyclohexane in Part (b) (ii).

It was challenging for most candidates to draw the fully labelled boiling point-composition curve for the mixture of ethanol and cyclohexane.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 5.1, 10.1, 10.2
Mean: 4.31 Standard Deviation: 2.31

In this question, candidates were asked to

- outline the process of converting sucrose to ethanol with relevant equations
- state the name of the process which produces alcoholic beverages of high alcohol content
- describe what could happen to wine stored in bottles whose cork stoppers have dried out
- outline two advantages and disadvantages associated with the packaging of alcoholic beverages in glass bottles
- state two permanent physiological changes in the body due to the sustained abuse of alcoholic beverages

Again, this question was generally not answered well. Candidates showed limited knowledge and understanding in their responses to the parts of the question. Many candidates had challenges in describing the conversion of sucrose to ethanol in Part (a). Candidates had difficulty writing balanced equations for each step.

Only a few candidates were able to state that fractional distillation was the process by which alcoholic beverages of high alcohol content are produced in Part (b). Part (c) proved to be very challenging for candidates. Candidates were unable to describe the changes that would occur as well as the balanced chemical equations for these changes.

The responses in Part (d) showed that candidates had difficulty linking advantages and disadvantages associated with the packaging of alcoholic beverages in glass bottles in terms of waste management and economic benefit. However, many candidates were able to provide two permanent physiological changes in the body that can result from the sustained abuse of alcoholic beverages in Part (e).

Paper 032 – Alternative to the School-Based Assessment (SBA)

Syllabus objectives: Module 1: 2.6, 2.9
Module 2: 3.4

Candidate performance was moderate. The maximum mark available was 48. The mean score was 17.42 and the standard deviation 6.92.

Question 1

This question focused on the properties of the alcoholic and carbonyl groups. Candidates were required to perform the various tests and record the relevant observations in the tables provided thereby allowing appropriate deductions to be made.

Overall, candidates' performance was fair. A number of candidates were able to accurately record many of the test observations though the observance of the silver mirror with the Tollen's reagent was not widely recorded. Candidates struggled with identifying the unknowns as well as giving their reasons for the choices made.

Question 2

This question sought to assess candidates'

- understanding of gravimetric analysis by using the process to determine the amount of $CaCO_3$ in an eggshell
- exposure to skills associated with the experimental aspect.

Candidates were generally able to calculate the mass of the clean, dry eggshell from the experimental data given. However, the writing of ionic equations, even for the simple reaction between $CaCO_3$ and HCl, continues to be a challenge for the majority of candidates and is clearly an area that needs to be extensively reviewed in the classrooms and laboratory.

Determining the equation resulting in the formation of the calcium oxalate monohydrate also seems too difficult a task for the majority of candidates, with the resultant calculations being very poorly done. The overall result is that this question was not very well done.

Question 3

This question sought to test candidates' level of competence in the various skills associated with the planning and design (PD) of practical investigations.

Candidates obtained marks for determining the necessary reagents and equipment needed. However, the other segments of the exercise presented varying degrees of difficulty. Hypothesis formulation continue to be an area of difficulty, while some confusion was exhibited in the variables involved and a lack of clarity was manifested in the description of the various experimental designs offered.

It is evident that the area of planning and design remains a significant challenge for the majority of private candidates.