CARIBBEAN EXAMINATIONS COUNCIL

CAPE® Chemistry

SYLLABUS
2007–2019

Macmillan Education
4 Crinan Street, London, N1 9XW
A division of Macmillan Publishers Limited
Companies and representatives throughout the world

www.macmillan-caribbean.com

ISBN 978-1-380-03084-9

www.cxc.org
www.cxc-store.com

First published 2018

Designed by Macmillan Publishers Limited
Cover design by Macmillan Publishers Limited and Red Giraffe

CAPE® Chemistry Free Resources

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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
CAPE®

CHEMISTRY
SYLLABUS

Unit 1 - effective for examinations from May/June 2007
Unit 2 - effective for examinations from May/June 2008

Published by the Caribbean Examinations Council

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AMENDMENTS ARE INDICATED BY ITALICS.

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. 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 CAPE Associate Degree, awarded for the satisfactory completion of a prescribed cluster of seven CAPE Units including Caribbean Studies and Communication Studies. For the CAPE diploma and the CAPE Associate Degree, candidates must complete the cluster of required Units within a maximum period of five years.

Recognised educational institutions presenting candidates for CAPE Associate Degree in one of the nine categories must, on registering these candidates at the start of the qualifying year, have them confirm in the required form, the Associate Degree they wish to be awarded. Candidates will not be awarded any possible alternatives for which they did not apply.

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 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.

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 CAPE syllabus is, therefore, designed to provide a coherent course of study which addresses, in addition to a specific knowledge base, the development of related skills and attitudes. The syllabus takes into account the requirements for tertiary education at regional and international institutions. The syllabus is structured in such a way as to ensure that students become aware of their moral, social, and ethical responsibilities, as well as the benefits intrinsic to the practical application of scientific knowledge to careers in the scientific field.

Chemical principles are currently applied to societal concerns, such as, birth control, communicable diseases, environmental pollution 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. Chemistry is, therefore, a fundamental science, that should be included as a part of our science education.

◆AIMS

The syllabus aims to enable students 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 the ability to communicate chemical information derived from the collection, analysis and interpretation of data;

3. appreciate, understand and use the scientific method in the solving of problems;

4. develop good laboratory skills and practise safety measures when using equipment and chemicals *as well as the safe disposal of chemical waste*;

5. apply chemical knowledge to everyday life situations;

6. appreciate that *some of the advances* in the field of chemistry are the results of the contributions from scientists in *other* disciplines;

7. 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;

8. recognise that advances in chemistry are constantly influenced by technological, economic, social, cultural and ethical factors;

9. recognise the power, impact and influence which chemistry has in a modern scientific world;

10. contribute to making the Caribbean *numerate and 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:

(i) Knowledge and Comprehension;
(ii) Use of Knowledge;
(iii) Experimental Skills.

Knowledge and Comprehension (KC)

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

Use of Knowledge (UK)

Application	*The ability to:* - *use facts, concepts, principles and procedures in familiar and in novel situations;* - *transform data accurately and appropriately;*

- *use formulae accurately for computational purposes.*

Analysis and Interpretation

The ability to:

- *identify and recognise the component parts of a whole and interpret the relationship among those parts;*
- *identify causal factors and show how they interact with each other;*
- *infer, predict and draw conclusions;*
- *make necessary and accurate calculations and recognise the limitations and assumptions involved.*

Synthesis

The ability to:

- *combine component parts to form a new and meaningful whole;*
- *make predictions and solve problems.*

Evaluation

The ability to:

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

Experimental Skills (XS)

Observation, Recording and Reporting

The ability to:

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

Manipulation and Measurement

The ability to:

- *handle chemicals carefully and use them economically;*

- *appropriately prepare materials for observation or investigation;*
- *assemble and use simple apparatus and measuring instruments.*

Planning and Designing

The ability to:

- *recognise the problem and formulate valid hypotheses;*
- *choose appropriate experimental methods and sampling techniques;*
- *choose appropriate apparatus;*
- *plan and execute experimental procedures in a logical and sequential form within the time allotted;*
- *use controls where appropriate;*
- *modify experimental methods after initial work or unexpected outcomes.*

PRE-REQUISITES 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 and written communication skills.

STRUCTURE OF THE SYLLABUS

This syllabus is arranged into TWO Units, each made up of three Modules. Whilst each Module in each Unit is independent, together they form a coherent course of study which should prepare candidates for the world of work and studies at the tertiary level.

Unit 1: Chemical Principles and Applications I

Unit 1 is expected to be covered in 150 hours, and consists of three Modules, each requiring approximately 50 contact hours. This Unit is structured as follows:

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

Unit 2: Chemical Principles and Applications II

Unit 2 is expected to be covered in 150 hours, and consists of three Modules, each requiring approximately 50 contact hours. This Unit is structured as follows:

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

The syllabus is arranged into two (2) Units, Unit 1 which will lay foundations, and Unit 2 which expands on, and applies, the concepts formulated in Unit 1. It is, therefore, recommended that Unit 2 be taken after satisfactory completion of Unit 1 or a similar course. Each Unit will be certified separately.

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 single underlining of a specific objective and its explanatory notes, indicate those areas of the syllabus that are suitable for practical work. However, practical work should not necessarily be limited to these objectives.

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.

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. appreciate that equilibrium concepts can be applied to chemical systems;
8. understand the kinetic theory;
9. understand concepts associated with energy changes;
10. develop the ability to perform calculations involving energy changes.

SPECIFIC OBJECTIVES	**EXPLANATORY NOTES**
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;	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.

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

Atomic Structure and the Periodic Table (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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: (i) mass number; (ii) isotopes; (iii) relative atomic and isotopic masses based on the $^{12}_{6}C$ scale.	
1.4 explain the phenomenon of radioactivity;	*Write equations representing nuclear reactions involving* $\propto$, β *and* γ *emissions; n/p ratio. Positrons(r) are not required.*
1.5 *cite the use of radioisotopes*;	
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, the emission spectrum of hydrogen; *Lyman series, Balmer series;* ΔE *or* $dE = h\nu$.
1.8 describe the *atomic orbitals*;	*Principal quantum numbers, s, p and d orbitals; relative energies of 4s and 3d orbitals.*
1.9 describe the shapes of the s and p orbitals;	

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
<u>Atomic Structure and the Periodic Table (cont'd)</u>	
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;	*Period* 3.
1.13 derive the electronic configuration of an element from data on successive ionisation energies.	
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.
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.
2.4 explain the formation of the following: (i) ionic bonds; (ii) covalent bonds; (iii) 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.

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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES
Forces of Attraction (cont'd)		
2.5	*illustrate practically the properties of ionic and covalent compounds*;	Refer to melting point and boiling point determinations; solubilities in polar and non-polar solvents, *electrical conductivity*.
2.6	describe co-ordinate (dative covalent) bonding;	Use 'dot-cross' diagrams; refer to simple systems (for example, BF_3/NH_3).
2.7	describe the origin of inter-molecular forces;	Refer to hydrogen bonding; *Van* der Waals forces, *permanent dipole*.
2.8	predict the shapes of, and bond angles in simple molecules and ions;	Apply 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^- , NH_3), non-linear (for example, H_2O), octahedral (for example, SF_6).
2.9	explain the shapes and bond angles of simple organic compounds;	*Ethane*, ethene and benzene; apply the concept of hybridization and resonance.
2.10	predict the shapes and bond angles of molecules similar to ethane, ethene.	*Simple substituted derivatives for example dichloroethane.*
2.11	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
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;	Students may be given combustion data; absolute masses or relative abundances of elements.
3.8 perform titrimetric analyses;	Include acid/base titrations and redox titrations. *(dichromate(VI), hydrogen peroxide, iodide thiosulphate, 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: (i) mole ratios; (ii) molar concentration and mass concentration.	

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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 Unit 1 Module 1 Specific Objective 3.8.*
4.2 deduce balanced equations for redox reactions from relevant half equations;	
4.3 perform simple displacement reactions to order elements in terms of oxidizing or reducing ability.	
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.*
5.3 perform calculations using:	Calculations involving the use of Van der Waals *equation of state* are not required. *Include graphical representations.*
(i) Boyle's law;	
(ii) Charles' law;	
(iii) the ideal gas equation (pV = nRT).	Include calculations of relative molar mass.

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

SPECIFIC OBJECTIVES	**EXPLANATORY NOTES**
Kinetic Theory (cont'd)	
5.4 explain the following: (i) the liquid state; (ii) melting; (iii) *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;	
6.4 explain the term 'bond energy';	
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.

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

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
	Energetics (cont'd)	
6.6	apply concepts associated with enthalpy changes;	Include enthalpy change of formation, combustion, reaction, hydration, solution, neutralisation, 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' law *of constant heat summation;*	*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. *Calculations involving bond energy data.*

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. 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.

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

3. Class discussion in which current examples of the impact of radioactivity in everyday life are cited (from newspaper articles and the electronic media including the Internet).

4. Provide students with appropriate reading material prior to class session and teacher and students discuss the strengths and weaknesses of the Bohr and Rutherford models of the atom.

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

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

2. Use ball and stick models for molecular shapes.

The Mole Concept

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

2. Conduct laboratory work.

Redox Reactions, Kinetic Theory and Energetics

Use practical activities, diagrams, graphs and guided questions.

RESOURCES

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

Clarke, J.	*Calculations in AS/A Level Chemistry*, Essex: Pearson Education Limited, 2000.
Hill, G., and Holman, J.	*Chemistry in Context,* London: Nelson Thorne Limited, 2000.
Lister, T., Renshaw, J.	*Understanding Chemistry for Advanced Level,* Cheltenham: Trans-Atlantic Publications, 2000.
Ramsden, E.	*A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

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

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 of chemical equilibrium;
3. appreciate that principles of kinetics and equilibria can be applied to industrial and biological processes.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
1. Rates of Reactions	
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 and carry out suitable experiments for studying the factors which affect rates of reactions;	Include effects of concentration, temperature and catalysts. 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.
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.

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA (cont'd)

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
	Rates of Reactions (cont'd)	
1.7	perform simple calculations using half-life data;	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.	**Principles of Chemical Equilibrium**	
	Students should be able to:	
2.1	*explain the concept of 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*.*
2.4	perform a simple experiment to determine the value of K_c for a reaction;	
2.5	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.*
2.6	apply Le Chatelier's principle to explain the effects of changes in temperature, concentration and pressure on a system in equilibrium;	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.

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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, 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*;	
3.6 *state the basis for the selection of acid-base indicator for use in titrations.*	*Include phenolphthalein and methyl orange.* *Titration curves.*
3.7 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;	
4.4 perform simple experiments to determine the pH of buffer solutions;	

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Buffers and pH (cont'd)	
4.5 discuss the importance of buffers in biological systems and in industrial processes.	Include reference to blood *buffer systems such as hydrogencaronale, 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;	
5.3 perform calculations involving solubility product;	*Quadratic equations are not required.*
5.4 perform a simple experiment to determine the solubility product of a substance;	
5.5 relate the solubility product principle to the selective precipitation of substances.	Include reference to qualitative analysis and kidney stone formation.
6. **Redox Equilibria**	
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.*

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Redox Equilibria (cont'd)	
6.3 describe methods used to measure the standard electrode potentials of: (i) metals or non-metals in contact with their ions in aqueous solutions; (ii) ions of the same element in different oxidation states;	*Include labelled diagrams of electrochemical cells.*
6.4 calculate standard cell potentials from standard electrode potentials of two half cells;	
6.5 use standard electrode potentials of cells: (i) to determine the direction of electron flow; (ii) to determine the feasibility of a reaction.	Include cell diagram *or notation of the type* $Zn(s)\vert\ Zn^{2+}(aq)\vert\vert\ Cu^{2+}(aq)\vert Cu(s)$
6.6 predict how the value of an electrode potential varies with concentration;	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 batteries and fuel cells.

Suggested Teaching and Learning Strategies

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 equilbria 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:

   (i) orders of reactions (practise writing rate equations);

   (ii) rate and equilibrium constant including K_a and K_b, pH $\leftrightarrow$ H^+, pH $\leftrightarrow$ 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:

   (i) the direction of electron flow;

   (ii) the nature of the electrodes;

   (iii) the reaction that may occur;

   (iv) cell potentials.

5. Relate the importance of Kinetics and *Equilibria to industrial and biological processes.*

RESOURCES

Clarke, J.	*Calculations in AS/A Level Chemistry*, Essex: Pearson Education Limited, 2000.
Clugston, M. and Flemming, R.	*Advanced Chemistry*, London: Oxford University Press, 2000.
Lister, T., Renshaw, J.	*Understanding Chemistry for Advance Level,* Cheltenham: Trans-Atlantic Publications, 2000.
Ramsden, E.	*A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA (cont'd)

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;

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

SPECIFIC OBJECTIVES | EXPLANATORY NOTES

1. Period Sodium to Argon

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 radii, electronegativity and density.*
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;	
1.5	explain the trend in the acid/base behaviour of the oxides and hydroxides;	
1.6	predict the types of chemical bonding present in the chlorides and oxides.	Refer to differences in electronegativities and ionic radii of the elements.

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
2. Group II Elements	
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;	
2.3 explain the variation in the solubility of the sulphates;	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;	
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.
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;	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
<u>Group IV Elements (cont'd)</u>	
3.3 discuss the trends in: (i) bonding; (ii) acid/base character; (iii) thermal stability of the oxides of oxidation states II and IV;	Make reference to $E^\ominus$ values of the elements.
3.4 discuss the relative stabilities of the oxides and aqueous cations of the elements in their higher and lower oxidation states;	Make reference to $E^\ominus$ values where appropriate.
3.5 discuss the uses of ceramics based on silicon (IV) oxide.	
4. <u>Group VII Elements</u>	
Students should be able to:	
4.1 *explain the variations in physical properties of the elements in terms of structure and bonding;*	*Volatility, density, state; only a description of colour is required.*
4.2 explain the relative reactivities of the elements as oxidising agents;	Include reactions with sodium thiosulphate and refer to $E^\ominus$ values. Use solutions of the elements with bleach, bromine water and iodine solution.
4.3 describe the reactions of the elements with hydrogen;	
4.4 explain the relative stabilities of the hydrides;	Include bond energies in explanations.

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Group VII Elements (cont'd)	
4.5 describe the reactions of the halide ions with (i) aqueous solution of $AgNO_3$ followed by aqueous ammonia; (ii) conc. sulphuric acid;	
4.6 describe the reactions of chlorine with cold and with hot aqueous solution of sodium hydroxide.	Mention changes in oxidation number.
5. First Row Transition Elements	
Students should be able to:	
5.1 describe the characteristics of transition elements;	*Include variation in oxidation number, complex formation, coloured compounds, catalytic activity, magnetic properties.*
5.2 *determine* the electronic configuration of the first row transition elements and of their ions;	Mention changes in oxidation number.
5.3 explain the relatively small changes in atomic radii, ionic radii and ionisation energies of the elements across the period;	
5.4 explain the formation of coloured ions *by* transition elements;	*d orbital separation of energy in octahedral complexes.*
5.5 *Perform experiments to show the variation in oxidation states of vanadium*;	Include the use of an acidified solution of ammonium vanadate(V) and granulated zinc. Refer to $E^\ominus$ values.

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
	First Row Transition Elements (cont'd)	
5.6	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.
5.7	*predict the shapes of complexes of transition elements;*	*Octahedral, tetrahedral and square planar.*
5.8	discuss the use of $Fe^{3+}_{(aq)}/Fe^{2+}_{(aq)}$, $MnO_{4}^{-}{}_{(aq)}/Mn^{2+}_{(aq)}$, $Cr_2O_7^{2-}{}_{(aq)}/Cr^{3+}_{(aq)}$ as redox systems;	
5.9	explain the principle of ligand exchange;	*Stability constants and the* CO/O_2 *haemoglobin and* $NH_{3(aq)}/Cu^{2+}_{(aq)}$ *systems.*
5.10	perform experiments to demonstrate ligand exchange.	*Include reactions involving* $Co^{2+}_{(aq)}$, $Cu^{2+}_{(aq)}$.

6. Identification of Cations and Anions

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 Unit 1 Module 1, Specific Objective 1.7.*
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* $OH^{-}{}_{(aq)}$, $CO_3^{2-}{}_{(aq)}$ *and* $NH_{3(aq)}$ *and confirmatory tests.*
6.3	*explain the principles upon which the reactions in Specific Objective 6.2 are based;*	*Refer to equilibrium concepts. Unit 1 Module 2, Specific Objective 5.2.* *Basic, amphoteric oxide and complexation.*

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Identification of Cations and Anions (cont'd)	
6.4 *write ionic equations for the reactions in Specific Objective 6.2;*	
6.5 *identify anions:* CO_3^{2-}, NO_3^-, SO_4^{2-}, $SO_3^{2-}{}_{(aq)}$, Cl^-, Br^-, I^-, CrO_4^{2-};	*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.*
6.6 write ionic equations for the reactions in Specific Objective 6.5.	Include state symbols.

Suggested Teaching and Learning Strategies

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. Use charts and tables when establishing trends and differences in properties of elements and compounds.

3. Use computer software in simulations to demonstrate the chemistry of the elements and their compounds.

4. Link theory with appropriate laboratory work.

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

RESOURCES

Clugston, M. and Flemming, R. *Advanced Chemistry*, London: Oxford University Press, 2000.

Hill, G., and Holman, J. *Chemistry in Context*, London: Nelson Thorne Limited, 2000.

Lister, T., Renshaw, J. *Understanding Chemistry for Advance Level*, Cheltenham: Trans-Atlantic Publications, 2000.

Ramsden, E. *A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

<u>Websites</u>

www.Chemsoc.org
www.Chemguide.co.uk
www.creative-chemistry.org.uk
www.a-levelchemistry.co.uk

◆UNIT 2: CHEMICAL PRINCIPLES AND APPLICATION II

MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS

GENERAL OBJECTIVES

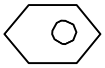
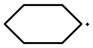
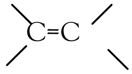
On completion of this Module, students should:

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;
4. critically assess the impact of carbon-based compounds on our daily lives.

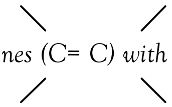
SPECIFIC OBJECTIVES	EXPLANATORY NOTES
1. Structure and Formulae	
Students should be able to:	
1.1 Explain the *occurrence* of carbon compounds *with* straight chains, branched chains and rings;	Catenation, tetravalency, *hybridization and resonance* of carbon atoms to be used as basis.
1.2 Explain the meaning of the term 'homologous series';	*Chemical* and physical characteristics.
1.3 distinguish between empirical, molecular and structural formulae;	
1.4 determine formulae from experimental data;	

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

Structure and Formulae (cont'd)

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
1.5 write structural formulae;	Structural formulae may be written in the following *formats*: Displayed H H H–C– | | C–O–H | | H H 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, with examples, structural isomerism;	Include chain, functional group and positional isomers.
1.8 explain stereoisomerism;	*Geometrical* (*cis/trans*) isomers resulting from restricted rotation about  double bond; optical isomerism due to asymmetry in molecules (confined to compounds with one chiral centre).
1.9 *determine* the possible isomers from given molecular formulae.	

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
2. <u>Functional Group Analysis, Reactions and Mechanisms</u>	
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, combustion.* *Equations required.*
2.3 *explain the steps involved in the mechanism of free radical substitution;*	*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* ($C=C$) *with* Br_2 (ℓ), $Br_{2(aq)}$, $KMnO_{4(aq)}/H^+_{(aq)}$/(*hot and cold*); *conc. sulphuric acid* *Hydrogen halides.* *Include hydrogenation of fats to produce trans–fats which are harmful.* *Equations for reactions of alkenes with* $KMnO_{4(aq)}/H^+_{(aq)}$ *are not required.*
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.*

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

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
	<u>Functional Group Analysis, Reactions and Mechanisms (cont'd)</u>	
2.6	*describe selected chemical reactions of alcohols;*	*Alcohols to include* $1^0, 2^0, 3^0$ *with* $KMnO_{4(aq)}/H^+_{(aq)}$; $K_2Cr_2O_{7(aq)}/H^+_{(aq)}$; *Carboxylic acid (R-COOH);* *conc. sulphuric acid.* I_2, *NaOH (iodoform test).* *Equations for reactions of alcohols with carboxylic acid and conc. sulphuric acid only are required.*
2.7	*describe selected reactions of halogenoalkanes;*	*Hydrolysis of primary and tertiary halogenoalkanes.* *Illustrate bond breaking or bond making as occurring in either a stepwise or concerted manner.*
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.*
2.9	*describe selected chemical reactions of* ╲ *carbonyl compounds* (C=0); ╱	$NaCN/HCl_{(aq)}$; *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.*
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.*

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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES
Functional Group Analysis, Reactions and Mechanisms (cont'd)		
2.13	*carry out suitable laboratory tests for functional groups in carbon compounds referred to above;*	*$SOCl_2$ and PCl_3 should be used in a fume cupboard.*
2.14	*describe the chemical reaction of primary amines (RNH_2) with dilute acid;*	*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 required.*
2.18	*describe the formation of an azo compound;*	*Phenylamine with HNO_2 and HCI. coupling with phenol to give azo compounds.*
2.19	*state uses of azo compounds.*	*Dyes, intermediates in organic synthesis.*

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

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
3.	Acidic and Basic Character of Organic Compounds	
	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;	pH and pK_b. Inductive and conjugative effects.
3.3	explain the acid-base properties of amino acids.	*Formation* of zwitterions.
4.	Macromolecules	
	Students should be able to:	
4.1	describe the characteristics of addition polymerisation;	Examples to include polyethene; polyvinyl chloride; polytetrafluoroethene.
4.2	describe the characteristics of condensation polymerisation;	*Terylene*; nylon 6.6; proteins, starch.
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.
4.6	identify carbohydrates as naturally occurring macromolecules;	Include the following: cellulose, starch and pectin. Treat simple sugars as monomeric materials.

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Macromolecules (cont'd)	
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. View taped materials on industrial carbon chemistry.

2. Arrange site visits, wherever possible, to industrial institutions, for example, (refineries, breweries, forensic laboratories, petrochemical plants).

3. Use models in section dealing with structures.

4. Use relevant reference journals and periodicals, for example, Chemistry in Education.

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, 2005.
Clugston, M. and Flemming, R.	*Advanced Chemistry*, London: Oxford University Press, 2000.
Hill, G., and Holman, J.	*Chemistry in Context,* London: Nelson Thorne Limited, 2000.
Lister, T., Renshaw, J.	*Understanding Chemistry for Advance Level,* Cheltenham: Trans-Atlantic Publications, 2000.
Ramsden, E.	*A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

<u>Websites</u>

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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, 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;

3. use experimental data to quantify substances or elucidate structure;

4. 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
1.	Uncertainty in Measurements	
	Students should be able to:	
1.1	apply appropriate concepts to the analysis of scientific data;	*Mean, standard deviation, precision, accuracy, calibration curves, 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;	Examples should include: pipettes, burettes, volumetric flasks, thermometers, top-loading balances, analytical balances.
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.

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

2. Titrimetric (Volumetric) Methods of Analysis

Students should be able to:

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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.
2.3	*use data obtained from potentiometric thermometric and conductrimetric methods for titration which do not require the use of indicators;*	
2.4	carry out 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;	*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*.

3. Gravimetric Methods of Analysis

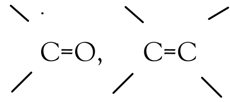
Students should be able to:

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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 and ovens and furnaces.

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Gravimetric Methods of Analysis (cont'd)	
3.3 carry out experiments based on gravimetric determinations;	Limited to experiments involving volatilisation methods, such as, moisture content of soils; water of crystallization.
3.4 perform calculations based on data obtained from gravimetric analyses;	Use data from actual experiments carried out or from the literature.
3.5 cite examples of the use of gravimetric analysis in quality control.	
4. Spectroscopic Methods of Analysis	
Students should be able to:	
4.1 explain the nature of electromagnetic radiation;	*Calculations using the equation*: $E = h\nu = hc/\lambda$ *are* required.
4.2 state the approximate wavelength ranges of the X-ray, UV/VIS, IR and *radiofrequency* regions of the electromagnetic spectrum;	*Relative* energies and dangers associated with exposure to high energy wavelengths.
4.3 recall that the energy levels in atoms and molecules are quantised.	
5. Ultra Violet-Visible (UV/VIS) Spectroscopy	
Students should be able to:	
5.1 explain the origin of absorption in UV/VIS spectroscopy;	
5.2 explain why some species will absorb light in the UV/VIS region whereas others will not;	

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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES
Ultra Violet-Visible (UV/VIS) Spectroscopy (cont'd)		
Students should be able to:		
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;	*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.*
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.*
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.
6.4	deduce the functional groups present in organic compounds from IR *spectra*;	Groups to be identified include: -OH, -NH$_2$,  C=O, C=C , -CO$_2$H, -CONH$_2$. Use should be made of IR spectral *data.*
6.5	*cite examples of the use of IR spectroscopy in the monitoring of air pollutants.*	CO$_2$, *SO$_2$.*

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
7. **Mass Spectrometry**	
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;	
7.3 use mass spectral data to:	Use should be made of mass spectral sheets.
(i) determine relative isotopic masses; and relative isotopic abundance;	
(ii) distinguish between molecules of similar relative molecular mass;	
(iii) predict possible identities of simple organic molecules based on their fragmentation pattern.	
8. **Chromatographic Methods of Separation**	
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; 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.

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
Chromatographic Methods of Separation (cont'd)	
8.4 name examples of commonly used stationary phases;	Include reference to cellulose, silica gel, alumina.
8.5 carry out simple experiments to separate the components of mixtures, using paper, column and thin layer chromatographic techniques;	Suitable mixtures which could be used include amino acids, plant pigments, food colouring.
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;	*Raoult's Law.* 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.*
9.2 discuss the advantages of carrying out distillation processes under reduced pressures;	
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 is required.
9.5 select appropriate methods of separation, given the physical and chemical properties of the *components* of a mixture;	

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

Phase Separations (cont'd)

	SPECIFIC OBJECTIVES	EXPLANATORY NOTES
9.6	perform distillation experiments;	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	carry out simple separation experiments based on solute partitioning between two immiscible solvents;	These could include the separation of an acid/base mixture.
9.8	*cite examples of the applications of the distillation methods used in various industries.*	*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.

    (i) Make arrangements for site visits with your students.

    (ii) Make use of personnel from such industries and institutions to come in and give lectures and demonstrations.

    (iii) Access any 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.

3. In cases where limited equipment is available, students can work in groups. Class demonstrations, set up by teachers, could be also useful.

4. Since this Module is geared to prepare students for work in industry, there is need to emphasise the practical aspects of the various analytical techniques.

RESOURCES

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

Clugston, M. and Flemming, R.	*Advanced Chemistry*, London: Oxford University Press, 2000.
Ramsden, E.	*A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

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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. *understand* the sources of pollution and strategies which assist in reduction of pollutants;
3. understand that there are physical and chemical changes occurring in the environment and assess their impact on it;
4. recognise the influence of industrial processes on social and economic life;
5. appreciate the impact of man's activities on the environment.

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
1. __Locating Industrial plants; Benefits and Risk__	
Students should be able to:	
1.1 discuss factors which influence the location of an industrial plant;	
1.2 *discuss general safety requirements for industry.*	
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. *High energy consumption in the production of aluminium.*
2.2 explain the uses of aluminium in relation to its physical and chemical properties;	
2.3 assess the impact of the aluminium industry on the environment;	

SPECIFIC OBJECTIVES | **EXPLANATORY NOTES**

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;	Refer to *Unit 2 Module 3 Specific Objective* 9.6. *Include fractional distillation, catalytic cracking and reforming techniques.*
3.3	*assess the impact of the petroleum industry on the environment.*	

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. Apply the principles of chemical equilibrium and kinetics.
4.2	discuss the uses of ammonia;	In agriculture and chemical industry.
4.3	assess the impact of the ammonia industry on the environment.	

5. Ethanol

Students should be able to:

5.1	explain the process of fermentation *and distillation* in the manufacture of alcoholic beverages;	
5.2	*discuss the uses of ethanol;*	*Include fuel, pharmaceutical industry.*

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

Ethanol (cont'd)

SPECIFIC OBJECTIVES		EXPLANATORY NOTES
5.3	*discuss the social and economic impact of alcohol production and consumption;*	*Include physiological changes.*
5.4	*assess the impact of the alcohol industry on the environment.*	

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;	*Bleaches*, PVC, halogenated hydrocarbons, solvents, aerosols, refrigerants, *anaesthetics.*
6.4	*assess the impact of the chlor-alkali industry on the environment.*	

7. Sulphuric Acid

Students should be able to:

7.1	describe the Contact process for the manufacture of sulphuric acid;	*Include the principles of chemical equilibrium and kinetics.*
7.2	discuss the industrial importance of compounds of sulphur;	SO_2 in food preservation and H_2SO_4 manufacture.
7.3	*assess the impact of the sulphuric acid industry.*	

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES
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;*	*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;	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.	
9. The Atmosphere	
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.

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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES
The Atmosphere (cont'd)		
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;	*Nitrogen* cycle and acid rain.
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.	Solid Waste	
Students should be able to:		
10.1	*distinguish among reduce, reuse, recycle.*	
10.2	*describe the process involved in waste reduction.*	*Consider reusing and recycling of glass, paper, plastic, steel and aluminium; reduce.*
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, *nuclear waste; proper and improper disposal techniques-dumps and sanitary landfills.*

Suggested Teachings 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.

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

2. Establish contact with environmental groups (Non-Governmental Organisations, Community Based Organisations) and the Environmental Management Authority (EMA) in their territories.

3. Have students collect newspaper articles and journal articles and conduct web-based searches on issues relating to industry and environment.

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 references to the following resource materials useful. The latest editions are recommended.

Clugston, M. and Flemming, R.	*Advanced Chemistry*, London: Oxford University Press, 2000.
Hill, G., and Holman, J.	*Chemistry in Context,* London: Nelson Thorne Limited, 2000.
Ramsden, E.	*A-Level Chemistry*, Cheltenham: Nelson Thorne Limited, 2000.

<u>Websites</u>

www.Chemsoc.org
www.Chemguide.co.uk www.creative-chemistry.org.uk www.a-levelchemistry.co.uk

◆OUTLINE OF ASSESSMENT

EXTERNAL ASSESSMENT FOR EACH UNIT (80%)

Paper 01 *(1 hour 30 minutes)*	*Forty-five multiple-choice items, 15 from each Module. Each item is worth 1 mark.*	40%
Paper 02 (2 hours 30 minutes)	Section A - Three compulsory structured questions testing the application of experimental skills, one from each Module. Each question is worth 15 marks. Section B – Three compulsory essay questions one from each Module. Each question is worth 15 marks.	40%

INTERNAL ASSESSMENT FOR EACH UNIT (20%)

The Internal Assessment will consist of selected practical exercises which are to be designed by the teacher.

MODERATION OF INTERNAL ASSESSMENT

Each year, an Internal Assessment Record Sheet will be sent to schools submitting candidates for these examinations.

All Internal Assessment Record Sheets and a sample of practical workbooks must be forwarded to the Local Registrar for submission to CXC by May 31 of the year of the examination.

The sample, which is to be selected using guidelines provided by the Council, will be reassessed by external examiners, to inform the moderation of the Internal Assessment marks awarded by teachers. The reliability (consistency) of teachers' Internal Assessment marks is an important characteristic of high quality assessment. Teachers' marks may be adjusted as a result of the moderation, and feedback reports will be provided.

All candidates' workbooks must be retained by the school, until three months after publication, by CXC, of the examination results.

ASSESSMENT DETAILS

Each Unit of the syllabus is assessed as outlined below.

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

1. An answer sheet will be provided for Paper 01. A separate answer booklet will be provided 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.

<u>Paper 01 (1 hour 30 minutes – 40% of Total Assessment)</u>

1. **Composition of the Paper**

   This paper will consist of forty-five multiple-choice items, fifteen 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, with each question being allocated 1 mark.

3. **Question Type**

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

<u>Paper 02 (2 hours 30 minutes - 40% of Total Assessment)</u>

1. **Composition of Paper**

   This paper will consist of two sections:

   Section A will consist of three compulsory structured questions testing the application of experimental skills, one question from each Module.

   Section B will consist of three compulsory essay questions, one from each Module. Knowledge of the entire Unit is expected.

2. **Mark Allocation**

   The paper will be worth 90 marks.

Section A - each question	-	15 marks
Section B - each essay	-	15 marks

   Total marks of Section A - 45 marks
   Total marks of Section B - 45 marks

3. **Question Type**

Questions in Section A will be presented in a structured form testing the application of experimental skills. Answers are to be written in a separate answer booklet.

Questions in Section B will be essays. The mark allocation for each section will be included. Answers for this section are to be written in a separate answer booklet.

Internal Assessment (20%)

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.

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

Internal 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. Internal 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. Internal 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 Internal Assessment scores that contribute to the overall scores of candidates are 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:

a. Analysis and Interpretation
b. Manipulation and Measurement
c. Observation, Recording and Reporting
d. Planning and Designing

In each Unit, a total of 12 marks are to be allocated for each skill as indicated in Table 1.

Table 1
Internal Assessment Skills

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

*** Five of the 12 marks for Observation, Recording and Reporting (ORR) are to be awarded for communicating in a logical way using correct grammar as described in the definition of the Observation, Recording and Reporting skill on pages 1 and 2. Teachers are required to provide criteria which clearly indicate how they award marks.**

Each Module carries a maximum of 16 marks.

Each candidate's Internal Assessment mark for any Unit should be divided by 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;
(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.

Specific 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 maximum mark for any skill will be 12. The mark recorded 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.

4. Specific Objectives lending themselves to practical work are highlighted by single underlining. However, teachers need not confine their practical exercises to these objectives.

INTERNAL ASSESSMENT – GENERAL GUIDELINES FOR TEACHERS

1. For each Unit marks must be submitted to CXC on the Internal Assessment forms provided. The forms should be despatched through the Local Registrar for submission to CXC by May 31 of the year of the examination.

2. The Internal Assessment Forms for each Unit should be completed in duplicate. The original should be submitted to CXC and the copy retained by the school.

3. CXC will require a sample of the laboratory books for external moderation. Additional laboratory books may be required. These laboratory books must be retained by the school for at least three months after publication of examination results.

4. Candidates who do not fulfil the requirements for the Internal Assessment will be considered absent from the whole examination.

5. Teachers are asked to note the following:

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

   (ii) teachers' criteria and breakdown of marks for assessing a skill must be clearly stated and submitted with the laboratory books;

   (iii) the relationship between the marks in the laboratory books and those submitted on the Internal Assessment Form should be clearly shown;

   (iv) the standard of marking should be consistent.

◆REGULATIONS FOR PRIVATE CANDIDATES

1. Candidates who are registered privately will be required to sit Papers 01, 02 and 03B.

2. **Paper 03B (Alternate to Internal School-Based Assessment)** - 20%

   This paper will be of 2 hours duration and will consist of THREE questions as follows:

   (i) a practical question;

(ii) a data analysis question;
(iii) a planning and design exercise.

This paper will constitute 20% of the overall assessment of the candidates' performance on the Unit.

◆REGULATIONS FOR RESIT CANDIDATES

Candidates who have earned a moderated score of at least 50% of the total marks for the Internal Assessment component, may elect not to repeat this component, provided they re-write the examination no later than TWO years following their first attempt. These resit candidates must complete Papers 01 and 02 of the examination for the year in which they register.

Resit candidates must be entered through a school or other approved educational institution.

Candidates who have obtained less than 50% of the moderated marks for the Internal Assessment component must repeat the component at any subsequent sitting or write Paper 03B.

◆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.

Papers	**Module 1**	**Module 2**	**Module 3**	**Total**	(%)
External Assessment Paper 01 Multiple Choice	15 30 (weighted)	15 30 (weighted)	15 30 (weighted)	45 90 (weighted)	(40)
Paper 02 A. Structured questions B. Essay questions	15 15	15 15	15 15	45 45	(40)
Internal Assessment Papers 03A and 03B	16	16	16	48	(20)
TOTAL	**76**	**76**	**76**	**228**	**(100)**

◆GLOSSARY

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
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
Cite	requires a quotation or a reference to the subject.	
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

WORD	DEFINITION	NOTES
Construct	requires either the use of a specific format for the representations, such as graphs, using data or material provided or drawn from practical investigations, or building of models or the drawing of scale diagrams.	Such representations should normally bear a title, appropriate headings and legend; UK
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.	
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.	
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 analyzed 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.	
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
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.	

WORD	DEFINITION	NOTES
Label	implies the inclusion of names to identify structures or parts as indicated by pointers.	
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 characterise 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
Show	see Demonstrate.	

WORD	DEFINITION	NOTES
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.	
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

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION (CAPE)

CHEMISTRY

DATA BOOKLET

TABLE 1: SOME IMPORTANT CONSTANTS

the Avogadro constant	L	=	6.02×10^{23} mol^{-1}
electronic charge	e	=	-1.60×10^{-19}C
the Faraday constant	F	=	9.65×10^{4} C mol^{-1}
ionic product of water	K_w	=	1.00×10^{-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 condition
the Planck constant	h	=	6.63×10^{-34} J s
rest mass of electron, $^{0}_{-1}e$	m_e	=	9.11×10^{-31}kg
rest mass of neutron, $^{1}_{0}n$	m_n	=	1.67×10^{-27} kg
rest mass of proton, $^{1}_{1}H$	m_p	=	1.67×10^{-27} kg
specific heat capacity of water		=	4.18 kJ kg^{-1}K^{-1}
speed of light in a vacuum	c	=	3.00×10^{8}m s^{-1}
iJoule	J	=	Pa M^{3}

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	7458
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
	metallic	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
		Al	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
$A\ell^{3+} + 3e^- \rightleftharpoons A\ell$	−1.66
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	−2.90
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	−2.87
$C\ell_2 + 2e^- \rightleftharpoons 2C\ell^-$	+1.36
$2HOC\ell + 2H^+ + 2e^- \rightleftharpoons C\ell_2 + 2H_2O$	+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

TABLE 5 CONT'D

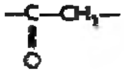
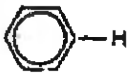
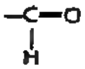
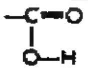
Electrode reaction	$E^{\ominus}$/volts at 298 K(25°C)
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	−2.38
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	−1.18
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+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
$V^{2+} + 2e^- \rightleftharpoons V$	−1.2
$V^{3+} + e^- \rightleftharpoons V^{2+}$	−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

TABLE 7: SELECTED ^1H NMR DATA

Type of proton	Chemical shift in region of
$R-CH_3$	0.9
$R-CH_2-R$	1.3
 R_3C-H	2.0
 $-C(=O)-CH_2-$	2.3
$-O-CH_3$	3.8
$-O-CH_2-R$	4.0
$-O-H$	5.0 (variable)
	7.5
 $-C(H)=O$	9.5
 $-C(OH)=O$	11.0 (variable)

The Periodic Table of the Elements

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
							1 H 1.008										2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Uun (271)	111 Uuu (272)	112 Uub (277)						
			58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0	
			90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)	

Western Zone Office
2006/08/16

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

SPECIMEN PAPER
MULTIPLE CHOICE QUESTIONS
FOR

CHEMISTRY

UNIT 1- Paper 01

90 minutes

READ THE FOLLOWING DIRECTIONS CAREFULLY

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.

Sample Item

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

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

Sample Answer

Ⓐ Ⓑ ● Ⓓ

The best answer to this item is "σ to σ^*", so answer space (C) has been blackened.

---

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 $109^o\,28'$?

(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 $24dm^3$. If 0.032g of a gas occupies $48cm^3$ at r.t.p., what is the molar mass?

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

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 8.8g of propane is burnt in oxygen at r.t.p.?

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

(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. $BaCl_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2HCl\ (aq)$
II. $2H_2O_2\ (aq) \rightarrow 2H_2O\ (l) + O_2\ (g)$
III. $NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$
IV. $Fe_2O_3\ (s) + 2Al\ (s) \rightarrow Al_2\ O_3\ (s) + 2\ Fe\ (l)$

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

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) Macroscopic properties are constant.

(B) Microscopic processes are in balance.

(C) It is reversible.

(D) It cannot be achieved in a closed system.

<u>Item **10**</u> 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 25g of an unknown gas, X, is pumped through an industrial pipeline of volume $60m^3$ at a pressure of 120 kPa and temperature of 150°C. (Molar gas constant = $8.31JK^{-1}$ 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.

IV. At 380 K, the particles of Y are not mobile.

(A) I and II only

(B) I and III only

(C) II and III only

(D) II and IV only

GO ON TO THE NEXT PAGE

Items **13 and 14** refer to the following options.

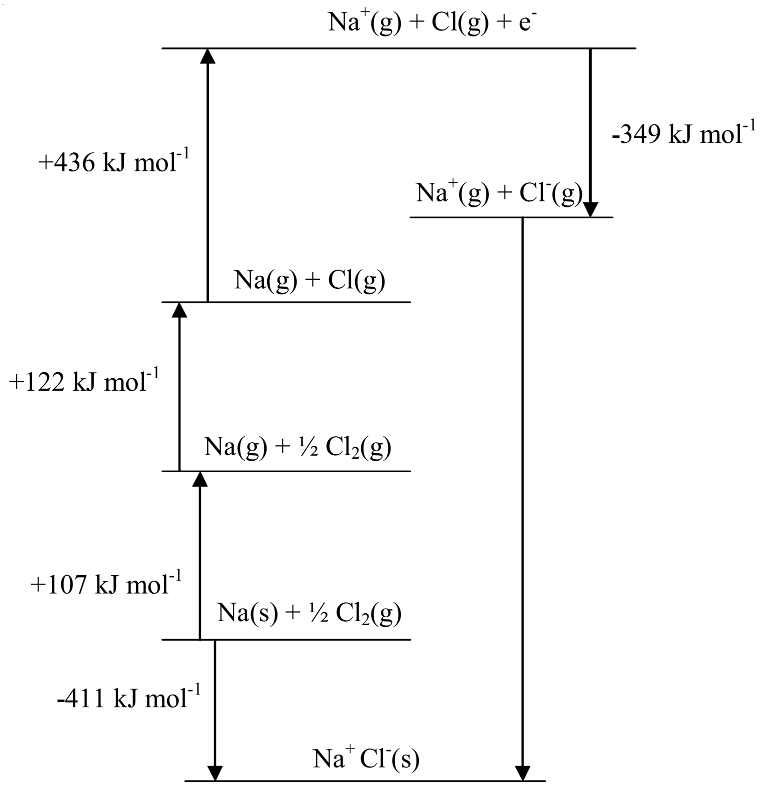
(A) Enthalpy of formation
(B) Lattice energy
(C) Enthalpy of solution
(D) Enthalpy of hydration

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. $XY(s) + \text{water} \rightarrow XY(aq)$

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) $\frac{1}{2}$
(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

$2X(g) + Y_2(g) \rightarrow X_2Y_2(g)$

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

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

Experiment number	**Concentration/ mol dm^{-3}**			**Reaction 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

GO ON TO THE NEXT PAGE

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

19. Which statements are correct for the Boltzmann distribution?

Increasing temperature

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

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

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

Item **21** 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 Kp for the equilibruim $N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$?

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

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

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

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

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

I. NH_4^+
II. CH_3COO^-
III. C_6H_5OH
IV. PH_3

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

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

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

GO ON TO THE NEXT PAGE

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. $CH_3COO^- + H^+ \rightarrow CH_3COOH$
II. $CH_3COO^- + NH_4^+ \rightarrow CH_3COONO_4$
III. $CH_3COOH + HCO_3^- \rightarrow CH_3COO^- + H_2O + CO_2$
IV. $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

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

<u>Item **26**</u> refers to the following reaction:

$$CH_3COOH(aq) \rightleftarrows H^{\oplus}(aq) + CH_3\,COO^{\ominus}(aq)$$

[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:

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

From this it can be deduced that

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

Items **31** and **32** refer to the graphs below which show trends displayed by elements in Period 3.

In answering Items **31 - 32**, match each item with one of the graphs above. 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. $\underline{P}_4O_6$

34. $\underline{Na}_2O$

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.
IV. The electronelectronegativity of the atoms decreases.

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

37. Group IV elements show an increaseing 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 can be described by all of the following statements EXCEPT

(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?

	(A)	(B)	(C)	(D)
Precipitate with $AgNo_3$	white	white	off-white	off-white
Dissolves in dilute NH_3	sparingly	readily	sparingly	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) Vacant d-orbitals on the metal atom or ion
(B) The presence of lone pairs of electrons on ligands
(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: $[Ar] = ls^2, 2s^2 2p^6, 3s^2 3p^6$

		3d					4s
(A)	[Ar]	↑	↑	↑	↑	↑	↑↓
(B)	[Ar]	↑	↑	↑	↑		
(C)	[Ar]	↑	↑	↑			
(D)	[Ar]	↑	↑				↑↓

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, FA1, is subjected to analysis and the results are shown in the table.

Reaction	**Results**
KI(aq) + FA1 (aq)	No visible reaction
NH_3 (aq) + FA1(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) $[Ag(NH)_4]^{2+}$

TEST CODE 02112
SPECIMEN

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

Unit 1 - Paper 02

2 hours 30 minutes

Specimen

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of SIX COMPULSORY questions in two sections.
2. Section A consists of THREE compulsory questions, one from each Module. Write your answers in the spaces provided in this booklet. Each question is worth 15 marks
3. Section B consists of THREE compulsory questions, one from each Module. Write your answers in the answer booklet provided. Each question is worth 15 marks.
4. Attach your answer booklet to the question booklet and return them to the supervisor.
5. The use of non-programmable calculators is allowed.
6. A data booklet is provided.

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

SECTION A

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.

[1mark]

(b) 20 cm^3 of a solution of phosphorous (V) acid containing 1.96g 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.

[2marks]

(ii) sodium hydroxide that reacted.

[1 mark]

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

[1mark]

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

[1mark]

(d) (i) State Avogadro's Law.

[1 mark]

(e) Outline the steps involved in carrying out the reaction described in (b) on page 2.

[5 marks]

Total 15 marks

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.

[5 marks]

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

[2 marks]

(iii) Identify the anode and the cathode.

Anode: ________________

Cathode: ________________

[1 mark]

(iv) Explain the direction of electron flow.

____

____

[1 mark]

(v) Write the cell diagram.

____

____

[1 mark]

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

____

____

[1 mark]

(b) Use the $E^\ominus$ value for each electrode (in the data booklet) to determine the $E^\ominus_{cell}$. Does your calculated value concur with the measured value of $E^\ominus_{cell} = 1.10V$ given on page 4?

[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.

____

____

____

____

____

[2 marks]

Total 15 marks

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+} ?

(ii) Mn^{2+} ?

[2 marks]

(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]

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

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

Formula:

[2 marks]

(ii) an excess of ammonia solution is added to (e) (i) on page 6.

____

Formula: ____________________________________

[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.

____

____

____

____

[4 marks]

Total 15 marks

SECTION B

Answer ALL questions

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. (a) State Hess's Law.

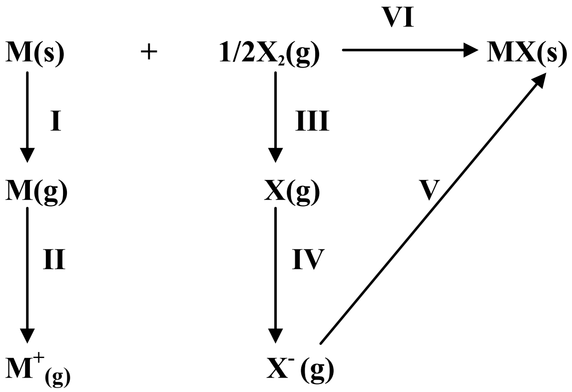
[1 mark]

(b) Define

(i) standard enthalpy change of formation

(ii) lattice energy. **[2 marks]**

(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^{θ}_{A} M(s) = +86; ΔH^{θ}_{I} M(g) = + 408; ΔH^{θ}_{F} (MX(s)) = -431; ΔH^{θ}_{D} X_2 = + 122; ΔH^{θ}_{E} X(g) = -372

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

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

[6 marks]

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

[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 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. (a) 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.

[3 marks]

(b) (i) Derive the relationship for the ionic product of water, K_w.

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

[3 marks]

(c) (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}

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

[4 marks]

(d) 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'.

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

(iii) Explain how small additions of H^+ and OH^- ions are accommodated in the buffer solution prepared in 5 (d) (ii).

[5 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

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

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

[5 marks]

(b) (i) Explain the terms 'atomic radius' and 'ionic radius'.

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

(iii) Account for the variation in the solubility of the sulphate (VI) of the Group II elements.

[5 marks]

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

[5 marks]

Total 15 marks

END OF TEST

TEST CODE 02112032

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CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY-SPECIMEN PAPER

Unit 1 - Paper 032

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. **This paper consists of THREE questions. Answer ALL questions.**
2. **The use of silent non-programmable calculators is allowed.**

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

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

1. (a) You have been provided with samples of three solids, A, B and C. Carry out the following tests on EACH sample and record your observations in Table 1 below.

TABLE 1: DATA ON TESTS CARRIED OUT ON SOLIDS A, B AND C

Test	Observation		
	A	B	C
(i) Appearance			
(ii) Add 5 cm^3 of distilled water and shake.			
(iii) Add 1cm^3 of carbon tetrachloride, cork, and shake.			
(iv) Heat 1g in a dry hard glass test tube, until the sample melts. Record the temperature at which the sample melts. *			

* If the solid does not melt at the temperature of the bunsen burner, write "High melting point" in the Observation column.

(12 marks)

(b) Suggest, giving reasons, the type of bonding present in EACH of A, B and C, which is responsible for the observations in (a) on page 2.

Bonding in A: ____

Reason: ____

Bonding in B: ____

Reason: ____

Bonding in C: ____

Reason: ____

(6 marks)

Total 18 marks

GO ON TO THE NEXT PAGE

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 readings 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.

(a)(i) 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)

(ii) On the graph paper (page 7), plot a graph of time taken for the magnesium ribbon to disappear against volume of acid added from the burette.

(4 marks)

(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)

(v) What can you deduce about the rate of reaction from your answer in (a)(iv) on page 5?

____

(1 mark)

(vi) What is the order of the reaction?

____

(1 mark)

(vii) Using the data from the graph, determine the time it would take for 25 cm^3 of the acid to react with the magnesium ribbon. Suggest the significance of this time.

Time:

____

Significance:

____

____

(2 marks)

Total 18 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^θ = -1.39V, and the fourth contains another reducing agent of E^θ = -0.14V. All are colourless liquids.

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

Plan and design an experiment which will allow you to correctly classify each of the above chemicals. Write you answer in the spaces below.

(i) Hypothesis:

____

____

____

____

(1 mark)

(ii) Apparatus and materials:

____

____

____

____

(1 mark)

(iii) Method:

____

____

____

____

(3 marks)

(iv) Variables:

(1 mark)

(v) Expected results:

(2 marks)

(vi) Treatment of results:

(1 mark)

(vii) Chemical principles:

(2 marks)

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(viii) Sources of error/assumptions/limitations:

(1 mark)

Total 12 marks

END OF TEST

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

SPECIMEN PAPER
MULTIPLE CHOICE QUESTIONS
FOR

CHEMISTRY

UNIT 2 - Paper 01

90 minutes

READ THE FOLLOWING DIRECTIONS CAREFULLY

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.

Sample Item

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

(A) n to $\sigma*$
(B) n to $\pi*$
(C) σ to $\sigma*$
(D) π to $\pi*$

Sample Answer

Ⓐ Ⓑ ● Ⓓ

The best answer to this item is "σ to $\sigma*$", so answer space (C) has been blackened.

---

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

- I. Carbon forms strong bonds with itself.
- II. Carbon forms four bonds.
- III. Carbon exists in three allotropic forms.
- IV. 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?

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

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

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

- I. Presence of OH and COOH groups in monomers
- II. Elimination of a small molecule
- III. 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:

The pair of monomers in Qiana is

6. Which of the following represent naturally occuring macromolecules?

(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?

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.

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

<u>Items **10** and **11**</u> 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)?

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

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 cm^3.

$$5Fe^{2+}_{(aq)} + MnO^{-}_{4(aq)} + 8H^{+}_{(aq)} \rightarrow 5Fe^{3+}_{(aq)} + Mn^{2+}_{(aq)} + 4H_2O_{(l)}$$

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) $\dfrac{207 \text{ x } 8.00}{303 \text{ x } 4.75} \text{ x } 100$

(B) $\dfrac{303 \text{ x } 4.75}{207 \text{ x } 8.00} \text{ x } 100$

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

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

21. Which region of the electromagnetic spectrum below provides the required energy for n.m.r spectroscopy?

22. Which is the correct sequence of steps for the detection of the concentration of heavy metals in marine sediments by Atomic Absorption Spectroscopy (AAS)?

(A) Concentration of sample solution → aspiration → atomisation
(B) Concentration of sample solution → atomisation → aspiration
(C) Aspiration → concentration of sample solution → atomisation
(D) Atomisation → concentration of sample solution → aspiration

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

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

<u>Item **24**</u> refers to the following structure of caesalpinin.

24. The compound caesalpinin exhibits absorption at wave numbers 3400 cm^{-1} and 1750 cm^{-1} in the IR spectrum. Which functional groups are responsible for these absorptions?

(A) –OH and $\rangle C=O$
(B) C – H and – OH
(C) –OH and $-\overset{|}{\underset{|}{C}}-O$
(D) $-\overset{|}{\underset{|}{C}}-O$ and $\rangle C=O$

Item **25** refers to the diagram below which shows a double beam instrument used in spectroscopic analysis of liquid/solution.

25. What is the name of the device labelled I?

(A) Grating
(B) Photodetector
(C) Shutter
(D) Monochromator

Item **26** refers to the following information.

Hydrogen bromide undergoes fragmentation when passed into a spectrometer. Bromine has two isotopes, Br–79 and Br–81. The hydrogen involved here has only ${}^{1}_{1}H$ isotope. The spectrum is given below.

26. Which of the following combinations of ionic isotopes is responsible for the peaks at mass 79, 80, 81 and 82?

	Particle			
	I	II	III	IV
(A)	${}^{79}Br^{+}$	${}^{1}_{1}H\ {}^{79}Br^{+}$	${}^{81}Br^{+}$	${}^{3}H\ {}^{79}Br^{+}$
(B)	${}^{79}Br$	${}^{1}H\ {}^{79}Br$	${}^{81}Br$	${}^{1}H\ {}^{81}Br$
(C)	${}^{79}Br^{+}$	${}^{1}H\ {}^{79}Br^{+}$	${}^{81}Br^{+}$	${}^{1}H\ {}^{81}Br^{+}$
(D)	${}^{79}Br^{-}$	${}^{1}H\ {}^{79}Br$	${}^{81}Br^{-}$	${}^{1}H\ {}^{81}Br$

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 ${}^{31}p$

Item **28** refers to the following n.m.r spectrum of a compound of molecular formula $C_2H_3Cl_3$.

28. Which of the following compounds may be assigned to the n.m.r. spectrum?

(A) Chloroethane
(B) Trichloroethane
(C) 1,1, 1 – Trichloroethane
(D) 1,1,2 – Trichloroethane

GO ON TO THE NEXT PAGE

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 cm^3 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) $\frac{3.7 \times 10^{-2}}{6.5 \times 10^{-3}}$

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

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

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) $Al(OH)_3$

(B) $Al(OH)_4^-$

(C) SiO_3^{2-}

(D) $Al_2(CO_3)_3$

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.

$$N_2\,(g) + 3H_2\,(g) \text{ catalyst} \rightleftarrows 2NH_3(g)$$

$$\Delta H^2 = -92 \text{ kJ mol}^{-1}$$

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) $S(g) + O_2(g) \rightleftarrows SO_2(g)$

(B) $2S(g) + 3O_2(g) \rightleftarrows 2SO_3(g)$

(C) $2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$

(D) $2S(g) + 3O_2(g) + 2H_2O(l) \rightleftarrows 2H_2SO_4(aq)$

36. Sulphur dioxide is used in food preservation because it is

(A) weakly acidic
(B) a reactive gas
(C) a reducing agent
(D) colourless

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. High tensile strength
III. Imperneable oxide
IV. Conducts electricity

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

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

TEST CODE 02212
SPECIMEN

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

Unit 2 - Paper 02

2 hours 30 minutes

Specimen

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. **This paper consists of SIX COMPULSORY questions in two sections.**
2. **Section A consists of THREE compulsory questions, one from each Module. Write your answers in the spaces provided in this booklet. Each question is worth 15 marks.**
3. **Section B consists of THREE compulsory questions, one from each Module. Write your answers in the answer booklet provided. Each question is worth 15 marks.**
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5. **The use of non-programmable calculators is allowed.**
6. **A data booklet is provided.**

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

SECTION A

Answer ALL questions.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

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

(a) (i) Circle and name THREE functional groups in the dopamine molecule.

[3 marks]

(ii) Would the dopamine molecule exhibit optical activity? Give a reason for your answer.

____

____

[2 marks]

(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 this species be expected to migrate?

____

[1 mark]

(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.

[4 marks]

TABLE 1: RESULTS OF CHEMICAL ANALYSIS OF DOPAMINE

Test	**Observation**	**Inference**
PCl_3 or PCl_5 is added to dopamine.	(i)	(ii)
(iii)	White crystals are produced on heating.	(iv)

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

2. The chromatogram in Figure 1 is obtained when a mixture of organic compounds, A – D is analysed by gas-liquid chromatography.

Figure 1: Chromatogram

(a) Define EACH of the following terms:

(i) Retention time

____

____

[1 mark]

(ii) Mobile phase

____

____

[1 mark]

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

____

[1 mark]

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

____

[1 mark]

(ii) For how long was this compound retained on the column?

____

[1 mark]

(c) Assuming that the mixture contained methanol, methanal, propane and propanoic acid suggest the identities of A, B, C, D.

A: ____

B: ____

C: ____

D: ____

[4 marks]

(d) Give reasons for your answer in (c) above.

____

____

____

____

[2 marks]

(e) Outline how a mixture of food dyes could be separated by column chromatography.

[4 marks]

Total 15 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) on page 6, 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 2 below shows the average concentration of pollutants NO and NO_2 in an urban area during a 24-hour period.

Figure 2: Concentration of NO and NO_2

(i) What is meant by EACH of the following terms:

a) Primary pollutant

____

____

b) Secondary pollutant

____

____

____

[2 marks]

(ii) Use the following equilibrium reaction

$N_2(g) + O_2 \leftrightarrows 2NO(g)$; $\Delta H = +180 \text{ kJ mol}^{-1}$

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

____

____

____

[2 marks]

(iii) Suggest a reason for the time lapse between maximum concentrations of NO(g) and $NO_2(g)$ shown in Figure 2.

____

____

____

[1 mark]

(iv) On Figure 2, show 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]

Total 15 marks

SECTION B

Answer ALL questions.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

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

[3 marks]

(b) State TWO ways by which covalent bond breaking occurs, and using the covalent compound A – B, illustrate EACH of these TWO ways.

[3 marks]

(c) 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.

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

[6 marks]

(d) 2-chloro-2-methylpropane (tertiary butyl chloride) can be converted to the corresponding alcohol by reacting with aqueous sodium hydroxide.

(i) Deduce the formula of the reacting nucleophile.

(ii) Outline the mechanism of the reaction.

[3 marks]

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

5. (a) Briefly explain the principles upon which mass spectrometry is based. Include in your answer a simple schematic (block) diagram of the instrument.

[6 marks]

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

(i) What is the relative molecular mass of A?

(ii) What is the name of the M+1 peak in the spectrum?

(iii) Suggest a possible identity for EACH of the species corresponding to peaks B, C and F.

(iv) Suggest the identity of Compound A, <u>and</u> draw its structure.

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

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

[9 marks]

Total 15 marks

MODULE 3

INDUSTRY AND THE ENVIRONMENT

6. Ammonia is produced industrially by the Haber process. In this process, nitrogen and hydrogen are allowed to react in the presence of a catalyst.

   (a) In the Haber process:

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

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

   (iii) Name the catalyst used.

   [4 marks]

   (b) Figure 3 shows the yield of ammonia under varying conditions of temperature and pressure.

Figure 3: Yield of ammonia

Using the data given in Figure 3 above:

(i) Determine the effect on the yield of ammonia by

  a) increasing the pressure

  b) increasing the temperature.

(ii) Predict the conditions of temperature and pressure which would maximize the yield of ammonia.

(iii) State whether the conditions used in industry are similar to those you predicted in 6 (b) (ii). Account for any variations in these conditions.

[6 marks]

(c) Ammonia itself is not directly used as a fertilizer. Instead, it is first converted into other compounds before it is applied to the soil. Suggest TWO reasons for this.

[2 marks]

(d) 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]

(e) The presence of NH_4^+ ions in the soil as a result of the use of nitrogenous fertilizers, such as ammonium nitrate, can cause an increase in soil acidity. Suggest a reason for this.

[2 marks]

Total 15 marks

END OF TEST

TEST CODE 02212032

FORM TP 2007-SPEC

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY-SPECIMEN PAPER

Unit 2 - Paper 032

ALTERNATIVE TO SBA

2 hours

Candidates are advised to use the first 15 minutes for reading through this paper carefully.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. **This paper consists of THREE questions. Answer ALL questions.**
2. **The use of silent non-programmable calculators is allowed.**

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

Answer **ALL** questions.

Write your answers in the spaces provided in this booklet.

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 (M_1).

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 (M_2).

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 (M_3).

TABLE 1: DATA FOR EXPERIMENTAL PROCEDURE

STEP	**DATA**	
A	Initial mass of Sample A in crucible, M_1. ______________	**(1 mark)**
B	Change in appearance of Sample A. ____ ____	**(2 marks)**
C	Mass of Sample A in crucible after the first heating process, M_2. ________________________________	**(1 mark)**
D	Colour of mixture. ________________________________	**(1 mark)**
F	Colour of filtrate obtained from washing residue: first washing ________________________________ second washing ______________________________	**(1 mark)** **(1 mark)**
H	Change in appearance of sand. ____ ____	**(2 marks)**
J	Mass of dried residue and crucible, M_3. ______________	**(1 mark)**
	2 marks for correct units for M_1, M_2 and M_3	**(2 marks)**

(b) Determine EACH of the following:

(i) The mass of copper sulphate crystals with water of crystallization, Sample A

____

____

____

(1 mark)

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

(1 mark)

(iii) The mass of anhydrous copper sulphate

(1 mark)

(iv) The value of n

(3 marks)

TOTAL 18 marks

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).

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) In the space below construct 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.

(5 marks)

TABLE 2: TITRATION RESULTS

(iii) What is the volume of KMnO4 (aq)/ H^+ (aq) to be used for calculation?

(1 mark)

(iv) Write the ionic equation for the reaction that occurs during the titration.

(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)

GO ON TO THE NEXT PAGE

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

(4 marks)

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

(2 marks)

Total 18 marks

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) Apparatus and materials

(1 mark)

(iv) Procedure

(3 marks)

(v) Variables to be controlled

(1 mark)

(vi) Variables to be manipulated and responding variables

(1 mark)

(vii) Data to be collected.

(1 mark)

(viii) Discussion of expected results

(1 mark)

(ix) TWO possible sources of error

(1 mark)

(x) Precautions

(1 mark)

Total 12 marks

END OF TEST

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CHEMISTRY

Unit 2 - Paper 032

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 1 - PAPER 032

MARK SCHEME

Question 1

(a)

Step	Data	
A	Given	Candidate’s reading for M [1 mark]
B	Given	Colour changes from blue/green to white [2 marks]
C	Given	Candidate’s reading for M^2 [1 mark]
D	Given	Glue / green mixture [1 mark]

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CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY – SPECIMEN PAPER

Unit 1 - Paper 032

MARK SCHEME

2007

CHEMISTRY
UNIT 1 - PAPER 032

1. (a)

	Observation

Test	**A**	**B**	**C**
(i) Given	Shiny grey solid.	White crystalline solid.	Soft flaky solid.
(ii) Given	Suspension formed/A did not dissolve.	Dissolved to a colourless solution.	Suspension formed/ C did not dissolve.
(iii) Given	Suspension formed/ A did not dissolve.	Suspension formed/ A did not dissolve.	Dissolved to a colourless solution
(iv) Given	High melting point.	High melting point.	47 - 64 ºC

[1 mark each = 12 marks]

(b) Bonding in A: Metallic bond.
Reason: Shining with high melting point, and insoluble.

Bonding in B: Ionic bond.
Reason: Soluble in water but insoluble in organic solvents; high melting point.

Bonding in C: van der Waal's forces between molecules.
Reason: Soluble in non-polar solvent, with low melting point.

[1 mark each = 6 marks]

CHEMISTRY
UNIT 1 - PAPER 032
QUESTION 2

(a) (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 = 1 mark
Shape of graph = 1 mark
4-6 points correct = 2 marks
<4 points correct = 1 mark
[Total 4 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]

(v) The rate decreases with time.
[1 mark]

CHEMISTRY
UNIT 1 - PAPER 032
QUESTION 2 cont'd

(vi) Second order.
[1 mark]

(vii) Time = 13 seconds (accept time from candidates' graphs).

Significance: This is the half-life for the reaction.

[1 mark each = 2 marks]

CHEMISTRY
UNIT 1 - PAPER 032
Question 3

(i) Hypothesis

Any correct answer, for example:

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

[2 marks]

(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.

[4 marks]

- Logical sequence and written in the form of instructions.

[2 marks]

(iv) Variables

Correct and relevant

[2 marks]

(v) Expected results

Any reasonable answer

[4 marks]

(vi) Treatment of results

[2 marks]

CHEMISTRY
UNIT 1 - PAPER 032
Question 3 cont't

(vii) 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:
  $H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O(l)$ $E^\theta = + 1.77V$
- Reducing agent half-cell reaction:
  $-e \rightarrow$ Product $E^\theta = + 1.39V$
  $E_{cell} = + 3.16V$
- E_{cell} is produced for the weak reducing agent.

[4 marks]

(viii) Sources of error/assumptions/limitations
Any correct answer, for example:

- It is assumed that the reducing agents are non-acidic.

[2 marks]

Total 24 marks ÷ 2 = 12 marks

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CHEMISTRY

Unit 2 - Paper 02

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 2 - PAPER 02
MODULE 1

MARK SCHEME

Question 1

CHEMISTRY
UNIT 2 - PAPER 02

MARK SCHEME

(e) (i) Colourless gas evolves which forms dense white fumes with NH_3

[I mark]

(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]

Total Marks 15

Specific Objectives: 2.11, 2.14

CHEMISTRY
UNIT 2 - PAPER 02

MARK SCHEME

Question 2

(a) (i) Length of time a solute remains in the column, before entering the detector

[1 mark]

(ii) Mobile phase: The solvent or solvent mixture which moves over the stationary phase carrying the solutes with it

[1 mark]

(iii) A commonly used mobile phase in GLC is nitrogen or helium

[1 mark]

(b) (i) B

[1 mark]

(ii) approximately 6.8 minutes
0.1 minute

[1 mark]

(c) A – methanal
B – propane
C – methanol
D – propanoic acid

[1 mark each]

(d)
- methanol has lowest density
- propane is more volatile than methanol and propanoic acid
- propanoic acid is the heaviest or densest

[Any 2 = 2 marks]

(e)
- Pack a glass column with a paste of SiO_2, $CaCo_3$ or AlO_3
  Ensure there are no air spaces
- Place about $5cm^3$ of liquid food dye mixture in the column
- Add the solvent (water) to the mixture
- Open the tap at the base of the column and allow each coloured solute to elute into separate beakers

[4 mark]

Total Marks 15

Specific Objectives: 8.1, 8.2, 8.5

CHEMISTRY
UNIT 2 - PAPER 02
MODULE 3

MARK SCHEME

Question 3

(a) (i) Fertilisers, decaying plants or animals

(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]

(iii) NO_2^-

[1 mark]

(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]

(b) (i) a) Primary pollutant: an air pollutant emitted directly from a source

[1 mark]

b) Secondary pollutant: not directly emitted as such, but forms when other pollutants (1^o pollutants) react in the atmosphere

[1 mark]

(ii) 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]

(iii) NO is produced first as the primary pollutant after which NO_2 is formed by the oxidation of NO.

[1 mark]

(iv)

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]
Total Marks 15

Specific Objectives: 8.4, 8.5, 9.3, 9.6

CHEMISTRY
UNIT 2 - PAPER 02
MODULE 3

MARK SCHEME

Question 4

(a)

- They show a steady gradation in physical and chemical properties
- Chemical properties are similar
- Relative molecular mass of consecutive members increase by H or CH_2

[1 mark each]

(b) Covalent bond breaking

- Homolytic fission
- Heterolytic fission

[1 mark]

$A - B \rightarrow A\bullet + \bullet B$ [1 mark]

$\overset{\curvearrowright}{A - B} \rightarrow A^{+} + B^{-}$

OR

$\overset{\curvearrowleft}{A - B} \rightarrow A^{-} + B^{+}$

[1 mark]

(c) (i) $Cl - Cl \xrightarrow{uv/\,sumlight} 2\,Cl\bullet$ [1 mark]

$Cl\bullet + CH_3CHCH_3CH_3 \rightarrow CH_3\ \overset{\bullet}{C}\ CH_3CH_3 + HCl$ [1 mark]

$Cl\bullet + CH_3CHCH_3CH_3 \rightarrow \overset{\bullet}{C}\ H_2CHCH_3CH_3 + HCl$ [1 mark]

$CH_3\,\overset{\bullet}{C}\ CH_3CH_3 + \overset{\bullet}{C}\,l \rightarrow CH_3CClCH_3CH_3$ [1 mark]

$\bullet CH_2CHCH_3CH_3 + \overset{\bullet}{C}\,l \rightarrow CH_2ClCHCH_3CH_3$ [1 mark]

(ii) $CH_3CClCH_3CH_3$

Stability of the tertiary free radical in the intermediate stage

[2 marks]

(d) (i) OH^{-}

[1 mark]

(ii)

[2 marks]

Total Marks 15

Specific Objectives: 1.2, 2.3, 2.8

CHEMISTRY
UNIT 2 - PAPER 02
MODULE 3

MARK SCHEME

Question 5

(a)
- 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 marks]

Taken from Graham Hill and John Holman, Chemistry in Context, Thomas Nebon and Sons Ltd., 1995, p.3.

CHEMISTRY
UNIT 2 - PAPER 02
MODULE 3

MARK SCHEME

Question 5

(b) (i) 46

[1 mark]

(ii) J

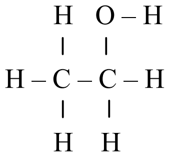
[1 mark]

(iii) B: CH_3
C: OH
F: CH_2OH

[3 marks]

(iv) Ethanol

[1 mark]



$$\begin{array}{ccccccc} & & H & & O & - & H \\ & & | & & | & & \\ H & - & C & - & C & - & H \\ & & | & & | & & \\ & & H & & H & & \end{array}$$

[1 mark]

(v) $\frac{3}{7} \times 100\% = 43\%$

[1 mark]

(vi) Most stable fragment

[1 mark]

Total Marks 15

Specific Objectives: 7.1 – 7.3

CHEMISTRY
UNIT 2 - PAPER 02

SECTION B
MODULE 3

MARK SCHEME

Question 6

(a) (i) Source of Nitrogen

- Air (atmosphere)
- Can be obtained by liquefaction of air

[2 marks]

(ii) Hydrogen from Methane

$CH_4 + H_2O = CO + 2H_2$

[1 mark]

Accept Also
$CH_4 + 2H_2O = CO_2 + H_2$
$CO + H_2O = CO_2 + H_2$

(iii) Catalyst

- Iron in presence of traces of oxides
- Magnesium, silicon and aluminium and potassium hydroxide

Accept iron

[Any ONE, 1 mark]

(b) (i) Effects of

(a) Increasing pressure
Yield would increase

[1 mark]

(b) Increasing temperature
Yield would decrease

[1 mark]

(ii) Conditions for maximum yield:
High pressures and low temperatures

[2 marks]

(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]

(c) Award marks based on the following -
Toxicity of ammonia
Ammonia is a gas (difficulty in handling)

[2 marks]

(d) Nitrogen fixation
Electrical discharges (thunderstorms)
Accept also combustion of fuels from aircrafts

[Any ONE, 1 mark]

CHEMISTRY
UNIT 2 - PAPER 02

SECTION B
MODULE 3

MARK SCHEME

Question 6 cont'd

(e) Soil acidity

NH_4^+ ions combine with water in soil to form a weak base. In the process H^+ are liberated

[2 marks]

Total Marks 15

Specific Objectives: 4.1, 4.2, 9.7

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CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

Unit 2 - Paper 032

MARK SCHEME

2007

SPECIMEN

CAPE CHEMISTRY
UNIT 2 - PAPER 032
Question 1

(a)

Step	**Data**		
A	Given	Candidate's reading for M_1.	**[1 mark]**
B	Given	Colour changes from blue/green to white.	**[2 marks]**
C	Given	Candidate's reading for M_2.	**[1 mark]**
D	Given	Blue/green mixture.	**[1 mark]**
F	Given	First washing: light blue/green Second washing: colourless	**[1 mark]** **[1 mark]**
H	Given	Sand becomes lighter, less fine particles observed.	**[2 marks]**
J	Given	Candidate's reading for M_3.	**[1 mark]**
		2 marks for 3 correct units **[1 mark for 1 - 2 correct units]**	**[2 marks]**

[Total 12 marks]

(b) (i) $M_1 - M_3 =$ **[1 mark]**

(ii) $M_1 - M_2 =$ **[1 mark]**

(iii) $M_2 - M_3 =$ **[1 mark]**

(iv) $\frac{M_1 - M_2}{18} = P$ **[1 mark]**

$\frac{M_2 - M_3}{63.5} = Q$ **[1 mark]**

$\frac{P}{Q} / \frac{Q}{P}$ **[1 mark]**

CAPE CHEMISTRY
UNIT 2 - PAPER 032
Question 2

<u>Specific Objectives</u> 2.4, 2.5

(a) (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

Table headings = **[2 marks]**
Correct burette readings = **[3 marks]**
(If one incorrect = 2 marks)
(If two incorrect = 1 mark)
(More than two incorrect = 0 marks)

Table Headings appropriate (must include unit, that is, cm^3)
Volumes recorded to 2 decimal places

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

(iv) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5\ Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$ **[1 mark]**

(v) 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

$$= \frac{5x10.55x0.02x10^{-3}}{20}$$ **[1 mark]**

$= 5.275 \times 10^{-2}\ mol\ dm^{-3}$

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Question 2 cont'd

(a) (v) cont'd

Conc. of Fe^{2+} = $(5.275 \times 10^{-2} \times 56)$

= $2.95\ g\ dm^{-3}$ **[1 mark]**

(vi) % purity = $\left(\frac{2.95}{10} x100\right) = 29.5\%$ **[1 mark]**

(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]**

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Question 3

(i) Hypothesis: For example, chromatograms will be identical/different from beef and chicken. **[2 marks]**

(ii) Aim **[2 marks]**

(iii) Apparatus and materials
(Subtract one mark if fume hood missing) **[2 marks]**

(iv) Procedure

- Present Tense
- Hydrolyse with dilute acid
- At least 30 mins.
- Use of visualising agent
- Use of appropriate solvent
- Separate using chromatography
- Compare 2 chromatograms **[6 marks]**

(v) Variables to control: amount of each protein, time of hydrolysis, Vol. acid. **[2 marks]**

(vi) Variables to be manipulated: proteins **[1 mark]**

(vii) Responding variable. **[1 mark]**

(viii) Data to be collected. **[2 marks]**

(ix) Discussion of results as it relates to Hypothesis: compare R_f values of different components of the 2 proteins. **[2 marks]**

(x) Possible sources error:
For example: proteins could be incompletely hydrolysed – introduction of extraneous protein from improper handling. **[2 marks]**

(xi) Precautions
For example: use of fume hood; be careful not to touch chromatography paper with fingers; introduce protein to sample, etc. **[2 marks]**

Total 24 marks ÷ 2 = 12 marks