CARIBBEAN
EXAMINATIONS
COUNCIL

Caribbean Advanced
Proficiency Examination®

SYLLABUS
CHEMISTRY

CXC A11/U2/17

Effective for examinations from May–June 2019

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Contents

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

Introduction

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

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

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

Chemistry Syllabus

♦ RATIONALE

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

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

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

The most important natural resource in the Caribbean is its people. If the Caribbean is to play an important role in the new global village and survive economically, a sustained development of the scientific and technological resources of its people is essential. This syllabus contributes to the development of the Ideal Caribbean Person as articulated by the CARICOM Heads of Government in the following areas: respect for human life, awareness of the importance of living in harmony with the environment. Students will be given the opportunity to demonstrate multiple literacies, independent and critical thinking, and the innovative application of science and technology to problem-solving. In keeping with the UNESCO Pillars of Learning, on completion of this course of study, students will learn to do, learn to be and learn to transform themselves and society.

♦ AIMS

The syllabus aims to:

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

♦ SKILLS AND ABILITIES TO BE ASSESSED

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

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

1. **Knowledge and Comprehension (KC)**

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

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

2. **Use of Knowledge (UK)**

   (a) Application

   The ability to:

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

   (ii) transform data accurately and appropriately; and,

   (iii) use formulae accurately for computational purposes.

   (b) Analysis and Interpretation

   The ability to:

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

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

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

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

   (c) Synthesis

   The ability to:

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

   (ii) make predictions and solve problems.

   (d) Evaluation

   The ability to:

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

3. **Experimental Skills (XS)**

(a) Observation, Recording and Reporting

The ability to:

(i) use the senses to perceive objects and events accurately;

(ii) record the results of a measurement accurately;

(iii) select and use appropriate formats and presentations, such as tables, graphs and diagrams;

(iv) organise and present a complete report in a clear and logical form using spelling, punctuation and grammar with an acceptable degree of accuracy; and,

(v) report accurately and concisely.

(b) Manipulation and Measurement

The ability to:

(i) handle chemicals carefully and use them economically;

(ii) appropriately prepare materials for observation or investigation; and,

(iii) assemble and use simple apparatus and measuring instruments.

(c) Planning and Designing

The ability to:

(i) recognise the problem and formulate valid hypotheses;

(ii) choose appropriate experimental methods and sampling techniques;

(iii) choose appropriate apparatus;

(iv) plan and execute experimental procedures in a logical and sequential form within the time allotted;

(v) use controls where appropriate; and,

(vi) modify experimental methods after initial work or unexpected outcomes.

♦ PREREQUISITES OF THE SYLLABUS

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

♦ STRUCTURE OF THE SYLLABUS

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

Unit 1: Chemical Principles and Applications I

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

Unit 2: Chemical Principles and Applications II

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

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

♦ SUGGESTIONS FOR TEACHING THE SYLLABUS

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

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

This syllabus caters to varying teaching and learning styles, with specific attention made to ensure the interrelatedness of concepts. Whenever possible, a variety of teaching and learning strategies suitable to varying learning needs of students should be employed with special attention given to the identification of variables and the use of controls in chemical investigations. The need for repeated investigations and observations to arrive at meaningful conclusions should be emphasised.

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

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

♦ THE PRACTICAL APPROACH

The syllabus is designed to foster the use of inquiry-based learning through the application of the practical approach. Students will be guided to answer scientific (testable) questions by a process of making observations, asking questions, doing experiments and analysing and interpreting data. Students should be made aware of the environmental impact of the improper disposal of waste and the associated safety hazards. Teachers should emphasise the use of appropriate safety gear and the need for acceptable laboratory practices. The **CAPE®** Chemistry Syllabus focuses on the skills listed below.

1. **Planning and Designing (PD)**

   Student's ability to:

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

   Sample Problem: It has been observed that exposed wine usually acquires a sour taste after a few weeks.

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

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

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

   (c) Design an experiment to test the hypothesis. Experimental reports must include the following:

   (i) problem statement;

   (ii) aim;

   (iii) list of materials and apparatus to be used;

   (iv) clear and concise step by step procedure;

   (v) manipulated and responding variables;

   (vi) controlled variables;

   (vii) observations to be made or measurements to be taken;

(viii) suggested display of results (for example, graphs tables);

(ix) proposed use of results;

(x) possible limitations, assumptions; and,

(xi) precautions to be taken.

2. **Measurement and Manipulation (MM)**

Student's ability to:

(a) Handle scientific equipment competently.

The list of equipment includes:

(i) Bunsen burner;

(ii) measuring cylinder;

(iii) beakers;

(iv) thermometer;

(v) ruler;

(vi) stop watch/clock;

(vii) balance;

(viii) boiling tube;

(ix) burette;

(x) pipette;

(xi) conical flask;

(xii) syringe;

(xiii) sintered glass crucible;

(xiv) suction pump;

(xv) voltmeter; and,

(xvi) ammeter.

This list is not exhaustive.

(b) Use appropriate apparatus.

(c) Take accurate measurements.

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

(a) **Recording**

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

(i) Prose - Written description of observations in the correct tense.

(ii) Table (Neatly enclosed):

- Numerical: physical quantities in heading, correct units stated in heading, symbols, decimal points.

- Non-numerical: headings correct, details present.

(iii) Graph – Axes labelled with units, correct scales, correct plotting, and smooth curves/best fit lines.

(iv) Drawing of apparatus as set up for use.

(b) **Reporting**

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

(i) **Date** (date of experiment).

(ii) **Aim** (what is the reason for doing the experiment).

(iii) **Apparatus and Materials** (all equipment, chemicals and materials used in the experiment must be listed).

(iv) **Method/Experimental Procedure** (step-by-step procedure written in the past tense, passive voice).

(v) **Results and Observations** (see (a) above: Recording).

(vi) ***Discussion*** *(see 4: Analysis and Interpretation).*

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

4. **Analysis and Interpretation**

Student's ability to:

(a) identify patterns and trends;

(b) make accurate calculations;

(c) identify limitations and sources of error;

(d) make a conclusion to either support or refute the hypothesis;

(e) compare actual results with expected results if they are different;

(f) suggest alternative methods or modifications to existing methods; and,

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

◆ UNIT 1: CHEMICAL PRINCIPLES AND APPLICATIONS I

MODULE 1: FUNDAMENTALS IN CHEMISTRY

GENERAL OBJECTIVES

On completion of this Module, students should:

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

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

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

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

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

<u>Atomic Structure and the Periodic Table (cont'd)</u>

Students should be able to:

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

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

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

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

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

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

Energetics cont'd

Students should be able to:

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

Suggested Teaching and Learning Activities

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

Atomic Structure and the Periodic Table

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

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

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

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

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

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

Forces of Attraction

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

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

The Mole Concept

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

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

Redox Reactions, Kinetic Theory and Energetics

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

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

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 1
MODULE 2: KINETICS AND EQUILIBRIA

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the concepts associated with reaction rates;

2. understand the concepts associated with chemical equilibrium;

3. appreciate that equilibrium concepts can be applied to chemical systems; and,

4. appreciate that principles of kinetics and equilibria can be applied to industrial and biological processes.

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

Rates of Reaction cont'd

Students should be able to:

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
1.5.	interpret concentration against time and concentration against rate for zero and first order reactions;	Qualitative and quantitative treatments required.	
1.6.	perform calculations from rate data;	Calculate initial rates and rate constants.	
1.7.	perform simple calculations using half-life data; and,	Limited to first order reactions.	
1.8.	explain the effect of temperature and catalysts on the rate of the reaction using Boltzmann distribution of energies (and of collision frequency).	Include the use of Boltzmann distribution curves.	

2. **Principles of Chemical Equilibrium**

Students should be able to:

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
2.1.	explain the concept of dynamic equilibrium;	Consider examples of static and dynamic equilibrium. Refer to physical and chemical processes.	
2.2.	state the characteristics of a system in dynamic equilibrium;		
2.3.	define the terms K_c and K_p;	Write equilibrium constant expressions in terms of K_c and K_p.	Conduct a simple experiment to determine the value of K_c for a reaction.
2.4.	perform calculations involving equilibrium constants in terms of concentration, (K_c) and partial pressure, (K_p);	Conversion of K_c to K_p is not required. Quadratic equations are not required.	

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

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

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

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

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

Suggested Teaching and Learning Activities

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

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

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

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

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

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

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

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

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

   (a) the direction of electron flow;

   (b) the nature of the electrodes;

   (c) the reaction that may occur; and,

   (d) cell potentials.

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

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

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

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 1
MODULE 3: CHEMISTRY OF THE ELEMENTS

GENERAL OBJECTIVES

On completion of this Module, students should:

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

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

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

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

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

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

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

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

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

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

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

Suggested Teaching and Learning Activities

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

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

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

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

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

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

♦ UNIT 2: CHEMICAL PRINCIPLES AND APPLICATIONS II

MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS

GENERAL OBJECTIVES

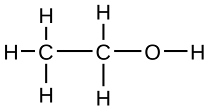
On completion of this Module, students should:

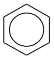
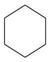
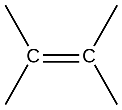
1. appreciate the scope and nature of carbon-based compounds;

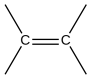
2. understand the processes involved in the formation of carbon compounds;

3. understand the reactions of various functional groups of carbon compounds; and,

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

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

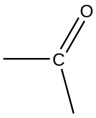
SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
<u>Structure and Formulae cont'd</u> Students should be able to:		
	<u>Condensed</u> $CH_3(CH_2)_4CH_3$; CH_3CH_2OH Benzene can be represented by  and cyclohexane by 	
1.6. apply the IUPAC rules to named organic compounds;		
1.7. define,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

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

Functional Group Analysis, Reactions and Mechanisms cont'd

Students should be able to:

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

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

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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
3.	**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; and,	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; and, polytetrafluoroethene. Include monomers for each polymer respectively.	
4.2.	describe the characteristics of condensation polymerisation;	Terylene; nylon 6.6, (specific monomers are required); proteins, starch, (representative structure required).	

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

Suggested Teaching and Learning Activities

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

1. Arrange for students to view videos and interactive materials on industrial carbon chemistry. This should be followed by class or group discussion.

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

3. *Ask students to create a product which is marketable using simple organic reactions.*

4. Ask students to construct and use models in sections dealing with structures.

5. Discuss articles in relevant reference journals and periodicals, for example, Chemistry in Education.

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 2
MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES

GENERAL OBJECTIVES

On completion of this Module, students should:

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

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

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

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

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

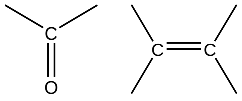
SPECIFIC OBJECTIVES	**EXPLANATORY NOTES**	**SUGGESTED PRACTICAL ACTIVITIES**
1. **Uncertainty in Measurements**		
Students should be able to:		
1.1. apply appropriate concepts to the analysis of scientific data;	Definitions required for: mean, standard deviation, precision, accuracy, calibration curves,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

SPECIFIC OBJECTIVES		EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Uncertainty in Measurements cont'd			
Students should be able to:			
1.3.	select appropriate pieces of equipment to make measurements, depending upon the degree of accuracy required.	Selection of equipment limited to those in Specific Objective 1.2 above.	
2.	**Titrimetric (Volumetric) Methods of Analysis**		
Students should be able to:			
2.1.	explain the basic principles upon which titrimetric analyses are based;		
2.2.	discuss the criteria used in selecting primary standards;	$NaHCO_3$, Na_2CO_3, KIO_3, $(COOH)_2$ and its salts as primary standards. Definition of primary standards required.	
2.3.	use data obtained from potentiometric, thermometric, and conductrometric methods for titration which do not require the use of indicators;		
2.4.	perform experiments based on titrimetric analyses;		Experiments should be limited to acid-base, back and redox titrations. Include preparation of standard solutions.
2.5.	perform calculations based on data obtained from titrimetric analyses; and,	Refer to Unit 1, Module 2, Specific Objective 3.6.	
2.6.	cite examples of the use of titrimetric analysis in the quantification of various substances.	Refer to vinegar, household cleaners, vitamin C tablets, aspirin, antacids.	

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
3. <u>**Gravimetric Methods of Analysis**</u>		
Students should be able to:		
3.1. explain the principles upon which gravimetric analyses are based;	Limited to a discussion on precipitation and volatilisation methods.	
3.2. describe the functions of the various pieces of basic equipment used in gravimetric analyses;	Limited to suction flasks, suction funnels, silica crucibles, sinter glass crucibles, ovens, and furnaces.	
3.3. perform experiments based on gravimetric determinations;		Limited to experiments involving volatilisation methods, such as, moisture content of soils; water of crystallisation.
3.4. perform calculations based on data obtained from gravimetric analyses; and,	Use data from actual experiments carried out or from the literature.	
3.5. cite examples of the use of gravimetric analysis in quality control.	Examples include determination of SO_2 in the air, in wine or fruit drink; determination of the amount of elements such as phosphorous in fertilizers; the chloride ion presence in water supply.	
4. <u>**Spectroscopic Methods of Analysis**</u>		
Students should be able to:		
4.1. explain the nature of electromagnetic radiation;	Calculations using the equation: $E = hv = hc/\lambda$ are required.	

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

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
Spectroscopic Methods of Analysis cont'd		
Students should be able to:		
4.2. state the approximate wavelength ranges of the X-ray, UV/VIS, IR and radiofrequency regions of the electromagnetic spectrum; and,	Relative energies and dangers associated with exposure to high energy wavelengths. Insert actual ranges for x-ray, UV, VIS, IR and RF.	
4.3. recall that the energy levels in atoms and molecules are quantised.	Refer to Unit 1, Module 1.	
5. **Ultra Violet-Visible (UV/VIS) Spectroscopy**		
Students should be able to:		
5.1. explain the origin of absorption in UV/VIS spectroscopy;	Simple treatment based on Unit 1, Module 1. *Consideration of sigma* (σ), *pi* (π), *anti-bonding* (σ^*, π^*) *and non-bonding* (*n*) *orbitals.*	
5.2. explain why some species will absorb light in the UV/VIS region whereas others will not;		
5.3. describe the basic steps involved in analysing samples by UV/VIS spectroscopy;	Brief mention should be made of the use of complexing reagents to form coloured compounds. Sensitivity and detection limits.	
5.4. use Beer-Lambert's Law to calculate the concentration of a given species in solution; and,	Use of standards and calibration curves.	
5.5. list examples of the use of UV/VIS spectroscopy in the quantitation of substances.	Iron tablets; glucose and urea in blood; cyanide in water.	

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

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

Chromatographic Methods of Separation cont'd

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
8.4. name examples of commonly used stationary phases;	Include reference to cellulose, silica gel, alumina.	
8.5. separate the components of mixtures; and,	Suitable mixtures which could be used include amino acids, plant pigments, food colouring.	Perform simple experiments to separate the components of mixtures *using paper and column chromatographic techniques.*
8.6. cite the wide applications of chromatographic methods of separation.	Refer to pesticide analysis, forensic testing, purification of natural products.	

9. **Phase Separations**

Students should be able to:

SPECIFIC OBJECTIVES	EXPLANATORY NOTES	SUGGESTED PRACTICAL ACTIVITIES
9.1. discuss the chemical principles upon which simple distillation and fractional distillation are based;	State Raoult's Law. *Definition of ideal and non-ideal mixture required.* The interpretation of boiling point composition curves of both ideal and non-ideal mixtures is required. A qualitative treatment of boiling point composition curves of azeotropic mixtures is required.	*Perform simple experiments to illustrate the concept of boiling point elevation.*
9.2. discuss the advantages of carrying out distillation processes under reduced pressures;		

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

Suggested Teaching and Learning Activities

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

1. Establish contact with industries and institutions in your locality which make use of the spectroscopic methods or separation techniques in their operations in order to:

   (a) facilitate site visits with your students;

   (b) make use of personnel from such industries and institutions to come in and give lectures and demonstrations; and

   (c) access *appropriate* written, audio or visual material available at such industries and institutions.

2. Prepare handouts compiled from data in literature (readily available) for use by students. This is especially important where spectral data are concerned. Students should be able to work with spectral data sheets.

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

www.Chemguide.co.uk

www.creative-chemistry.org.uk

www.a-levelchemistry.co.uk

UNIT 2
MODULE 3: INDUSTRY AND THE ENVIRONMENT

GENERAL OBJECTIVES

On completion of this Module, students should:

1. appreciate that chemical principles can be applied to industry;

2. appreciate that using Green Chemistry principles in industry helps to produce a sustainable world that supports a healthy economy;

3. understand the sources of pollution and strategies which assist in reduction of pollutants;

4. understand that there are physical and chemical changes occurring in the environment and assess their impact on it;

5. recognise the influence of industrial processes on social and economic life; and,

6. appreciate the impact of man's activities on the environment.

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

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

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

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

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

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

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

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

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

Suggested Teaching and Learning Activities

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

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

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

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

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

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

RESOURCES

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

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

WEBSITES

www.Chemsoc.org

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www.a-levelchemistry.co.uk

www.asc.org

www.epa.gov

www.rsc.org

♦ OUTLINE OF ASSESSMENT

EXTERNAL ASSESSMENT *(80%)*

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

SCHOOL-BASED ASSESSMENT *(20%)*

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

MODERATION OF SCHOOL-BASED ASSESSMENT

The reliability (consistency) of the marks awarded by teachers on the School-Based Assessment is an important characteristic of high quality assessment. To assist in this process, the Council undertakes on-site moderation of the School-Based Assessment during Term 2/3. This is conducted by visiting External Moderators who will visit the centre.

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

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

1. Candidates' total marks on the SBA are arranged in descending order (highest to lowest).

2. The sample comprises the work of the candidates scoring the:

   (a) highest Total Mark;

   (b) middle Total Mark;

   (c) lowest Total Mark;

   (d) mark midway between the highest and middle Total Mark; and,

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

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

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

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

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

A copy of the Assessment Sheets and all candidates' work must be retained by the school for ***three months*** *after the examination results are published by* ***CXC®****.*

ASSESSMENT DETAILS

Each Unit of the syllabus is assessed as outlined below.

External Assessment by Written Papers (*80%* of Total Assessment)

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

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

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

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

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

1. **Composition of the Paper**

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

2. **Mark Allocation**

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

3. **Question Type**

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

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

1. **Composition of Paper**

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

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

   Knowledge of the entire Unit is expected.

2. **Mark Allocation**

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

3. **Question Type**

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

School-Based Assessment (*20%*)

School-Based Assessment is an integral part of student assessment in the course covered by this syllabus. It is intended to assist students in acquiring certain knowledge, skills and attitudes that are associated with the subject. *Students are encouraged to work in groups.*

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

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

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

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

Award of Marks

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

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

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

Table 1
School-Based Assessment Skills

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

***Includes *an* investigative project**

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

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

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

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

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

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

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

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

♦ INVESTIGATIVE PROJECT

Objectives of the Investigative Project

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

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

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

CRITERIA FOR ASSESSING INVESTIGATIVE SKILLS

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

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

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

SCHOOL-BASED ASSESSMENT – GENERAL GUIDELINES FOR TEACHERS

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

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

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

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

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

♦ REGULATIONS FOR PRIVATE CANDIDATES

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

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

♦ REGULATIONS FOR RESIT CANDIDATES

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

2. *Candidates reusing SBA scores should register as "Resit candidates" and must provide the previous candidate number when registering.*

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

♦ ASSESSMENT GRID

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

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

♦ GLOSSARY OF EXAMINATIONS TERMS

KEY TO ABBREVIATIONS

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

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

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

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

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

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

Western Zone Office
9 August 2018

APPENDIX II

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION (CAPE®)

CHEMISTRY DATA BOOKLET

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

DATA BOOKLET

DO NOT TAKE AWAY FROM THE EXAMINATION ROOM

Revised: January 2015

TABLE 1: SOME IMPORTANT CONSTANTS

The Avogadro constant	L	=	6.02×10^{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 conditions
The Planck constant	h	=	6.63×10^{-34} J s
Rest mass of electron, ${}^{0}_{-1}\mathrm{e}$	m_e	=	9.11×10^{-31} kg
Rest mass of neutron, ${}^{1}_{0}\mathrm{n}$	m_n	=	1.67×10^{-27} kg
Rest mass of proton, ${}^{1}_{1}\mathrm{H}$	m_p	=	1.67×10^{-27} kg
Specific heat capacity of water	C_{water}	=	4.18 kJ kg^{-1} K^{-1}
Speed of light in a vacuum	c	=	3.00×10^{8} m s^{-1}

TABLE 2: IONISATION ENERGIES OF SELECTED ELEMENTS

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

TABLE 3: ATOMIC AND IONIC RADII OF SELECTED ELEMENTS

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

TABLE 4: SELECTED BOND ENERGIES

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

TABLE 5: STANDARD ELECTRODE AND REDOX POTENTIALS

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

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

Electrode Reaction	**$E^{\ominus}$/volts at 298 K (25 °C)**
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO^-_4 + e^- \rightleftharpoons MnO^{2-}_4$	+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
$SO^{2-}_4 + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$S_2O^{2-}_8 + 2e^- \rightleftharpoons 2SO^{2-}_4$	+2.01
$S_4O^{2-}_6 + 2e^- \rightleftharpoons 2S_2O^{2-}_3$	+0.09
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	–0.14
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$V^{2+} + 2e^- \rightleftharpoons V$	–1.20
$V^{3+} + e^- \rightleftharpoons V^{2+}$	–0.26
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$VO^+_2 + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00
$VO^-_3 + 4H^+ + e^- \rightleftharpoons VO^{2+} + 2H_2O$	+1.00
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	–0.76

TABLE 6: SELECTED INFRARED ABSORPTION SPECTROSCOPIC DATA

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

*due to stretching vibrations

The Periodic Table

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

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

Key

a
X
b

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

CARIBBEAN EXAMINATIONS COUNCIL

Caribbean Advanced Proficiency Examination®
CAPE®

CHEMISTRY

Specimen Papers and Mark Schemes/Keys

Specimen Papers:

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

Mark Schemes and Key:

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

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

SPECIMEN 2017

TABLE OF SPECIFICATIONS

Unit 1 – Paper 02

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

Unit 1 – Paper 032 (Alternative to SBA)

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

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

SPECIMEN 2017

TABLE OF SPECIFICATIONS

Unit 2 – Paper 02

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

Unit 2 – Paper 032

Alternative to SBA

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

CANDIDATE – PLEASE NOTE!

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

____

TEST CODE **02112010**

SPEC 2017/02112010

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

Unit 1 - Paper 01

1 hour 30 minutes

SPECIMEN PAPER

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

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

   Sample Item

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

   Sample Answer

   Ⓐ Ⓑ ● Ⓓ

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

   The correct answer to this item is “σ to σ^*”, so (C) has been shaded.
6. If you want to change your answer, erase it completely before you fill in your new choice.
7. When you are told to begin, turn the page and work as quickly and as carefully as you can. If you cannot answer an item, go on to the next one. You may return to that item later.
8. You may do any rough work in this booklet.
9. Figures are not necessarily drawn to scale.
10. You may use a silent, non-programmable calculator to answer items.

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

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

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

2. Radioactivity is hazardous because it

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

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

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

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

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

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

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

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

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

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

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

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

7. Which of the following are redox reactions?

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

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

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

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

Which of the following is the overall balanced equation?

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

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

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

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

What is the relative molecular mass of the gas?

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

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

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

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

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

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

<u>Items 13 and 14</u> refers to the following options.

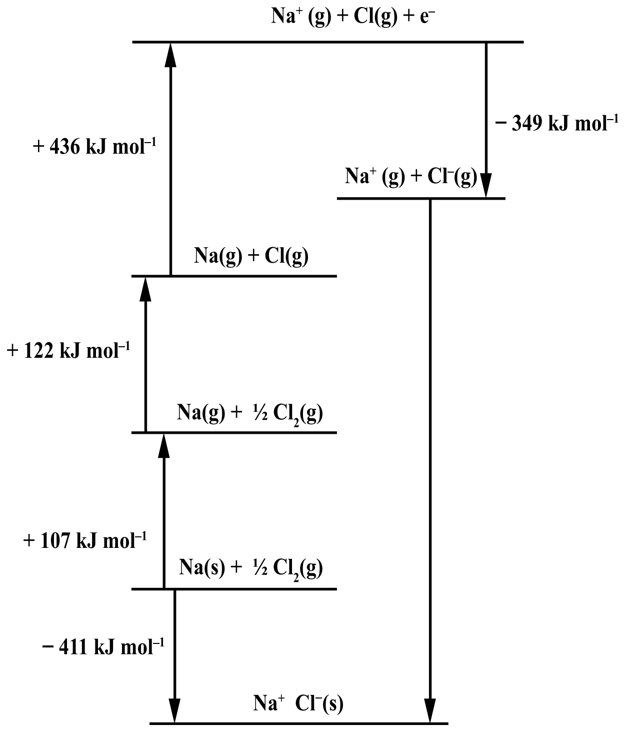
(A)	Enthalpy of formation
(B)	Lattice energy
(C)	Enthalpy of solution
(D)	Enthalpy of hydration

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

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

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

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) 1/2
(C) 1
(D) 2

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

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

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

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

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

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

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

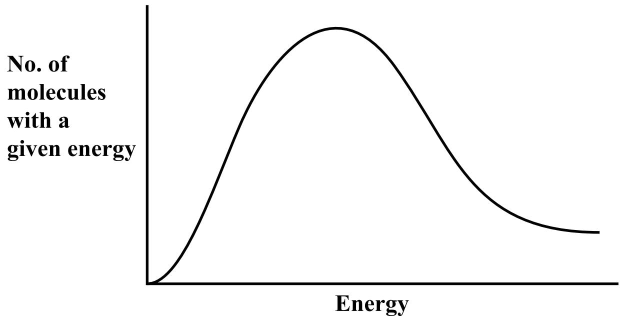
Expt. no	**Concentration/mol dm^{-3}**			**Rate/ mol dm^{-3}s^{-1}**
	CH_3COCH_3	**H^+**	**I_2**	
1	0.1	0.1	0.1	0.04
2	0.2	0.1	0.1	0.08
3	0.1	0.2	0.1	0.08
4	0.1	0.2	0.2	0.08

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

18. The values of x, y and z are

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

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



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

Increasing temperature

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

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

---

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

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

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 K_p for the equilibruim $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Item 26 refers to the following reaction:

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

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

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

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

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

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

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

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

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

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

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

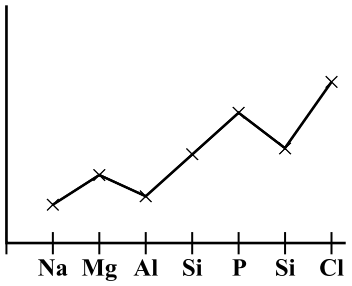
From this it can be deduced that

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

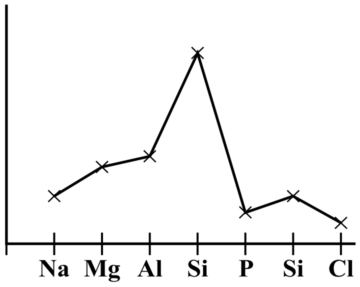
GO ON TO THE NEXT PAGE

<u>Items 31 and 32</u> refer to the following graphs.

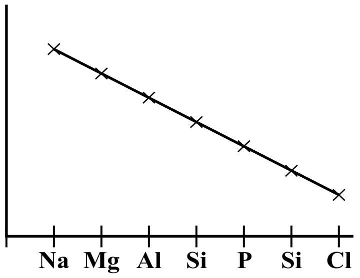
(A)



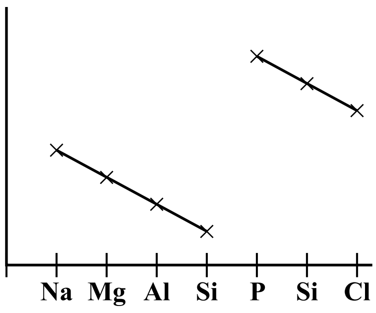
(B)



(C)



(D)



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

31. Atomic radius

32. First ionization energy

<u>Items 33 and 34</u> refer to the following oxidation states.

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

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

33. P_4O_6

34. Na_2O

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

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

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

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

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

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

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

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

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

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

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

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

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

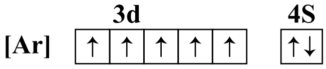
	Precipitate with $AgNO_3$	**Dissolves in dilute NH_3**
(A)	white	sparingly
(B)	white	readily
(C)	off-white	sparingly
(D)	off-white	readily

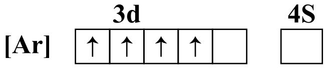
41. Transition metal complexes contain a central metal atom or ion surrounded by ligands. Which of the following does NOT explain why these complexes are formed?

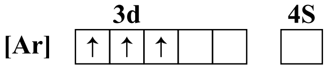
(A) The presence of lone pairs of electrons on ligands
(B) The presence of vacant d-orbitals on the metal atom or ion
(C) The formation of covalent bonds between the metal and ligands
(D) The complex ion formed is stable with respect to its constituents

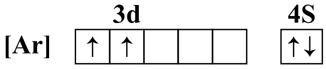
42. Which of the following represents the electronic configuration of Mn^{3+}?

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

(A) 

(B) 

(C) 

(D) 

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

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

Item 44 refers to the following information.

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

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

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

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

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

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

END OF TEST

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

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

DO NOT

WRITE ON

THIS PAGE

CANDIDATE'S RECEIPT

INSTRUCTIONS TO CANDIDATE:

1. **Fill in all the information requested clearly in capital letters.**

0	2	1	1	2	0	1	0

TEST CODE: 0 2 1 1 2 0 1 0

SUBJECT: CHEMISTRY – UNIT 1 – Paper 01

PROFICIENCY: ADVANCED

REGISTRATION NUMBER:

FULL NAME: ____

(BLOCK LETTERS)

Signature: ____

Date: ____

2. **Ensure that this slip is detached by the Supervisor or Invigilator and given to you when you hand in this booklet.**

3. **Keep it in a safe place until you have received your results.**

INSTRUCTION TO SUPERVISOR/INVIGILATOR:

Sign the declaration below, detach this slip and hand it to the candidate as his/her receipt for this booklet collected by you.

I hereby acknowledge receipt of the candidate's booklet for the examination stated above.

Signature: __________________________

Supervisor/Invigilator

Date: __________________________

Unit 1 Paper 01 Keys

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

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TEST CODE	0	2	1	1	2	0	2	0

SUBJECT CHEMISTRY – UNIT 1 – Paper 02

PROFICIENCY ADVANCED

REGISTRATION NUMBER										

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

CANDIDATE’S FULL NAME (FIRST, MIDDLE, LAST)

DATE OF BIRTH	D	D	M	M	Y	Y	Y	Y

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CHEMISTRY

SPECIMEN PAPER

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

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

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Answer ALL questions.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

1. (a) Define the terms

(i) Mole

....

....

....

[2 marks]

(ii) Molar mass

....

....

....

[1 mark]

(iii) State the units of molar mass

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....

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[1 mark]

(iv) State Avogadro's Law.

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....

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[1 mark]

GO ON TO THE NEXT PAGE

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

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

Calculate the number of moles of

(i) phosphorous (V) acid that reacted

[2 marks]

(ii) sodium hydroxide that reacted

[1 mark]

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

[1 mark]

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

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[1 mark]

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

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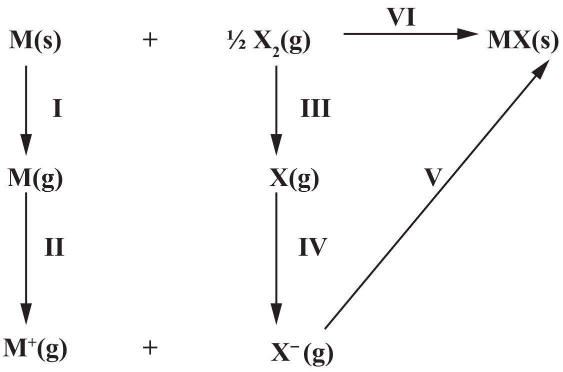
[5 marks]

GO ON TO THE NEXT PAGE

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



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

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

(i) State Hess' Law of heat summation.

....

....

[1 mark]

(ii) Define standard enthalpy change of formation.

....

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[1 mark]

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

....

....

[3 marks]

(iv) Define lattice energy.

....

....

[1 mark]

GO ON TO THE NEXT PAGE

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

[3 marks]

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

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[4 marks]

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

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

....

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....

[2 marks]

Total 30 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.

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[5 marks]

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

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[2 marks]

(iii) Identify the anode and the cathode.

Anode: ....

Cathode: ....

[1 mark]

(iv) Explain the direction of electron flow.

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(v) Write the cell diagram.

....

....

[1 mark]

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

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....

[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 8?

....

[2 marks]

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

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[2 marks]

GO ON TO THE NEXT PAGE

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

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

....

....

....

[3 marks]

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

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[2 marks]

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

....

....

[1 mark]

GO ON TO THE NEXT PAGE

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

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

[3 marks]

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

Solution	**pH**

[1 mark]

GO ON TO THE NEXT PAGE

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

(i) Define the term 'buffer solution'.

....

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[1 mark]

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

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[2 marks]

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

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[2 marks]

Total 30 marks

GO ON TO THE NEXT PAGE

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. (a) Transition elements form coloured compounds.

State THREE other characteristic properties of transition elements

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....

....

[3 marks]

(b) What are the colours of aqueous

(i) CO^{2+}?

....

[1 mark]

(ii) Mn^{2+}?

....

[1 mark]

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

....

[1 mark]

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

....

....

[1 mark]

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

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

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[2 marks]

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

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[2 marks]

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

Use the ligand exchange theory to account for this occurrence.

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[5 marks]

GO ON TO THE NEXT PAGE

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

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

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[5 marks]

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

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[2 marks]

GO ON TO THE NEXT PAGE

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

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[2 marks]

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

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[5 marks]

Total 30 marks

END OF TEST

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

EXTRA SPACE

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

Question No. ☐

EXTRA SPACE

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Question No. ☐

DO NOT

WRITE ON

THIS PAGE

CANDIDATE'S RECEIPT

INSTRUCTIONS TO CANDIDATE:

1. **Fill in all the information requested clearly in capital letters.**

TEST CODE: | 0 | 2 | 1 | 1 | 2 | 0 | 2 | 0 |

SUBJECT: CHEMISTRY – UNIT 1 – Paper 02

PROFICIENCY: ADVANCED

REGISTRATION NUMBER: | | | | | | | | | | |

FULL NAME: ____________________

(BLOCK LETTERS)

Signature: ____________________

Date: ____________________

2. **Ensure that this slip is detached by the Supervisor or Invigilator and given to you when you hand in this booklet.**

3. **Keep it in a safe place until you have received your results.**

INSTRUCTION TO SUPERVISOR/INVIGILATOR:

Sign the declaration below, detach this slip and hand it to the candidate as his/her receipt for this booklet collected by you.

I hereby acknowledge receipt of the candidate's booklet for the examination stated above.

Signature: ____________________

Supervisor/Invigilator

Date: ____________________

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CHEMISTRY

UNIT 1 — PAPER 02

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question 1

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

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

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

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

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question 2

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

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

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

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

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

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

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

[2 marks]

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

[1 mark]

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

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

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

Question **3**

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

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

O_2 + haemoglobin $\rightleftarrows$ oxhaemoglobin

CO + haemoglobin $\rightarrow$ carboxyhaemoglobin

CHEMISTRY
UNIT 01 — PAPER 02
MARK SCHEME

			KC	UK	XS
(g)		Mg = +2 $[Al\ OH_4]^-$: $X - 4 = -1$, $X = +3$, $Al = +3$ SiF_6^{2-}: $x - 6 = -2$, $x = +4$, $Si = +4$ PO^{3-}_3: $x - 6 = -3$, $x = +3$, $P = +3$ **[4 correct = 4 marks]** **[3 correct = 3 marks]** **[2 correct = 2 marks]** **[1 correct = 1 mark]** Oxidation number results from the need of elements to Achieve configuration of ns^2np^6 Hence, oxidation numbers: +2, +3, +4, +3 **[1 mark]**		5	
(h)	(i)	Atomic radius: half the distance between two covalently bonded atoms. **[1 mark]** **OR** Distance of nearest approach to another identical atom. **[1 mark]**	1		
		Ionic radius: this is assigned by considering the distance between the two centres of adjacent ions in a crystal lattice. **[1 mark]**	1		
	(ii)	As Group II is descended, atomic size increases due to electrons in additional valence shell. **[1 mark]**	1		
		As Group II is descended, ionic size increases: ion has E.C. given by $(n-1)s^2(n-1)p^6$. **[1 mark]**	1		
(i)		Oxides vary: CO, SiO are neutral; SiO are neutral; GeO, SnO, PbO are amphoteric. **[1 mark]** CO, SiO – no reaction with acids or bases **[1 mark]** GeO, SnO, PbO – with acids give divalent ions (M^{2+}) **[1 mark]** GeO, SnO, PbO – with alkalis produce complex ions $[M(OH)_4]^{2-}$ **[2 marks]**		5	
		Total 30 marks	10	15	5

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SUBJECT CHEMISTRY – UNIT 1 – Paper 032

PROFICIENCY ADVANCED

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SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

CANDIDATE’S FULL NAME (FIRST, MIDDLE, LAST)

DATE OF BIRTH	D	D	M	M	Y	Y	Y	Y

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CHEMISTRY

UNIT 1 – Paper 032

ALTERNATIVE TO SCHOOL-BASED ASSESSMENT

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

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

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

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Answer ALL questions.

1. You are provided with TWO solutions:

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

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

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

The results are to be entered into Table 1.

(a) **Procedure**

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

TABLE 1: DATA FOR EXPERIMENTAL PROCEDURE

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

[6 marks]

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

....

....

[1 mark]

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

[1 mark]

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

[1 mark]

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

[1 mark]

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

[2 marks]

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

....

....

[2 marks]

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

....

[1 mark]

Total 15 marks

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 reading for the volume of acid added and the time taken for the magnesium to disappear for each reaction. The initial burette reading is always 0.0 cm^3.

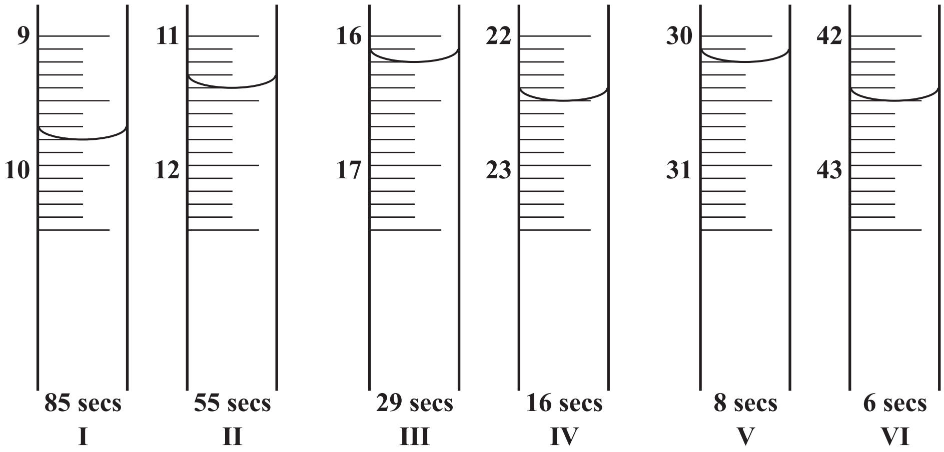

Figure 1

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

[5 marks]

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

GO ON TO THE NEXT PAGE

(iii) Explain the shape of the graph.

....

....

[2 marks]

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

Rate at 10 s: ....

Rate at 20 s: ....

Rate at 30 s: ....

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

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

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

(i) Hypothesis:

....

....

[1 mark]

(ii) Apparatus and materials:

....

....

....

....

[2 marks]

(iii) Method:

....

....

....

....

....

....

[3 marks]

GO ON TO THE NEXT PAGE

(iv) Variables:

....

....

....

....

[2 marks]

(v) Expected results:

....

....

....

....

....

[2 marks]

(vi) Chemical principles:

....

....

....

[3 marks]

(vii) TWO sources of error:

....

....

....

[2 marks]

Total 15 marks

END OF TEST

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

EXTRA SPACE

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

Question No. ☐

EXTRA SPACE

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

Question No. ☐

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Question No. ☐

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Question No. ☐

DO NOT
WRITE ON
THIS PAGE

CANDIDATE'S RECEIPT

INSTRUCTIONS TO CANDIDATE:

1. **Fill in all the information requested clearly in capital letters.**

TEST CODE:	0	2	1	1	2	0	3	2

SUBJECT: CHEMISTRY – UNIT 1 – Paper 032

PROFICIENCY: ADVANCED

REGISTRATION NUMBER:										

FULL NAME: ____
(BLOCK LETTERS)

Signature: ____

Date: ____

2. **Ensure that this slip is detached by the Supervisor or Invigilator and given to you when you hand in this booklet.**

3. **Keep it in a safe place until you have received your results.**

INSTRUCTION TO SUPERVISOR/INVIGILATOR:

Sign the declaration below, detach this slip and hand it to the candidate as his/her receipt for this booklet collected by you.

I hereby acknowledge receipt of the candidate's booklet for the examination stated above.

Signature: ______________________________
Supervisor/Invigilator

Date: ______________________________

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CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

UNIT 1 — PAPER 032

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 1

S.O.: Module: 1 —3.8, 3.9

(a)

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

Correct burette readings **[6 marks]**

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

(More than FIVE incorrect = 0 marks)

Volumes recorded to 2 decimal places – 1 mark

(b)

Pink tinge **[1 mark]**

(c)

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

(d)

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

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

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

(e)

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

KC	UK	XS
		6
		1
	1	
	1	
	1	

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

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 2

S.O.: Module: 2 —1.4 - 1.6

(i)

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

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

[Total 5 marks]

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

[Total 5 marks]

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

[2 marks]

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

[1 mark each = 3 marks]

Total 15 marks

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

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

Question 3

S.O.: Module: 2 —6.26

(i) Hypothesis

Any correct answer, for example:

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

[1 mark]

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

(iii) Method

Any reasonable workable set of procedures, for example:

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

[3 marks]

(iv) Variables

Correct and relevant **[2 marks]**

(v) Expected results

Any reasonable answer **[2 marks]**

(vi) Chemical principles

- Weak acid has low $[H^+]$ and strong acid has high $[H^+]$. $pH = -\log_{10}[H^+]$. Therefore, weak acid has high pH, and strong acid has low pH.
- Low $[H^+]$ in solution produces slow rate of reaction and vice versa.
- H_2O_2 half-cell reaction:

  $H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O(l)$ $E^\theta = +1.77V$
- 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.

[3 marks]

	KC	UK	XS
(i)			1
(ii)			2
(iii)			3
(iv)			2
(v)			2
(vi)		3	

CHEMISTRY
UNIT 1 — PAPER 032
MARK SCHEME

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

CANDIDATE – PLEASE NOTE!

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

TEST CODE **02212010**

SPEC 2017/02212010

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CHEMISTRY

UNIT 2 – Paper 01

1 hour 30 minutes

SPECIMEN PAPER

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This test consists of 45 items. You will have 1 hour and 30 minutes to answer them.
2. In addition to this test booklet, you should have an answer sheet and a data booklet.
3. Each item in this test has four suggested answers lettered (A), (B), (C), (D). Read each item you are about to answer and decide which choice is best.
4. On your answer sheet, find the number which corresponds to your item and shade the space having the same letter as the answer you have chosen. Look at the sample item below.

   Sample Item

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

   Sample Answer

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

   Ⓐ ● Ⓒ Ⓓ

   The correct answer to this item is "σ to $\sigma*$", so (B) has been shaded.

5. If you want to change your answer, erase it completely before you fill in your new choice.
6. When you are told to begin, turn the page and work as quickly and as carefully as you can. If you cannot answer an item, go on to the next one. You may return to that item later.
7. You may do any rough work in this booklet.
8. Figures are not necessarily drawn to scale.
9. You may use a silent, non-programmable calculator to answer items.

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

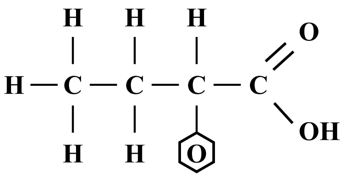
1. Which of the following may be responsible for the wide diversity of organic compounds?

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

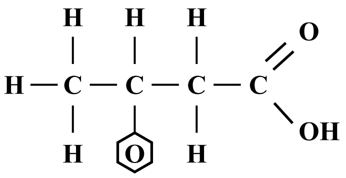
(A) I and II only
(B) I, II and III only
(C) I, II and IV only
(D) I, II, III and IV

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

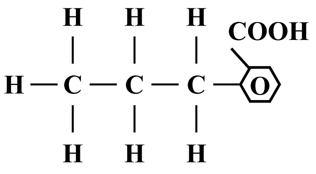
(A)



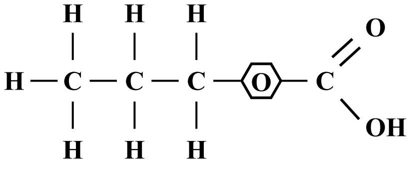
(B)



(C)



(D)



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

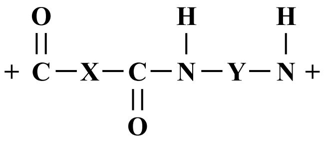
(A) $(CH_3)_2CHCH_2OH$
(B) NH_2CH_2COOH
(C) $NH_2CH(CH3)\ COOH$
(D) $(CH_3)_2CHOCH_3$

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

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

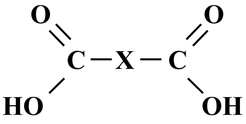
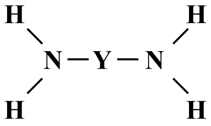
(A) I only
(B) II only
(C) I and II only
(D) I, II and III

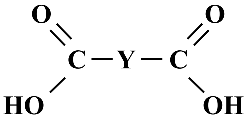
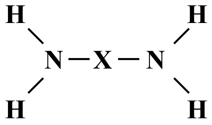
5. Qiana is a polymer that feels like silk and has the following generalized partial structure:

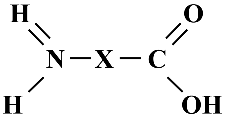
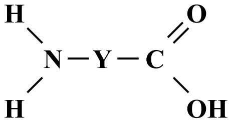


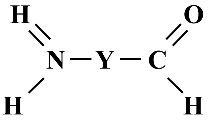
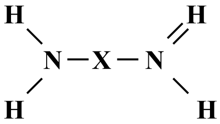
$$+\ \overset{O}{\overset{\|}{C}} - X - \underset{\underset{O}{\|}}{C} - \overset{H}{\overset{|}{N}} - Y - \overset{H}{\overset{|}{N}}\ +$$

The pair of monomers in Qiana is

(A)  **and** 

(B)  **and** 

(C)  **and** 

(D)  **and** 

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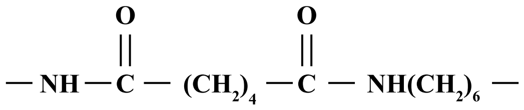
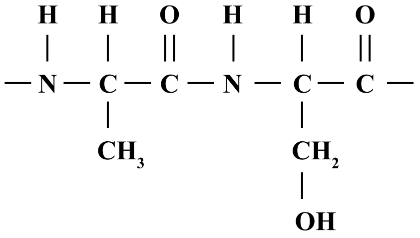
6. Which of the following represent naturally occuring macromolecules?

(I)



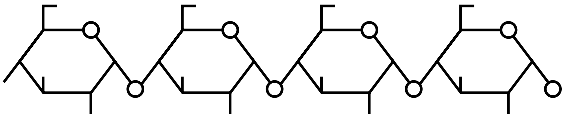
$$-\mathrm{NH}-\overset{\substack{\mathrm{O}\\ \|}}{\mathrm{C}}-(\mathrm{CH_2})_4-\overset{\substack{\mathrm{O}\\ \|}}{\mathrm{C}}-\mathrm{NH(CH_2)_6}-$$

(II)

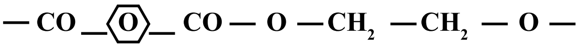


$$-\overset{\substack{\mathrm{H}\\ |}}{\mathrm{N}}-\underset{\substack{|\\ \mathrm{CH_3}}}{\overset{\substack{\mathrm{H}\\ |}}{\mathrm{C}}}-\overset{\substack{\mathrm{O}\\ \|}}{\mathrm{C}}-\overset{\substack{\mathrm{H}\\ |}}{\mathrm{N}}-\underset{\substack{|\\ \mathrm{CH_2}\\ |\\ \mathrm{OH}}}{\overset{\substack{\mathrm{H}\\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

(III)



(IV)

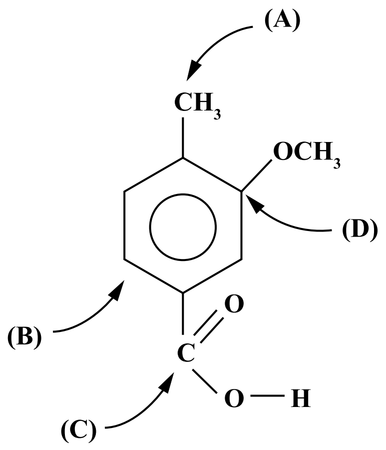


$-\mathrm{CO}-\langle\mathrm{O}\rangle-\mathrm{CO}-\mathrm{O}-\mathrm{CH_2}-\mathrm{CH_2}-\mathrm{O}-$

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

GO ON TO THE NEXT PAGE

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



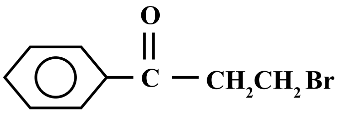
(A) A
(B) B
(C) C
(D) D

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

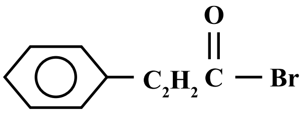
(A) an ion
(B) an electrophile
(C) a nucleophile
(D) a free radical

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

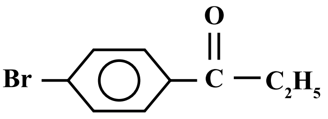
X



Y



Z



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

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

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

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

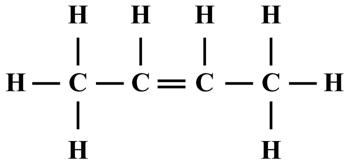
Match EACH item below with one of the options above, each of which may be used once, more than once or not at all.

10. Aldehyde

11. Ester

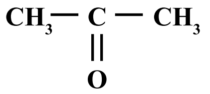
12. Which of the following is NOT oxidised by $KMnO_4/H^+(aq)$?

(A)



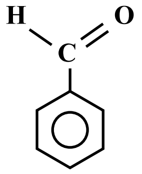
$$H_3C-CH=CH-CH_3$$

(B)

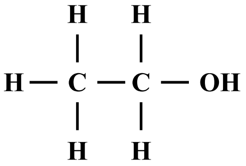


$$CH_3-\underset{\underset{\displaystyle O}{\|}}{C}-CH_3$$

(C)



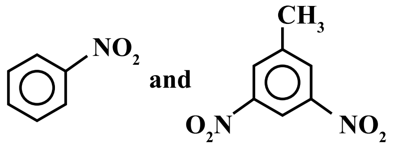
(D)



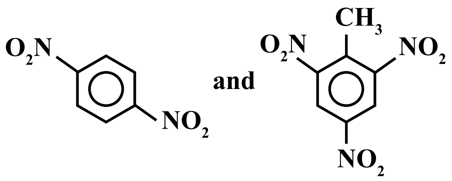
$$H_3C-CH_2-OH$$

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

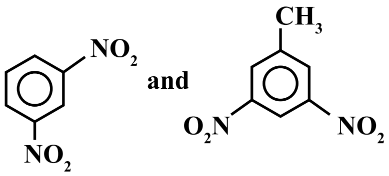
(A)



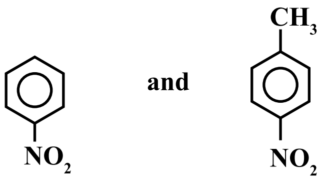
(B)



(C)



(D)



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

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

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

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

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

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

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

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

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

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

---

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

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

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

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

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

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

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

GO ON TO THE NEXT PAGE

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

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

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

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

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

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

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

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

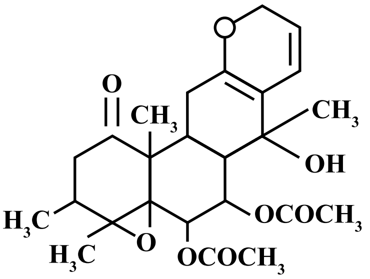
22. In the determination of the purity of a sample of magnesium carbonate by a back titration method, which of the following statements is INCORRECT?

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

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

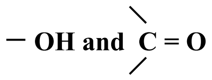
(A) Azeotrope then nitric acid
(B) Water then azeotrope
(C) Nitric acid only
(D) Water only

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

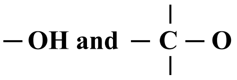


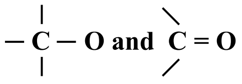
The compound caesalpinin exhibits absorption at wave numbers 3400 cm^{-1} and 1750 cm^{-1} in the IR spectrum.

24. Which functional groups are responsible for these absorptions?

(A)

$-\mathrm{OH}$ and $>\mathrm{C=O}$

(B) **C — H and — OH**

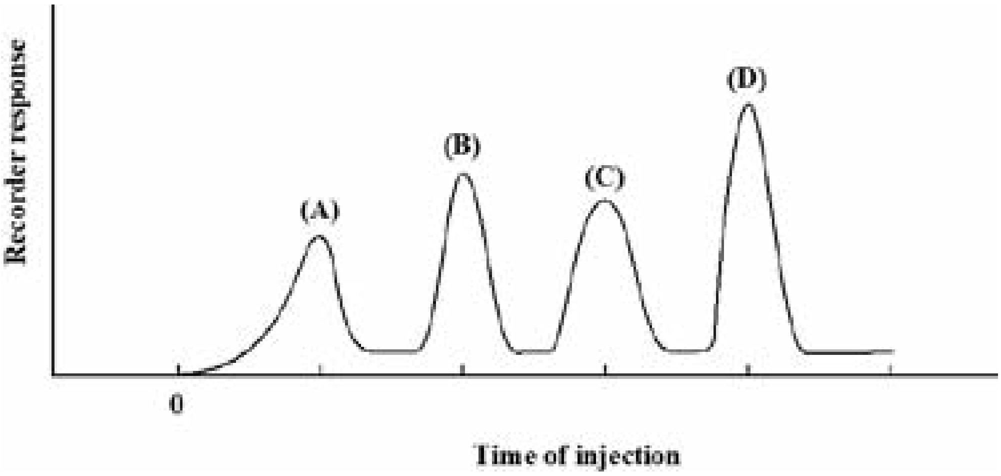
(C)

$-\mathrm{OH}$ and $-\overset{|}{\underset{|}{\mathrm{C}}}-\mathrm{O}$

(D)

$-\overset{|}{\underset{|}{\mathrm{C}}}-\mathrm{O}$ and $>\mathrm{C=O}$

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(A) $A1(OH)_3$

(B) $A1(OH)_4^-$

(C) SiO_3^{2-}

(D) $A1_2(CO_3)_3$

GO ON TO THE NEXT PAGE

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

Which fractions would be obtained between 20 - 200 ^{o}C and 275 - 375 ^{o}C respectively?

	20 - 200 ^{0}C	275 - 375 ^{0}C
(A)	Bitumen	refinery gas
(B)	Diesel	kerosene
(C)	Naphtha	refinery gas
(D)	Diesel	gasoline

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

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

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

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

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

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

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

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

36. What is the purpose of green chemistry?

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

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

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

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

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

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

Which feature of chlorine radicals may account for this?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

END OF TEST

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Unit 1 Paper 02 Keys

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

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CHEMISTRY

SPECIMEN PAPER

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

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

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Answer ALL questions.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

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

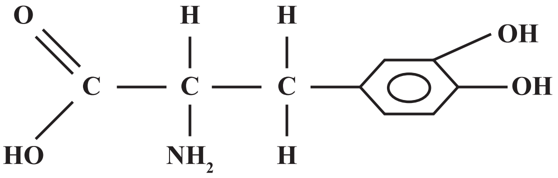

Figure 1. Dopamine

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

....

....

....

[3 marks]

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

....

....

[2 marks]

GO ON TO THE NEXT PAGE

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

[2 marks]

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

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

[1 mark]

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

....

[1 mark]

GO ON TO THE NEXT PAGE

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

[2 marks]

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

TABLE 1: RESULTS OF CHEMICAL ANALYSIS OF DOPAMINE

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

[5 marks]

GO ON TO THE NEXT PAGE

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

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[3 marks]

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

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

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[5 marks]

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

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[2 marks]

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

[4 marks]

Total 30 marks

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MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

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

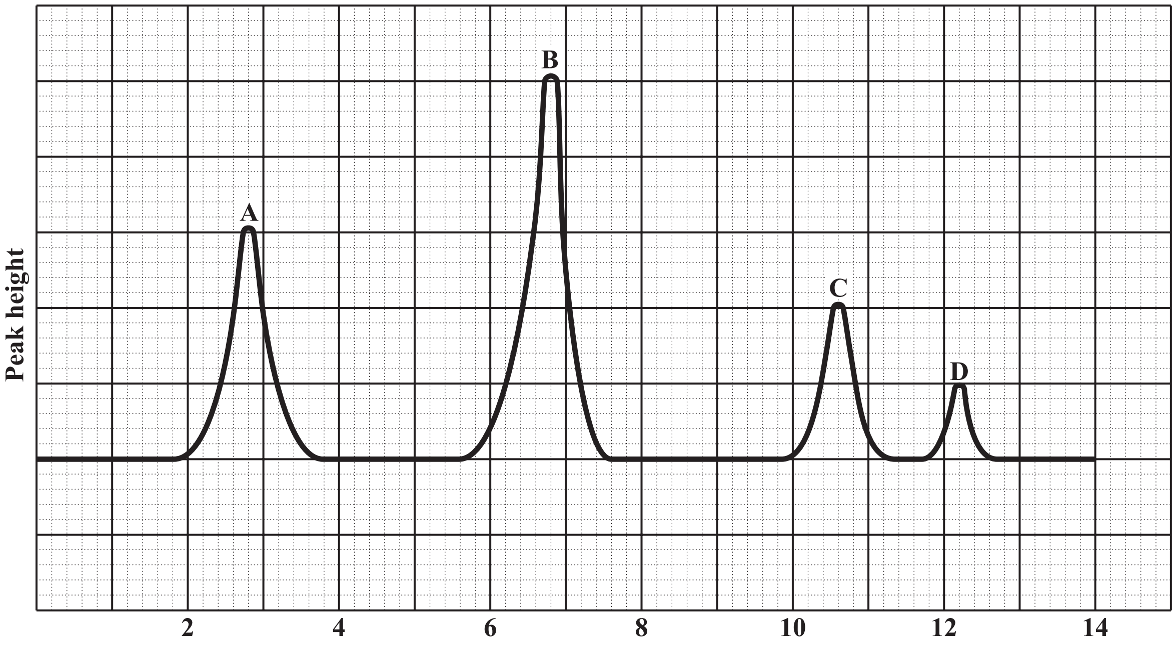

Figure 2: Chromatogram

(a) Define EACH of the following terms:

(i) Retention time

....

....

[1 mark]

(ii) Mobile phase

....

....

[1 mark]

GO ON TO THE NEXT PAGE

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

....

....

[2 marks]

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

....

....

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....

....

....

[3 marks]

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

....

[1 mark]

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

....

[1 mark]

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

....

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Reasons:

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[6 marks]

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

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[5 marks]

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

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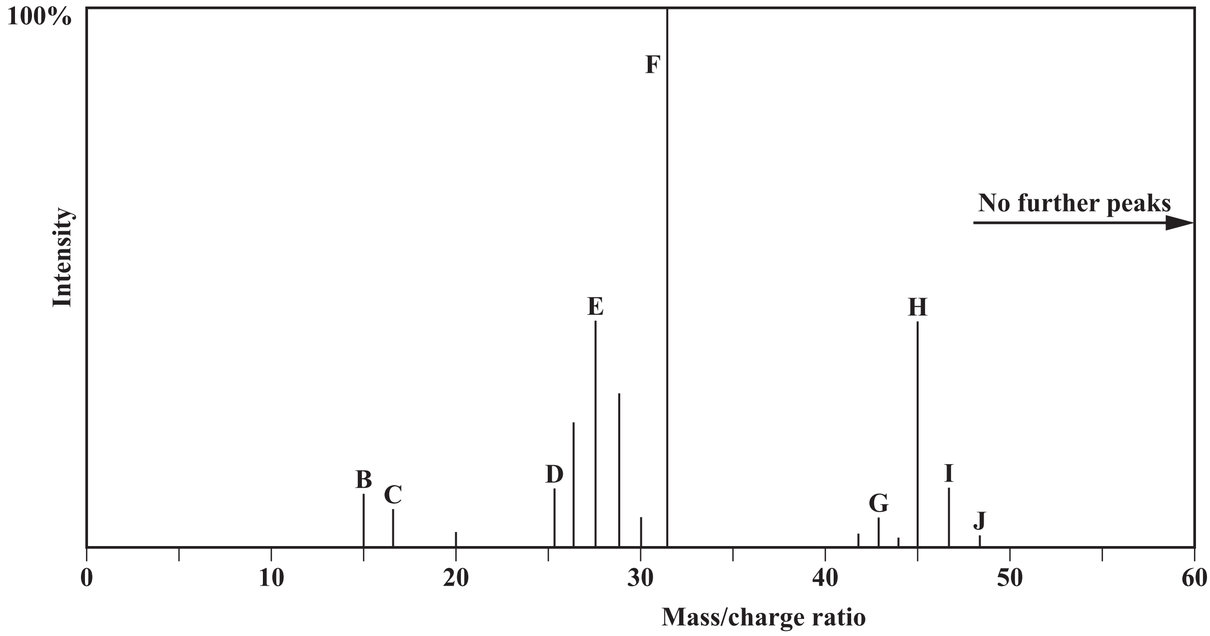
[3 marks]

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



(i) State the relative molecular mass of A.

....

[1 mark]

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

....

[1 mark]

GO ON TO THE NEXT PAGE

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

B: ....

C: ....

F: ....

[3 marks]

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

[1 mark]

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

....

....

....

[1 mark]

Total 30 marks

GO ON TO THE NEXT PAGE

MODULE 3

INDUSTRY AND THE ENVIRONMENT

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

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

....

[2 marks]

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

....

....

....

[2 marks]

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

....

[1 mark]

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

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[2 marks]

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

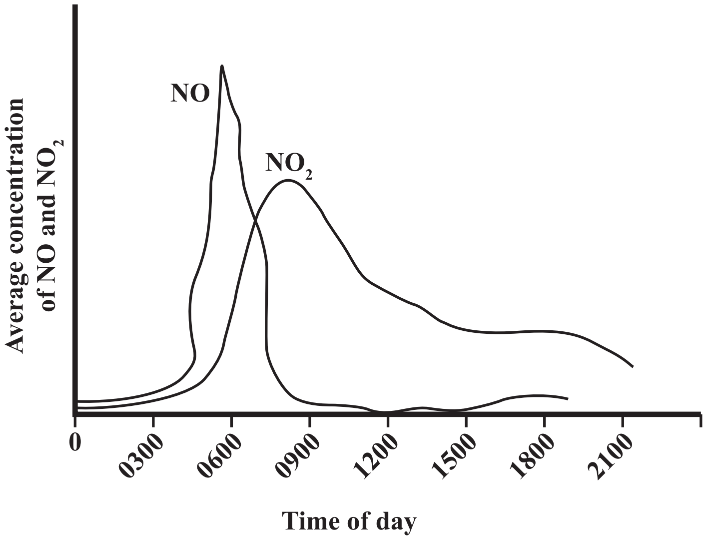

Figure 3: Concentration of NO and NO_2

(i) Using the following equilibrium reaction

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

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

....

....

....

[2 marks]

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

....

....

....

[1 mark]

GO ON TO THE NEXT PAGE

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

....

....

....

[3 marks]

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

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

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

....

....

[2 marks]

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

....

....

[2 marks]

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

....

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....

[2 marks]

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

....

....

....

[2 marks]

GO ON TO THE NEXT PAGE

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

....

....

[2 marks]

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

....

....

....

....

[3 marks]

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

....

....

....

....

[3 marks]

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

....

[1 mark]

Total 30 marks

END OF TEST

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

EXTRA SPACE

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

Question No. ☐

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CHEMISTRY

UNIT 2 — PAPER 02

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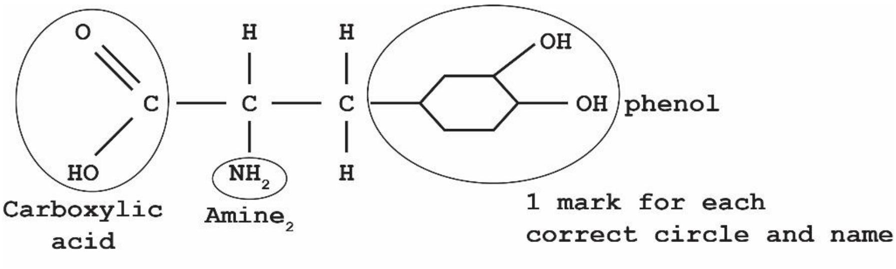
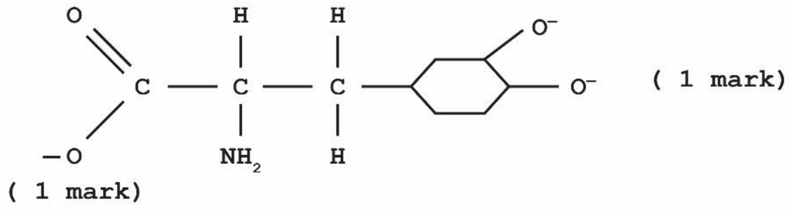
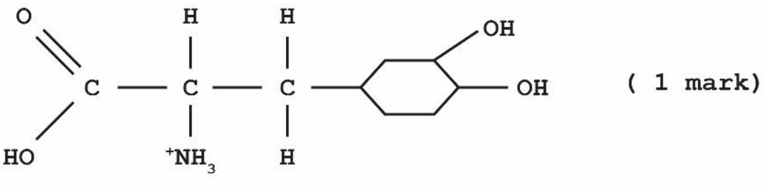
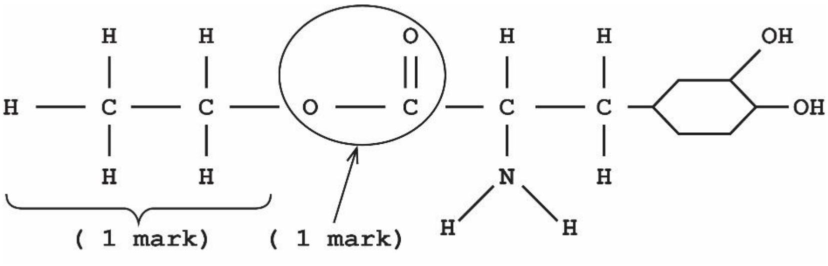
CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

Question 1

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

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

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

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

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

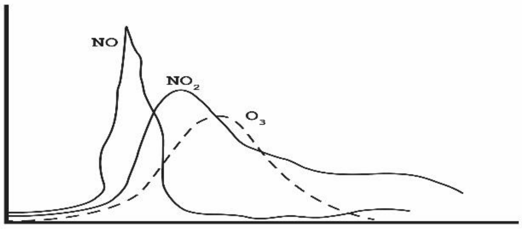
			KC	UK	XS
	Question 2				
	S.O.: Module: 2 — 7.1, 7.2, 8.1, 8.2, 8.3, 8.5				
(a)	(i)	Length of time a solute remains in the column, before entering the detector **[1 mark]**	1		
	(ii)	Mobile phase: The solvent or solvent mixture which moves over the stationary phase carrying the solutes with it **[1 mark]**	1		
	(iii)	Commonly used mobile phase in GLC: nitrogen, helium, argon. **Any two** **[2 marks]**	2		
(b)		Partitioning **[1 mark]** Substances A-D have different solubilities in the solvent being used. Based on the differences in their solubilities the substances have different speeds as they pass through the column. **[2 marks]**	3		
(c)	(i)	B **[1 mark]**		1	
	(ii)	Approximately 6.8 minutes 0.1 minute **[1 mark]**		1	
(d)		A – methanal B – propane C – methanol D – propanoic acid **[1 mark each]**		4	
		Methanol has lowest density Propane is more volatile than methanol and propanoic acid Propanoic acid is the heaviest or densest **[Any 2]**		2	
(e)		• Pack a glass column with a paste of SiO_2, $CaCO_3$ or Al_2O^3 Ensure there are no air spaces. • Using a Pasteur pipette, place about $5cm^3$ of liquid plant pigment mixture in the column. • Add the solvent (water) slowly to the mixture ensuring that the paste is not disturbed. • Open the tap at the base of the column and collect fractions of equal volumes into separate conical flasks. • Evaporate contents of flask and analyse via TLC. **[5 marks]**			5

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

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

Question 3

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

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

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

CHEMISTRY
UNIT 2 — PAPER 02
MARK SCHEME

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Front Page Bar Code

SPECIMEN PAPER

FILL IN ALL THE INFORMATION REQUESTED CLEARLY IN CAPITAL LETTERS.

TEST CODE	0	2	2	1	2	0	3	2

SUBJECT CHEMISTRY – UNIT 2 – Paper 032

PROFICIENCY ADVANCED

REGISTRATION NUMBER										

SCHOOL/CENTRE NUMBER					

NAME OF SCHOOL/CENTRE

CANDIDATE'S FULL NAME (FIRST, MIDDLE, LAST)

"*"Barcode Area"*"
Current Bar Code

DATE OF BIRTH	D	D	M	M	Y	Y	Y	Y

SIGNATURE ____________________

"*"Barcode Area"*"
Sequential Bar Code

DO NOT WRITE IN THIS SPACE

SUPERVISOR’S REPORT ON ANY ASSISTANCE GIVEN TO CANDIDATE

TEST CODE **02212032**

SPEC 2017/02212032

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CHEMISTRY

SPECIMEN PAPER

UNIT 2 – Paper 032

2 hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

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

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

"*"Barcode Area"*"
Sequential Bar Code

Answer ALL questions.

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

(a) Procedure

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

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

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

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

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

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

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

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

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

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

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

....

....

....

....

[5 marks]

TABLE 1: DATA FOR EXPERIMENTAL PROCEDURE

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

[10 marks]

(b) Determine EACH of the following:

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

....

....

....

[1 mark]

(ii) The mass of anhydrous copper sulphate

....

....

....

[1 mark]

(iii) The value of n

....

....

....

[3 marks]

Total 15 marks

GO ON TO THE NEXT PAGE

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

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

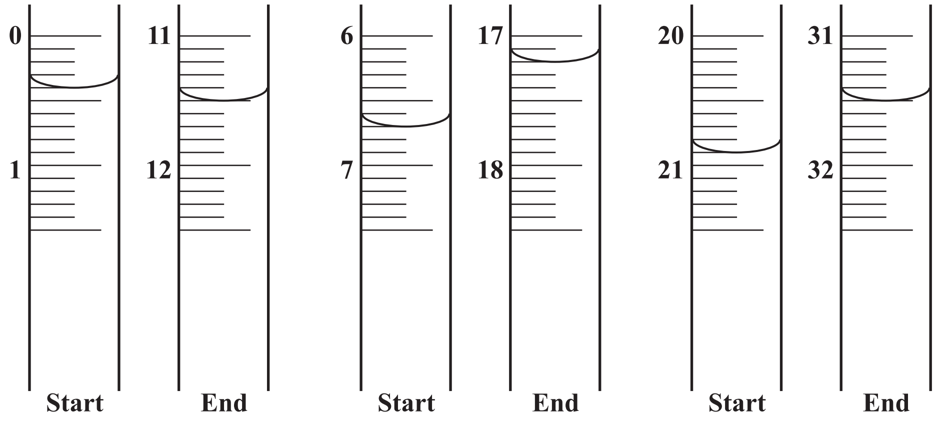

Figure 1. Readings on the burette

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

....

[1 mark]

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

TABLE 2: TITRATION RESULTS

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

[4 marks]

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

....

....

[1 mark]

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

....

....

[3 marks]

(vi) Calculate the percentage purity of the sample.

....

....

....

[1 mark]

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

....

....

....

....

....

....

[4 marks]

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

....

....

....

....

[1 mark]

Total 15 marks

GO ON TO THE NEXT PAGE

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

Your answer should include the following:

(i) Hypothesis

....

....

[1 mark]

(ii) Aim

....

....

[1 mark]

(iii) Procedure

....

....

....

....

....

....

[6 marks]

(iv) Variables to be controlled

....

....

[1 mark]

(v) **V**ariables to be manipulated and responding variables

....

....

[1 mark]

GO ON TO THE NEXT PAGE

(vi) Discussion of results

....

....

....

[1 mark]

(vii) TWO possible sources of error

....

....

....

[2 marks]

(viii) TWO precautions

....

....

....

[2 marks]

Total 15 marks

END OF TEST

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

EXTRA SPACE

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

Question No. ☐

CANDIDATE'S RECEIPT

INSTRUCTIONS TO CANDIDATE:

1. **Fill in all the information requested clearly in capital letters.**

TEST CODE:	0	2	2	1	2	0	3	2

SUBJECT: CHEMISTRY – UNIT 2 – Paper 032

PROFICIENCY: ADVANCED

REGISTRATION NUMBER:										

FULL NAME: ______________________________

(BLOCK LETTERS)

Signature: ______________________________

Date: ______________________________

2. **Ensure that this slip is detached by the Supervisor or Invigilator and given to you when you hand in this booklet.**

3. **Keep it in a safe place until you have received your results.**

INSTRUCTION TO SUPERVISOR/INVIGILATOR:

Sign the declaration below, detach this slip and hand it to the candidate as his/her receipt for this booklet collected by you.

I hereby acknowledge receipt of the candidate's booklet for the examination stated above.

Signature: ______________________________

Supervisor/Invigilator

Date: ______________________________

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CHEMISTRY

UNIT 2 — PAPER 032

MARK SCHEME

SPECIMEN

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

Question 1

S.O.: Module: 2 —3.3

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

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

(a)

Question 2

S.O.: Module: 2 —2.4, 2.5

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

(ii)

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

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

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

(More than THREE incorrect = 0 marks)

Volumes recorded to 2 decimal places

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

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

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

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

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

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

KC	UK	XS
		1
		4
	1	
	3	

			KC	UK	XS
(v)	% purity = $\left(\frac{2.95}{10} \text{x} 100\right)$ = 29.5%	**[1 mark]**		1	
(b)	Steps Dissolve the 10g of $FeSO_4$ in minimum volume of H_2SO_4 in a beaker. Transfer quantitatively to a 1 dm^3 volumetric flask. Make up to mark with distilled water. Stopper and shake/invert to ensure thorough mixing.	**[4 marks]**			
(c)	It is oxidised in air from Fe^{2+} to Fe^{3+}.	**[2 marks]**			
		Total 15 marks		5	10

CHEMISTRY
UNIT 2 — PAPER 032
MARK SCHEME

Question 3

S.O.: Module: 1 —3.3

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