SEC SYLLABUS (2013)

CHEMISTRY SEC 06

SYLLABUS

Chemistry SEC 06	Available in September (Paper I and Paper IIB only)
Syllabus	Paper I (2hrs)+Paper II (2hrs)+Laboratory work

1. Introduction

Chemistry involves a dynamic and engaging study of the material world. It is a field of human endeavour based on the broad understanding of physical concepts and models which are united by common procedural and intellectual processes. Chemistry and the work of chemists have a profound impact on the environment, quality of life and on social and cultural practices.

The examination papers will test the knowledge and understanding of chemical facts and principles and the ability to apply these to everyday situations as well as to solve theoretical and practical chemical problems both qualitatively and quantitatively.

Chemistry is an experimental science and practical work is central in a teaching programme of the subject at this level. An investigative approach to teaching Chemistry highlights the study of key concepts of chemistry in real-world contexts. While a practical paper will not be set, it is nevertheless expected that students taking the examination have had direct experience of the laboratory and have carried out a reasonable number of experimental investigations.

Every opportunity should be taken to expose the students to the applications of Chemistry to everyday situations and to help students develop higher order thinking skills. In order to allow more time for an investigative approach to teaching chemistry and for the development of reasoning skills this revised syllabus has reduced the emphasis on factual knowledge and decreased the content that students are expected to recall.

2. Aims

A course in SEC Chemistry aims to:

2.1 stimulate students, create and sustain their interest in, and enjoyment of, the study of chemistry.

2.2 enable students to acquire a knowledge of basic chemical concepts and an understanding of chemical principles and patterns.

2.3 lay a sound foundation for those who intend to pursue their studies in chemistry or related subjects further, and also cater for those students who intend to terminate their study of chemistry at this level.

2.4 encourage students to appreciate that chemistry is a dynamic and evolving subject and that its principles and theories may change.

2.5 make students aware of the importance of adopting the scientific method of investigation.

2.6 develop relevant practical skills whilst having due regard to correct and safe laboratory practice.

2.7 develop students' experimental and investigative competence.

2.8 develop students' abilities to:
- form hypotheses and design experiments to test these hypotheses;
- organize, interpret and evaluate chemical information in order to draw conclusions, make decisions and / or solve problems;
- communicate their chemical knowledge and findings in appropriate ways.

2.9 encourage students to apply their chemical knowledge and understanding to familiar and unfamiliar situations.

2.10 develop students' appreciation of the environmental and technological applications of chemistry and of the economic, ethical and social implications of these.

3. Assessment Objectives.

The following objectives will be assessed in the examination.
These objectives apply to the whole of the syllabus, throughout the ability range, though different candidates' performances should indicate the extent to which the objectives have been met.

3.1 Knowledge by simple recall.
Candidates should be able to recall:

3.1.1 chemical symbolism, nomenclature, terminology and units;
3.1.2 chemical facts, principles, definitions, laws, concepts, theories and patterns;
3.1.3 social, economic, environmental and technological applications of chemistry;
3.1.4 experimental techniques, procedures and safe laboratory practices.

3.2 Knowledge and Understanding.
Candidates should be able to:
3.2.1 explain their knowledge in terms of relevant principles, concepts, theories and patterns;
3.2.2 perform numerical calculations related to familiar problems in which guidance on the method of solution may or may not be provided;
3.2.3 give reasons for specific experimental steps or techniques and safe laboratory practices.
3.2.4 express and present their knowledge and ideas about chemistry in a logical, concise and clear form;
3.2.5 organize and present chemical information in written, diagrammatic, symbolic, numerical or graphical form.

3.3 Application of Knowledge, Analysis and Evaluation.
Candidates should be able to:
3.3.1 utilise chemical facts to illustrate a given chemical principle, concept, theory, model or pattern;
3.3.2 apply chemical principles and patterns to make generalisations and predictions;
3.3.3 organize, manipulate and interpret data in the form of symbols, tables, diagrams, graphs or written statements and translate information from one form to another;
3.3.4 select suitable apparatus, tests and techniques for carrying out experiments accurately and safely;
3.3.5 evaluate the social, economic, environmental and technological applications and implications of chemistry.

3.4 Competence in problem solving.
The coursework should not be restricted to an acquisition of information but should assess students' ability to:
3.4.1 select procedures, plan and organize experimental investigations to test a hypothesis, validateconclusions or solve a chemical problem;
3.4.2 organize data and perform calculations in which guidance on the method of solution is not provided;
3.4.3 recognize patterns, report trends and present reasoned explanations or draw conclusions;
3.4.4 interpret and evaluate the results of an experiment and appreciate the possibility of experimental error.

3.5 Experimental and Investigative work.
It is important that emphasis is laid on experimental work, mostly carried out by the students themselves. As a result, the students should be able to:
3.5.1 follow instructions for practical work and select appropriate apparatus;
3.5.2 handle and manipulate chemical apparatus and materials safely;
3.5.3 make accurate observations and measurements; record the results of experiments clearly and with an acceptable degree of accuracy, and communicate the results in various forms;
3.5.4 interpret and use experimental observations, data and results to draw conclusions and make generalisations from experiments;
3.5.5 evaluate the validity of methods or results, and suggest possible improvements.

4. Scheme of Assessment

The examination will consist of two written papers, each of two hours' duration, and an assessment of practical work in chemistry. Questions will be set in English and must be answered in English.

The examination will be structured as follows:
Paper I consists of a written paper and a practical component and is to be taken by all candidates registered for the examination; the practical component is assessed separately by a continuous method during the course of instruction.

There will be two versions of Paper II: Paper IIA and Paper IIB. Questions in Paper IIA will be more difficult than those in Paper I. Questions in Paper IIB will be easier than those in Paper I. In the September supplementary session only Paper I and Paper IIB will be offered.

Candidates will be required to indicate on the registration form which option in Paper II (A or B) they wish to sit for. No change in the choice of option will be allowed after the registration period. The written part of Paper I carries a total of 40% of the global mark. Paper II, (either option) carries a total of 45% of the global mark. The practical assessment carries a total of 15% of the global mark.

Each written paper will consist of two sections, 1 and 2, as follows:

Section 1 will contain two types of question: one type will require very short answers; the other type will consist of structured questions. All the questions in this section will be compulsory and the answers to the questions will be recorded on the question paper itself. There will be about ten questions in this section.

Section 2 of Paper I will consist of two compulsory questions.
Section 2 of Paper II (both options A and B) will consist of four questions and candidates will be expected to answer two questions.

Besides demonstrating their knowledge and comprehension of chemical facts and principles, in answering questions from Section 2, candidates may also be expected to organise their answer in a logical, critical and imaginative manner. In this section candidates may be asked to give descriptive accounts of processes and experiments.

In either section of Papers I and II, questions will be set to test the familiarity of candidates with experimental and investigative work as specified in 3.3 to 3.5 above.

Practical work will be assessed by the schools on the basis of a set of laboratory reports of experiments carried out during the candidates' course of study.
The mark for the practical work will be based on the average mark of the thirteen (13) experiments as explained in Section 5.4.

Laboratory Report Books are to be available at the candidates' school for moderation by the Markers' Panel.

The school assessments should reach the MATSEC Examinations Board by the date indicated by the Board.
CANDIDATES MAY BE CALLED FOR AN INTERVIEW ABOUT THEIR PRACTICAL WORK.

Private Candidates

(a) Private candidates who left school before 1994 will not be expected to present their laboratory report books. Their mark will be obtained by pro-rating of the written papers.
(b) Candidates who studied the subject at school and are re-sitting the subject may carry forward the practical report mark from a previous session.
(c) Candidates who have never studied the subject at school but have covered the coursework privately will be expected to present their laboratory report books to the MATSEC Board by the date indicated by the Board. Candidates will be asked to attend for an oral examination about their practical work.

<u>Weighting of Assessment Objectives</u>.
The examination will test candidates' abilities according to the following scheme:

Skill Area	Paper I	Paper IIA	Paper IIB	Practical skills
Knowledge / Recall	35%	30%	30%	-
Knowledge and Understanding	30%	30%	35%	-
Application of knowledge, analysis and evaluation (including problem solving)	35%	40%	35%	-
% of Global Mark	40%	45%	45%	15%

In the written papers, question items will target the following aspects of the syllabus in decreasing order of priority:

- Chemical theories, reactions and properties of matter;
- Experimental techniques and design of experiments;
- Quantitative techniques.

The minimum mathematical requirements of the chemistry syllabus are as follows:

1. the ability to perform simple arithmetical processes such as addition, subtraction, multiplication and division of quantities expressed in decimal form, as fractions, or in index notation;
2. the ability to calculate volumes; simple percentage calculations; calculations involving ratios and proportion;
3. the ability to use and interpret simple graphs, carry out extrapolations and interpolations and measure gradients.

The Periodic Table, complete with atomic numbers and relative atomic masses, will be provided in each examination paper.

The following 'Useful Data' will also be provided:

- Avogadro constant $L = 6.02 \times 10^{23}$
- Faraday constant $= 96500\ C\ mol^{-1}$
- specific heat capacity of water $= 4.2\ J\ g^{-1}\ {}^{o}C^{-1}$
- the molar volume for gases $= 22.4\ dm^3$ at stp
- stp condtions are to be taken as 0^oC and 1atm (760 mm Hg)
- $Q = It$
- $\Delta H = mc\Delta\theta$

Electronic calculators may be used in any part of the examination.

Results

Candidates sitting for Paper I and Paper IIA may qualify for grades 1, 2, 3, 4 or 5. The results of candidates who do not obtain at least a grade 5 shall remain Unclassified (U).

Candidates sitting for Paper I and Paper IIB may qualify for grades 4, 5, 6 or 7. The results of candidates who do not obtain at least a grade 7 shall remain Unclassified (U).

5. Syllabus Content

The subject matter is organised under four headings:
Facts of Chemistry; Principles of Chemistry; Chemistry, Society and the Natural Environment; and Chemical Laboratory Experience.

This organisation of the syllabus material is not intended to serve as a model of presentation of the subject matter. Nevertheless, pupils should be made aware of the distinction between the observational facts of any science, which tend to be permanent, and the possibly transient theories which attempt to rationalise the facts. Moreover, the concept of the impact of chemistry on society and on the natural environment should be allowed to permeate the entire fabric of the course material.

Throughout the course, students are expected to gain experience of the chemical laboratory and to observe and perform practical tasks related to the subject matter of the syllabus. Towards this end, a number of student laboratory experiments are indicated in the syllabus.

5.1 Facts of Chemistry

Topic	Description	Additional notes
(a) Pure substances and mixtures	Gas, liquid and solid interconversions. Pure substances and mixtures. Solvent, solute, solution. Suspension. Separation of mixtures by filtration, evaporation to dryness and crystallization (partial evaporation up to the point of crystallization), simple distillation, paper chromatography, sublimation and fractional distillation. The use of the separating funnel.	fractional distillation (simple treatment only - exemplified by alcohol and water).
	Boiling point and melting point of substances as criteria of purity.	Knowledge of experimental details to determine melting point and boiling point are not required but pupils should be able to interpret a simple heating / cooling curve.
(b) Action of heat on materials.	Decomposition of hydrates, carbonates, hydrogencarbonates, nitrates and hydroxides by heat. Thermally stable compounds. Reversible reactions, including the hydration/dehydration of silica gel and of hydrated copper (II) sulfate.	It is suggested that examples are chosen from substances mentioned in Section 5.4(B). (e.g. sodium chloride, sodium carbonate and oxides). In addition see also section 5.1(c) for the action of heat on magnesium, copper, carbon and sulfur.
(c) Gases in air. Oxygen.	The atmosphere - composition of: to include presence of water vapour, noble gases and carbon dioxide. An experimental determination of the percentage composition by volume of nitrogen and oxygen in air. Air pollution - see Section 5.3(e).	Isolation of 'atmospheric nitrogen' – details of the apparatus is not required.
	Handling techniques for preparation and collection of gases, including the use of the gas syringe.	Students should be familiar with different types of gas generators and methods/apparatus for drying and collecting gases.
	Principle of the extraction of oxygen by fractional distillation of liquid air	Technical details and conditions are not required.
	Preparation of oxygen by the catalytic decomposition of hydrogen peroxide; test for oxygen. Reaction of metals and non-metals with oxygen in air. Types of oxide. Oxides of the common elements and their reaction with water.	The catalytic decomposition of potassium chlorate as a method of preparing oxygen is not required. (e.g. magnesium, copper, carbon, sulfur)
	Rusting of iron and its prevention.	A treatment of respiration and photosynthesis is not required.
	Ozone as an unstable, naturally occurring, allotrope of oxygen.	See Section 5.3(e) for effect of pollutants, (e.g. chlorofluorocarbons).

Topic	Description	Additional notes
(d) Water and solutions	Simple treatment of soluble and insoluble substances in water. Saturated solutions and interpretation of solubility curves. Physical properties; test for purity. Chemical tests for the presence of water. Water of crystallisation, deliquescence and efflorescence; hygroscopic substances. The presence of air dissolved in water. Students should be aware that air dissolved in water has a different composition from ordinary air due to the difference in solubility of nitrogen and oxygen. Ground water and sea water as important examples of aqueous solutions of specific solutes. Methods of purifying water, including a simple qualitative treatment of the technique of reverse osmosis for purifying brackish water and seawater.	Polar nature of water - not required. The experimental determination of solubility is not required. A description of the experimental determination of the percentage of dissolved gases is not required.
(e) Acids, bases and salts	Aqueous solutions of acidic and alkaline substances and their action on indicators. The pH scale treated as an arbitrary scale of acidity and alkalinity. Strong and weak acids. Bases and alkalis. Reaction of dilute non-oxidising acids with metals, insoluble bases and alkalis, carbonates and hydrogencarbonates, sulfites. Normal salts and acid salts; preparation of salts. Comparison of solutions of hydrogen chloride in water and in methylbenzene. Standard solutions, acid-alkali titrations and related calculations in terms of moles and molar concentrations.	Simple treatment in terms of ionisation / non-ionisaton. Calculations involving back titrations will not be set. Concentration to be expressed as mol dm^{-3} or g dm^{-3} Calculation to determine concentration should not be carried out using the formula $\frac{MaVa}{\text{mole ratio (a)}} = \frac{MbVb}{\text{mole ratio (b)}}$
(f) Hydrogen	Preparation of hydrogen from action of dilute non-oxdising acids on certain metals, exemplified by dilute hydrochloric acid or dilute sulfuric acid on magnesium, zinc or iron. Test for hydrogen. Combustion of hydrogen - its advantages and disadvantages as a fuel. Reducing action of hydrogen with metal oxides. Uses of hydrogen.	

Topic	Description	Additional notes
5.1 (g) Carbon	Diamond and graphite as allotropes of carbon. Reaction of carbon with metal oxides. Laboratory preparation of carbon dioxide; test for carbon dioxide. Solubility in water and in alkali. Uses of carbon dioxide. Carbonates - some general properties limited to: solubility, reaction with dilute acids, action of heat, preparing insoluble carbonates by precipitation. Formation of carbon dioxide and carbon monoxide from processes of complete / incomplete combustion of carbon and hydrocarbons. Properties of carbon monoxide - neutral gas, toxic nature, combustion to form carbon dioxide; reducing action. Separation of carbon monoxide from a carbon monoxide / carbon dioxide mixture by absorption in alkali.	The laboratory preparation of carbon monoxide is not required.
(h) Nitrogen	Nitrogen as an unreactive gas. Principle of the industrial extraction of nitrogen from liquid air. Manufacture of ammonia by reversible direct union of its constituent elements. Laboratory preparation of ammonia from ammonium salts; test for ammonia gas. Properties of ammonia gas. Use of ammonia as a reducing agent for certain metallic oxides. Preparation and properties of aqueous ammonia - e.g. alkalinity, neutralisation of acids, precipitation of insoluble metallic hydroxides. Ammonium salts - preparation by neutralisation; reaction with alkalis; use as fertilisers. Sublimation / thermal dissociation of ammonium chloride. Nitric acid as a dilute acid - exemplified by its reaction with metallic oxides, e.g. magnesium oxide, and with metallic carbonates, e.g. magnesium carbonate. Nitric acid as an oxidising agent - exemplified by its reaction with copper. Uses of nitric acid. Nitrates - general properties, e.g. solubility, action of heat, general methods of preparation. Nitrogen monoxide - conversion to nitrogen dioxide on exposure to air. Nitrogen dioxide - laboratory preparation by the thermal decomposition of lead (II) nitrate; identification due to colour. Properties of nitrogen dioxide - e.g. solubility in water and acidity (linked to acid rain).	Technical details of the fractional distillation of liquid air are not required. The laboratory preparation of nitric acid is not required. Detailed formal equations representing the conversion of nitric acid to the various oxides of nitrogen are not required. Experimental details of the laboratory preparation of nitrogen monoxide are not required.

Topic	Description	Additional notes
5.1 (i) Sulfur	Allotropes of sulfur - rhombic / monoclinic. Uses of the element. Hydrogen sulfide – its formation by the action of dilute acids on metal sulfides; toxic nature of the gas. Laboratory preparation of sulfur dioxide by the action of a dilute acid on a sulfite; test for the gas. Reactions of sulfur dioxide which exemplify its acidic nature and its reducing action, e.g. colour change with acidified potassium dichromate solution. Sulfur trioxide – acidic nature. Manufacture of sulfuric acid and its uses. Properties of dilute sulfuric acid. Properties of concentrated sulfuric acid – including its action on metallic chlorides; dehydrating action, e.g. on sugar and on ethanol; oxidizing action e.g. on copper; and hygroscopic nature / use as a drying agent.	Details of the laboratory preparation of the allotropes are not required. The extraction of sulfur (Frasch process) is not required. A description of the laboratory preparation of hydrogen sulfide is not required. No experiments involving hydrogen sulfide are to be carried out. The equation for the reactions of sulfur dioxide with acidified potassium dichromate solution is not required. The laboratory preparation of sulfur trioxide is not required. The laboratory preparation of hydrogen chloride gas is not required.
(j) Halogens	Chlorine, bromine and iodine – similarities and trends in properties of elements in Group 7. Displacement reactions of one halogen by another. Laboratory preparation of chlorine by oxidation of concentrated hydrochloric acid using manganese (IV) oxide. Test for chlorine. Bleaching action of chlorine water. Uses of chlorine. Properties of dilute hydrochloric acid. Preparation of chlorides from dilute hydrochloric acid.	

Topic	Description	Additional notes
5.1 (k) Action of electricity on materials Electrolysis	The effect of electricity on various solids, liquids (including molten substances), and aqueous solutions. Conductors and non-conductors; electrolytes and non-electrolytes. Detailed description of electrolytic decomposition and the factors affecting product formation at the electrodes. Factors will include – the position of the ion in the reactivity series, concentration of ion and the nature of the electrodes. Quantitative aspects of electrolytic cells: the Faraday as a mole of electrons.	Examples suggested to illustrate this section are: dilute sulfuric acid, dilute ethanoic acid, copper (II) sulfate solution using carbon electrodes and sugar solution. Specific examples of electrolysis can include – dilute sulfuric acid, dilute hydrochloric acid, concentrated aqueous sodium chloride and copper (II) sulfate solution (all using inert electrodes); copper (II) sulfate solution using copper electrodes.
Reactivity Series	Reactivity series: to include potassium, sodium, calcium, magnesium, aluminium, zinc, iron, lead, hydrogen, copper and silver. Reactivity of these metals with air (oxygen), water and dilute acids. Displacement reactions involving these metals and their compounds to include: a metal displacing a less reactive metal from an aqueous metallic salt; a metal reducing an oxide of a less reactive metal. The simple cell – as a means of transforming chemical energy into electrical energy (e.g. Zn/Cu electrodes in dilute acid).	Explanation should be limited to the half equation showing the reaction of the more reactive metal (e.g. of zinc) resulting in electrons passing through the external circuit to the less reactive metal (e.g. to copper).
(l) Group 1 and Group 2 metals	Alkali metals and alkaline earths as representatives of two groups or families of elements in the Periodic Table.	Details of the extraction of these metals are not required.
Alkali metals	Sodium and potassium. Characteristics of the metals and similarities in the group: typical physical properties; chemical properties – reaction with oxygen (to form simple oxide, M_2O, only), with water and with chlorine. Trend in reactivity going down the group.	
Alkaline earth metals	Magnesium and calcium. Similarities in the group: typical physical properties; chemical properties – reaction with oxygen, water and dilute acids. Limestone – conversion of limestone ($CaCO_3$) to quicklime (CaO) and subsequently to slaked lime [$Ca(OH)_2$]. Hardness in water caused by dissolved calcium and magnesium salts. Hardness in ground water associated with limestone terrains. Temporary and permanent hardness of water; softening of water. The advantages of synthetic detergents over soap when used with hard water – simple treatment only. Scale formation, stalactites and stalagmites.	The structures of soap and synthetic detergent molecules are not required.

Topic	Description	Additional notes
5.1 (m) Less reactive metals: iron and copper	These metals are to be presented as typical of the transition elements, illustrating the properties of variable valency, the formation of coloured compounds and acting as catalysts.	
Iron	Action of steam, hydrogen chloride and chlorine on iron. Hydroxides of iron (II) and iron (III) : formation by precipitation, colour. Oxidation of iron (II) hydroxide to iron (III) hydroxide by exposure to air.	
Copper	Simple compounds of copper: Copper (II) oxide as a typical basic oxide and its use in preparing copper (II) salts by reaction with dilute acids. Reduction of copper (II) oxide by hydrogen. Thermal decomposition of copper (II) carbonate and copper (II) nitrate to give copper (II) oxide.	
(n) Qualitative analysis	Identification of sodium and potassium ions by flame tests. Simple test tube reactions for the identification of the following ions in solution: Cations - ammonium, calcium, magnesium, aluminium, lead (II), copper (II), iron (II) and iron (III); A flame test can be used to distinguish between calcium and magnesium. Amphoteric character of aluminium and lead (II) to be exploited in testing for these ions. Potassium iodide solution can be used to distinguish between aluminium and lead (II) ions.	By reaction with sodium hydroxide solution. Formulae and equations for the formation of hydroxometallates are not required.
	Anions - carbonate, sulfite, sulfate, chloride, bromide, iodide, and nitrate. Nitrates can be tested by reduction with aluminium and alkali to give ammonia.	The formal redox equation for this test is not required. N.B. The 'brown ring test' is not required.
	Tests for the following gases: oxygen, hydrogen, carbon dioxide, ammonia, chlorine, hydrogen chloride and sulfur dioxide.	

Topic	Description	Additional notes
(o) Organic chemistry	Definition of an organic compound. The unique ability of carbon to catenate leading to a large number of organic compounds. Concept of a homologous series.	
Alkanes	Alkanes as the first example of a homologous series: used to illustrate the terms empirical formula, molecular formula, structural formula and general formula for a homologous series.	The laboratory preparation of alkanes is not required.
	Nomenclature limited to the first five straight chain alkanes.	
	Chain isomerism of C_4H_{10} and C_5H_{12} only.	The systematic naming of branched isomers is not required.
	Alkyl groups limited to methyl and ethyl only. Gradation in physical properties of straight chain alkanes linked to length of hydrocarbon chain. Complete and incomplete combustion of hydrocarbons resulting in the formation of carbon dioxide, carbon monoxide and carbon. Uses of alkanes as fuels.	
	Saturated nature of the alkanes resulting in substitution reactions with halogens, limited to monosubstitution.	No knowledge of preparation and reactions of chlorofluorocarbons are required.
Alkenes and alkynes	Alkenes and alkynes as typical unsaturated hydrocarbons.	
	General formula; structural formulae.	Naming of positional isomers is not required.
	Combustion of alkenes / alkynes – sootiness of flame as an indication of unsaturation (or high percentage by mass of carbon).	
	Addition reactions of alkenes with hydrogen and halogens; and of ethene with hydrogen halide. Hydration of ethene. Test for unsaturation – distinction between alkanes and alkenes/alkynes using bromine water.	Detailed chemistry of the alkynes is not required however students will be expected to predict properties of straight chain alkynes by comparison to alkenes.
Polymerisation	Principle of addition polymerisation limited to polyethene, PTFE and PVC.	Preparation conditions are not required. Knowledge of condensation polymerisation is not required.
Petroleum	Petroleum (crude oil) as a mixture of hydrocarbons including natural gas which can be separated by fractional distillation (fractionation); limited to names of fractions and the fact that boiling point range of fraction is related to carbon number. Uses of fractions.	Only a schematic diagram is required; details of the structure and running of the fractionating tower is not required.
	Cracking of long chain alkanes to form one shorter chain alkane and ethene. The cracking of diesel to obtain petrol and ethene as an industrial application of this process.	

Topic	Description	Additional notes
5.1 (o) contd. Alcohols	OH as the functional group. General formula, structural formulae; nomenclature. Reactions of alcohols with sodium, with phosphorus (V) chloride to liberate misty fumes as a test for the OH group and with concentrated sulfuric acid to form alkenes. Ethanol; manufacture from glucose (fermentation) and from petroleum derived ethene (hydration). Oxidation of ethanol to ethanoic acid using acidified potassium dichromate, limited to test-tube reaction. Functional group isomerism limited to C_2H_6O.	Naming of positional isomers is not required. Naming of alkoxides is not required. Naming of the products of the reactions with phosphorus (V) chloride is not required. Experimental details are not required. Formal redox equations are not required. Naming of the ether is not required.
Carboxylic acids	COOH as the functional group. Naming of straight chain carboxylic acids up to pentanoic acid. Weak acidic nature. Formation of salts by the usual methods. Reaction of an organic acid and an alcohol to produce an ester and water in a reversible process. Role of concentrated sulfuric acid in esterification. Recognition of the esters as another homologous series characterised by their fruity smell.	The hydrolysis of esters is not required. Chemistry of the esters is not required and naming of esters is limited to ethylethanoate.

5.2 Principles of Chemistry

The facts of chemistry are explained on the basis of the unifying concepts of structure, bonding and energy change. It is expected that the principles outlined in this section would be introduced at suitable points and constantly reinforced during the teaching of the topics listed in Sections 5.1 and 5.3.

Topic	Description	Additional notes
(a) Atoms, molecules, Relative atomic mass, Relative molecular and formula mass.	Atomic nature of matter. Elements and compounds. Idea of size of atoms. Avogadro's constant and moles of atoms. Relative atomic mass with respect to ^{12}C. Molecules and relative molecular masses, expressed in grammes, as the mass of a mole of molecules. Mole of ions. Formula masses of ionic compounds. Mole/mass interconversions. Molar volume of gases and Avogadro's law. Mole/mass/volume interconversions for gases. Calculations to find the volume of a gas (measured at stp) that reacts, or is produced, in chemical reactions. Use of PV/T = constant for converting gas volumes to and from standard conditions. Gas to gas calculations based on Gay Lussac's law of combining volumes.	Numerical values for the size of atoms is not required. The oil drop experiment is not required. STP conditions will be stated in examination papers.

Topic	Description	Additional notes
5.2 (b) Chemical formulae and equations	Experimental determination of chemical formulae of binary compounds, from the reacting masses of the elements. (Oxides of metals offer suitable examples). Deriving the value of xH_2O in a hydrated compound by heating to constant mass. Percentage composition and related calculations. Balanced chemical equations to represent the relative number of particles involved in chemical reactions. States of substances, [using symbols (s), (l), (g) and (aq) for solid, liquid, gas and aqueous solution respectively], should be specified where appropriate. Experimental determinations intended to establish the combining ratios of rectants and products to include gravimetry and volumetric work, in addition to measurements involving gas volumes. All calculations involving chemical changes are to be performed in terms of moles of substance.	Suitable examples could be $MgSO_4.xH_2O$ or $ZnSO_4.xH_2O$ Suitable experimental example: precipitation of barium sulfate from barium chloride.
b) Atomic structure and the Periodic Table	Nuclear model of the atom; protons, neutrons and electrons. Isotopes and relation of isotopy to relative atomic masses (limited to two isotopes). Electrons in shells. Electronic configuration of the first eighteen elements (hydrogen through to argon). Relation of electronic configuration to electrovalency and covalency, and to the periodic property of valency / position of element in the Periodic Table.	
c) Structure and bonding	Ionic bonding - formation of simple ions by loss or gain of electrons as governed by the octet rule. Physical properties of ionic compounds - high melting points, solubility in water, conductivity. Electrostatic attractions and three dimensional lattice of ions, limited to sodium chloride. Covalent bonding - formation of simple molecules (e.g. H_2, Cl_2, O_2, N_2, HCl, H_2O, NH_3, CH_4, CO_2) by sharing of electrons as governed by the octet rule. Single, double and triple bonds. Giant molecular structures, limited to diamond and graphite. High sublimation temperatures of these materials explained in terms of strong covalent bonds holding the lattice structure together. Electrical conductivity in graphite explained in terms of free electrons.	Dative covalency not to be discussed. Shapes of molecules are not required.

Topic	Description	Additional notes
5.2 (d) Contd.	Distinction between physical properties of giant covalent structures and crystals composed of simple molecules. The latter to be considered as discreet molecules held together by weak intermolecular forces. Dry ice and iodine are suitable examples. Metallic crystals in terms of ions in a sea of mobile electrons. Thermal and electrical conductivity, and malleability, explained in terms of this bonding model.	A discussion of hydrogen bonding and polarity are not to be included.
(e) Kinetic molecular theory and states of matter	Diffusion and Brownian motion in terms of simple kinetic theory. Interconversions between the three states of matter. Application of kinetic theory to explain energy requirements for changes of state; different energy requirements for simple molecular versus giant molecular lattices in relation to the nature of bonding (simple treatment only). Qualitative treatment of the effect of change in temperature, or pressure or volume on a fixed mass of gas.	
(f) Ionic theory; oxidation and reduction	Ionic half equations to represent synthesis reactions involving binary compounds, displacement reactions and reactions at electrodes for electrolytes given in section 5.1 (k). Ionic equations omitting spectator ions for – neutralization, acid on a carbonate, acid on a sulfite, alkali on an ammonium salt and precipitation reactions. Oxidation and reduction; redox reactions in terms of loss and gain of oxygen/hydrogen; in terms of loss and gain of electrons. The concept of oxidation number limited to simple binary compounds between metals and non-metals. Its application in simple redox reactions. Electrolysis explained in terms of electron transfer between ions and electrodes. Tendency to lose or accept electrons related to the reactivity series.	

Topic	Description	Additional notes
5.2 (g) Energetics	The concept that energy changes accompany both physical and chemical changes. Exothermic and endothermic reactions; thermochemical equations and the ΔH notation. The Joule or kiloJoule as a unit of measuring heat energy. Definitions and calculations for energy changes accompanying combustion, solution, neutralisation and precipitation reactions. Simple experimental determination of heat of solution and heat of neutralisation and estimation of the heat of combustion of a flammable liquid. Heats of reaction as the result of energy changes when bonds are broken and formed. Principle of conservation of energy. Simple energy level diagrams illustrating the idea of activation energy.	Calculations involving bond energies will not be set.
(h) Rates of reactions	Concept of reaction rate as the increase of product concentration or decrease of reactant concentration with time. Dependence of rate of heterogeneous reactions on the state of subdivision of a solid explained in terms of particle collisions involved in chemical change. A simple kinetic picture to be used to account for the effect of concentration on the rate of homogeneous reactions. Effect of temperature. Definition of a catalyst. The effect of a catalyst on reaction rate. Effect of light on certain reactions, e.g. photoreduction of silver halides; reaction of hydrogen with chlorine.	
(i) Reversible reactions and chemical equilibrium	The concept of reversible change as exemplified by various processes, e.g. changes of state; hydration of copper (II) sulfate; chromate/dichromate interconversions; esterification. Kinetic picture of dynamic equilibrium and use of the appropriate symbol to denote reversible reactions. Le Chatelier's principle and its application to systems in dynamic equilibrium – qualitative treatment only. Shifting the equilibrium position of a system by changing the temperature, the total pressure or the concentration of a species. Thermal dissociation / dynamic equilibrium of dinitrogen tetraoxide / nitrogen dioxide. The effect of a catalyst on the rate of attainment of equilibrium and not on the equilibrium position.	This may include the addition of a reagent which changes the concentration of one of the species in the system.

5.3 Chemistry, Society and the Natural Environment

A deliberate and sustained effort should be made in conveying this aspect of chemistry to students. Chemistry should be seen as an essential human endeavour with relevance to the quality of everyday life. Chemical industry is conditioned by societal requirements and the activities of this industry can, in turn, have an impact on the environment in which society lives or for which it is responsible. Industrial processes should be considered from the point of view of the raw materials available, the chemical principles underlying the processes, the demand for the products of these processes as well as the effects which the industry, its wastes and its products could have on the natural environment.

Topic	Description	Additional notes
(a) Raw materials and energy requirements	Reference to the raw materials available for chemical processing as related to terrestrial abundance and ease of extraction from the source. Sources of materials: air, sea water, rock salt, limestone, iron ore, sulfur, gypsum and natural gas. Awareness that petroleum is a source of many useful organic products such as plastics, textiles, pharmaceuticals, dyes, explosives, etc. Coal and petroleum as non-renewable energy sources.	No details of processes other than those specified in other sections of this syllabus are required.
(b) Extraction of metals	Extraction of iron from haematite and aluminium from purified bauxite. Method of extraction related to position of metal in the activity series. Electrolytic purification of copper. Uses of these metals as related to their properties.	Candidates should be familiar with a simple outline diagram for each of these processes. Details of the industrial plant are not required. Knowledge of the methods for converting pig iron to steel are not required.
(c) The heavy chemicals industry	The Haber process for ammonia and the Contact process for sulfuric acid. Main uses of ammonia and sulfuric acid.	Details of the industrial plants are not required.
(d) Commonplace products of the chemical industry	Reference should be made to products of chemical industry which are typically found in the home and other familiar environments. The use of the following materials and associated properties should be discussed: action of soaps and detergents on hard water; domestic bleaches - their alkalinity and oxidising action exemplified by the liberation of iodine from potassium iodide solution; domestic LPG gas (mainly butane) and its flammability; the use of organic liquids as solvents, exemplified by alcohols, liquid alkanes and ethyl ethanoate. Baking soda (sodium hydrogencarbonate) and its leavening action; vinegar (ethanoic acid) and its acidity; quicklime (calcium oxide) and slaked lime (calcium hydroxide) and their alkalinity; caustic soda (NaOH); washing soda ($Na_2CO_3.10H_2O$); Milk of Magnesia (magnesium hydroxide); Plaster of Paris ($CaSO_4.½H_2O$). Polythene, polyvinylchloride (PVC) and polytetrafluoroethene (PTFE) should be mentioned as important examples of synthetic polymers with various uses.	The structures of soap and detergent molecules are not required. Both the common name and the chemical name or formula of these substances will be provided in the examination paper.

Topic	Description	Additional notes
(e) Pollutant gases	An appreciation of the problems posed to the natural environment by activities which involve the use of materials and their chemical interconversions. Carbon dioxide formation as a result of combustion processes of carbon-containing fossil fuels. The greenhouse effect and its increase leading to global warming. Recognition of the fact that most activities related to energy generation ultimately result in carbon dioxide emissions from power plants. An awareness that incomplete combustion of fossil fuels will result in the formation of toxic carbon monoxide. Sulfur dioxide as a pollutant gas; its source and presence in acid rain; harmful effects of acid rain. NO_x gases: nitrogen oxides formed in the internal combustion engine; contribution of nitrogen oxides to acid rain and to smog formation in urban polluted air. A simple treatment of the catalytic converter. Importance of the ozone layer in the upper atmosphere and its depletion by CFC's. Awareness of harmful effect of ozone near the Earth's surface.	Greenhouse gases to include excess carbon dioxide, water vapour and methane. No knowledge of preparation and reactions of chlorofluorocarbons are required.

5.4 Chemical Laboratory Experience

Chemistry is an experimental science and hands-on practical work carried out by students is an important component of SEC Chemistry. Through practical work, students gain a better understanding of chemical principles and trends and develop their understanding of the methods by which knowledge about chemistry has been gained. The chemical laboratory experience provided should facilitate understanding of phenomena and materials; ensure good grasp of explanations, models and theories; provide opportunities of carrying out scientific investigations and enhance students' ability to interpret and evaluate data critically.

- In order to ensure that these aims are reached, a list of experiments is provided.
- It is assumed that students carry out a number of experiments related to the different areas of the syllabus. Candidates are expected to choose 13 of these experiments to be included in their coursework assessment.
- The 13 experiments selected **must include one experiment from each of the sections (A) to (J)** below [giving a total of 10 experiments] and three other experiments.
- Not more than three experiments can be selected from the same section.
- A practical experience considered suitable for presentation as one of the 13 experiments is one that entails approximately the duration of a double lesson.
- **Two of the 13 experiments must be the investigative (problem solving) type**. The investigations must be related to two different areas of the syllabus. These experiments will be marked out of 30 marks instead of 15 in order to reflect the greater amount of work required. Further information about investigations is given in Appendix 1.
- Although candidates can present up to three experiments from the same sections, (A) to (J), candidates should **not** present more than one experiment (for example one experiment and one investigation) for the same sub-topic. For example an experiment and a problem-solving investigation both based on chromatography will not be accepted.
- Candidates are required to fill in details of the experiments included in the coursework assessment in a copy of the sheet given in Appendix 2.
- Although only 13 experiments will be included in the coursework assessment, it is not suggested that teachers restrict students' laboratory experience to 13 experiments only. Compliance with this syllabus requisite is to be considered as a minimum requirement. Additional practical work is encouraged and candidates are expected to present all the experiments carried out. The experiments that are not included in the coursework assessment are to be listed in a copy of the sheet given in Appendix 3.
- **The average mark is to be calculated from the total sum of the marks awarded for the 11 experiments and the two investigations by dividing this total sum by 15.**

<u>List of experiments:</u>

(A) Separation techniques

(i) Extraction of a soluble salt from a mixture by solution, filtration and crystallisation. (Section 5.1a)

(ii) Separation of coloured compounds by paper chromatography (Section 5.1a)

(iii) Simple distillation (Section 5.1a)

(B) Action of heat and electricity on materials

(i) Effect of heat on materials such as: magnesium; zinc oxide; sodium nitrate; lead (II) nitrate; sodium hydrogencarbonate; sodium carbonate; copper (II) carbonate; hydrated copper (II) sulfate. [Section 5.1(b)]

(ii) Electrolysis of three aqueous solutions such as dilute sulfuric acid, potassium iodide solution and copper (II) sufate solution. [Section 5.1(k)]

(C) Preparation and properties of gases

Such preparations are intended to be carried out on a test-tube scale and accompanied by simple investigations of the properties of the gas.

(i) Preparation of oxygen using catalytic decomposition of hydrogen peroxide. [Section 5.1(c)]

(ii) Preparation of hydrogen. [Section 5.1(f)]

(iii) Preparation of carbon dioxide. [Section 5.1(g)]

(iv) Preparation of ammonia from an ammonium salt. Investigations should include the reactions of aqueous ammonia. [Section 5.1(h)]

(v) Preparation of sulfur dioxide; simple investigations can include the reactions of the gas as an acid and as a reducing agent (e.g. with potassium dichromate (VI)). [Section 5.1(i)]

(D) Preparation of pure, dry simple salts

(i) Preparing any three insoluble salts by precipitation. [Section 5.1(e); 5.1(h) (i) (j)]

(ii) Preparing a soluble salt by one of the following methods – metal + acid; insoluble base + acid; insoluble carbonate + acid. [Section 5.1(e); 5.1(h) (i) (j)]

(E) The Reactivity Series

(i) Investigating the reaction of metals (e.g. magnesium, zinc, iron, copper) with dilute hydrochloric acid and dilute sulfuric acid. [Section 5.1(k); 5.2(f)]

(ii) Investigating the reaction of metals (e.g. magnesium, zinc, iron, copper) with solutions of their salts in order to determine a displacement series. [Section 5.1(k); 5.2(f)]

(F) Similarities and trends in a Group of the Periodic Table

(i) Reaction of halide ions (Cl^-, Br^-, I^-) with (i) chlorine water (acidified bleaching solution) and (ii) with lead nitrate solution [Section 5.1(j); 5.2(f)]

(ii) Reaction of Group 2 metals (e.g. Mg, Ca) with water and dilute hydrochloric acid [(Section 5.1 (l)]

(G) Energetics

(i) Estimating the heat of combustion of an alcohol [Section 5.2(g)]

(ii) Determination of the heat of neutralization [Section 5.2(g)]

(H) Rates of reactions

(i) Experiments to illustrate the dependance of rate of a reaction on concentration, temperature, catalyst or state of subdivision (in the case of heterogeneous reaction) [Section 5.2(h)]

(I) Volumetric analysis

(i) Experiments in acid-base titrimetry using volumetric glassware (pipettes, burettes, volumetric flasks). [Sections 5.1(e); 5.2(b)]

(J) Qualitative analysis

(i) An investigation involving the analysis of both the cation and anion in three ‘unknown substances’. The unknowns may be either supplied as solids or in solution [Section 5.1(n)]

<u>Suggested titles for Investigative (Problem Solving) practical sessions</u>:

The full text of these exemplars is available in Appendix 1.
It is to be noted that these are only suggested investigations. Teachers are encouraged to assign other problem-solving investigations.

1 Hidden Blue Gems. [Section 5.1(a)]

2 Are red flowers really red?[Section (5.1a)]

3 Indigestion Tablets [Section 5.1(e)]

4 Corrosion of Metal Objects [Sections 5.1 (e); 5.1 (k); 5.2 (f); 5.3 (e)]

5 Investigating electrical cells [Sections5.1 (k); 5.2 (f)]

6 Can You Help the Warehouse Manager? [Section 5.1 (n)]

7 Investigating the amount of calcium carbonate in eggshells [5.1 (e); 5.2 (a); 5.2 (b)]

8 Investigating the amount of salts in energy drinks [5.1 (k); 5.2 (f)]

9 Which is the Best Fuel for Boiling Water? [Section 5.2 (g)]

10 Investigating which is the best enzyme to decompose hydrogen peroxide [Section 5.2 (h)]

Notes on moderation of practical work

1. All practical work will be assessed by the schools during the candidates' course of study. Laboratory Report Books should be available in schools for moderation by the Markers' Panel.

2. When monitoring the candidates' Laboratory Report Books, the Markers' Panel will look for evidence that the candidates have actually carried out practical work and will follow the criteria suggested below for the experiments presented.

Criteria	**Marks**
Actual conduct of experiment including handling of apparatus	3
Description of Method	1
Observations	3
Diagram	2
Processing of experimental data and conclusion	3
Safety and experimental precautions	2
Evaluation of results	1

N. B. As stated in the introduction to Section 5.4, the investigative (problem solving) type of experiment will be marked out of **30 marks,** instead of 15, in order to reflect the greater amount of work required.
A suggested Marking Scheme is provided below.

Planning and Organisation

Criteria. The student	**Marks**
outlines simple steps / a detailed procedure	2
plans a fair test / identifies key factors to take into account	1
selects few items / all the appropriate equipment and/or chemicals	2
utilises/ includes information from secondary sources	1
includes safety measures and experimental precautions	2
	8

Carrying out the Investigation and Obtaining Evidence

Criteria. The student	**Marks**
handles chemicals and equipment correctly / skilfully and with due regard to safety	4
records observations and / or measurements systematically and accurately (e.g. tabulation, graph, etc.)	4
includes appropriate labelled diagram(s)	2
	10

Analysing Evidence and Drawing a Conclusion

Criteria. The student	**Marks**
processes observations and / or measurements satisfactorily; identifies a general principle / trend / pattern / relationship in observations and / or data	4
draws conclusions consistent with the evidence; shows application of scientific knowledge and understanding in giving a detailed explanation that supports the conclusion	4
	8

Evaluating the Investigation

Criteria. The student	Marks
comments on whether the procedure was devised appropriately, discusses any deficiencies in the method and describes any modifications to the investigation	2
comments on the quality of the investigation and suggests improvements	2
	4

6. Grade Descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content specified by the syllabus; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Weakness in some aspects of the examination may be balanced by above-average performance in others. Sufficient material will be included in the examination to allow responses over the necessary range of attainment levels.

Grade 1

Grade 1 candidates are likely to:

- recall a wide range of knowledge from all areas of the syllabus;
- relate facts to principles and theories and vice-versa;
- select and collate information from more than one source and communicate knowledge in a clear logical form;
- use chemical knowledge and understanding to identify patterns or trends and draw conclusions;
- use detailed chemical knowledge and understanding to support statements or explain phenomena e.g. use understanding of bonding to explain the properties of a material;
- use a wide range of scientific and technical vocabulary throughout their work and use routinely scientific, chemical or mathematical conventions;
- perform numerical calculations on which guidance on the method of solution is not provided;
- select and use a range of apparatus with precision and skill; decide the range of measurements and level of precision required; make appropriately precise measurements; make systematic observations and decide which observations are relevant to the task in hand; state why particular techniques are preferred for a multi-stage process;
- be able to formulate a hypothesis; plan an investigation to test a hypothesis, or to solve a problem which may involve several variables; identify the key factors to be considered and make predictions where appropriate; select a method of presenting findings; identify anomalous observations or measurements; use scientific knowledge to draw conclusions from evidence; identify shortcomings in an investigation and suggest improvements;
- show an insight of the applications and implications of chemistry to social, economic, environmental and technological problems.

Grade 5

Grade 5 candidates are likely to:

- recall a range of chemical information from most areas of the syllabus, for example, they recall simple chemical symbols and formulae;
- link facts to situations specified in the syllabus;
- select a range of information from a given source and present it in a clear logical form;
- use chemical knowledge and understanding to make inferences and identify trends in given information;
- apply knowledge and understanding in some general contexts, for example, use simple balanced chemical formula equations to support a description of a chemical reaction;
- use appropriate scientific and chemical vocabulary, for example, write simple formulae;
- be able to perform numerical calculations on which guidance on the method of solution is provided;
- be able to select apparatus and perform a simple operation; make careful and reasonably accurate measurements and systematic observations; recognise where it is necessary to repeat measurements and observations; describe the correct procedure for an operation involving several steps;
- make simple hypotheses and test them by planning and performing suitable experiments; solve a problem with more than one step, but with a limited range of variables; identify which key factors to control and where

appropriate make predictions; present data systematically and appropriately; draw conclusions consistent with evidence;
- show an awareness of the contributions and applications of chemistry to social, economic, environmental and technological problems.

Grade 7

Grade 7 candidates are likely to:

- recall a limited range of information and factual chemistry, (for example they state a use of a common gas or a naturally occurring material);
- show some understanding of the main ideas of chemistry;
- select and present a single piece of information;
- make simple generalisations from given information, or identify a trend where only a minor manipulation of data is needed;
- link cause and effect in simple or specific contexts, for example they suggest a way of increasing the rate of a chemical reaction;
- make some use of scientific and technical vocabulary, for example, write 'word' equations or draw and label simple diagrams;
- perform a simple numerical calculation if structured help is given;
- use simple apparatus to make measurements; follow the correct procedure for a single operation;
- recognise which of two given hypotheses explains a set of facts or data; make simple predictions and devise fair tests which involve only a few factors; record observations in tables and plot graphs in which the axes are labelled; offer simple explanations consistent with the evidence obtained;
- show some appreciation of the social, economic, environmental and technological problems.

Appendix 1: Problem Solving Investigations in Chemistry

Investigations involve an open-ended approach to practical work. This type of activity promotes creative scientific thinking as it encourages students to ask questions, put forward their tentative ideas and examine different possibilities of approaching an investigation. It also provides students with an opportunity to develop manipulative skills, whilst enhancing accuracy and precision in their approach.

It is important to note that classical experiments cannot be simply turned into investigations if students would have already learnt how to carry out the experiment. Investigations need to provide contexts for students to use their existing knowledge and understanding to arrive at solutions to problems, and apply chemical theories and principles to new situations. A true investigation should have the following characteristics:

- The investigation is problem-based.
- The exact outcome of the investigation is unknown to the students.
- It is usually possible to approach the investigation in different ways and it is up to the student to design the procedure.
- It involves real life situations.

Some suggested examples of investigations are given below.

	Investigations	Section
1	**Hidden Blue Gems**. In a road block, a policeman suspects that a man has been smuggling blue gems inside bags of copper (II) sulfate crystals, which are usually sold for agricultural purposes. The policeman seized the smuggled goods and has sent a sample to your laboratory for further investigation. Plan an investigation to show whether the sample contains blue gems or not, and at the same time return the copper (II) sulfate crystals to the owner.	5.1(a)
2	**Are red flowers really red?** Two students were having an argument about the pigments in red flowers. One said that red petals can only contain the red colour, whereas the other students thought that the red colour could actually be a mixture of colours. Plan an experiment to investigate if the pigment in red flowers consists of one or more colours. In your investigation think about how you can extract the pigment and check whether it consists of one or more colours.	5.1 (a)
3	**Indigestion Tablets** Martin is suffering from an upset stomach. After paying a visit to the doctor he found that his stomach is producing excess acid. The doctor prescribed a medicine which contains an antacid to remove the pain in his stomach. Indigestion medicines are found to contain a chemical that helps to neutralise the excess acid. Your teacher will provide you with two common indigestion medicines in powdered form such as magnesium hydroxide and sodium hydrogencarbonate. Hydrochloric acid will also be provided which is the acid found in your stomach. Design and carry out an investigation to find which of these two indigestion medicines works best.	5.1(e)

4 **Corrosion of Metal Objects** 5.1 (e) 5.1 (k) 5.2 (f) 5.3 (e)

Acid rain has become a major concern because of its devastating effect on the environment. One of the effects of acid rain is the corrosion of metal structures, such as bridges, metal plated domes, monuments and window frames. Some points that can be investigated about this problem are:

- Which metals are corroded by an acid and which are not?
- Do some metals corrode faster than others?
- Are some acids less corrosive than others?

Whilst planning your investigation think about how you are going to make a fair comparison between the metals.

5 **Investigating electrical cells** 5.1 (k) 5.2 (f)

Alessandro Volta is known for the development of the electric cell in 1800. The cell made by Volta consists of two electrodes; one made from zinc and the other of copper. The electrolyte is sulfuric acid. The metals have a different reactivity.
The more reactive metal becomes the negative pole from which the electrons flow in the external circuit.

Plan an experiment in which you are to design an electrical cell with the highest output.
In your investigation think about:

- which factors may affect the output of the cell.
- which factors you will investigate and which you are going to keep constant.
- how you will measure the output of the cell.
- how you can make sure that you use a 'pure' metal surface.
- how you can make sure that the experiments planned are safe to carry out.

6 **Can You Help the Warehouse Manager?** 5.1 (n)

Some bags of different salts have arrived at a warehouse. The new store man has put the bags of white powders in the store room without labelling them!
The list of salts in the bags is:

Bath salts	(sodium carbonate)
Common salt	(sodium chloride)
Epsom salts	(magnesium sulfate)
Smelling salts	(ammonium carbonate)

The warehouse manager asks you to help in identifying the powders. Plan a series of tests that you could carry out on samples of the white solids in order to identify the cation and anion in each salt.

7 **Investigating the amount of calcium carbonate in eggshells** 5.1 (e) 5.2 (a) 5.2 (b)

Calcium carbonate occurs naturally as limestone, marble and chalk. It is also found in eggshells and seashells, to which it provides hardness and strength. By applying your knowledge of the general patterns of reactions of carbonates, design an investigation to estimate the amount of calcium carbonate present in an eggshell.

8 **Investigating the amount of salts in energy drinks** 5.1 (k) 5.2 (f)

After strenuous exercise our body loses water and salts. Salts are necessary for transmitting nerve impulses and proper muscle function. A slight depletion of the salt concentration can cause problems. Energy drinks are generally consumed after training to replace the salt loss.

Design an investigation to estimate how much salts are provided by different energy drinks found on the market.

9 **Which is the Best Fuel for Boiling Water?** 5.2 (g)

Mark and Louise are planning to go camping next weekend. Among the things they need is a spirit cooking stove to boil water. However they have not decided which liquid fuel to use in the stove.

You are provided with a selection of fuels. Design an investigation to help Mark and Louise select the best fuel they should use to boil water. In your plan describe how you are going to determine which fuel is the best.

10 **Investigating which is the best enzyme to decompose hydrogen peroxide** 5.2 (h)

Hydrogen peroxide solution decomposes very slowly at room temperature to liberate a gas. Potato contains an enzyme which is thought to affect the decomposition of hydrogen peroxide. Other materials like celery and liver are also thought to influence the decomposition of hydrogen peroxide. A company asks you to extract the enzymes present in these substances, to check if they really break down the hydrogen peroxide and to find which one is the most effective.

Plan an investigation in which you will extract the enzymes present in each substance and determine how each extract affects the rate of decomposition of hydrogen peroxide.

<u>Recording the investigative (problem solving) type of experiment</u>

The write up of the investigative (problem solving) type of experiment is not to be recorded in the same manner as for the other experiments, i.e. aim, apparatus, description of method, results, errors/precautions and conclusion.

The **format for the write up of the investigation** should be as follows:

The page title is to be written as 'Problem solving - Investigation'

Next, the students should write the situation (The Problem) that they were assigned.

The rest of the write up is then divided into the following 4 sections;

- a **plan o**f the investigation (which in itself will include the apparatus, materials, intended experimental steps and possibly other information as listed below);
- the **record of observations /measurements**;
- **a conclusion/s based on the evidence obtained**; and
- an **evaluation of the investigation**.

<u>Plan</u>

N.B. Students are not required to use the passive voice when writing the plan. They can be personal and write statements such as 'We intend to …..; We are going to …..; etc.'

The plan of the investigation needs to include:

- the purpose of the investigation,
- a list of the apparatus and materials to be used,
- the practical steps to be followed (preferably, also including reasons for the choice/order of the proposed steps),
- the variables that are going to be kept constant and the one that is going to be changed (if applicable),
- an indication of how they are going to carry out fair tests (if applicable),
- the measurements to be taken (if applicable),
- any safety precautions to be taken,
- references to the sources consulted.

<u>Observations and/or Measurements</u>

In this section students are expected to record their observations accurately. In the case of numerical results, data should be collected and tabulated in an appropriate manner. Graphs can be plotted to illustrate trends in data collected. A labelled diagram of the apparatus set up used during the investigation is drawn in this section.

Analysis of Evidence and Conclusion

The results are processed to draw any patterns, or trends, or relationships noted in the results of chemical reactions and/or between variables. Any necessary calculations are worked out.
It is expected that any conclusion(s) drawn will be based on the students' own results and the conclusion should be supported using chemical theories or principles.

Evaluation of the Investigation

In this section, students should evaluate both the method that they used and the results obtained.
They should comment on any deficiencies in their plan and explain any modifications carried out to their original plan during the investigation. Results are assessed for accuracy and reliability. Anomalous results are identified and explained. Students should attempt to suggest any improvements to the practical steps and/or collection of data.
If applicable, students can also suggest a different approach to the investigation.

Appendix 2: SEC Chemistry

Candidates of SEC Chemistry are required to fill in this form and attach it to the first page of their practical report book. If additional practical books are presented the form should be attached to the first book.

Candidate's Name ______________________________ School ____

Name of 10 experiments presented from sections (A) to (J)		**Marks**	**Page No**
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
Name of the remaining 3 experiments presented		**Marks**	**Page No**
	Total number of marks:		
	Total number of experiments presented:		
	Average mark obtained by dividing the total number of marks by 15:		
	Average mark to the nearest whole number:		

On the above list mark with a * the **TWO** experiments presented as investigative (problem solving) experiments.

Appendix 3: SEC Chemistry

Candidates of SEC Chemistry are required to fill in this form with details of other experiments performed and presented which are not part of the coursework assessment.

Candidate's Name ______________________________ School ____

Name of other experiments presented		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
	Total number of experiments presented:	

On the above list mark with a ***** the experiments presented as investigative (problem solving) experiments.