SEC SYLLABUS (2011)

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

The syllabus places emphasis on the unifying concepts and central principles which render coherent the facts of chemistry. It requires students to master a necessary body of information and basic knowledge about chemistry. It also aims to present chemistry and the work of chemists as having a profound impact on society and its cultural and physical environment.

It is envisaged that the examination papers will test knowledge and understanding of chemical facts and principles and the ability to apply these to solve theoretical and practical chemical problems both qualitatively and quantitatively.

Chemistry is an experimental science and the importance of including practical work in the teaching programme cannot be overemphasised. 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.

2. Aims

A course in SEC Chemistry aims to:

2.1 stimulate students and 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 developing body of knowledge 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, validate conclusions 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 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 asessment 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 I 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 may be set which test the familiarity of candidates with practical chemistry.

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 best fifteen (15) experiments.

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

The school assessments should reach the MATSEC Examinations Board by the date indicated by the Board.

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.

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

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

Questions will be set in SI units.
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: the Avogadro constant; the Faraday constant; the specific heat capacity of water; the molar volume for gases; and the following formulae
$Q = It$, $\Delta H = mc\Delta\theta$;
stp conditions are to be taken as $0^{o}C$ and 1atm (760 mm Hg); the molar volume for gases at stp is 22.4 dm^3

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) States of matter	Gas, liquid and solid interconversions. Pure substances and mixtures. Solvent, solute, solution. 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. Boiling point and melting point of substances as criteria of purity.	fractional distillation (simple treatment only - exemplified by alcohol and water). 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. Action of electricity on materials	Decomposition of hydrates, carbonates, hydrogencarbonates, nitrates and hydroxides by heat. Effect of heat on sugar. Sublimation of iodine. Thermally stable compounds Reversible reactions, including the hydration/dehydration of silica gel and of hydrated copper (II) sulfate. The effect of electricity on various solids, liquids (including molten substances), and aqueous solutions. Conductors and non-conductors; electrolytes and non-electrolytes.	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 copper, carbon and sulfur. Examples suggested to illustrate this section are: dilute sulfuric acid, dilute ethanoic acid, copper (II) sulfate solution using carbon electrodes and sugar solution.
(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). Handling techniques for preparation and collection of gases, including the use of the gas syringe. Principle of the extraction of oxygen by fractional distillation of liquid air	Isolation of ‘atmospheric nitrogen’ – details of the apparatus is not required. Students should be familiar with different types of gas generators and methods/apparatus for drying and collecting gases. Technical details are not required.

Topic	Description	Additional notes
5.1 (c) contd	Preparation of oxygen by the catalytic decomposition of hydrogen peroxide; test for oxygen. Reaction of metals (e.g. magnesium, copper) and non-metals (e.g. carbon, sulfur) with oxygen in air. Rusting of iron and its prevention. Oxides of the common elements and their reaction with water. Ozone as an unstable, naturally occurring, allotrope of oxygen.	The catalytic decomposition of potassium chlorate as a method of preparing oxygen is not required. A treatment of respiration and photosynthesis is not required. See Section 5.3(e) for effect of pollutants, (e.g. chlorofluorocarbons).
(d) Water and solutions	Simple treatment of soluble and insoluble substances in water. Physical properties; test for purity. Water as an oxide of hydrogen; 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 is not required. The experimental determination of solubility is not required but students should be able to interpret a solubility curve. 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. Reaction of dilute non-oxidising acids with metals, insoluble bases and alkalis, carbonates and hydrogencarbonates. Bases and alkalis. 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.
(f) Hydrogen	Preparation of hydrogen from action of dilute non-oxidising 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. Manufacture of nitric acid by the Ostwald process/catalytic oxidation of ammonia, and its uses. 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. 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 (ll) nitrate; identification due to colour. Properties of nitrogen dioxide - e.g. solubility in water and acidity (linked to acid rain). Thermal dissociation / dynamic equilibrium of dinitrogen tetraoxide / nitrogen dioxide.	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 or by the oxidizing action of concentrated sulfuric acid on copper; test for the gas. Reactions of sulfur dioxide which exemplify its acidic nature and its reducing action, e.g. colour changes with acidified potassium dichromate solution or acidified potassium manganate (Vll) solution. Sulfites and their reaction with dilute acids. 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. Sulfates and hydrogensulfates from dilute sulfuric acid.	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. Equations for the reactions of sulfur dioxide with these reagents are not required. The laboratory preparation of sulfur trioxide 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. Chlorine as a by-product in the manufacture of sodium hydroxide; uses of chlorine. Laboratory preparation and test for hydrogen chloride. Laboratory preparation of hydrochloric acid. Properties of dilute hydrochloric acid. Preparation of chlorides from dilute hydrochloric acid.	i.e. electrolysis of brine using a membrane cell

Topic	Description	Additional notes
5.1 (k) Electrolysis Reactivity Series	Extending the discussion introduced in 5.1(b) to consider a more 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. 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).	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.
(l) Group 1 and Group 2 metals Alkali metals Alkaline earth metals	Alkali metals and alkaline earths as representatives of two groups or families of elements in the Periodic Table. Sodium and potassium. Characteristics of the metals and similarities in the group: typical physical properties; chemical properties – reaction with oxygen (to form simple oxide only), with water and with chlorine. Trend in reactivity going down the group. 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.	Details of the extraction of these metals are not required. 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 (ll) and iron (lll) : formation by precipitation, colour. Oxidation of iron (ll) hydroxide to iron (lll) hydroxide by exposure to air.	
Copper	Simple compounds of copper: Copper (ll) oxide as a typical basic oxide and its use in preparing copper (ll) salts by reaction with dilute acids. Reduction of copper (ll) oxide by hydrogen. Thermal decomposition of copper (ll) carbonate and copper (ll) nitrate to give copper (ll) 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 (ll), copper (ll), iron (ll) and iron (lll); A flame test can be used to distinguish between calcium and magnesium. Amphoteric character of aluminium and lead (ll) to be exploited in testing for these ions. Potassium iodide solution can be used to distinguish between aluminium and lead (ll) 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.

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. Nomenclature limited to the first five straight chain alkanes. Chain isomerism of C_4H_{10} and C_5H_{12} only. 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.	The laboratory preparation of alkanes is not required. The systematic naming of branched isomers is not required. No knowledge of preparation and reactions of chlorofluorocarbons are required.
Alkenes and alkynes	Alkenes and alkynes as typical unsaturated hydrocarbons. General formula; structural formulae. 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.	Naming of positional isomers is not required. 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. 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.	Only a schematic diagram is required; details of the structure and running of the fractionating tower is not required.

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 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 exam 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 reactants 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.
(c) 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.	
(d) 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).	
(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 (b). 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. 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. Quantitative aspects of electrolytic cells: the Faraday as a mole of electrons.	
(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 calorimetry limited to 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.	Calculations involving bond energies will not be set. Activation energy not to be included.

Topic	Description	Additional notes
5.2 (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. 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, nitrates, sulfur, gypsum. 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.

Topic	Description	Additional notes
5.3 (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	Electrolytic manufacture of sodium hydroxide, hydrogen and chlorine, using the membrane cell. The Haber process for ammonia; the Ostwald process for nitric acid and the Contact process for sulfuric acid. Main uses of the above mentioned materials.	The mercury cathode cell is not required. Details of the industrial plants are not required. ($NaOH$, H_2, Cl_2, NH_3, HNO_3 and H_2SO_4.)
(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 powder (sodium hydrogencarbonate) and its leavening action; vinegar (ethanoic acid) and its acidity; quicklime (calcium oxide) and slaked lime (calcium hydroxide) and their alkalinity; washing soda ($Na_2CO_3.10H_2O$); Epsom salts ($MgSO_4.7H_2O$); Milk of Magnesia (magnesium hydroxide); Plaster of Paris ($CaSO_4.½H_2O$). Polythene and polyvinylchloride (PVC) 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.
(e) Chemical pollutants	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 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.	No knowledge of preparation and reactions of chlorofluorocarbons are required.

5.4 Chemical Laboratory Experience

The following list contains experiments that are important in facilitating the understanding of chemical principles, developing scientific processes and acquiring diverse practical skills at SEC level.
A practical experience is considered to be one that entails approximately the duration of a double lesson.

The fifteen experiments presented must include at least **one** experiment from **each** of the sections (a) to (j) [giving a total of ten experiments] and five other experiments. Not more than **three** experiments can be presented from the same section. Furthermore, **two** of the fifteen experiments must be the **investigative (problem solving)** type. Experiments marked with an asterisk can be adapted as an investigative practical. See Appendix 1.

(a) Separation techniques

- (i) Extraction of a soluble salt from a mixture by 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; sucrose; hydrated copper (II) sulfate. [Section 5.1(b)]
- (ii) Electrolysis of aqueous solutions of a strong electrolyte and of a weak electrolyte. [Section 5.1(b)]

(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 manganate (VII) or potassium dichromate (VI). [Section 5.1(i)]

(d) Preparation of pure, dry simple salts

- (i) Preparing an insoluble salt 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) Halogens

- (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)]

(g) Energetics

- (i) A simple experiment on calorimetry (determination of heat of combustion) [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)]

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 were capable of:

(a) following verbal and written instructions;

(b) planning and organising practical work;

(c) handling laboratory apparatus;

(d) carrying out and recording observations and measurements;

(e) processing experimental data and drawing conclusions from it.

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.

Suggested Texts

1. B. Earl & L.D. Wilford - GCSE Chemistry (John Murray)
2. E. Ramsden - Key Science Chemistry (Stanley Thornes)
3. M. J. Denial, L. Davies, A. W. Locke & M. E. Reay - Investigating Chemistry (Heinemann Educational)

Appendix 1: 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 syllabus sections (a) to (j)		Marks	Page No
(a)			
(b)			
(c)			
(d)			
(e)			
(f)			
(g)			
(h)			
(i)			
(j)			
Name of the remaining 5 experiments presented		**Marks**	**Page No**
Total number of marks:			
Total number of experiments presented:			
Average mark for the 15 experiments:			
Average mark to the nearest whole number:			

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