Kingdom of Lesotho
Ministry of Education and Training

LESOTHO GENERAL CERTIFICATE OF SECONDARY EDUCATION

Lesotho General Certificate of Secondary Education

Syllabus

Physical Science

0181

For examination in November 2020

National Curriculum Development Centre
in collaboration with
Examinations Council of Lesotho

TABLE OF CONTENTS

1. Introduction

The two-year syllabus for Lesotho General Certificate of Secondary Education (LGCSE) is designed for all learners of different abilities and educational needs at the Senior Secondary Level, for grades 11 and 12. The Ministry of Education and Training of Lesotho appreciates the need for a syllabus that remains valid for many years to come. It also recognises the importance for its citizens to identify with global educational standards and to have access to educational institutions within the country, the Southern African Development Community (SADC) region. For this reason, the syllabus has been developed from the basis of the International GCSE Physical Science syllabus of Cambridge International Examinations (CIE). This development has produced a syllabus that is distinctly appropriate to the educational needs of the schools of Lesotho.

The syllabus achieves progressive learning by building on the foundations laid by Lesotho Junior Certificate Science, with much of the content of that syllabus being assumed in the construction of this. In certain topics, it has been thought necessary to repeat some of the Junior Certificate Science content in this syllabus. A good knowledge and understanding of all the Junior Certificate Science is considered necessary for learners proceeding successfully to the Lesotho GCSE in Physical Science. The syllabus lays a foundation for the CIE AS -level as a pre-tertiary qualification.

The syllabus will be examined for the first time in November 2018. Thereafter, any minor changes will be published as annexes. Schools are advised to request such annexes from ECol when teaching the syllabus.

Av ailability

The syllabus is examined in the October/November examination sessions. It is available to all candidates, including private candidates.

2. Syllabus aims and objectives

2.1 Aims

The aims, which are not listed in order of priority, are:

1. to provide a worthwhile educational experience for all candidates, through well-designed studies of experimental and practical science, whether or not they go on to study science beyond this level.

2. to enable candidates to acquire sufficient understanding and knowledge to:
   - become confident citizens in a technological world and to take or develop an informed interest in scientific matters
   - recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life
   - be suitably prepared for studies beyond the LGCSE level in pure sciences or in science-dependent vocational courses

3. to develop abilities and skills that:
   - are relevant to the study and practice of physical science
   - are useful in everyday life
   - encourage efficient and safe practice
   - encourage effective communication

4. to develop attitudes relevant to physical science such as:
   - concern for accuracy and precision
   - objectivity
   - integrity
   - enquiry
   - initiative
   - inventiveness

5. to stimulate interest in, and care for, the environment

6. to promote an awareness that:
   - scientific theories and methods have developed, and continue to do so, as a result of the co-operative activities of groups and individuals
   - the study and practice of science is subject to social, economic, technological, ethical and cultural influences and limitations
   - the applications of science may be both beneficial and detrimental to the individual, the community and the environment
   - science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal

2.2 Assessment objectives

The three assessment objectives in LGCSE Physical Science are:

A: Knowledge with understanding
B: Handling information and problem solving
C: Experimental skills and investigations

A: Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

1. scientific phenomena, facts, laws, definitions, concepts and theories
2. scientific vocabulary, terminology and conventions (including symbols, quantities and units)
3. scientific instruments and apparatus, including techniques of operation and aspects of safety
4. scientific quantities and their determination
5. scientific and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual material that candidates may be required to recall and explain. Questions testing this will often begin with one of the following words: *define*, *state*, *describe*, *explain* or *outline*.

B: Handling information and problem solving

Candidates should be able, using oral, written, symbolic, graphical and numerical forms of presentation to:

1. locate, select, organise and present information from a variety of sources
2. translate information from one form to another
3. manipulate numerical and other data
4. use information to identify patterns, report trends and draw inferences
5. present reasoned explanations for phenomena, patterns and relationships
6. make predictions and hypotheses
7. solve problems.

Questions testing these skills may be based on information that is unfamiliar to candidates, requiring them to apply the principles and concepts from the syllabus to a new situation, in a logical, reasoned or deductive way.

Questions testing these objectives will often begin with one of the following words: *discuss*, *predict*, *suggest*, *calculate*, or *determine* (see glossary of terms).

C: Experimental skills and investigations

Candidates should be able to:

1. plan simple investigations and use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
2. make and record observations, measurements and estimates
3. interpret and evaluate experimental observations and data
4. plan investigations and/or evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials).

Specification grid

The approximate weightings allocated to each of the assessment objectives in the assessment model are summarised in the table below.

Assessment objective	Weighting
A: Knowledge with understanding	50% (not more than 25% recall)
B: Handling information and problem solving	30%
C: Experimental skills and investigations	20%

2.3 Scheme of assessment

All candidates must enter for three papers: Paper 1; one from either Paper 2 or Paper 3; and Paper 4.

Candidates who have only studied the Core Curriculum, or who are expected to achieve a grade D or below, should normally be entered for Paper 2.

Candidates who have studied the Extended Curriculum, and who are expected to achieve a grade C or above, should be entered for Paper 3.

All candidates must take the practical paper: Paper 4 (Practical Knowledge).

<table>
<tr><th colspan="2">All candidates take:</th></tr>
<tr><td colspan="2">Paper 1 45 minutes
A multiple-choice question paper consisting of 40 items (20 from Chemistry and 20 from Physics). This paper will test skills mainly in assessment objectives A and B.
Questions will be based on the Core Curriculum and will be of a difficulty appropriate to grades C to G.
Weighted at 30% of the total available marks.</td></tr>
<tr><th>Candidates take either:</th><th>or:</th></tr>
<tr><td>Paper 2 1 hour 30 minutes
80 marks (40 marks from Chemistry, 40 marks from Physics)
Core Curriculum – Grades C to G available
Core theory paper, consisting of short-answer and structured questions, based on the Core Curriculum. The questions will be of a difficulty appropriate to grades C to G and will test skills mainly in Assessment A and B.
Chemistry questions will not alternate with Physics questions.
Weighted at 50% of the total available marks.</td><td>Paper 3 1 hour 30 minutes
80 marks (40 marks from Chemistry, 40 marks from Physics)
Extended Curriculum – Grades A* to G available
Extended theory paper, consisting of short-answer and structured questions. The questions will be based on all the material, both from the core and supplement, and will allow candidates to demonstrate their knowledge and understanding. The questions will be of a difficulty appropriate to the higher grades and will test skills mainly in assessment objectives A and B.
Chemistry questions will not alternate with Physics questions.
Weighted at 50% of the total available marks.</td></tr>
<tr><td colspan="2">Paper 4 1 hour
40 marks
Practical Knowledge
Written paper, designed to test familiarity with laboratory based procedures. Questions may provide data in different forms and require knowledge of practical skills.
Candidates will not be required to use knowledge outside the Core Curriculum.
Weighted at 20% of the total available marks.</td></tr>
</table>

2.4 Experimental work

Experimental work is an essential component of all science. Experimental work within science education:

- gives candidates first-hand experience of phenomena
- enables candidates to acquire practical skills
- provides candidates with the opportunity to plan and carry out investigations into practical problems.

This can be achieved by individual or group experimental work, or by demonstrations which actively involve the candidates.

Throughout the curriculum content section of this syllabus some clear indications are given of opportunities to use practical work, using the command words *'perform experiments to'* and *'investigate'*. These instructions mean that such statements may be examined in terms of practical skills (assessment objective **C**) in Paper 4, but also in terms of other skills (assessment objectives **A** and **B**) in Papers 1, 2 and 3 covering such skills as planning, prediction, recall, explanation, handling of data (including calculations) and interpretation of results.

2.5 Duration of course

The syllabus is designed to be covered in two years and should be allocated 6 x 40 minute lessons each week.

3. Curriculum content

The curriculum content that follows is divided into two parts: Chemistry (5 sections) and Physics (5 sections). Candidates must study both parts. Both the Chemistry and the Physics parts of the curriculum are arranged into core and the supplement. Together the core and supplement form the Extended Curriculum. Candidates can either follow the Core Curriculum only, or they can follow the Extended Curriculum, which includes both the core and the supplement.

All candidates can be taught the Extended Curriculum, for exposure to a broad Physical Science content. However, not all candidates should be entered for examinations in the Extended Curriculum. Candidates who have been observed to have the capability to achieve a D grade or lower should be entered for Paper 2; which would give them a chance of a better performance. Those who are capable of obtaining C, B & A grades, and plan to pursue a career in science, should study the Extended Curriculum and be entered for Paper 3.

The curriculum content below is a guide to the areas on which candidates are assessed. It is designed to provide guidance to teachers as to what will be assessed in the overall evaluation of the candidate. It is not meant to limit, in any way, the teaching programme of any particular school, and it should be noted that the order of topics in this syllabus does not form a sequential programme of study – the order of teaching is left to the teacher to determine.

The content is set out in sections within Chemistry and Physics. Each section is divided into a number of topics. The middle column outlines the supplement content, which should be studied by candidates following the Extended Curriculum.

It is important that, throughout the course, teachers should make candidates aware of the relevance of the concepts studied to everyday life, and to the natural and man-made worlds. In particular, attention should be paid to:

- the incorporation of scientific explanations into cultural practices and beliefs
- the dependence of humanity on the world's natural resources
- the finite nature of the world's resources, the impact of human activities on the environment, and the need for recycling and conservation
- economic considerations for agriculture and industry, such as the availability and cost of raw materials and energy
- the importance of natural and man-made materials, including chemicals, in both industry and everyday life.

Specific content has been limited in order to encourage this approach and to allow flexibility in the design of teaching programmes.

Introduction

Chemistry is an experimental science and uses a number of standard laboratory procedures. Learners should be able to name and use apparatus accurately and appropriately for measuring:

- volume (measuring cylinder, burette, pipette)
- mass (digital balance, triple beam balance, lever arm balance)
- temperature (laboratory thermometer)
- time (stopwatch – analogue and digital) and standard items of laboratory glassware

In all measurements, learners should use the appropriate units. Relevant safety precautions should also be incorporated in the teaching of the syllabus, especially for practical activities.

The following techniques may be found in the topics below:

- paper chromatography
- preparation and collection of gases
- preparation of salts
- determination of purity by melting point or boiling point
- separation and purification by use of suitable solvent, filtration, crystallisation and distillation
- construction of graphs to enable interpretation of data
- test procedures for cations, anions and gases

Names, symbols, formulae and equations

Learners are expected to use names, symbols and formulae, and construct both symbol and word equations as a normal part of their studies in this curriculum. When appropriate, they should do so without prompting in answer to questions in the examination paper. However, questions will be set that ask for specific names, symbols, formulae or equations at levels appropriate to the Core or Extended Curriculum.

List of topics

CPT: Atomic structure and the Periodic Table
CR: Chemical reactions
CS: Stoichiometry
CAW: Air, water and the environment
CO: Organic chemistry

NB: These topics do not form a teaching sequence, either individually or as a whole.

3.1 Chemistry

CORE	SUPPLEMENT	REMARKS (Notes)
CPT: Atomic structure and the Periodic Table		
CPT1: Elements, compounds and mixtures		
1. demonstrate the differences between, and use these to identify, elements, compounds and mixtures 2. determine purity through paper chromatography and fixed points 3. state and explain the interconversions of the states of matter 4. investigate the melting and boiling of mixtures 5. construct and interpret temperature/time graphs and tables	6. explain temperature/time graphs as a means of assessing purity	Learners are expected to know and use the symbols of the elements mentioned in this syllabus. Revise kinetic particle theory covered in the Physics section.
CPT2: Atomic structure		
1. state the relative charge and approximate relative mass of a proton, a neutron and an electron 2. define *proton number* and *nucleon number* 3. use the notation $^{a}_{b}X$ for an atom 5. describe the simple structure of atoms with particular reference to the elements of proton number 1 to 20 7. describe the build-up of electrons in ‘shells’	4. define *isotopes*, and explain that mass number of an element is the average of the masses of the isotopes 6. use proton number and simple atomic structure to explain the arrangement of elements in the Periodic Table 8. relate the inert nature of the noble gases to their electron arrangements	Revise the particulate nature of matter. Use the history of particle ideas and the atom to form a storyline through this topic. The ideas of the distribution of electrons in s- and p-orbitals and in d-block elements are not required. A copy of the Periodic Table will be provided in Papers 1, 2 and 3.
CPT3: The Periodic Table		
1. describe the Periodic Table as a method of classifying elements into families of similar elements called Groups, forming sequences from family to family called periods 2. describe the change from metallic to non-metallic character across a Period	3. describe the relationship between group number and the number of outer electrons 4. relate atomic structure to classification of the elements into metals and non-metals in the Periodic Table	

CPT4: Group properties		
1. describe trends in physical properties of Group I metals and in their reactions with water 2. describe trends in physical properties of Group VII elements and state their reactions with other halide ions	3. explain trends in physical properties of Group I metals 4. predict the properties of other elements in the group given data, where appropriate 5. identify trends in other groups, given data about the elements concerned	Group II elements (Mg and Ca) are a good example for a class investigation by students.
CPT5: Transition elements		
1. investigate the characteristic physical properties (density, fixed points, hardness, conductivity and colour of compounds) and chemical properties (variable oxidation states) of the transition metals and their compounds, exemplified by copper and iron	2. give examples of the use of transition metals as catalysts (e.g. iron in the Haber process)	
CPT6: Bonding		
CPT6.1: Ions and ionic bonds		
1. describe the formation of *ions* by electron transfer leading to the noble gas configuration and use the term valency 2. describe the formation of ionic bonds in the reactions between the alkali metals and the halogens	3. describe and explain the formation of ionic bonds between metallic and non-metallic elements 4. deduce the formulae of ionic compounds from the ions and the numbers of atoms present 5. relate the electrostatic forces in the lattice structures of ionic compounds to their typical physical properties	Formulae of ionic compounds should be known. Word, symbol and ionic equations are included, also diagrammatic explanations of ionic compound formation.
CPT6.2: Metallic bonding		
	1. describe the structure of metallic solids as a lattice of positive ions in a ‘sea of electrons’ and use this to explain the electrical conductivity and malleability of metals	

CPT6.3: Molecules and covalent bonds		
1. describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4 and HCl 2. relate sharing of electrons to the noble gas configuration 3. draw dot-and-cross diagrams to show the formation of single covalent bonds 5. investigate the differences in volatility, solubility in water, and electrical conductivity between ionic and covalent compounds	4. describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH and CO_2, including the drawing of dot-and-cross diagrams 6. explain the differences in properties between ionic and covalent compounds	Formulae of molecules should be known. Word and symbol equations to be included, also use of structural formulae.
CPT6.4: Giant structures		
1. describe the structure of graphite and of diamond 2. relate the structures of graphite and diamond to their melting points, hardness, conductivities, and uses		
CPT7: Metals		
CPT7.1: Properties of metals		
1. describe differences in the general physical and chemical properties of metals and non-metal		
CPT7.2: Reactivity series		
1. deduce the order of reactivity for aluminium, calcium, copper, (hydrogen), iron, magnesium, potassium, sodium, and zinc, using the reactions, if any and where relevant, of the metals with: • water or steam • oxygen • dilute hydrochloric acid • aqueous ions of other metals • oxides of other metals 4. deduce an order of reactivity from a given set of experimental results	2. design experiments to investigate the order of reactivity of metals 3. explain the apparent unreactivity of aluminium in terms of the oxide layer adhering to the metal	
CPT7.3: Extraction of metals		
1. state the occurrence of aluminium, copper, iron and gold as ores 3. describe the importance of conserving resources	2. relate the occurrence in nature of the metals to the reactivity series 4. describe the essential reactions in the extraction of iron from haematite	

CPT7.4: Uses of metals		
1. define an *alloy* 2. name and state the composition and important uses of the alloys: brass, bronze, mild steel, stainless steel 4. state the uses, related to their properties, of copper (electrical wiring and in cooking utensils) and of aluminium (aircraft parts and food containers)	3. draw structural diagrams to show how atoms of other elements can change the properties of the main element in an alloy	
5. state the uses of zinc for galvanising and making brass	6. relate the protective effect of galvanising steel to the oxide layer on the surface of zinc	

CR: Chemical reactions		
CR1.1: Physical and chemical change		
1. distinguish between physical and chemical changes using general characteristics 2. classify physical and chemical changes		
CR1.2: Energy changes		
1. define *exothermic* and *endothermic* reactions in terms of associated energy changes 3. recall that light can provide the energy needed for some endothermic chemical reactions to occur, exemplified by photosynthesis and photography	2. explain why bond breaking is endothermic and bond forming is exothermic 4. perform an experiment to measure the energy released in combustion of fuels (e.g. ethanol) and foods (e.g. peanuts), with associated calculations to find the energy released per unit mass 5. write a symbol chemical equation for photosynthesis	Simple test-tube reactions should be used to measure temperature changes. Relate results to nutritional information on food labels. NB: check that nobody has an allergy to nuts before using peanuts in this experiment.
CR1.3: Speed of reaction		
1. describe the effects of concentration, particle size, catalysts (including enzymes) and temperature on the speeds of reactions 2. define a *catalyst* 3. describe a practical method for investigating the speed of a reaction involving gas evolution 4. plot graphs and interpret data obtained from experiments concerned with speed of reaction	5. devise and explain a suitable method for investigating the effect of a given variable on the speed of a reaction 6. explain the effects of temperature, concentration and surface area in terms of collisions between reacting particles	
7. describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. mines)		Use the custard powder explosion demonstration with proper care. This may be dangerous if not used in small amounts.
CR1.4: Redox		
1. define *oxidation* and *reduction* in terms of gain/loss of oxygen and hydrogen 2. define oxidation and reduction in terms of electron transfer, limited to the formation of binary compounds	3. define oxidation and reduction in terms of electron transfer in reactions involving compounds covered in the syllabus 4. identify redox reactions	Teachers may wish to use the concept of oxidation number.

CR2: Acids, bases and salts		
CR2.1: The characteristic properties of acids and bases		
1. define acids in terms of release of hydrogen ions in solution 2. define a soluble base (alkali) in terms of release of OH^- ions in solution 3. investigate the characteristic properties of acids, including the three common mineral acids: hydrochloric acid, nitric acid and sulphuric acid, as in their reactions with metals, bases, and carbonates 4. investigate the reaction of alkalis with ammonium salts and with indicators 5. describe effects of acids and alkalis on indicators, including Universal Indicator paper and litmus 6. describe neutrality, relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator paper and pH scale 8. describe and explain applications of neutralisation, e.g. laboratory preparation of salts, use of lime to control acidity in soil and water, and of antacids (e.g. bicarbonate of soda) to control stomach acid	7. write a ionic equation for neutralisation in aqueous solution 9. classify acids and alkalis as strong or weak	
CR2.2: Types of oxides		
1. by investigation, classify oxides as acidic, basic or neutral, related to metallic and non-metallic character of the element forming the oxide	2. classify other oxides as amphoteric, given sufficient information	
CR2.3: Preparation of Salts		
1. describe different ways for preparation, separation and purification of soluble and insoluble salts	2. suggest a method of making a given salt from suitable starting materials, given appropriate information, including precipitation	It is very useful for students to know the simple solubility rules for salts.

CR2.4: Identification of ions		
1. use the following tests to identify: • *aqueous cations:* ammonium, copper (II), iron (II), iron (III), and zinc, using aqueous sodium hydroxide and aqueous ammonia as appropriate • *anions:* carbonate (by reaction with dilute acid and then limewater), chloride (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium to ammonia) and sulfate (by reaction under acidic conditions with aqueous barium ions)	2. describe how to distinguish between aluminium and calcium cations using aqueous ammonia and sodium hydroxide	NB: The test for calcium ions with hydroxide ions requires a sufficiently high concentration of calcium ions.
CR2.5: Identification of gases		
1. identify, using the test specified: – ammonia: damp red litmus paper – carbon dioxide: limewater – chlorine: damp litmus paper – hydrogen: a lighted splint – oxygen: a glowing splint		
CR2.6: Lime and limestone		
1. describe the manufacture of calcium oxide (lime) from calcium carbonate (limestone) in terms of the chemical reactions involved 2. state uses of lime and calcium hydroxide (slaked lime) as in treating acidic soil and neutralising acidic industrial waste products		
CR3: Electricity and chemistry		
1. describe electrolysis as a process that causes the chemical break up of compounds into simpler substances, usually elements 2. draw a labelled circuit diagram for an electrolytic cell, using the terms *electrode*, *electrolyte*, *anode* and *cathode* 4. investigate the electrode products formed in the electrolysis of copper chloride (aqueous solution) and the electrolysis of dilute sulphuric acid (as essentially the electrolysis of water) between carbon electrodes 6. describe the process of electroplating of metals	3. explain electrode reactions as redox reactions involving electron transfer 5. state the general principles that metals or hydrogen are formed at the negative electrode and that oxygen or halogens are formed at the positive electrode, and use this to predict electrolysis products 7. recall the use of electrolysis for the extraction of very reactive metals and the manufacture of many chemicals	Simple home-made cells can be assembled from common materials found in the home or school.

CS: Stoichiometry and mole concept		
1. define *relative atomic mass*, *Ar* 2. define *relative formula mass*, *RFM*, and calculate it as the sum of the relative atomic masses (the term *relative molecular mass* or *Mr* will be used for covalent compounds) 4. calculate the percentage mass of components of a compound	3. define the mole using Avogadro's Constant 5. calculate stoichiometric reacting masses and volumes of gases and solutions, solution concentrations expressed in g/dm^3 and mol/dm^3 6. determine limiting reactants in chemical reactions	The appropriate use of symbols, formulae and equations is expected. Emphasise/relate mole concept to stoichiometry ratio and everyday life experiences. Calculations based on limiting reactants may be set; questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will not be set.

CAW: Air, water and the environment		
CAW1: Water		
1. describe a chemical test for water using copper(II) sulphate and cobalt(II) chloride 2. distinguish between the ion content of soft and hard water 3. distinguish between temporary and permanent hardness 4. relate hardness of water to its source, e.g. underground water, surface water e.t.c. 5. state advantages and disadvantages of hard water as having health, domestic and industrial implications 6. describe how hard water can be made soft by distillation and by using an ion exchanger 8. state the sources and effects of chemicals as water pollutants 9. outline the purification of water on a large scale for domestic use	7. explain how distillation and an ion exchanger soften hard water	Distilled water and deionised water are both important for industrial purposes for different processes.

CAW2: Air		
1. recall the composition of air, including the noble gases 2. determine the percentage of oxygen in air, given a description of a simple method with results 4. describe the source and adverse effects of: – carbon monoxide – sulphur dioxide – oxides of nitrogen – excess carbon dioxide – methane and CFCs as air pollutants 6. state uses of He, Ne and Ar as noble gases (Group VIII elements)	3. describe the fractional distillation of liquid air to obtain oxygen gas, nitrogen gas and the noble gases for industrial use 5. explain the importance of the presence of catalytic converters in the car exhaust system 7. relate uses of noble gases to their properties	Simple methods used would remove oxygen from a measured sample of air using a reagent that reacts with oxygen (e.g. heated copper, alkaline pyrogallol, white phosphorus). Include the adverse effect of common pollutants on buildings and on health, and the combustion of sulphur compounds leading to ‘acid rain’.
CAW3: Oxygen		
1. state the uses of oxygen including oxygen tents in hospitals, and with acetylene (ethyne) in welding 2. describe methods of rust prevention: ● paint and other coatings, to exclude oxygen ● galvanising 3. explain sacrificial protection in terms of the reactivity of zinc and iron	4. explain galvanising in terms of the protective oxide layer on zinc	
CAW4: Nitrogen		
1. describe the industrial production of ammonia by the Haber process 3. state the use of ammonia in the production of fertilisers, including ammonium nitrate and ammonium sulphate	2. describe the essential conditions for the manufacture of ammonia in the Haber process	
CAW5: Carbon dioxide		
1. describe the formation of carbon dioxide as a product of: ● complete combustion of carbon containing substances ● as a product of respiration		

CO: Organic chemistry		
CO1: Homologous series		
1. describe the concept of a homologous series as a 'family' of similar compounds with similar chemical properties due to the presence of the same functional group	2. be able to use standard nomenclature for alkanes, alcohols and alkenes for chains not exceeding four carbon atoms	Positional isomers will not be examined. The meanings of the stems of the names up to eight carbon atoms should be known.
CO2: Alkanes		
1. identify and draw structures of the alkanes limited to methane and ethane 3. describe the chemical properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning	2. predict the structures of higher members of the alkanes, given the names, limited to eight carbon atoms 4. explain physical trends in their density, fixed points and state of matter in relation to molecular mass 5. describe the stepwise substitution reaction of methane with chlorine	
CO3: Fuels		
1. state that coal, natural gas and petroleum are fossil fuels that produce carbon dioxide on combustion 2. name methane as the main constituent of natural gas 3. describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation 5. state the uses of the fractions: • refinery gas for cooking, heating, e.t.c. • petrol as fuel in cars • naphtha for making petrochemicals • paraffin for oil stoves and aircraft fuel • diesel for fuel in diesel engines • lubricating oil for lubricants and making waxes and polishes • bitumen for making roads	4. relate boiling points of the components to the intermolecular forces in each fraction	

CO4: Alkenes		
1. identify and draw structures of ethene and propene 3. describe with equations the addition reactions of ethene with bromine and hydrogen 5. distinguish between *saturated* and *unsaturated* hydrocarbons from molecular structures, and by simple chemical tests restricted to bromine and $KMnO_4$ in alkaline solution	2. describe the manufacture of alkenes and of hydrogen by cracking of alkanes under raised pressure and high temperature, with a catalyst 4. explain the addition reactions of alkenes with bromine, hydrogen, steam and addition polymerisation in terms of the breaking of the double bond	Emphasise the conditions of temperature, pressure and catalysts without details. Safety precautions are needed for use of bromine.
CO5: Alcohols		
1. identify and draw the structure of ethanol 2. describe the combustion of ethanol as a typical alcohol 4. state the uses of ethanol as a solvent, as a fuel and as a constituent of alcoholic beverages 5. describe the fermentation of simple sugars to produce ethanol and carbon dioxide, and the importance for brewing and wine-making	3. describe the oxidation of ethanol as the cause of souring of wines, and the formation of vinegar containing ethanoic acid 6. describe the formation of ethanol by the catalytic addition of steam to ethene	Ethanol is also a constituent of homemade brew. Not all alcohols can be consumed; methanol is poisonous, and laboratory ethanol has additives that can be poisonous.
CO6: Carboxylic acids		
1. identify, name and draw the structure of ethanoic acid	2. describe, with an equation, the reaction of ethanoic acid with ethanol to form ethyl ethanoate (an ester with a characteristic odour) 3. recall esters as components of flavourings and perfumes	
CO7: Macromolecules		
1. describe the formation of macromolecules (polymers) as the linking of smaller units (monomers) 3. classify macromolecules as man-made/synthetic (e.g. polyester, nylon, plastics) and natural (e.g. fats, proteins, carbohydrates) 4. state the monomers of the natural and synthetic macromolecules (proteins, starch, nylon, polyester and polythene) 5. describe some advantages and disadvantages of the use of man-made macromolecules, including their environmental problems	2. draw part-structures of poly(ethene) and poly(propene) macromolecules	Details of manufacture and mechanisms of these polymerisations are not required.

3.2 Physics

CORE	SUPPLEMENT	REMARKS (Notes)
P1: General physics		
P1.1: Length and time		
1. use: • rules to determine length • rules and measuring cylinders to determine volume 3. use clocks and devices for measuring an interval of time	2. use callipers and micrometers 4. describe how to measure the period of a pendulum	Relevance to everyday life of what was traditionally used in Lesotho. Remember to consider precisions and accuracy of the callipers and micrometers.
P1.2: Speed, velocity and acceleration		
1. calculate speed using: $\frac{\textit{total distance}}{\textit{total time}}$ 4. plot and interpret for uniform motion • a distance-time graph • a speed-time graph when a body is at rest, moving at constant speed and moving at changing speed 6. calculate distance travelled for uniform motion using area under a speed-time graph	2. distinguish between scalar and vector quantities 3. recall and use: velocity = displacement/time 5. calculate acceleration using: • graphs of linear motion • equations of motion 7. interpret graphs of motion for which the acceleration is not constant 8. calculate distance travelled for horizontal and vertical motion using equations of motion	
P1.3: Mass and weight		
1. measure mass and weight using a balance, and deduce g using the relationship W/m 2. distinguish between mass and weight and state that weight is a force 3. calculate the weight of a body using the relationship $W=mg$	 4. recall and use the relationship $W=mg$ 5. relate the effect of gavitational field strength to the weight of an object	Consider the variation of g on other planets and on the Moon.
P1.4: Density		
1. describe an experiment to determine the density of a liquid and of a regularly shaped solid, and make the necessary calculation	2. describe the determination of the density of: • an irregularly shaped solid by the method of displacement • air using evacuation method (use of a vacuum pump)	Density of air is included from the LJC Science Syllabus.

CORE	SUPPLEMENT	REMARKS (Notes)
P1.5: Forces		
P1.5 (a): Effects of force		
1. explore the effects of a force on the size and shape of a body 2. use a spring balance to measure force 3. identify weight as a force 4. state that force is measured in newtons 5. investigate the effect of force on size 6. draw extension-load graphs (including Hooke's Law) 8. explore ways in which a force may change the motion of a body 9. use $F = ma$ to calculate the resultant force	10. interpret extension-load graphs and use proportionality in simple calculations 11. recall and use $F = ma$ 12. describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)	Newton's Laws of Motion may be referred to, but examination of them lies beyond this syllabus.
P1.5 (b): Centre of mass		
1. perform and describe an experiment to determine the position of the centre of mass of a plane lamina 2. describe qualitatively the effect of the position of the centre of mass on the stability of simple objects		
P1.5 (c): Turning effect		
1. investigate and describe the moment of a force as a measure of its turning effect and give everyday examples 2. perform and experiment to verify the principle of moments, including calculations		

CORE	SUPPLEMENT	REMARKS (Notes)
P1.6: Energy, work and power		
P1.6 (a): Energy		
1. relate energy transfer to work done and state the unit of energy as the joule 2. identify different forms of energy including *kinetic* and *potential* 3. identify energy conversions and apply the principle of energy conservation to simple examples	4. recall and calculate using the expressions: $k.e. = \frac{1}{2}mv^2$ $p.e. = mgh$	
P1.6 (b): Major sources of energy and alternative sources of energy		
1. distinguish between renewable and non-renewable sources of energy 2. describe how the Sun provides a primary energy source for Earth and for life on Earth 3. describe how electrical or other useful forms of energy may be obtained from: • chemical energy stored in fuel • water, including the energy stored in waves, tides, and water behind dams • geothermal resources • nuclear fission • heat and light from the Sun (solar cells and panels) giving advantages and disadvantages of each method in terms of reliability, scale and environmental impact 4. demonstrate a qualitative understanding of efficiency	5. recall and use the equation: $\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$	
P1.6 (c): Work		
1. relate, with calculation, work done to the magnitude of force and distance moved ($W = F \times d$)	2. recall and use $\Delta W = F \times d = \Delta E$	
P1.6 (d): Power		
1. relate, with calculation, power to work done and time taken, using appropriate examples ($P = W/t$)	2. recall and use the equation $P = W/t = E/t$ in simple systems	

CORE	SUPPLEMENT	REMARKS (Notes)
P2: Thermal physics		
P2.1: Thermal properties		
P2.1 (a): Particulate nature of matter		
1. describe states of matter and changes of state in terms of kinetic theory	2. relate properties of common states of matter to: • forces and distances between molecules • motion of molecules	
P2.1 (b): Thermal expansion of solids, liquids and gases		
1. perform experiments to illustrate the thermal expansion of solids, liquids and gases 2. explain expansion in terms of particle motion 4. identify and explain some of the everyday applications and consequences of thermal expansion	3. describe the relative order of magnitude of the expansion of solids, liquids and gases in terms of motion and arrangement of molecules	
P2.1 (c): Measurement of temperature		
1. state a physical property of liquids which varies with temperature 2. demonstrate how such a property may be used for the measurement of temperature 3. measure temperature using a liquid-in-glass thermometer and state that temperature is measured in degrees Celsius 6. identify fixed points and describe their everyday applications	4. relate °C to K (Kelvin) 5. explain the terms *sensitivity* and *range* in relation to thermometers 7. describe the structure and action of a thermocouple and show understanding of its use for measuring high temperatures and those which vary rapidly	Review of qualitative effect of impurities on the melting point and boiling point.
P2.1 (d): Thermal capacity		
	1. demonstrate understanding of the term *thermal capacity* 2. perform experiments to measure specific heat capacity (c) of a substance 3. recall and use: thermal energy transfer = $mc\Delta T$ 4. define the terms *latent heat of fusion* and *latent heat of vaporisation* 5. recall and use: latent heat = specific latent heat	

CORE	SUPPLEMENT	REMARKS (Notes)
P2.2: Transfer of thermal energy		
P2.2 (a): Conduction		
1. perform experiments to demonstrate the properties of good and bad conductors of heat 2. explain thermal energy (heat) transfer in solids in terms of motion of atoms and molecules	3. explain thermal energy (heat) transfer in metals in terms of electron diffusion	
P2.2 (b): Convection		
1. perform experiments to illustrate convection in fluids 2. relate convection in fluids to density changes		
P2.2 (c): Radiation		
1. describe radiation as the method of heat transfer that does not require a medium to travel 2. perform experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation 3. identify good and bad emitters and good and bad absorbers of infra-red radiation		
P2.2 (d): Consequences and applications		
1. identify and explain some of the everyday applications and consequences of conduction, convection and radiation		

CORE	SUPPLEMENT	REMARKS (Notes)
P3: Waves		
P3.1: General wave properties		
1. perform experiments to illustrate wave motion using water waves (e.g. ripple tank) and vibrations in ropes and springs 2. state that wave motion transfers energy without transfer of matter 3. distinguish between longitudinal and transverse waves 4. state the meaning of *wavefront*, *amplitude*, *frequency*, *wavelength* and speed and use the equation $v = f\lambda$	5. recall and use the equation $v = f\lambda$ 6. perform experiments to illustrate: • reflection of water waves at a plane surface • refraction of water due to a change of speed 7. interpret reflection and refraction using wave theory	
P3.2: Light		
P3.2 (a): Reflection of light		
1. perform an experiment to illustrate the formation of an optical image as seen in a plane mirror 2. state and explain the characteristics of the optical image as seen in the plane mirror 3. investigate reflection of light rays in a plane mirror 4. draw ray diagrams using the law: *angle of incidence* = *angle of reflection*	5. use the law of reflection in constructions, measurements and calculations for reflections in a plane mirror	The terms 'virtual image' and 'real image' will be used when needed.
P3.2 (b): Refraction of light		
1. perform experiments to illustrate the refraction of light 2. construct ray diagrams for the passage of light through a parallel-sided transparent material indicating the angle of incidence i and angle of refraction r 3. calculate the refractive index using $n = \sin i / \sin r$ 5. draw graph of i vs r'	4. recall and calculate the refractive index using $n = \sin i / \sin r$ 6. perform experiments using prisms to demonstrate dispersion of light	Refractive index can be related to changes in speed of light in different materials.

CORE	SUPPLEMENT	REMARKS (Notes)
P3.2 (c): Thin converging lens		
1. perform a experiment to demonstrate the action of a thin converging lens on a beam of light 2. use the terms *focal point* and *focal length* 3. draw simple ray diagrams that illustrate the formation of a real image by a thin converging lens 5. use and describe the use of a single lens as a magnifying glass	4. interpret simple ray diagrams that illustrate the formation of real and virtual images by a thin converging lens 6. use $1/f = 1/u + 1/v$	
P3.2 (d): Electromagnetic spectrum		
1. state the components of the electromagnetic spectrum 2. describe the properties of the electromagnetic spectrum, including the sped of electromagnetic waves 4. describe the role of electromagnetic waves in: • radio and television communications (radio waves) • satellite television and telephones (microwaves) • electrical appliances, remote controllers for televisions and intruder alarms (infrared) • medicine and security (X-rays) 5. identify safety issues in the use of some parts of the electromagnetic spectrum	3. recall and use the equation $v = f\lambda$ for electromagnetic waves	
P3.3: Sound		
1. perform experiments to illustrate the production of sound by vibrating sources 2. describe transmission of sound in a gas as a longitudinal wave composed of successive compressions and rarefactions 3. state that a medium is required in order to transmit sound waves 4. relate the loudness and pitch of sound waves to amplitude and frequency 5. state the approximate human range of audible frequencies, and use the term ultrasound	6. state the order of magnitude of the speed of sound in air, liquids and solids 7. perform an experiment to determine the speed of sound in air and make the necessary calculations 8. describe some uses of ultra sound in medical imaging, cleaning, e.t.c.	Learners should appreciate that the speed of sound is much lower than the speed of light. Everyday application would be seeing the lightning in a storm, before hearing the thunder.

CORE	SUPPLEMENT	REMARKS (Notes)
P4: Electricity and magnetism		
P4.1: Simple phenomena of magnetism		
1. perform experiments to illustrate the properties of magnets 2. perform experiments to magnetise by: • induction • single and double stroking • using an electromagnetic coil 3. determine the polarity of a magnetised material 4. perform an experiment to demagnetise a magnet 5. distinguish between ferromagnetic and nonferromagnetic materials 6. perform an experiment to identify the pattern of field lines round a bar magnet 7. distinguish between the magnetic properties of iron and steel 8. distinguish between the design and use of permanent magnets and electromagnets		
P4.2: Electrostatics		
1. perform simple experiments to show the production and detection of electrostatic charges: • state that there are positive and negative charges • state that unlike charges attract and like charges repel 3. distinguish between conductors and insulators 4. identify and explain everyday applications of electrostatics including lightning	2. state that charge is measured in coulombs	Use of any detector, including the electroscope is acceptable.
P4.3: Current Electricity		
P4.3 (a): Current		
1. identify and use circuit symbols 2. state that current is related to the flow of charge and is measured in amperes 4. measure current using an ammeter 5. recall and use the conventional current direction arrows in circuit diagrams	3. recall and use the equation $I = Q/t$	A list of expected circuit symbols is given in the Appendix 5.3.

CORE	SUPPLEMENT	REMARKS (Notes)
P4.3 (b): Electromotive force (e.m.f)		
	1. define e.m.f. in terms of energy supplied by a source in driving charge in a complete circuit 2. state that the e.m.f. of a source of electrical energy is measured in volts	
P4.3 (c): Potential difference (p.d.)		
1. state that the potential difference across a circuit component is measured in volts 2. measure potential difference using a voltmeter	3. relate e.m.f. to p.d.	Make reference to the internal resistance of the source.
P4.3 (d): Resistance		
1. perform an experiment to determine resistance in a simple circuit and use the equation $V = IR$ 3. Perform an experiment to relate (without calculation) the resistance of a wire to its length and to its diameter	2. plot, draw and interpret V/I characteristic graphs for ohmic and non-ohmic materials 4. recall and use the equation $V = IR$ 5. recall and use quantitatively $R = \rho l/A$	Where ρ is the resistivity of the material.
P4.4: Electric circuits		
1. draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters, magnetising coils, bells, fuses, relays 2. perform an experiment to verify that the current at every point in a series circuit is the same 4. use $R = R_1 + R_2 + ...$ for resistors in series 6. use $I = I_1 + I_2 + ...$ for a parallel circuit 8. use $1/R = 1/R_1 + 1/R_2$ for two resistors in parallel	3. perform an experiment to demonstrate that the sum of the p.d.'s across the components in a series circuit is equal to the total p.d. across the supply 5. recall and use $R = R_1 + R_2 + ...$ for resistors in series 7. recall and use $I = I_1 + I_2 + ...$ for branches in a parallel circuit 9. recall and use $R = R_1 R_2/R_1 + R_2$ for resistors in parallel	A list of expected circuit symbols is given in the Appendix 5.3. Where other circuit symbols are used in a question, they will be labelled.

CORE	SUPPLEMENT	REMARKS (Notes)
P4.5: Practical electric circuitry		
P4.5 (a): Uses of electricity		
1. describe the uses of electricity in • heating • lighting (including lamps in parallel) • motors 2. use $P = IV$	3. recall and use the equations $P = IV$ and $E = IVt$ and their alternative forms 4. calculate the cost of using electrical appliances given the cost of electricity per kilowatt hour	
P4.5 (b): Safety considerations		
1. describe the hazards of: • damaged insulation • overloaded cables • damp conditions	2. demonstrate understanding of the use of: • fuses and fuse ratings • Earth wire connected to the metal case • live and neutral wires • switches and fuses in live leads • double insulation • circuit breakers	
P4.6: Electromagnetic effects		
P4.6 (a): Electromagnetic induction		
1. perform an experiment to demonstrate that a changing magnetic field can induce an e.m.f. in a circuit 2. state the factors affecting the magnitude of the induced e.m.f. 3. perform an experiment to illustrate that the direction of an induced e.m.f. opposes the change causing it		
P4.6 (b): a.c. generator		
1. describe the difference between d.c. and a.c. electrical supplies	2. describe a rotating-coil generator and the use of slip rings 3. sketch a graph of voltage output against time for a simple a.c. generator	
P4.6 (c): d.c. motor		
1. describe the turning effect of a current carrying coil in a magnetic field 2. describe the effect of increasing: • the number of turns in the coil • the current 3. relate this turning effect to the action of an electric motor		

CORE	SUPPLEMENT	REMARKS (Notes)
P4.6 (d): Transformer		
1. describe the construction of a basic iron-cored transformer as used for voltage transformations 2. show a qualitative understanding of the principle of operation of a transformer	3. recall and use the equation $(V_p/V_s) = (N_p/N_s)$ 4. recall and use the equation $V_p I_p = V_s I_s$ (for 100% efficiency) 5. show understanding of energy loss in cables (calculation not required) 6. describe the use of the transformer in high-voltage transmission of electricity 7. explain why energy losses in cables are lower when the voltage is higher	

CORE	SUPPLEMENT	REMARKS (Notes)
P5: Atomic physics and radioactivity		
P5.1: Detection of radioactivity		
1. identify sources of background radiation 2. name the commonly used detectors for radiation 3. state three types of nuclear emission as alpha-particles, beta-particles and gamma-rays		Review content of chemistry topic CPT. Be aware of modern detectors that are more versatile and cheaper than GM tubes
P5.2: Characteristics of the three kinds of emission		
1. state, for radioactive emissions: ● their nature ● their realtive ionising effects ● their relative penetrating abilities	2. describe their deflections in electric fields and magnetic fields	
P5.3: Radioactive decay and half-life		
1. state the meaning of *radioactive decay*, using equations to represent changes in the composition of the nucleus when particles are emitted 3. use the term *half-life* in simple calculations which might involve information in tables or decay curves	2. state that radioactive emissions occur randomly over space and time	
P5.4: Nuclear energy		
	1. describe fission and fusion of nuclei 2. recall and use $E = mc^2$	
P5.5: Safety precautions		
1. describe the safety precautions required when handling radioactive materials		

4. Practical assessment

Practical Assessment: Paper 4

Scientific subjects are, by their nature, experimental. It is therefore important that an assessment of a student's knowledge and understanding of science should contain a component relating to practical work and experimental skills (as identified by assessment objective **C**). To accommodate differing circumstances within Lesotho schools – such as the availability of resources – only one means of assessing assessment objective **C** is provided in the form the Practical Knowledge Paper.

For this assessment, the following points should be noted:

- practical skills are to be learned and developed
- planning of simple investigations by learners brings greater understanding
- benefits to theoretical understanding come from all practical work
- experience of practical work has a motivational effect, creating enthusiasm and enjoyment
- a progressive sequence of practical activities throughout the course will develop the experimental skills that will be examined in Paper 4

4.1 Paper 4: Practical Knowledge

This paper is designed to test candidates' familiarity with laboratory practical procedures. Questions may be set requiring candidates to:

- plan a simple investigation, and describe their plan
- describe in simple terms how they would carry out practical procedures
- explain and/or comment critically on described procedures or points of practical detail
- follow instructions for drawing diagrams
- draw, complete and/or label diagrams of apparatus
- take readings from their own diagram, drawn as instructed, and/or from printed diagrams including:
  - reading a scale with appropriate precision/accuracy with consistent use of significant figures and with appropriate units
  - interpolating between scale divisions
  - taking repeat measurements to obtain an average value
- resent data graphically, using suitable axes (appropriately labelled) and plotting the points accurately
- take readings from a graph by interpolation and extrapolation
- determine a gradient, intercept or intersection on a graph
- draw and report a conclusion or result clearly
- identify and/or select, with reasons, items of apparatus to be used for carrying out practical procedures

- explain, suggest and/or comment critically on precautions taken and/or possible improvements to techniques and procedures
- describe, from memory, tests for gases and ions, and/or draw conclusions from such tests

(Notes for Use in Qualitative Analysis (Appendix 5.5) will not be provided in the question paper.)

5. Appendix

5.1 Symbols, units and definitions of physical quantities

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state units in which they are measured. Candidates should be able to define those items indicated by an asterisk (*). The list for the extended curriculum includes both the core and the supplement. SI units are in bold.

Conventions (e.g. signs, symbols, terminology and nomenclature)
Syllabuses and question papers will conform with generally accepted international practice.

Litre / dm^3: to avoid any confusion over the symbol for litre (*l* or litre), dm^3 will always be used.

Core			**Supplement**		
Quantity	**Symbol**	**Unit**	**Quantity**	**Symbol**	**Unit**
Length	*l, h ...*	km, m, cm, mm			
Area	*A*	m^2, cm^2			
Volume	*V*	m^3, dm^3, cm^3			
Weight	*W*	N			
Mass	*m, M*	kg, g			
Density	*d*, ρ	kg/m^3, g/cm^3			
Time	*t*	h, min, s	period	*T*	s
Speed*	*u, v*	km/h, m/s,cm/s			
Acceleration	*a*	m/s^2	Acceleration*		m/s^2
Acceleration of free fall	*g*	m/s^2			
Force	*F*	N	Force*		N*
Moment of force		Nm	Moment of force*		N m
Work done	*W, E*	J	Work done by a force*		J*
Energy	*E*	J			J*, kW h*
Power	*P*	W	Power*		W*
Temperature	*t, T*	°C			
Frequency	*f*	Hz	Frequency*	*f*	Hz
Wavelength	λ	mm, cm, m	Wavelength*	λ	m, cm
Focal length	*f*	cm mm	Focal length	*f*	cm, mm
Angle of incidence	*i*	degree (°)			
Angle of reflection/refraction	*r*	degree (°)			
Potential difference/voltage	*V*	V, mV	Potential difference*		V*
Current	*I*	A, mA	Current*		
e.m.f.	*E*	V	e.m.f.*		
Resistance	*R*	Ω			
Resistivity	ρ	Ωm	Resistivity*		
Charge	*Q*	C			

5.2 Prefixes

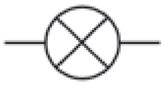
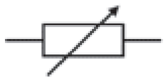
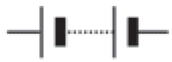
The symbols and meanings of prefixes should be understood and used.

Multiples			Submultiples		
name	**meaning**	**symbol**	**name**	**meaning**	**symbol**
deca-	10	da	deci-	1/10	d
hecta-	100	h	centi-	1/100	c
kilo-	1000	k	milli-	1/1000	m
mega-	10^6	M	micro-	10^{-6}	µ
giga-	10^9	G	nano-	10^{-9}	n

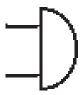
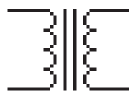
5.3 Circuit Symbols

The following circuit symbols will be used without any explanatory label:

switch	resistor	cell
		

lamp	variable resistor	battery
		

ammeter	fuse	voltmeter
		

bell	transformer	magnetising coil
		

Other circuit symbols may be used in circuits given in a question, but will be clearly labelled.

5.4 Chemical nomenclature

Simple inorganic compounds will be named using stock notation where necessary, for example: copper (II) sulphate, iron (III) oxide
[NB: $KMnO_4$ will be named as potassium permanganate, and not potassium manganate (VII)]

Molecular inorganic compounds will be named as e.g. sulfur dioxide.
Organic nomenclature will be used as in the Organic Chemistry syllabus topic, CO.

5.5 Notes for use in qualitative analysis

Test for anions

Anion	Test	Test result
Carbonate (CO_3^{2-})	Add dilute acid	Effervescence, carbon dioxide produced
Chloride (Cl^-)	Acidify with dilute nitric acid, then add aqueous silver nitrate	White ppt
Nitrate (NO^{3-}) [in solution]	Add aqueous sodium hydroxide, then aluminium foil, warm carefully	Ammonia produced
Sulfate (SO_4^{2-}) [in solution]	Acidify with dilute nitric acid, then add aqueous barium nitrate	White ppt

Test for aqueous cations

Cation	Effect of aqueous sodium hydroxide	Effect of aqueous ammonia
Aluminium (Al^{3+})	White ppt, soluble in excess	White ppt, not readily soluble
Ammonium (NH^{4+})	Ammonia produced on warming	
Calcium (Ca^{2+})	White ppt, insoluble to excess	Ppt not formed
Copper(II) (Cu^{2+})	Light blue ppt, insoluble in excess	Light blue ppt, soluble in excess, giving a dark blue solution
Iron(II) (Fe^{2+})	Green ppt, insoluble in excess	Green ppt, insoluble in excess
Iron(III) (Fe^{3+})	Red-brown ppt, insoluble in excess	Red-brown ppt, insoluble in excess
Zinc (Zn^{2+})	White ppt, soluble in excess, giving a colourless solution	White ppt, soluble in excess, giving a colourless solution

Test for gases

Gas	Test and test result
Ammonia (NH_3)	Turns damp red litmus paper blue
Carbon dioxide (CO_2)	Turns lime water milky
Chlorine (Cl_2)	Bleaches damp litmus paper
Hydrogen (H_2)	‘pops’ with a lighted splint
Oxygen (O_2)	Relights a glowing splint

5.6 The Periodic Table of the Elements

The Periodic Table of the Elements

Group

I	II											III	IV	V	VI	VII	0
						1 **H** Hydrogen 1											4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

*58-71 Lanthanoid series
†90-103 Actinoid series

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

Key

a **X** b	a = relative atomic mass X = atomic symbol b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

5.7 Grade Descriptions

The scheme of assessment is intended to encourage positive achievement by all candidates. Mastery of the Core Curriculum is required for further academic study.

A Grade A candidate must show mastery of the Core Curriculum and the Extended Curriculum.

A Grade C candidate must show mastery of the Core Curriculum plus some ability to answer questions which are pitched at a higher level.

A Grade F candidate must show competence in the Core Curriculum.

A Grade A candidate is likely to:

- relate facts to principles and theories and vice versa
- state why particular techniques are preferred for a procedure or operaion
- select and collate information from a number of sources and present
- solve problems in situations which may involve a wide range of variables
- process data from a number of sources to identify any patterns or trends
- generate a hypothesis to explain facts, or find facts to support a hypothesis.

A **Grade C** candidate is likely to:

- links facts to situations not specified in the syllabus
- describe the correct procedure(s) for a multi-stage operation
- select a range of information from a given source and present it in a clear logical form
- identify patterns or trends in given information
- solve problems involving more than one step, but with a limited range of variables
- generate a hypothesis to explain a given set of facts or data.

A **Grade F** candidate is likely to:

- recall facts contained in the syllabus
- indicate the correct procedure for a single operation
- select and present a single piece of information from a given source
- solve a problem involving one step, ore more than one step if structured help is given
- identify a pattern or trend where only a minor manipulation of data is needed
- recognise which of two given hypotheses explains a set of facts or data.

5.8 Mathematical requirements

Calculators may be used in all parts of the assessment.

Candidates should be able to:

- add, subject, multiply and divide
- understand and use *averages*, *decimals*, *fractions*, *percentages*, *ratios* and *reciprocals*
- recognised and use standard notation
- use direct and inverse proportion
- use positive, whole number indices
- draw charts and graphs from given data
- interpret charts and graphs
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recognise and use the relationship between length, surface areas and volume and their units on metric scales
- use usual mathematical instruments (rules, compasses, protractor, set square)
- understand the meaning of *angle*, *curve*, *circle*, *radius*, *diameter*, *square*, *parallelogram*, *rectangle* and *diagonal*
- solve equations of the form $x = y\,z$ for andy term when the other two are known
- recognise and use points of the compass (N, S, E, W).

5.9 Glossary of terms used in science papers

It is hoped that the glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide (e.g. it is neither exhaustive nor definitive). The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend, in part, on its context.

1 *Define* (the term(s) ...) is intended literally, only a formal statement or equivalent paraphrase being required.

2. *What do you understand by/What is meant by* (the term(s) ...) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

3. *State* implies a concise answer with little or no supporting argument (e.g. a numerical answer that can readily be obtained 'by inspection').

4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified this should not be exceeded.

5. *Explain* may imply reasoning or some reference to theory, depending on the context.

6. *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena.

   In other contexts, *describe* should be interpreted more generally (i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer). *Describe and explain* may be coupled, as may state and explain; in some cases, *state or describe* may be followed by *give a reason for your answer* to indicate there are two parts to the expected answer.

7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.

8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).

9. *Predict* implies that the candidate is not expected to produce the required answer by recall but making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question. *Predict* also implies a concise answer with no supporting statement required.

10. *Deduce* is used in similar way to *predict* except that some supporting statement is required (e.g. reference to a law, principle or the necessary reasoning is to be included in the answer).

11. *Suggest* is used in two main contexts, either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.

12. *Find* is a general term that may variously be interpreted as calculate, measure, determine, e.t.c. and will often indicate that the answer does not require extensive calculation.

13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values or other quantities into a standard formula (e.g. resistance, the formula of an ionic compound).

16. *Estimate* implies a reasoned order or magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

17. *Sketch*, when applied to graph, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept). In diagrams, *sketch* implies that simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

18. *Perform an experiment* in the syllabus implies that learners will gain great benefit from carrying out such an experiment themselves, and as a result will be able to recall and explain the procedures and the associated science knowledge and understanding, demonstrate how to handle and interpret data from the experiment, and draw conclusions.

19. *Investigate* in the syllabus implies that learners will have planned the experiment themselves before carrying it out, and as a result will be able to use hypotheses to make predictions and so explain the experimental plan, as well as the issues included in perform the experiment above.