UNIVERSITY OF ESWATINI

FACULTY OF EDUCATION

DEPARTMENT OF CURRICULUM AND TEACHING

MAIN EXAMINATION PAPER

M. Ed.

November/December 2018

Title of paper: Curriculum Studies: Chemistry I

Course Code: CTE615

Time allowed: Three (3) hours

Instructions:

1. This paper contains FIVE questions.
2. Answer ANY FOUR questions
3. Answer questions in continuous essay form.
4. Questions carry marks as indicated.
5. Any piece of material or work that is not intended for marking purposes should be clearly CROSSED OUT. Ensure that responses to questions are NUMBERED CORRECTLY.

Special Requirement:

SGCSE Physical Science 2018-2020–Chemistry section

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

QUESTION 1

a) Identify and describe **five** features of a chemical/scientific revolution. [15]

b) How might understanding features of chemical revolutions help to improve one's understanding of the nature of science? [10]

QUESTION 2

"...the scientific method will bring us close to truth even though we will never arrive at truth, for we are always theory bound. Science always results in theory, not pure objective truth". (Naugle, undated)

Within the context of chemistry, discuss your views about the ideas raised in the statement above. [25]

QUESTION 3

With reference to the SGCE Physical Science-Chemistry curriculum, discuss **five (5)** factors Mbajiorgu (2006) notes as important in designing chemistry curricula to **show how** considering them may improve chemistry learning. [25]

QUESTION 4

Reforms in science education have called for reconceptualization of the goals of science education to extend from focusing on *scientific knowledge, scientific methods, social issues, personal needs* and *career awareness* to address 21st Century goals.

In the context, and role, of chemistry, discuss **three** of the basic goals of science education so as to reflect the kind of goals science education is to attain in the 21st Century. [25]

QUESTION 5

The core role of science and technology for sustainable development in modern societies suggests the central role of science education in ESD (Bradley, 2005 cited in Eilks, 2015).

Discuss **four** models presented by Eilks (2015) to show the role chemistry education can play in sustainable development for modern societies. [25]

EXAMS COUNCIL OF SWAZILAND

SGCSE

Swaziland General Certificate of Secondary Education

PHYSICAL SCIENCE

SYLLABUS

Subject Code 6888

For examination in 2019 - 2020

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NOTE

Changes have been made to the Curriculum content. These include additions to and deletions of topics and concepts, and movement of topics.

SWAZILAND GENERAL CERTIFICATE OF SECONDARY EDUCATION

Broad Guidelines

The Ministry of Education and Training is committed, in accordance with the National Policy Statement on Education, to provide a Curriculum and Assessment System so that at the completion of senior secondary education (Form 4 and Form 5), learners will:

- be equipped to meet the changing needs of the Nation, and
- have attained internationally acceptable standards.

Swaziland's National Education Policy Directives

SGCSE syllabuses for studies in Form 4 and Form 5 will individually, and collectively, enable learners to develop **essential skills** and provide a broad **learning experience** which

- inculcates values and attitudes as well as knowledge and understanding,
- encourages respect for human rights and freedom of speech,
- respects the values and beliefs of others, relating to issues of gender, culture and religion,
- develops desirable attitudes and behaviour towards the environment,
- provides insight and understanding of global issues which affect quality of life in Swaziland and elsewhere, e.g., the AIDS pandemic; global warming; maldistribution of wealth; and technological advances.

The National Curriculum for Form 4 and Form 5

Learners will be given opportunities to develop essential skills which will overlap across the entire range of subjects studied. These skills are listed below.

- Communication and language skills
- Numeracy skills: mathematical ideas, techniques and applications
- Problem-solving skills
- Technological awareness and applications
- Critical thinking skills
- Work and study skills
- Independent learning
- Working with others

To develop these skills, learners must be offered five compulsory subjects and at least two elective subjects chosen from one or more Field of Study.

Compulsory Subjects

- SiSwati – either First Language or Second Language
- English Language
- Mathematics
- Sciences (Biology or Physical Science)
- Religious Education

Fields of Study

- Agriculture Field of Study
- Business Studies Field of Study
- Consumer Science Field of Study
- Social Sciences and Humanities Field of Study
- Technical Field of Study
- Science Field of Study

SGCSE PHYSICAL SCIENCE Syllabus 6888
November 2019 and November 2020 Examinations

INTRODUCTION

The Swaziland General Certificate of Secondary Education (SGCSE) syllabuses are designed as two-year courses for examination in Form 5. Physical Science is designed for learners with a wide range of abilities and relevant to those from different backgrounds and experiences. It requires a wide range of learner-centred activities which are based on practical work. This provides learners with opportunities to acquire scientific knowledge and develop skills and processes which will enable them to apply science in everyday situations. As the learners explore and interpret the physical world, emphasis will be directed to the development of innovative ideas, processes and use of scientific equipment in this advancing technological world. It will also prepare candidates for an assessment that will, within familiar and unfamiliar contexts, test expertise, understanding and insight. This syllabus serves as a basis for further studies in science.

All SGCSE syllabuses follow a general pattern. The main sections are:
Aims
Assessment Objectives
Assessment
Curriculum Content

Physical Science falls into the Science Compulsory Subjects Group which includes Biology. It is also an Elective Subject in the following Field of Study Groups: Agriculture, Consumer Science and Technical Field of Study.

AIMS

The aims of the syllabus are the same for all learners. These aims are set out below and describe the educational purposes of a course in Physical Science for the SGCSE Examination. They are not listed in order of priority.

The aims are to:

1. provide, through well designed studies of experimental and practical science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to
   - 1.1 become confident citizens in a technological world, to take or develop an informed interest in matters of scientific import;
   - 1.2 recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life;
   - 1.3 inspire learners to seek, acquire and develop scientific explanations of natural phenomena;
   - 1.4 be suitably prepared for studies beyond the SGCSE level in pure sciences, in applied sciences or in science-dependent vocational courses.
2. develop abilities and skills that:
   - 2.1 develop and enhance scientific knowledge and understanding;
   - 2.2 are useful in everyday life and applicable in domestic, environmental and industrial situations;
   - 2.3 are necessary to communicate scientific findings of practical investigations using proper technical scientific terminology;
   - 2.4 encourage efficient and safe practice;
   - 2.5 will evaluate the positive and negative impact of scientific or technological development.
3. develop attitudes relevant to Physical Science such as:
   - 3.1 concern for accuracy and precision;
   - 3.2 objectivity;
   - 3.3 integrity;
   - 3.4 enquiry;
   - 3.5 initiative;
   - 3.6 inventiveness;
   - 3.7 perseverance;
   - 3.8 validity and reliability
4. stimulate learner interest in, and care for, the environment.

5. promote an awareness
   5.1 of the potential of the indigenous technologies in developing local societies;
   5.2 that scientific theories and methods have developed, and continue to do so, as a result of the co-operative activities of groups and individuals;
   5.3 that the study and practice of science is subject to social, economic, technological, ethical and cultural influences and limitations;
   5.4 that the applications of science may be both beneficial and detrimental to the individual, the community and the environment;
   5.5 that science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal.

PRIOR KNOWLEDGE AND SKILLS

Learners beginning this course should normally have completed the junior secondary school science or its equivalent. Learners should also have adequate mathematical skills for the content contained in this syllabus.

ASSESSMENT OBJECTIVES

Assessment Objectives in Physical Science are:

A Knowledge with Understanding
B Handling Information and Solving Problems
C Experimental Skills and Investigations

A description of each Assessment Objective follows.

A KNOWLEDGE WITH UNDERSTANDING

Learners should be able to demonstrate knowledge and understanding in relation to:

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 Curriculum 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 (using your knowledge and understanding) or outline. (See Appendix: Glossary of Terms.)

B HANDLING INFORMATION AND SOLVING PROBLEMS

Learners should be able, in words or using other written forms of presentation (i.e., symbolic, graphical and numerical), 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, including some of a quantitative nature.

These Assessment Objectives cannot be precisely specified in the Curriculum Content because questions testing such skills are often based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: discuss, predict, suggest, calculate, explain or determine. (See Appendix: Glossary of Terms.)

C EXPERIMENTAL SKILLS AND INVESTIGATIONS

Learners should be able to:

1. demonstrate knowledge of how to safely use techniques, apparatus and materials (including the following of a sequence of instructions)
2. make and record observations, measurements and estimates;
3. interpret and evaluate experimental observations and data;
4. plan and carry out investigations;
5 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 Objectives	**Paper 1 (marks)**	**Paper 2 (marks)**	**Papers 3 and 4 (marks)**	**Weighting of assessment objectives in overall qualification**
A Knowledge with understanding	25-30	48-53	0	50% (not more than 25% recall)
B Handling information and solving problems	10-15	27-32	0	30%
C Experimental skills and investigations	0	0	40	20%
Weighting of paper qualification	27%	53%	20%	

Teachers should take note that there is an equal weighting of 50% for skills (including handling information, solving problems, practical, experimental and investigative skills) and for knowledge and understanding. Teacher's schemes of work and the sequence of learning activities should reflect this balance, so that the aims of the syllabus may be met, and the candidates prepared for the assessment.

ASSESSMENT

Scheme of Assessment

All candidates must enter for three papers. These will be Paper 1, Paper 2, and **one** from the practical assessment Papers 3 (Practical Test) or 4 (Alternative to Practical).

A description of each paper follows.

The Data Sheet (The Periodic Table of the Elements) ***will*** *be included in Papers 1 and 2 while chemistry practical notes will be included in Paper 3.*

Paper 1 (1 hour)
Compulsory short answer paper consisting of 40 marks. The paper will test skills mainly in Assessment Objectives **A** and **B**.
This paper will be weighted at 27% of the final total available marks.

Paper 2 (1 hour 15 minutes)
Compulsory theory paper consisting of 80 marks of structured questions.
The questions will be based on all material and will test skills mainly in Assessment Objectives **A** and **B**.
This paper will be weighted at 53% of the final total available marks.

Practical Assessment
The purpose of this component is to test appropriate skills in Assessment Objective **C**. Candidates must be entered for one of the following:

Either
Paper 3 Practical Test (1 hour 15 minutes), consisting of 40 marks, with questions covering experimental skills and investigations. (See Appendix: Assessment Criteria for Practicals.)

Or
Paper 4 Alternative to Practical (1 hour), consisting of 40 marks. This is a written paper designed to test familiarity with laboratory based procedures. (See Appendix: Assessment Criteria for Practicals.)

The practical assessment will be weighted at 20% of the final total available marks.

EXPERIMENTAL WORK

Experimental work is an essential component of all sciences. 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
- promotes mastery of concepts.

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, for example '*describe*' 'perform *experiments* to...' and *'investigate...'* These instructions mean that such statements may be examined in terms of practical skills in Paper 3 or Paper 4, but also in terms of other skills (Assessment Objectives **A** and **B**) in Papers 1 and 2 covering such skills as planning, prediction, recall, explanation, handling data (including calculations) and interpretation of results.

CURRICULUM CONTENT

Notes:

(i) The Curriculum Content is designed to provide guidance to teachers as to what will be assessed in the overall evaluation of the learner. It is not meant to limit, in any way, the teaching programme of any particular school.

(ii) Due to the spiral nature of the curriculum, it is assumed that the elementary concepts of the syllabus have been covered during study at Junior Secondary level.

(iii) The Curriculum Content is set out in topic areas within Chemistry and Physics. The main topic areas and concepts are indicated in **bold**.

(iv) Cross-references are provided to indicate areas of overlap or close association within the syllabus.

(v) It is intended that, in order to avoid difficulties arising out of the use of *l* as the symbol for litre, use of dm^3 in place of *l* or litre will be made.

DURATION OF COURSE

Appropriate teaching time for the Physical Science syllabus should be equivalent to at least six (6) periods of forty (40) minutes each over a period of sixty (60) weeks/cycles.

Introduction

The syllabus content that follows is divided into two sections: Chemistry (C1-C13) and Physics (P1-P15). Candidates must study both sections.

Chemistry is the study of composition of substances and their effect upon one another. Physics is the study of the relationship or interaction between matter and energy.
Physical science is a scientific subject, experimental by nature. Learners in Physical science are expected to use a number of standard laboratory procedures and should be able to name and use apparatus accurately and appropriately, for measuring

- volume (measuring cylinder, burettes, pipettes)
- mass (digital balance, triple beam balance, lever arm balance)
- temperature (laboratory thermometer)
- time (stopwatch- analogue and digital)
- potential difference (voltmeter)
- Current (ammeter)
- Length (micrometer screw gauge, vernier calipers)

The following experimental techniques may be found

- paper chromatography
- methods of purification by use of suitable solvent, filtration, evaporation, crystallisation, distillation (simple and fractional) and sublimation
- determination of purity by melting point and boiling point
- construction of graphs for interpretation of data
- preparation of salts
- preparation and collection of gases
- determination of density
- determination of resistance of wires
- construction of simple circuits
- detection of charges

CHEMISTRY SECTION

C1.0 Particulate nature of matter

All learners should be able to:

1. describe the states of matter and explain their interconversions in terms of the kinetic particle theory
2. describe the evidence for the movement of particles in gases and liquids i.e. diffusion and Brownian motion

C2.0 Elements, compounds and mixtures

All learners should be able to:

1. define an atom, compound, element, mixture and a molecule
2. demonstrate an understanding of the differences between elements, compounds and mixtures
3. identify elements, compounds and mixtures

C3.0 Experimental techniques

C3.1 Methods of purification

All learners should be able to:

describe methods of purification by use of a suitable solvent, filtration, evaporation, crystallization, distillation (simple and fractional), separating funnel and sublimation

C3.2 Criteria for purity

1. describe paper chromatography
2. interpret simple chromatograms
3. describe how chromatography techniques can be applied to colourless substances by exposing chromatograms to locating agents.
4. identify substances and test their purity by melting point and boiling point determination and by paper chromatography
5. investigate the melting point and boiling point of pure and impure substances
6. draw and interpret temperature/time graphs as a means of assessing purity
7. interpret a cooling and a heating curve

C4.0 Physical and chemical change

All learners should be able to:

1. list properties of a:
   - chemical change,
   - physical change.
2. identify and describe physical and chemical changes

C5. 0 The Periodic Table

All learners should be able to:

C5.1 Periodic trends

1. describe the Periodic Table as a method of classifying elements and its use in predicting properties of elements
2. explain, for the first 20 elements, the basis of the Periodic Table using the proton number and the simple structure of atoms
   (note that a copy of the Periodic Table will be provided in Papers 1 and 2.)
3. describe the relationship between the periodic number and the number of shells
4. describe the trend from metallic to non-metallic character across a Period
5. identify alkali metals, alkaline earth metals, halogens and noble gases

C5.2 Group properties

1. describe the relationship between group number and the number of outer electrons
2. describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and in reaction with water
3. predict the properties of other elements in the Group given data, where appropriate
4. describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour and state of matter; and state their reactions with other halide ions
5. predict the properties of other elements in the Group given data where appropriate
6. identify trends in other groups given information about the elements concerned

10 calculate stoichiometric reacting masses and volumes of gases and solutions, solution concentrations expressed in mol/dm^3 or g/dm^3 (Calculations based on limiting reactants may be set. Questions on the gas laws and the conversions of gaseous volumes to different temperatures and pressures will **not** be set.)
11. determine limiting reactants in a chemical reaction

C8.0 Chemical reactions

All learners should be able to:

C8.1 Production of energy
1. describe the use of hydrogen as a fuel e.g. in rockets
2. describe the use of uranium-235 as a source of energy
3. describe the production of electrical energy from simple cells i.e. two electrodes in an electrolyte (this should be linked with the reactivity series)

C8.2 Energetics of a reaction
1. describe, using examples, exothermic and endothermic reactions
2. describe bond breaking as endothermic and bond formation as exothermic
3. 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 using the formula $q = mc\Delta T$

C8.3 Speed of reaction
1. define speed of a reaction
2. define a catalyst
3. classify catalysts into inorganic and organic (enzymes) catalysts
4. investigate the effect of concentration, particle size, catalysts (including enzymes) and temperature on the speed of reactions
5. plot graphs and interpret data obtained from experiments concerned with speed of reaction
6. explain the effect of concentration, particle size, catalysts (including enzyme) and temperature on the speed of reactions in terms of the collision theory
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)
8. devise and explain a suitable method for investigating the effect of a given variable on the speed of a reaction

C8.4 Redox
1. define oxidation and reduction in terms of oxygen/hydrogen gain/loss
2. define oxidation and reduction in terms of electron transfer limited to the formation of binary compounds
3. identify redox reactions
4. show awareness that light can provide energy needed for certain chemical reactions by:
   - describing the use of silver salts in photography i.e. reduction of silver ions to silver
   - stating that photosynthesis leads to the production of glucose from carbon dioxide and water in the presence of chlorophyll and sunlight (energy)

C9.0 Acids, bases and salts

All learners should be able to:

C9.1 Characteristics and properties of acids and bases
1. define acids and bases in terms of proton transfer, limited to aqueous solutions
2. list common examples of acids and bases
3. define alkalis as soluble bases
4. describe the characteristic properties of acids as in their reactions with metals, bases, carbonates and their effect on indicators, e.g. litmus paper, Universal indicator, phenolphthalein
5. describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator and pH chart
6. use the ideas of acidity, alkalinity and neutrality to explain acid/base reactions
7. describe and explain applications of neutralisation e.g. laboratory preparation of salts; use of lime to control acidity in soil and water; and antacids (e.g. bicarbonate of soda) to control stomach acid

C9.2 Types of oxides
1. classify oxides as either basic or acidic related to metallic and non-metallic character of the element forming the oxide.
2. classify other oxides as neutral or amphoteric given sufficient information

C9.3 Preparation of salts
1. describe and prepare soluble salts from bases, carbonates, metals and ammonium salts
2. prepare, separate and purify insoluble salts (see C3.1 – Methods of purification)

C9.4 Identification of ions
describe and use the following tests to identify:

C9.4.1 Aqueous cations
ammonium, calcium, copper(II), iron(II), iron(III) and zinc using aqueous sodium hydroxide and aqueous ammonia as appropriate. (Formulae of complex ions are **not** required)

C9.4.2 Aqueous anions
carbonate (by reaction with dilute acid and then lime water), chloride (by reaction under acidic conditions with aqueous silver nitrate), iodide (by reaction under acidic conditions with aqueous lead(II) nitrate/aqueous silver nitrate), nitrate (by reduction with aluminium to ammonia) and sulfate (by reaction under acidic conditions with aqueous barium ions)

C9.5 Identification of gases
1. identify carbon dioxide using limewater
2. identify hydrogen using a lighted splint
3. identify oxygen using a glowing splint
4. identify ammonia using damp litmus paper
5. identify chlorine using damp litmus paper

C10.0 Metals

C10.1 Properties
All learners should be able to:
compare the general physical and chemical properties of metals with those of non-metals

C10.2 Reactivity series
1. place in order of reactivity: calcium, aluminium, copper, (hydrogen), iron, magnesium, potassium, sodium, zinc and gold by reference to their reactions, if any, with aqueous ions of other metals, reaction with: water, steam and dilute hydrochloric acid
2. account for the apparent unreactivity of aluminium in terms of the oxide layer adhering to the metal
3. deduce an order of reactivity from a given set of experimental results
4. design experiments to investigate the order of reactivity of metals

C10.3 Extraction of metals
1. describe the ease in obtaining metals from their ores by relating the elements to the reactivity series.
2. name metals that occur native including copper and gold
3. name the main ores of aluminium, copper and iron
4. describe the essential reactions in the extraction of iron in the Blast Furnace
5. outline the manufacture of aluminium from pure aluminium oxide using electrolysis
6. describe the importance of conserving resources
7. describe the environmental impact of the mining and extraction of metals on vegetation, human beings and animals

C10.4 Uses of metals
1. define an alloy
2. state the composition of elements in the following alloys: brass, bronze, mild steel and stainless steel
3. draw the structural diagrams to show how atoms of other elements can change the properties of the main element in an alloy
4. explain why alloying affects the properties of metals
5. state the important uses of alloys: brass, bronze, mild steel and stainless steel
6. state the uses of aluminium (aircraft bodies and food containers), and copper (electrical wiring, cooking utensils) related to their properties
7. state the uses of zinc for galvanizing and making brass

C11.0 Electricity and chemistry

All learners should be able to:
1. describe electrolysis
2. draw a labelled circuit diagram for an electrolytic cell, using the terms electrode, electrolyte, anode and cathode
3. describe the electrode products formed in the electrolysis of copper(II) chloride (aqueous solution) between inert electrodes (platinum or carbon)

4. describe electrolysis in terms of the ions present and reactions at the electrodes in examples given.
5. state the general principle that metals or hydrogen are formed at the negative electrode and that oxygen or halogens are formed at the positive electrode
6. outline the manufacture of chlorine and sodium hydroxide from concentrated aqueous sodium chloride (starting materials and essential conditions should be given)
7. describe the electrolysis of dilute sulfuric acid (as essentially the electrolysis of water).
8. predict the likely products of the electrolysis of a specified binary compound in the molten state or in aqueous solution
9. construct equations for the electrode reactions involved in the manufacture of aluminium, chlorine and sodium hydroxide
10. describe the process of electroplating of metals

C12.0 Non-metals

All learners should be able to:

C12.1 Air

1. describe the volume composition of air
2. describe the fractional distillation of liquid air to obtain oxygen gas, nitrogen gas and the noble gases for industrial use
3. name common pollutants in air as carbon monoxide, sulfur dioxide, oxides of nitrogen, lead compounds, chlorofluorocarbons (CFCs) and excess carbon dioxide
4. describe the sources of each of the pollutants:
   - carbon monoxide from incomplete combustion of carbon-containing compounds,
   - sulfur dioxide from the combustion of fossil fuels containing sulfur compounds leading to 'acid' rain,
   - oxides of nitrogen from car exhausts,
   - lead compounds from car exhausts,
   - excess carbon dioxide from the combustion of fuels and
   - CFCs from aerosol sprays
5. state adverse effects of the pollutants on:
   - buildings (SO_2 and oxides of nitrogen),
   - plants (SO_2 and oxides of nitrogen)
   - health (oxides of nitrogen, sulfur dioxide, lead compounds, carbon monoxide)
   - the ozone layer (CFCs)
6. state the composition of catalytic converters in car exhaust systems (palladium, platinum and rhodium)
7. explain the importance of catalytic converters in car exhaust systems to remove carbon monoxide and oxides of nitrogen
8. describe the role of carbon dioxide in global warming
9. describe the role of ozone in absorbing ultraviolet (UV) radiation

C12.2 Water

1. describe and perform a chemical test for water using anhydrous copper(II) sulfate or cobalt(II) chloride
2. distinguish between the ion content of soft and hard water
3. distinguish between temporary hardness and permanent hardness
4. state advantages and disadvantages of hard water as having health, domestic and industrial implications
5. describe how hard water can be made soft by boiling, distillation and by using an ion exchanger
6. describe, in outline, the purification of water in terms of filtration, sedimentation and chlorination

C12.3 Hydrogen

1. name the uses of hydrogen in the manufacture of ammonia, margarine (see C13.6 – Organic Chemistry) and as a fuel in rockets
2. describe the preparation, collection and properties of hydrogen
3. describe formation of hydrogen as a product of electrolysis of water (see C11.7 – Electricity and Chemistry)

C12.4 Oxygen

1. describe the combustion of elements e.g. magnesium
2. describe the properties of oxygen
3. describe the preparation and collection of oxygen using potassium manganate (VII) and hydrogen peroxide
4. state the uses of oxygen including use in oxygen tents, in hospitals and with acetylene in welding
5. describe, in simple terms, respiration, combustion and rusting
6. investigate the conditions necessary for rusting to occur
7. describe methods of rust prevention: paint and other coatings e.g., galvanising to exclude oxygen
8. explain sacrificial protection in terms of the reactivity of zinc and iron

C12.5 Carbon dioxide

1. describe formation of carbon dioxide from:
   - the complete combustion of carbon containing substances
   - as a product of respiration
   - and as a product of the reaction between an acid and a carbonate
2. describe the preparation, collection and properties of carbon dioxide

C12.6 Nitrogen

1. describe the need for nitrogen, phosphorus and potassium compounds in plant life
2. describe the essential conditions in the manufacture of ammonia by the Haber process
3. explain why the conditions used in the manufacture of ammonia are essential to obtaining the best yield of ammonia
4. name the uses of ammonia in the manufacture of fertilisers e.g. ammonium sulfate, ammonium nitrate and in the manufacture of household detergents

C12.7 Carbon and carbonates

1. define allotropy
2. name the allotropes of carbon as diamond, graphene and graphite
3. describe the manufacture of calcium oxide (quick lime) in a kiln from calcium carbonate (limestone) in terms of the chemical reaction involved.
4. state some uses of lime and slaked lime in treating acidic soil and neutralising acidic industrial waste products.
5. describe the uses of calcium carbonate in the manufacture of iron, glass and cement
6. interpret the ease of decomposition of metal carbonates in terms of the reactivity series

C13.0 Organic chemistry

All learners should be able to:

C13.1 Name of compounds

1. name, and draw the structure of unbranched alkanes, alkenes, alcohols and acids containing up to six carbon atoms; and the products of the reactions stated in C13.5 -C13.8
2. state the type of compound present given a chemical name, ending in *-ane, -ene, -ol* or *-oic acid* or a molecular structure

C13.2 Fuels

1. name as fuels coal, natural gas and petroleum
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

C13.3 Uses of petroleum fractions

1. name the uses of the fractions:
   - liquefied petroleum gas, as a fuel for cooking,
   - petrol in petrol engines,
   - the paraffin fraction in oil stoves and aircraft fuel,
   - the diesel fraction for fuel in diesel engines,
   - the lubricating fraction for lubricants and making waxes and polishes,
   - bitumen for making roads.
2. discuss the hazards associated with the use of petroleum fractions

C13.4 Homologous series

1. describe the homologous series as a 'family' of similar compounds with similar properties due to the presence of the same functional group
2. describe the general characteristics of a homologous series

C13.5 Alkanes

1 describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning.
2. predict the structures of longer–chained alkanes given the number of carbon atoms
3. explain physical trends in their density, state of matter, melting and boiling points

C13.6 Alkenes

1. describe the catalytic and thermal cracking of alkanes
2. explain why cracking of longer chain alkanes to manufacture alkenes and hydrogen is an important industrial process
3. describe the properties of alkenes in terms of:
   (a) combustion,
   (b) addition reactions with
   - bromine

- hydrogen
- and steam

4. distinguish between saturated and unsaturated hydrocarbons from molecular structures and by simple chemical tests (use of bromine and potassium manganate (VII)).

C13.7 Alcohols

1. describe the formation of ethanol by the catalytic addition of steam to ethene
2. describe the formation of ethanol (and carbon dioxide) by fermentation and its importance to the wine and brewing industry.
3. describe the properties of alcohols in terms of combustion and dehydration
4. state the uses of ethanol as:
   - a solvent,
   - a fuel,
   - for sterilisation.
   - as a constituent of alcoholic beverages
5. state the advantage of using alcohol as a fuel over petrol

C13.8 Carboxylic acids

1. describe the formation of ethanoic acid by the
   - oxidation of ethanol
   - the action of atmospheric oxygen
2. describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate), a sweet-smelling compound
3. state the uses of esters as components of flavouring and perfumes

C13.9 Macromolecules

1. describe macromolecules (polymers) in terms of large molecules built up from small units (monomers), different macromolecules having different units and/ or different linkages.
2. classify macromolecules as man-made/synthetic (poly(ethene), terylene, nylon) and natural (fats, proteins, carbohydrates)
3. state the monomers of the natural and synthetic macromolecules (carbohydrates, fats, nylon, poly(ethene), proteins and terylene)
4. describe the formation of poly(ethene) as an example of addition polymerisation of monomer units
5. explain why non-biodegradable plastics cause serious pollution problems
6. describe the formation of carbohydrates, fats and proteins, nylon and terylene macromolecules as examples of condensation polymerisation
7. draw part - structures of the following macromolecules:
   - poly(ethene),
   - nylon,
   - terylene,
   - fats,
   - proteins
   - and carbohydrates macromolecules
8. identify monomers from the structures of given macromolecules