Eswatini General Certificate of Secondary Education

Examinations Council of Eswatini

PHYSICAL SCIENCE
SYLLABUS
Subject Code : 6888

For Examinations in 2024 - 2026

TABLE OF CONTENTS

ESWATINI 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.

Eswatini's National Education Policy Directives

EGCSE 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 Eswatini 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

INTRODUCTION

The Eswatini General Certificate of Secondary Education (EGCSE) 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 EGCSE 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.

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.

PURPOSE

The EGCSE syllabus prepares students for life, helping them develop an informed curiosity and a lasting passion for learning, by equipping them with problem solving skills useful in everyday life.

PROGRESSION

EGCSE Physical Science qualification enables candidates to further their studies at tertiary institutions in Eswatini.

TEACHING HOURS

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

TEACHER SUPPORT MATERIAL

A wide range of materials and resources are available to support teachers in Eswatini schools. The resources suit a variety of teaching methods in the local context. Through targeted training forums, teachers can access the expert advice they need for teaching this syllabus.

EXAM PREPARATION RESOURCES

Examination reports, syllabuses, past papers and specimen papers are available on ECESWA website
www.examscouncil.org.sz

SPECIAL REQUIREMENTS

Laboratories furnished with functional equipment for conducting practicals.

AVAILABLE GRADES

Candidates in this syllabus are eligible for Grades A* to G.

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 EGCSE 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 EGCSE 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 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.

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, identify, 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.

SCHEME OF ASSESSMENT

All candidates must enter for three papers. These will be Paper 1, Paper 2, and **one** from the practical assessment papers, Paper 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-C14) and Physics (P1-P13).
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 thermometers)
- time (stopwatch- analogue and digital)
- potential difference (voltmeter)
- current (ammeter)
- length (metre rule, 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 Introduction to Chemistry

All learners should be able to:

1. Use and describe how to use measuring cylinders, burettes and pipettes to measure the volume of liquids

C2.0 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

C3.0 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

C4.0 Experimental techniques

C4.1 Methods of purification
All learners should be able to:
1. describe methods of purification by use of a suitable solvent, filtration, evaporation, crystallisation, distillation (simple and fractional), separating funnel and sublimation

C4.2 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

C5.0 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

C6. 0 The Periodic Table

All learners should be able to:

C6.1 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

C6.2 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

C6.3 Transition elements
1. investigate the characteristic physical properties (density, fixed points, hardness, conductivity and colours of compounds) and chemical properties (variable oxidation states) of the transition metals and their compounds, exemplified by copper and iron
2. state the use of transition elements as catalysts

C6.4 Noble gases
1. describe the noble gases as being unreactive
2. describe the uses of noble gases in providing an inert atmosphere, e.g., argon in lamps; helium for filling weather balloons

C7. 0 Atomic structure and bonding

C7.1 Atomic structure

All learners should be able to:
1. describe the simple structure of atoms in terms of neutrons, protons and electrons
2. state relative charges and approximate relative masses of protons, neutrons and electrons
3. define proton (atomic) number and nucleon number
4. deduce information from the notation $^{A}_{Z}X$ for an atom
5. describe the build-up of electrons in shells with special reference to the elements with protons numbers from 1 to 20
6. describe the significance of the outermost electrons and the noble gas electronic configuration
7. define isotopes (The ideas of the distribution of electrons in s- and p-orbitals and in d-block elements are **not** required.)

C7.2 Bonding

C7.2.1 Ions and ionic bonds
1. describe the formation of ions by electron loss or gain
2. describe the formation of ionic bonds between the alkali metals and the halogens
3. describe the formation of ionic bonds between metallic and non-metallic elements
4. draw 'dot and cross' diagrams to show the formation of ionic bonds

C7.2.2 Molecules and covalent bonds
1. describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4 and HCl as the sharing of pairs of electrons leading to the noble gas configuration
2. draw 'dot and cross' diagrams to show the formation of single covalent bonds
3. describe the electron arrangement in more complex molecules such as N_2, C_2H_4, CH_3OH and CO_2
4. investigate the differences in volatility (including melting point and boiling point), solubility and electrical conductivity between ionic and covalent compounds

C7.2.3 Macromolecules
1. describe the structure of
   - graphite
   - diamond
   - graphene
2. relate these structures to their melting points, conductivities, hardness and uses

C7.2.4 Metallic bonding
1. describe metallic bonding
2. use metallic bonding to describe the electrical conductivity and malleability of metals

C8.0 Stoichiometry

All learners should be able to:

1. use the symbols of the elements and write the formulae of simple compounds found in the syllabus
2. deduce formulae of simple compounds from relative numbers of atoms present
3. determine the formula of an ionic compound from the charges of the ions present
4. construct word equations and simple balanced chemical equations
5   deduce the balanced equation of a chemical reaction given relevant information
6. define relative atomic mass (A_r), relative molecular mass (M_r) and relative formula mass *(RFM)*
7. calculate M_r and RFM as the sum of the relative atomic masses
8. calculate the percentage of mass of components of a compound
9. use the mole and the Avogadro's Constant
10. use molar gas volume taken as 24 dm^3 at room temperature and pressure
11. 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 examined. Questions on the gas laws and the conversions of gaseous volumes to different temperatures and pressures will **not** be examined.)
12. calculate the empirical formulae of a compound
13. deduce the molecular formulae from the empirical formulae given the molar mass
14. determine limiting reactants in a chemical reaction

C9.0 Chemical reactions

All learners should be able to:

C9.1 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)

C9.2 Energetics of a reaction
1. describe, using examples, exothermic and endothermic reactions
2. describe bond breaking as endothermic and bond formation as exothermic
3. describe net energy change of a reaction as either endothermic or exothermic given the relevant information
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 using the formula

$Q = mc\Delta T$

C9.3 Speed of a reaction
1. define speed of a reaction
2. define a catalyst
3. classify catalysts into inorganic and organic (enzymes)
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 a 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

C9.4 Redox
1. describe oxidation and reduction in terms of:
    *   oxygen/hydrogen gain/loss
    *   electron transfer limited to the formation of binary compounds
2. identify redox reactions
3. 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)

C10.0 Acids, bases and salts

All learners should be able to:

C10.1 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

C10.2 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

C10.3 Preparation of salts
1. describe and prepare soluble salts from bases, carbonates, metals and ammonium salts
2. prepare, separate and purify insoluble salts (see C4.1 – Methods of purification)

C10.4 Identification of ions
describe and use the following tests to identify:
_____

C10.4.1 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)
_____

C10.4.2 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)

C10.5 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

C11.0 Metals

C11.1 Properties
All learners should be able to:
compare the general physical and chemical properties of metals with those of non-metals

C11.2 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

C11.3 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

C11.4 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 (electrical cables, aircraft bodies and food containers), and copper (electrical wiring, cooking utensils) related to their properties
7. state the uses of zinc for galvanising and making brass

C12.0 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. distinguish between an aqueous solution and a molten compound
4. describe the electrode products formed in the electrolysis of copper(II) chloride (aqueous solution) between inert electrodes (platinum or carbon)
5. describe electrolysis in terms of the ions present and reactions at the electrodes in examples given
6. 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
7. outline the manufacture of chlorine and sodium hydroxide from concentrated aqueous sodium chloride (starting materials and essential conditions should be given)
8. describe the electrolysis of dilute sulfuric acid (as essentially the electrolysis of water)
9. predict the likely products of the electrolysis of a specified binary compound in the molten state or in aqueous solution
10. construct equations for the electrode reactions involved in the manufacture of aluminium, chlorine and sodium hydroxide
11. describe the process of electroplating of metals

C13.0 Non-metals

All learners should be able to:

C13.1 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

C13.2 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

C13.3 Hydrogen
1. name the uses of hydrogen in the manufacture of ammonia, margarine (see C14.6 – 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 C12.7 – Electricity and Chemistry)

C13.4 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

C13.5 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
3. state the uses of carbon dioxide including use in fire extinguishers and fizzy drinks

C13.6 Nitrogen
1. describe the preparation of nitrogen by fractional distillation of liquid air
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
5. describe the need for nitrogen, phosphorus and potassium compounds in plant life

C13.7 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

C14.0. Organic chemistry

All learners should be able to:
C14.1 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 C14.5 -C14.8
2. distinguish between the molecular and structural formula of alkanes, alkenes, alcohols and acids
3. state the type of compound present given a chemical name, ending in *-ane, -ene, -ol* or *-oic acid* or a molecular structure

C14.2 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

C14.3 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 in terms of flammability and harm to the environment

C14.4 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

C14.5 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

C14.6 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))

C14.7 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 sterilization
   - as a constituent of alcoholic beverages
5. state the advantage of using alcohol as a fuel over petrol

C14.8 Carboxylic acids

1. describe the formation of ethanoic acid by the
   - oxidation of ethanol using potassium dichromate(VI)
   - 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. draw the structure of ethyl ethanoate
4. identify the ester linkage structure in ethyl ethanoate
5. state the uses of esters as components of flavouring and perfumes

C14.9 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 (at least four monomer units):
    *   poly(ethene),
    *   nylon,
    *   terylene,
    *   fats,
    *   proteins
    *   and carbohydrates macromolecules
8. identify monomers from the structures of given macromolecules with reference to structures in C14.9.7

PHYSICS SECTION

P1.0 Introduction to Physics

All learners should be able to:

1. name quantities and their units including base SI units
2. use and describe how to use metre rules, micrometer screw gauge, vernier callipers to determine length and volume of regular objects
3. use and describe how to use clocks and other devices for measuring an interval of time including the period of a pendulum
4. use suitable balances to measure mass of solids and liquids
5. measure the volume of regular and irregular objects using the displacement method
6. determine density
7. state that an object floats when put in a liquid of higher density than it
8. work with significant figures (see Mathematical requirements on page 30)

P2.0 Speed, velocity and acceleration

All learners should be able to:

1. define speed and velocity

2. calculate speed/velocity from: speed = total distance ÷ time

3. identify speed as a scalar quantity and velocity as a vector quantity
4. define acceleration
5. recognise from a speed-time graph when a body is (a) at rest, (b) moving with constant speed, (c) moving with constant acceleration and calculate the acceleration
6. plot and interpret speed-time graphs
7. calculate the area under a speed-time graph to determine the distance travelled for motion with constant acceleration
8. state that the acceleration of free-fall, g, for a body near to the Earth is constant ($g = 10 \, m/s^2$)
9. recognise and interpret graphs of motion for which the acceleration is not constant
10. describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)
11. describe some applications on terminal velocity including reference to parachutes and hailstones

P3.0 Mass and force

All learners should be able to:

P3.1 Mass and weight
1. define mass as the measure of the amount of matter in a body
2. demonstrate an understanding that inertia is the property of mass to resist change in motion
3. state that weight is a force
4. measure the weight of a body using appropriate balances
5. describe, and use the concept of weight as the effect of a gravitational field on a mass
6. calculate the weight of a body from its mass (w = mg)
7. describe how weights (and hence masses) can be compared using a balance

P3.2 Forces and stretching
1. define the elasticity of an object
2. perform and describe extension-load experiments
3. plot and interpret extension-load graphs (Hooke's Law as such is **not** required)
4. identify and interpret the significance of the term 'limit of proportionality' for an extension-load graph
5. use proportionality in simple calculations

P3.3 Forces and motion
1. describe the ways in which a force may change the motion of a body
2. describe friction
3. state the advantages and disadvantages of friction
4. use the relationship between force, mass and acceleration (F = ma)

P3.4 Moments
1. describe the moment of a force as a measure of its turning effect and give everyday examples
2. calculate the moment of a force given the necessary information
3. define centre of mass
4. perform and describe an experiment to determine the position of the centre of mass of a plane lamina
5. describe qualitatively the effect of the position of the centre of mass on the stability of simple objects
6. state the principle of moments
7. perform and describe an experiment (involving vertical forces) to verify that there is no net moment on a body in equilibrium (including calculations)

P4.0 Work, energy and power

All learners should be able to:

P4.1 Work
1. recognise that work is done against an opposing force
2. recall and use the equation work done = force x distance moved in the direction of force

P4.2 Energy
1. relate energy transfer to work done and state the unit of energy as the joule, J
2. identify different forms of energy including kinetic and potential energy

P4.3 Energy conversion and conservation
1. use the terms kinetic and potential energy in context
2. give examples of conversion and conservation of energy and apply the principle of conservation to simple examples
3. describe energy transfer in terms of work done and make calculations using Work = F x d
4. describe processes by which energy is converted from one form to another, including reference to:
- chemical/fuel energy (a regrouping of atoms)
- energy from water (hydroelectric energy, tides, waves)
- geothermal energy
- wind energy (wind mills, wind turbines, sailing boats and ships)
- nuclear energy (nuclear fission)
- nuclear fusion: solar energy (fusion of atoms in the Sun)
5. recall and use the equations k.e.= $\frac{1}{2}mv^2$, p.e. = mgh
6. identify examples of energy changes that are less than 100% efficient and explain why this happens

P4.4 Power
1. define power as energy transferred (work done) per unit time
2. recall and use the equation P = E/t = work/t in simple systems

P5.0 Waves

All learners should be able to:

P5.1 Wave properties
1. describe what is meant by wave motion as illustrated by vibrations in ropes, springs and by experiments using water waves
2. name and identify longitudinal and transverse waves; and distinguish between longitudinal and transverse waves
3. define and draw wavefronts
4. state what is meant by wave speed, frequency, wavelength and amplitude
5. identify a crest, trough, amplitude and wavelength in a wave diagram
6. demonstrate the use of water waves to show:
- reflection at a plane surface,
- refraction due to a change of speed
- diffraction through a narrow gap and a wide gap
7. describe reflection, diffraction and refraction in water
8. describe some applications of diffraction including radio transmissions
9. recall and use the equation $v = f\lambda$

P5.2 Light
1. perform and describe experiments to find the position of an optical image formed by a plane mirror
2. state the characteristics of an optical image formed by a plane mirror
3. perform simple constructions, measurements and calculations to show reflection of light and formation of images by a plane mirror
4. use the law: angle of incidence = angle of reflection
5. describe refraction, including the angle of refraction, in terms of the passage of light through a parallel sided glass block
6. explain *apparent depth* using the refraction of light in water
7. determine and calculate the refractive index using $n = \sin i / \sin r$
8. describe the action of thin lenses (concave and convex lenses) on light rays
9. perform an experiment to find the focal point and the focal length of a thin converging lens
10. perform simple constructions to show the action of a thin converging lens on light rays
11. use and describe the use of a convex lens as a magnifying glass

P 5.3 Electromagnetic spectrum
1. describe the main features of the electromagnetic spectrum and state that all electromagnetic (e.m.) waves travel at the same speed in a vacuum
2. state the approximate value of the speed of the electromagnetic waves in a vacuum
3. state the everyday applications of e.m. waves such as in microwave ovens, mobile phones, medical use, wireless communication (radio, Bluetooth, Wi-Fi), etc
4. state the dangers of exposure to e.m. waves

P 5.4 Sound
1. state that sound waves are longitudinal
2. state the approximate range of audible frequencies
3. explain why a medium is required for the transmission of sound waves
4. relate the loudness and pitch of sound waves to amplitude and frequency
5. describe how the reflection of sound may produce echoes
6. describe an experiment to determine the speed of sound in air and make the necessary calculations

P6.0 Thermal Physics

All learners should be able to:

P 6.1 Expansion and contraction
1. describe, using the kinetic theory, the thermal expansion/contraction of solids, liquids and gases
2. explain in terms of intermolecular forces why solids, liquids and gases expand with temperature at different rates
3. identify and describe some of the everyday applications and consequences of thermal expansion/contraction including bimetallic strips in thermostats

P6.2 Thermometry
1. describe how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties (volume, potential difference, resistance)
2. describe how to determine the fixed points and use them to calibrate a thermometer

3. describe the structure and function of liquid-in-glass thermometers
4. demonstrate understanding of sensitivity, range and linearity
5. describe the safe disposal of mercury-in-glass thermometers
6. describe the structure and action of a thermocouple and show understanding of its use for measuring high temperatures and those which vary rapidly

P6.3 Change of state
1. describe the difference between boiling and evaporation
2. state the meaning of melting point and boiling point in terms of energy input without change in temperature

P6.4 Thermal energy transfer
1. describe experiments to demonstrate the good and bad conductors of heat
2. describe how thermal energy is transferred in solids in terms of molecular vibrations and free electrons
3. relate convection in fluids to density changes and describe experiments to illustrate convection
4. identify infra-red radiation as electromagnetic radiation
5. describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation
6. identify and explain some of the everyday applications and consequences of conduction, convection and radiation

P7.0 Electrostatics

All learners should be able to:
1. describe simple experiments to show the production of electrostatic charges in terms of electron transfer
2. describe the detection of electrostatic charges
3. state that there are positive and negative charges
4. state that like charges repel and unlike charges attract
5. state that charge is measured in Coulombs
6. carry out and interpret experiments with the electroscope
7. explain in simple terms the occurrence of the phenomenon of lightning

P8.0 Electricity

All learners should be able to:

P8.1 Current and potential difference
1. define current as the rate of flow of charge
2. distinguish between conventional current flow and electron current flow
3. recall and use the equation $I = Q/t$
4. use and describe the use of ammeters and voltmeters in measuring current and potential difference
5. state that electromotive force (e.m.f.) of a source of electrical energy is measured in volts
6. describe how e.m.f. is defined in terms of energy supplied by a source in driving a unit charge round a complete circuit
7. distinguish between e.m.f. and potential difference

P8.2 Resistance
1. state that resistance = p.d. ÷ current
2. describe an experiment to determine V/I characteristics for ohmic (metallic) conductors
3. plot and interpret the V/I characteristic graphs for ohmic (metallic) conductors
4. recall and use the equation $V = IR$
5. recall and use qualitatively the direct proportionality between resistance and the length and the inverse proportionality between resistance and cross-sectional area of a wire

P9.0 Electric Circuits

All learners should be able to:

P9.1 Basic circuits
1. draw and name symbols for sources, switches, resistors (fixed and variable), ammeters, voltmeters, bells, fuses, lamps, relays and diodes
2. draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), ammeters, voltmeters, bells, fuses, lamps, relays and diodes as rectifiers

P9.2 Resistors in series and parallel
1. state that current is the same at every point in a series circuit
2. state that for a parallel circuit, the current from the source is larger than the current in each branch
3. determine the combined resistance of two or more resistors in series
4. state that the combined resistance of two resistors in parallel is less than either resistor by itself

5. recall and use the fact that the sum of the potential differences across the components in a series circuit is equal to the total p.d. across the source
6. recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit
7. calculate the effective resistance of two resistors in parallel
8. recall and use the fact that the p.d. across separate branches of a parallel circuit is equal to p.d across a battery

P10.0 Practical electricity

All learners should be able to:

1. describe how to wire a three pin-plug
2. describe the uses of electricity in heating, lighting (including lamps in parallel) and motors
3. recall and use the equations $P = IV, E = IVt$
4. describe how a semiconductor such as silicon works
5. describe how energy savers (light emitting diodes (LEDs) and fluorescent lights) produce light
6. state the hazards of:
    - damaged insulation
    - overheating of cables
    - damp conditions
    - broken fluorescent lamps
7. describe and explain the use of electrical safety measures, to include:
    - fuses
    - double insulations
    - earthing
    - switches

P11.0 Magnetism

All learners should be able to:

Basic magnetism
1. state the properties of magnets
2. describe magnetic induction
3. distinguish between ferrous and non-ferrous materials
4. describe experiments to identify the pattern of field lines round a bar magnet and two bar magnets
5. distinguish between the magnetic properties of iron and steel
6. explain magnetism using simple domain theory

P12.0 Digital electronics

All learners should be able to:

1. explain and use the terms analogue and digital in terms of continuous variation and high/low states
2. describe the action of NOT, AND, OR, NAND and NOR gates
3. recall and use the symbols for logic gates
4. design and interpret simple digital circuits combining several logic gates
5. use truth tables to describe the action of individual gates and simple combinations of gates

P13.0 Electromagnetic effects

All learners should be able to:

P13.1 Electromagnets
1. state that a current carrying wire has a magnetic field
2. distinguish between the design of permanent magnets and electromagnets
3. state the factors affecting the strength of an electromagnet

P13.2 Electromagnetic induction
1. describe an experiment which shows 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. show understanding that the direction of an induced e.m.f. opposes the change causing it

4. describe a rotating coil generator and the use of slip rings
5. sketch a graph of voltage output against time for a simple a.c. generator
6. describe the function of a diode as a rectifier

P13.3 Electric Motor

1. state that a current carrying wire in a magnetic field experiences a force
2. explain why a current carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing the number of turns in the coil and by increasing the current
3. relate the turning effect of the current carrying coil to the action of an a.c. electric motor
4. describe applications of an a.c. motor including the control of an automated gate, hairdryers, fans

P13.4 Transformer

1. describe the principle of operation of a transformer
2. recall and use the equation $(V_p/V_s) = (N_p/N_s)$
3. recall and use the equation $V_pI_p = V_sI_s$ (for 100% efficiency)
4. describe energy loss in cables (no calculation)
5. describe the use of the transformer in high voltage transmission of electricity
6. state benefits of high voltage transmission

P14.0 Atomic Physics

All learners should be able to:

14.1 Nuclear atom
1. describe the composition of the nucleus in terms of protons and neutrons
2. use the term proton number (atomic number), Z
3. use the term nucleon number (mass number), *A*
4. use the term nuclide and nuclide notation $^A_Z X$
5. use the term isotope
6. give and explain examples of practical applications of isotopes

14.2 Radioactive emissions
1. show awareness of the existence of background radiation
2. state that radioactive emissions occur randomly over space and time
3. state the meaning of radioactive decay
4. describe the three types of radioactive emissions
5. describe the detection of α-particles, β-particles and γ–rays using a GM tube and cloud chamber
6. state, for the three types of radioactive emissions:
    - their nature
    - their relative ionising effect
    - and their relative penetrating abilities
7. describe their deflection in electric fields and magnetic fields
8. describe radioactive isotopes such as ^{235}U as a source of energy
9. describe how radioactive materials are handled, used and stored in a safe way

P14.3 Radioactive decay and half-life
1. use the nuclide notation in equations to show α and β decay
2. use equations to represent changes in composition of the nucleus during radioactive decay
3. define the term *half-life*
4. use the term *half-life* in simple calculations which might involve information in tables or decay curves

15.0 LED Monitors

All learners should be able to:
1. describe the simple structure of an LED (P-N junction)
2. describe the principle of the operation of an LED
3. explain how a light-emitting diode produces a picture in flat screen monitors

GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all candidates. Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The grade awarded will depend on the extent to which the candidate has met the assessment objectives overall and may conceal weakness in one aspect of the examination that is balanced by above-average performance on some other.

Grade A	Candidate must show mastery of the curriculum
	A candidate should be able to: • relate facts to principles and theories and vice versa; • state why particular techniques are preferred for a procedure or operation; • select and collate information from a number of sources and present it in a clear logical form; • 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 an hypothesis to explain facts, or find facts to support an hypothesis.
Grade C	Candidate must show a high level of competence in the curriculum.
	A candidate should be able to: • link 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 an hypothesis to explain a given set of facts or data.
Grade G	Candidate must show competence in the curriculum.
	A candidate should be able 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, or 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.

APPENDIX 1: ASSESSMENT CRITERIA FOR PRACTICALS

Practical Assessment

Scientific subjects are, by their nature, experimental. It is, accordingly, important that an assessment of a student's knowledge and understanding of Physical Science should contain a component relating to practical work and experimental skills (as identified by Assessment Objective C). In order to accommodate, within EGCSE, differing circumstances - such as the availability of resources - two alternative means of assessing Assessment Objective C objectives are provided, namely, a formal Practical test and a written Alternative to Practical paper, as outlined in the scheme of assessment.

Paper 3, Practical Test

CHEMISTRY
Candidates may be asked to carry out exercises involving:
- carry out the specified manipulation of the apparatus *(e.g. pipette a specified volume of solution, carry out specified qualitative tests);*
- take readings from a measuring device, including: reading a scale with appropriate precision/accuracy, consistent use of significant figures, interpolating between scale divisions, allowing for zero errors, where appropriate, taking repeated measurements to obtain an average value *(all exemplified by carrying out a simple acid/alkali titration)*
- record their observations systematically, with appropriate units;
- process their data, as required; present their data graphically, using suitable axes (appropriately labelled) and scales (plotted points should occupy at least half of the grid in both x- and y- axes);take readings from a graph by interpolation and extrapolation; determine gradient, intercept or intersection on a graph;
- draw and report a conclusion or result clearly;
- describe precaution taken in carrying out a procedure;
- give reasons for making a choice of items of apparatus;
- comment on a procedure used in an experiment and suggest an improvement.

  (*Notes for Use in Qualitative Analysis*, will be provided in the question paper.)

PHYSICS
Exercises may be set requiring the candidates to:
- follow written instructions for the assembly and use of provided apparatus (e.g., for using ray-tracing equipment, for wiring up simple electrical circuits);
- select, from given items, the measuring device suitable for the task;
- carry out the specified manipulation of the apparatus (e.g., when determining a (derived) quantity such as the extension per unit load for a spring, when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length, when comparing physical quantities such as the thermal capacity of two metals);
- take readings from a measuring device, including: reading a scale with appropriate precision/accuracy, consistent use of significant figures, interpolating between scale divisions, allowing for zero errors, where appropriate, taking repeated measurements to obtain an average value;
- record their observations systematically, with appropriate units;
- process their data, as required;
- present their data graphically, using suitable axes (appropriately labelled) and scales (plotted points should occupy at least half of the grid in both x- and y- axes);
- 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;
- indicate how they carried out a required instruction;
- describe precautions taken in carrying out a procedure;
- give reasons for making a choice of items of apparatus;
- comment on a procedure used in an experiment and suggest an improvement.

(Note: The examination will **not** require the use of textbooks nor will candidates need to have access to their own records of laboratory work made during their course; candidates will be expected to carry out the experiments from the instructions given in the paper.)

Paper 4, Alternative to Practical

This paper is designed to test candidates' familiarity with laboratory practical procedures.

Questions may be set requesting candidates to:

- describe in simple terms how they would carry out practical procedures; explain and /or comment critically on described procedures or points of practical detail;
- explain and/or comment critically on described procedures or points of practical detail;
- follow instructions for drawing diagrams;
- draw, complete and/or label diagrams;
- take readings from their own diagrams, drawn as instructed, and/or from printed diagrams including:
  - reading a scale with appropriate precision/accuracy and with consistent use of significant figures and with appropriate units,
  - interpolating between scale divisions,
  - taking repeat measurements to obtain an average value;
- process data;
- present data graphically, using appropriate axes and scales, plotting points accurately and drawing appropriate lines;
- take readings from a graph, including 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, apparatus to be used for particular 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, will **not** be provided in the question paper.)

APPENDIX 2: SYMBOLS, UNITS AND DEFINITIONS OF PHYSICAL QUANTITIES

Learners should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured.

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

Quantity	Symbol	Unit
wavelength	λ	mm, cm, m
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	kg, g
density	d, ρ	kg/m^3, g/cm^3
time	t	h, min, s
speed	u, v	km/h, m/s, cm/s
acceleration	a	m/s^2
acceleration of free fall	g	m/s^2
force	F	N
work done	w, E	J
energy	E	J
power	P	W
temperature	T	°C
focal length	f	cm, mm
angle of incidence	i	degree (°)
angle of reflection/refraction	r	degree (°)
potential difference/voltage	V	V, mV
current	I	A, mA
e.m.f.	$\mathscr{E}$	V
resistance	R	Ω
frequency	f	Hz

APPENDIX 3: NOTES FOR USE IN QUALITATIVE ANALYSIS

Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
Iodide ion (I^-) in solution]	Acidify with dilute nitric acid, and then add aqueous lead(II) nitrate/aqueous silver nitrate	yellow 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.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
ammonium (NH_4^+)	ammonia produced on warming	-
Calcium (Ca^{2+})	white ppt, insoluble in excess	no ppt or very slightly white ppt.
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

Tests 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

APPENDIX 4: Data Sheet - The Periodic Table of the Elements

DATA SHEET
The Periodic Table of the Elements

Group								
I	II		III	IV	V	VI	VII	0

				1 **H** Hydrogen 1				4 **He** Helium 2

Period 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 |

Period 3:
| 23 **Na** Sodium 11 | 24 **Mg** Magnesium 12 | 27 **A*l*** Aluminium 13 | 28 **Si** Silicon 14 | 31 **P** Phosphorus 15 | 32 **S** Sulfur 16 | 35.5 **C*l*** Chlorine 17 | 40 **Ar** Argon 18 |

Period 4:
| 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 |

Period 5:
| 85 **Rb** Rubidium 37 | 88 **Sr** Strontium 38 | 89 **Y** Yttrium 39 | 91 **Zr** Zirconium 40 | 93 **Nb** Niobium 41 | 96 **Mo** Molybdenum 42 | 98 **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 |

Period 6:
| 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 **T*l*** Thallium 81 | 207 **Pb** Lead 82 | 209 **Bi** Bismuth 83 | 209 **Po** Polonium 84 | 210 **At** Astatine 85 | 222 **Rn** Radon 86 |

Period 7:
| 223 **Fr** Francium 87 | 226 **Ra** Radium 88 | 227 **Ac** Actinium 89 † |

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

Lanthanoid series:
| 140 **Ce** Cerium 58 | 141 **Pr** Praseodymium 59 | 144 **Nd** Neodymium 60 | 147 **Pm** Promethium 61 | 150 **Sm** Samarium 62 | 152 **Eu** Europium 63 | 157 **Gd** Gadolinium 64 | 159 **Tb** Terbium 65 | 163 **Dy** Dysprosium 66 | 165 **Ho** Holmium 67 | 167 **Er** Erbium 68 | 169 **Tm** Thulium 69 | 173 **Yb** Ytterbium 70 | 175 **Lu** Lutetium 71 |

Actinoid series:
| 232 **Th** Thorium 90 | 231 **Pa** Protactinium 91 | 238 **U** Uranium 92 | 237 **Np** Neptunium 93 | 244 **Pu** Plutonium 94 | 243 **Am** Americium 95 | 247 **Cm** Curium 96 | 247 **Bk** Berkelium 97 | 251 **Cf** Californium 98 | 252 **Es** Einsteinium 99 | 257 **Fm** Fermium 100 | 258 **Md** Mendelevium 101 | 259 **No** Nobelium 102 | 260 **Lr** Lawrencium 103 |

Key

a
X
b

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

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

APPENDIX 5: APPARATUS LIST

The list below details the apparatus expected to be generally available for both the teaching and the examination of Paper 3. The list is not exhaustive: in particular, some items that are commonly regarded as standard equipment in a science laboratory are not included.

The *Confidential Instruction*s, provided to Centres prior to the examination of Paper 3, will give the detailed requirements for each examination.

- rulers capable of measuring to 1 mm
- metre rule
- means of writing on glassware
- beakers, 100 cm^3, 250 cm^3
- a polystyrene or other plastic beaker of approximate capacity 150 cm^3
- test-tubes (Pyrex or hard glass), approximately 125 mm × 16 mm
- boiling tubes, approximately 150 mm × 25 mm
- delivery tubes
- conical flasks, within the range 100 cm^3 to 250 cm^3
- measuring cylinders, within the range 10 cm^3 to100 cm^3
- dropping pipettes
- white tiles
- large containers (e.g. plastic bowl) to hold cold water
- thermometers, −10 °C to +110 °C with 1 °C graduations
- stop clocks (or wall clock or wrist-watch), to measure to an accuracy of 1 s
- glass rods
- spatulas
- wooden splints
- indicators (e.g. litmus paper, Universal Indicator paper, full range Universal Indicator)
- common reagents for tests (e.g. limewater test)
- burettes, 50 cm^3
- pipettes, 25 cm^3
- pipette fillers
- filter funnels and filter paper
- wash bottle
- an ammeter FSD 1 A, 1.5A
- voltmeter FSD 1 V, 5 V
- electrical cells (batteries) and holders to enable several cells to be joined
- connecting leads and crocodile clips
- d.c. power supply, variable to 12 V
- low-voltage filament lamps in holders
- various resistors and resistance wire
- switches
- good supply of masses and holders
- 2 cm expendable springs
- clamps and stands
- pendulum bobs
- newton meters
- plasticine or modelling clay

- wooden boards

- converging lens with $f = 156$ cm

- glass or Perspex block, rectangular and semi-circular

- glass or Perspex prism, triangular

- optics pins

- plane mirrors

- ray box

Note: the standard concentration for most laboratory stock solutions is usually 1 M.

APPENDIX 6: MATHEMATICAL REQUIREMENTS

Calculators may be used in all parts of the Assessment.

Candidates should be able to:

1. add, subtract, multiply and divide;

2. understand and use *averages, decimals, fractions, percentages, ratios* and *reciprocals;*

3. recognise and use standard notation;

4. use direct and inverse proportion;

5. use positive, whole number indices;

6. draw charts and graphs from given data;

7. interpret charts and graphs;

8. select suitable scales and axes for graphs;

9. make approximate evaluations of numerical expressions;

10. recognise and use the relationship between length, surface area and volume and their units on metric scales;

11. use usual mathematical instruments (ruler, compasses, protractor, set square);

12. understand the meaning of *angle, curve, circle, radius, diameter, square, parallelogram, rectangle, diagonal, vertical* and *horizontal;*

13. solve equations of the form $x = yz$ for any one term when the other two are known;

14. recognise and use points of the compass (N, S, E, W);

15. calculate to 3 significant figures if answer is not exact.

APPENDIX 7: GLOSSARY OF TERMS

It is hoped that the glossary will prove helpful to candidates as a guide, i.e., it is neither exhaustive nor definitive. The glossary has been deliberately kept brief 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.

In all questions, the number of marks allocated is shown on the examination paper, and should be used as a guide by candidates to how much detail to give or time to spend in answering. In describing a process, the mark allocation should guide the candidate about how many steps to include. In explaining why something happens, it guides the candidate on how many reasons to give, or how much detail to give for each reason.

CALCULATE   Used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

DEDUCE   Used in a 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).

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

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".

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

DISCUSS   Requires the candidate to give a critical account of the points involved in the topic.

ESTIMATE   Implies a reasoned order of 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.

EXPLAIN   May imply reasoning or some reference to theory, depending on the context.

FIND   Is a general term that may variously be interpreted as "Calculate", "Measure", "Determine", etc.

IDENTIFY   Requires the candidate to use given data to look for patterns, trends or locate a particular feature in a given diagram. Also, provide examples where a particular phenomenon is manifested or can be observed.

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.

MEASURE   Implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g., length using a rule, or mass using a balance).

OUTLINE   Implies brevity (i.e., restricting the answer to giving essentials).

PREDICT   Implies that the candidate is not expected to produce the required answer by recall but by 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.

SKETCH   When applied to graph work, 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.

STATE   Implies a concise answer with little or no supporting argument (e.g., a numerical answer that can readily be obtained 'by inspection').

SUGGEST   Used in two main contexts (i.e., 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').

WHAT DO YOU UNDERSTAND BY/WHAT IS MEANT BY: "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.

PERFORM   Perform an experiment in the syllabus implies that the 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.

INVESTIGATE   Investigate in the syllabus implies that the 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 above.

P. O. Box 1394, MBABANE
Tel: (+268) 2417 8000
Fax: (+268) 2416 2862
Email: registrar@examscouncil.org.sz
Website: www.examscouncil.org.sz