BOTSWANA
EXAMINATIONS
COUNCIL

BOTSWANA GENERAL CERTIFICATE
OF SECONDARY EDUCATION

ASSESSMENT SYLLABUS

SCIENCE DOUBLE AWARD

CODE 0569

Effective for examination from 2020

0569
CODE

Changes to Syllabus effective from 2020

The changes in this Assessment Syllabus are;

Syllabus Content

The syllabus content has **not** changed but the core and extended objectives have been combined to make the specific objectives.

Structure of Assessment

The assessment structure has **not** changed, however, the Theory paper and the Alternative to Practical paper have been renumbered. The papers are now:

Paper 1: Multiple Choice

Paper 2: Theory

Paper 3: Alternative to Practical Test

Reporting

The Grade descriptors have been revised to make them communicate better.

The grade descriptors for F have been replaced by grade descriptors for E.

Assessment Grid

The relationship between the assessment objectives and components is more detailed showing the number of marks for each assessment objective per component.

The Periodic Table

The Periodic Table has been revised to improve its relevance.

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1. Introduction

As part of the Botswana General Certificate of Secondary Education, this Science Double Award Assessment Syllabus is designed to assess the outcome of instruction for candidates who have completed a course based on the Senior Secondary Science Double Award Teaching Syllabus.

This syllabus aims to assess positive achievement at all levels of ability. Candidates will be assessed in ways that encourage them to show what they know, understand and can do, and which provide opportunities to articulate their insights, perceptions and responses.

This Science Double Award Assessment Syllabus should be read in conjunction with the Senior Secondary Science Double Award Teaching Syllabus

Progression

The BGCSE is a general qualification that enables candidates to progress either directly to employment or to proceed to further qualifications.

2. Scheme of Assessment

All candidates must take **three** papers; Paper 1, Paper 2 and Paper 3, which are described below. The questions will be based on the whole syllabus.

2.1 The components

All candidates must take:

Paper 1 1 hour 30 minutes
Multiple Choice

A Multiple-Choice paper consisting of 60 items each with four options.

The questions will test skills in **Assessment Objectives 1 (AO 1)** and **2 (AO 2)** and will be of a difficulty appropriate to grades A to G.

The paper will be weighted at 30% of the final total mark

Paper 2 2 hours
Theory

A written paper consisting of short-answer and structured questions.

The questions will test skills in **Assessment Objectives 1 (AO 1)** and **2 (AO 2)** and will be of a difficulty appropriate to grades A to G.

100 marks.

The paper will be weighted at 50% of the final total marks

Paper 3 1 hour 30 minutes
Alternative to Practical Test

This paper will test **Assessment Objective 3 (AO 3).** It is designed to test familiarity with laboratory equipment and procedures.

The paper will be of difficulty appropriate to grades A to G.

60 marks.

The paper will be weighted at 20% of the final total marks

2.2 Availability

This syllabus is available to both school candidates and private candidates.

2.3 Combining this syllabus with other syllabuses

Candidates may **not** combine this syllabus in an examination series with the following:

- 0568 Science Single Award
- 0570 Chemistry
- 0571 Physics
- 0572 Biology
- 0573 Human and Social Biology

3. Syllabus Aims and Assessment Objectives

3.1 Aims

According to the Science Double Award Teaching Syllabus, candidates following the syllabus should:

1. develop manipulative skills to assist them in solving technical and technological problems as they relate to day-to-day life situations.

2. become confident citizens in a technological world to make informed decisions in matters of scientific interest.

3. develop desirable attitudes and behavioural patterns in interacting with the environment in a manner that is protective, preserving, developmental and nurturing.

4. develop an understanding of the applications of science and of the technological, economic, ethical and social implications of these.

5. develop an understanding of the significance of information and communication technology in the day-to-day life situations and the world of work.

6. acquire knowledge, attitudes and practices that will promote good family life and health including awareness and management of epidemics such as HIV / AIDS practices that prepare them for productive life.

7. develop positive attitudes such as open-mindedness, inventiveness, concern for accuracy and precision, objectivity, integrity and initiative towards scientific skills

8. develop an interest in and an enjoyment of science and science related-work.

9. develop an understanding of key concepts and principles of science as they are experienced in everyday life.

10. develop abilities and skills that are relevant to the study, safe practice and application of science (such as experimenting and investigating).

11. develop problem solving, critical thinking, communication, inquiry and teamwork / interpersonal skills to help them to be productive and adaptive to cope in a changing environment.

12. develop an appreciation of the role of science in improving the quality of life.

13. recognise the usefulness of science, and limitations of scientific method.

14. promote an awareness that the applications of science may be both beneficial and detrimental to the individual, the community and the environment.

3.2 Assessment Objectives

The main Assessment Objectives are:

AO1 Knowledge with Understanding

AO2 Handling Information and Problem Solving

AO3 Experimental Skills and Investigations

A description of each assessment objective is:

AO1 Knowledge with Understanding

Candidate should be able to demonstrate knowledge and understanding of:

1. the concepts, laws, theories and principles of Science;
2. the vocabulary, terminology and conventions of Science, including symbols, quantities and units;
3. applications of Science and of their technological, economic, environmental and social implications;
4. the significance of information and communication technology in the day-to-day life and in the world of work.

Questions assessing these objectives will often begin with words such as *define, state, describe, outline, etc.*

AO2 Handling Information and Solving Problems

Candidates should be able to:

1. solve problems as they relate to day-to-day life, including some of a quantitative nature;
2. use information to identify patterns, report trends, draw inferences, make predictions and propose hypotheses;
3. locate, select, organise and present information from a variety of sources;
4. translate information from one form to another;
5. manipulate numerical and other data;
6. present explanations for phenomena, patterns and relationships.

Questions assessing these objectives may contain information which is unfamiliar to candidates. In answering such questions, candidates are required to take principles and concepts in the syllabus and apply them to the situations described in the questions.

Questions assessing these objectives will often begin with words such as *discuss*, *predict*, *suggest*, *calculate*, *determine, etc*.

AO3 Experimental Skills and Investigations

Candidates should be able to:

1. follow a sequence of instructions;
2. use appropriate techniques, apparatus and materials;
3. make and record observations, measurements and estimates;
4. interpret and evaluate observations and data;
5. plan investigations and / or evaluate methods and suggest possible improvements;
6. convert acquired skills into creative innovations;
7. apply knowledge and draw conclusions in practical situations.

3.3 Relationship between Assessment Objectives and Components

The table shows the raw marks and the weighting of each skill area by component as well as the total for each skill area in the overall assessment.

Assessment Objectives		Marks for Skill Areas and Weightings in Paper			Weighting of AO in qualification
		Paper 1	Paper 2	Paper 3	
AO1: Knowledge with Understanding	recall	19 ± 2 (30 %)	31 ± 2 (30 %)	–	50 %
	understanding	19 ± 2 (33 %)	31 ± 2 (33 %)	–	
AO2: Handling Information and Problem Solving		22 (37 %)	38 (37 %)	–	30 %
AO3: Experimental Skills		–	–	100 %	20 %
Total Marks		60	100	60	
Weighting of paper in overall qualification		30 %	50 %	20 %	100 %

4. CONTENT

This section presents the content as prescribed in the Science Double Award Teaching Syllabus.

EXPERIMENTAL / INVESTIGATION SKILLS

TOPIC	GENERAL OBJECTIVES	SPECIFIC OBJECTIVES
	Candidates should be able to;	*Candidates should be able to;*
Experimental / Investigation Skills	apply basic skills for scientific investigation:	
	• using and organising apparatus and materials:	- follow a sequence of instructions - identify apparatus and materials useful for scientific activities - practise accepted safety procedures - apply appropriate techniques in manipulating laboratory equipment and materials
	• collecting data	- make observations using the senses - collect qualitative and quantitative data - measure and make estimations - accurately record an observation - record data on a table or chart or graphs - make Biological diagrams as record of observation
	• handling experimental observations and data	- predict outcome of an event based upon previous observations - identify relationships among phenomena - draw and interpret graphs or tables - interpolate or extrapolate conclusions when given appropriate data - identify conditions which cause or influence change - distinguish among independent, dependent or controlled variables - draw conclusions - comment, recognise anomalies and make modifications - describe orally and in writing a sequence of events occurring in an experiment or investigation

	apply basic process skills to problem solving	- identify a problem - plan for an investigation - carry out an investigation - evaluate investigations
	acquire some knowledge and skills about the techniques for separating mixtures and purifying substances	- practise the techniques of paper chromatography - interpret simple chromatograms - practise methods of purification by the use of a suitable solvent, filtration, crystallisation, distillation (include fractional distillation) - identify substances and assess their purity from melting point and boiling point information - solve a problem by correctly applying separation and purification techniques

PHYSICS

1.0 GENERAL PHYSICS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
1.1. Length and Time	1.1.1. perform accurate measurement of length and time	1.1.1.1 state fundamental physical quantities and give their SI units 1.1.1.2 measure small lengths accurately using vernier and micrometer 1.1.1.3 identify sources of errors in measurement of length from a given measuring instrument 1.1.1.4 measure time accurately using stop clock / watch 1.1.1.5 estimate the accuracy of a given measuring instrument 1.1.1.6 identify sources of errors in measurements of time 1.1.1.7 determine the period of a pendulum
1.2. Motion	1.2.1. show understanding of motion and the relationship between the variables	1.2.1.1 define distance, displacement, speed, velocity and acceleration 1.2.1.2 identify motion with uniform and non-uniform velocity 1.2.1.3 identify uniformly accelerated and non-uniformly accelerated motion 1.2.1.4 plot and interpret speed-time graphs for uniform motion 1.2.1.5 plot and interpret speed-time graphs for non-uniform motion 1.2.1.6 use equations of motion in simple calculation 1.2.1.7 define *g* (acceleration due to gravity) 1.2.1.8 use g in solving problems on motion 1.2.1.9 state that acceleration of free fall for a body near earth is constant 1.2.1.10 describe motion of a body freely falling in air 1.2.1.11 describe qualitatively motion of objects falling in a liquid 1.2.1.12 understand the meaning of the term “terminal velocity”

1.3. Mass, Weight and Centre of mass	1.3.1. show the relationship between mass, weight and centre of mass	1.3.1.1 demonstrate an understanding that mass is a measure of the amount of substance in a body 1.3.1.2 define inertia and relate it to mass 1.3.1.3 define weight and its relationship to mass 1.3.1.4 measure mass and weight using appropriate balances 1.3.1.5 define centre of mass 1.3.1.6 determine centre of mass of plane laminas 1.3.1.7 perform and explain an experiment to determine the centre of mass of an irregular lamina 1.3.1.8 demonstrate and describe factors affecting stability of objects
1.4. Forces **(a). effects on shape and size**	1.4.1. show understanding of the effects of forces on shape and size of objects	1.4.1.1 demonstrate that force may cause change in shape / size of objects 1.4.1.2 determine the relationship between load and extension 1.4.1.3 plot, draw and interpret extension-load graphs and describe the associated experimental procedure 1.4.1.4 recognise the significance of the term "Limit of Proportionality" for an extension - load graph and use proportionality in simple calculations
(b). effects on motion	1.4.2. show understanding of the effects of force on motion	1.4.2.1 describe ways in which a force may cause change in motion of a body 1.4.2.2 use the relationship F = ma in calculations 1.4.2.3 demonstrate the effects of friction on motion of a body 1.4.2.4 perform simple calculations in cases where there is friction
(c). turning effects of forces	1.4.3. acquire knowledge on turning effects of forces and appreciate their role in everyday life	1.4.3.1 describe the moment of a force in terms of its turning effect, and give everyday examples e.g. levers 1.4.3.2 perform and describe an experiment to verify the principle of moments 1.4.3.3 use the concept of moment of force in simple calculations

1.5. Energy, Work and Power **(a). energy**	1.5.1. acquire knowledge on sources of energy and their limitations	1.5.1.1 list various forms of energy and identify their sources 1.5.1.2 define kinetic and potential energy (mechanical) 1.5.1.3 use kinetic and gravitational potential energy in calculations involving energy conversions 1.5.1.4 describe energy conversions and apply the principle of conservation of energy giving examples 1.5.1.5 list major energy sources in Botswana 1.5.1.6 describe the socio- economic and environmental impact of each energy sources locally and globally
(b). work	1.5.2. show the relationship between work, energy	1.5.2.1 relate work done to the magnitude of a force and the distance moved 1.5.2.2 use the relationship $W = F \times s$ in simple calculations 1.5.2.3 describe the relationship between work and energy
(c). power	1.5.3. show the relationship between work and power	1.5.3.1 define power 1.5.3.2 use the equation $P = \frac{W}{t}$ in simple calculations

2.0 THERMAL PHYSICS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
2.1. Thermal expansion of matter	2.1.1. understand the concept of thermal expansion of matter	2.1.1.1 describe and demonstrate the thermal expansion of solids, liquids and gases 2.1.1.2 show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases 2.1.1.3 identify and explain some of the everyday applications and consequences of thermal expansion including thermostat
2.2. Measurement of temperature	2.2.1. demonstrate understanding of the concepts and instruments involved in the measurement of temperature	2.2.1.1 appreciate how a physical property which varies with temperature may be used for the measurement of temperature e.g. thermal expansion and e.m.f 2.2.1.2 recognise the need for and identify fixed points of a temperature scale 2.2.1.3 demonstrate understanding of sensitivity and range 2.2.1.4 describe the structure and action of liquid-in-glass thermometers
2.3. Melting and boiling	2.3.1. acquire knowledge on the concepts of melting and boiling	2.3.1.1 describe melting / solidification and boiling / condensation in terms of energy input without a change in temperature 2.3.1.2 state the meaning of melting point and boiling point 2.3.1.3 state the difference between boiling and evaporation 2.3.1.4 sketch and interpret cooling curves

2.4. Transfer of thermal energy	2.4.1 acquire knowledge on heat transfer by conduction, convection and radiation	2.4.1.1 give a simple molecular account of heat transfer in solids 2.4.1.2 perform and describe experiments to demonstrate good and bad conductors of heat 2.4.1.3 relate convection in fluids to density changes 2.4.1.4 perform and describe experiments to illustrate convection 2.4.1.5 show understanding of the term radiation (infrared) 2.4.1.6 perform and describe experiments to distinguish between good and bad emitters / absorbers of heat
	2.4.2. acquire knowledge on the applications and consequences of energy transfer	2.4.2.1 identify and explain some of the everyday applications of conduction, convection and radiation including Thermos flask, car cooling system, water heating system 2.4.2.2 identify and explain some of the everyday consequences of conduction, convection and radiation including; cyclones, typhoons, days and nights in deserts , global warming and the greenhouse effect

3.0 PROPERTIES OF WAVES, INCLUDING LIGHT AND SOUND

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
3.1. General wave properties	3.1.1. acquire basic knowledge about wave motion	3.1.1.1 describe wave motion 3.1.1.2 define the terms wave front, speed, frequency, wavelength and amplitude 3.1.1.3 perform experiments to show: (i) wave motion and wave front (ii) relationship between speed, frequency and wavelength ($v = f\lambda$) 3.1.1.4 use the wave equation $v = f\lambda$ 3.1.1.5 sketch and interpret displacement – time graphs 3.1.1.6 sketch and interpret displacement – distance graphs
	3.1.2. recognise the differences between transverse and longitudinal waves	3.1.2.1 describe transverse and longitudinal waves and their nature 3.1.2.2 give examples of transverse and longitudinal waves
3.2. Light	3.2.1. demonstrate understanding of refraction of light, total internal reflection and refractive index	3.2.1.1 describe and perform experiments to demonstrate refraction of light through transparent blocks 3.2.1.2 use the terminology for the angles i and r in refraction and describe the passage of light through parallel-sided transparent material 3.2.1.3 use the equation $\frac{\sin i}{\sin r}$ = constant 3.2.1.4 give the meaning of refractive index 3.2.1.5 understand the terms real depth and apparent depth and use them to determine the refractive index 3.2.1.6 give the meaning of critical angle and total internal reflection 3.2.1.7 describe the action of optical fibres 3.2.1.8 explain the formation of mirages

3.2. Light	3.2.2. understand the action of a thin lens on a beam of light	3.2.2.1 differentiate between the converging and diverging lenses 3.2.2.2 describe the action of a thin converging lens on a beam of light 3.2.2.3 use and understand the meaning of the terms focal length, principal focus and principal axis with respect to a thin converging lens 3.2.2.4 draw ray diagrams to illustrate the formation of real and virtual images of an object by a thin converging lens 3.2.2.5 use and describe the use of a single lens as a magnifying glass 3.2.2.6 describe the use of a single lens to form a real image, e.g. a camera, a projector, a photographic enlarger
3.3. Electro-magnetic spectrum	3.3.1. show understanding of the main features of the electro-magnetic spectrum	3.3.1.1 describe the main components of the electro-magnetic spectrum 3.3.1.2 state and describe their methods of detection 3.3.1.3 state the uses , sources and side effects of the components of the electromagnetic spectrum
	3.3.2. appreciate that all e.m. waves travel with the same high speed in vacuum	3.3.2.1 sate that all e.m. waves travel with the same high speed in vacuum 3.3.2.2 sate the magnitude of this speed 3.3.2.3 use the wave equation $c = f \lambda$ in simple calculations
3.4. Sound	3.4.1. understand how sound is produced	3.4.1.1 describe the longitudinal nature of sound waves and describe compression and rarefaction 3.4.1.2 state the approximate range of audible frequencies for human beings , dogs and bats 3.4.1.3 state the uses of ultra-sonic sound waves 3.4.1.4 understand noise pollution 3.4.1.5 perform an experiment to determine the speed of sound in air and make necessary calculations 3.4.1.6 state the order of magnitude of the speed of sound in gases , liquids and solids
	3.4.2. understand reflection of sound waves	3.4.2.1 describe how the reflection of sound may produce an echo
	3.4.3. understand the terms pitch, loudness and quality of sound	3.4.3.1 perform an experiment to relate the loudness and pitch of sound to amplitude and frequency respectively 3.4.3.2 describe the factors which influence the quality (timber) of sound waves 3.4.3.3 describe the effect of multiple reflections of sound waves (acoustics) on the quality of sound

4.0 ELECTRICITY AND MAGNETISM

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	*Candidates should be able to:*
4.1. Magnetism	4.1.1 understand simple phenomena of magnetism	4.1.1.1 state the properties of magnets 4.1.1.2 distinguish between magnetic and non-magnetic materials 4.1.1.3 describe the phenomenon of induced magnetism 4.1.1.4 describe different methods of magnetisation e.g. electricity, stroking, etc. 4.1.1.5 describe different methods of demagnetisation e.g. electricity, hitting and heating 4.1.1.6 describe and demonstrate methods of detecting a magnetic field around a magnet 4.1.1.7 use iron fillings to show the pattern of field lines of a magnetic field of a bar magnet 4.1.1.8 use a plotting compass to plot the field lines of a magnetic field of a bar magnet 4.1.1.9 distinguish between the magnetic properties of iron and steel 4.1.1.10 distinguish between the design and use of permanent magnets and electromagnets 4.1.1.11 give examples of the use of magnetic materials
4.2. Electricity	4.2.1 understand the concept of electric charge	4.2.1.1 describe the phenomenon of electrostatic charging 4.2.1.2 perform simple experiments to show electrostatic charging 4.2.1.3 state the two types of charges, namely positive and negative 4.2.1.4 state that charge is measured in coulombs 4.2.1.5 demonstrate that unlike charges attract and that like charges repel 4.2.1.6 understand the concept of discharging and relate it to occurrence of lightning 4.2.1.7 describe the design and use of a lightning conductor 4.2.1.8 describe an electric field as a region in which an electric charge experiences an electric force 4.2.1.9 state the direction of lines of force and describe simple field patterns 4.2.1.10 give an account of charging by induction e.g. touching and separation of charges 4.2.1.11 use the electron model to distinguish between electrical conductors and insulators and give examples

4.2. Electricity	4.2.2. understand the concept of electric current	4.2.2.1 define electric current as the rate of flow of charge and that it is measured in amperes (A) 4.2.2.2 use the equation $I = \frac{Q}{t}$ 4.2.2.3 use and describe the use of an ammeter with different ranges including a milliampere range
	4.2.3. understand the concept of electro-motive force	4.2.3.1 understand that the e.m.f. is measured by the energy dissipated by a source in driving a charge round a complete circuit (e.m.f = $\frac{W}{Q}$) 4.2.3.2 state that the e.m.f of a source of electrical energy is measured in volts 4.2.3.3 give a definition of the volt [Energy / Charge (J / C)]
	4.2.4. show an understanding of potential difference	4.2.4.1 give an explanation of potential difference 4.2.4.2 state that the potential difference across a circuit component is measured in volts 4.2.4.3 use and describe the use of a voltmeter with different ranges
	4.2.5. show an understanding of resistance	4.2.5.1 give an explanation of resistance 4.2.5.2 state that resistance is measured in ohms 4.2.5.3 state that resistance = p.d. / current and use the equation $R = \frac{V}{I}$ 4.2.5.4 perform and describe an experiment to determine resistance using a voltmeter and an ammeter and make the necessary calculation 4.2.5.5 describe qualitatively the relationship between resistance, length and cross-sectional area
	4.2.6. show an understanding of V / I characteristic graph (Ohms Law)	4.2.6.1 sketch and interpret the V / I characteristic graphs for metallic (ohmic) conductors 4.2.6.2 sketch and interpret the V / I characteristic graphs for non-ohmic conductors 4.2.6.3 appreciate the limitations of Ohm's law

4.2. Electricity	4.2.7. show an understanding of electric circuits	4.2.7.1 identify circuit components and their symbols 4.2.7.2 perform experiments using simple electric circuits 4.2.7.3 draw and interpret circuit diagrams 4.2.7.4 perform experiments to show that (i) current is the same at every point in a series circuit (ii) the sum of the p.d's in a series circuit is equal to the terminal p.d. across the source (iii) the current from the source is the sum of the currents in the separate branches of a parallel circuit (iv) the p.d across components in parallel is the same as the terminal p.d. 4.2.7.5 calculate the total resistance of two resistors in series 4.2.7.6 calculate the total resistance of two resistors in parallel 4.2.7.7 perform calculations involving components in different circuit combinations
4.3. Practical electric circuitry	4.3.1. appreciate the use of electricity in everyday life situations	4.3.1.1 state the use of electricity in lighting machines, security 4.3.1.2 use the equations P = VI, E = VIt 4.3.1.3 calculate the cost of using electrical appliances
	4.3.2. understand the dangers of electricity	4.3.2.1 state the hazards of; (i) damaged insulation (ii) overheating of cables (iii) damp conditions (iv) overloading of sockets 4.3.2.2 explain how these hazards can be prevented

4.3. Practical electric circuitry	4.3.3. acquire knowledge on the safe use of electricity in the home	4.3.3.1 show understanding of the use of fuses and fuse ratings 4.3.3.2 explain the need for earthing metal cases and for double insulation of electrical appliances 4.3.3.3 give the meaning of the terms: live, neutral and earth 4.3.3.4 describe and correctly wire, a mains plug 4.3.3.5 understand simple lighting (including lamps in parallel) in the house 4.3.3.6 give the reason for connecting switches and fuses in live wires 4.3.3.7 describe the necessary diagnostic steps to be followed when there is an electrical fault in an appliance e.g. blown fuse, loose connection, etc.
4.4 Electromagnetic effects	4.4.1. understand the concept of electromagnetic induction	4.4.1.1 perform and describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit 4.4.1.2 state the factors affecting the magnitude of the induced e.m.f.
	4.4.2. acquire basic knowledge on the operation of an a.c. generator	4.4.2.1 describe a simple form of an a.c. generator (e.g. rotating coil or rotating magnet) and the use of slip rings 4.4.2.2 sketch and interpret a graph of voltage output against time for a simple a.c. generator
	4.4.3. acquire knowledge on the operation of a Transformer	4.4.3.1 describe the structure of a basic iron-cored transformer as used for voltage transformations 4.4.3.2 describe the principle of operation of a transformer 4.4.3.3 use the equations $(\frac{V_p}{V_s}) = (\frac{N_p}{N_s})$ and $V_p I_p = V_s I_s$ (for 100% efficiency) in calculations 4.4.3.4 perform experiments to demonstrate the difference between a step-up transformer and a step-down transformer 4.4.3.5 describe the use of the transformer in high voltage transmission of electricity 4.4.3.6 give the advantage of high voltage transmission

5.0 ATOMIC PHYSICS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
5.1. Radioactivity	5.1.1. appreciate the existence of radioactive emissions	5.1.1.1 describe the process of radioactivity 5.1.1.2 give examples of radioactive materials 5.1.1.3 state the dangers of exposure to radioactive emissions 5.1.1.4 describe the safe handling and storage of radioactive material in a laboratory 5.1.1.5 state that alpha, beta and gamma emissions can be emitted during the process of radioactivity 5.1.1.6 describe methods of detection of these emissions by Geiger-Muller tubes 5.1.1.7 show awareness of the existence of background radiation
	5.1.2. understand the characteristics of the three emissions	5.1.2.1 show understanding that radioactive emissions occur randomly over space and time 5.1.2.2 state, for each radioactive emission: (i) its nature (ii) its relative ionising effect (iii) its relative penetrating power 5.1.2.3 describe their deflection in electric fields 5.1.2.4 interpret their relative ionising effects
	5.1.3. appreciate the uses and dangers of radioactive materials	5.1.3.1 state the uses of radioactive materials in industries, agriculture, medicine and production of electricity 5.1.3.2 describe the dangers of waste products of radioactive materials and give suggestions on safer disposal of these waste products

CHEMISTRY

6.0 MATTER

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
6.1. Particulate nature of matter	6.1.1. explain the nature of matter	6.1.1.1 explain states of matter in terms of particle arrangement and movement 6.1.1.2 explain changes of state of matter in terms of the Kinetic Particle Theory 6.1.1.3 describe diffusion of particles in fluids 6.1.1.4 demonstrate diffusion in gases 6.1.1.5 describe the dependence of rate of diffusion on molecular mass
6.2. Atomic structure	6.2.1. acquire an understanding of the structure and characteristics of atoms	6.2.1.1 describe the structure of an atom in terms of neutrons, protons and electrons 6.2.1.2 state the relative charges and approximate relative masses of protons, neutrons and electrons 6.2.1.3 define atomic number (proton number) 6.2.1.4 define mass number (nucleon number) 6.2.1.5 use and interpret symbols such as $^{12}_{6}C$ 6.2.1.6 describe the build-up of electrons in 'shells' 6.2.1.7 draw the structure of atoms of elements 1 to 20 in the periodic table showing the electron arrangement and the nucleus 6.2.1.8 explain the significance of outer shell electrons and the noble gas electron arrangement 6.2.1.9 define isotopes (give examples of hydrogen, carbon and chlorine isotopes)
6.3. Periodic Table	6.3.1. be aware of the periodic table as a method of classifying element	6.3.1.1 extract information from the periodic table 6.3.1.2 translate from element name to symbol and vice versa 6.3.1.3 describe the change from metallic to non-metallic character across a period (period III can be used to illustrate this) 6.3.1.4 state the relationship between period number and number of main shells 6.3.1.5 state the relationship between Group number and number of outer shell electrons

6.3. Periodic Table	6.3.2. use trends in the periodic table to acquire knowledge and understanding of properties of elements	6.3.2.1 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 6.3.2.2 predict the properties of other elements in Group I (given data where appropriate) 6.3.2.3 describe chlorine, bromine and iodine in Group VII as a collection of di-atomic non-metals showing a trend in colour, reactivity (as well as displacement reactions) and physical state at room temperature and pressure 6.3.2.4 predict the properties of other elements in Group VII, given data, where appropriate 6.3.2.5 describe elements in Group VIII or 0 as being unreactive 6.3.2.6 describe the uses of the Noble Gases in providing an inert atmosphere e.g. argon in lamps, helium for filling balloons, etc. 6.3.2.7 describe the transition elements as a collection of metals having high densities, high melting points, variable charges on ions, forming coloured compounds and which, as elements and compounds, often act as catalysts
6.4. Chemical Bonding	6.4.1. acquire knowledge and understanding of the structure of matter in terms of bonding between particles	6.4.1.1 describe the formation of ions by electron loss or gain 6.4.1.2 define an ionic bond as an electrostatic force of attraction between oppositely charged ions 6.4.1.3 describe the formation of ionic bonds between metallic and non-metallic elements, e.g. in NaCl, CaCl_2, 6.4.1.4 describe the formation of covalent bonds between non-metallic elements leading to the noble gas electron arrangement, e.g. H_2, Cl_2, HCl, H_2O, CH_4 6.4.1.5 define a single covalent bond as a shared pair of electrons 6.4.1.6 construct ‘dot’ and ‘cross’ diagrams to show the outer shell electrons in covalent molecules 6.4.1.7 compare the properties of ionic and covalent compounds 6.4.1.8 describe the lattice structure of Sodium Chloride 6.4.1.9 distinguish between inter and intra molecular forces 6.4.1.10 deduce the electron arrangement in other covalent molecules

7.0 CHEMICAL REACTIONS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
7.1. Energy changes	7.1.1. investigate chemical reactions and explore their nature using the investigative approach	7.1.1.1 state that chemical reactions involve energy changes 7.1.1.2 define exothermic and endothermic reactions 7.1.1.3 state that energy is released when bonds are formed 7.1.1.4 state that energy is absorbed when bonds are broken 7.1.1.5 carry out experiments which show exothermic and endothermic reactions
	7.1.2. be familiar with the energy changes that take place during chemical reactions	7.1.2.1 describe examples of endothermic reactions e.g. photosynthesis 7.1.2.2 describe examples of exothermic reactions e.g. respiration, combustion of fuels, reaction of reactive metals with water
7.2. Rate of reaction	7.2.1. investigate the qualitative effect of several variables on the rate of chemical reaction	7.2.1.1 represent and interpret data obtained from experiments concerned with rate of reaction 7.2.1.2 investigate effect of concentration, temperature, surface area and use of catalyst on the rate of chemical reaction 7.2.1.3 explain the effects of the above factors and pressure in terms of collisions between the reacting particles 7.2.1.4 compare enzymes with other catalysts 7.2.1.5 state uses of enzymes in baking, brewing, dairy industry 7.2.1.6 explain how explosive combustions with fine powders (e.g. in flour mills) and combustible gases (e.g. in mines) occur 7.2.1.7 identify some everyday instances of speeding up or slowing down reactions and the variable involved 7.2.1.8 describe practical applications of the effect of enzyme-catalysed reactions in food preservation e.g. freezing, refrigeration, cooking

7.3. Redox Reactions	7.3.1. understand concept of oxidation and reduction	7.3.1.1 define oxidation in terms of electron loss 7.3.1.2 define reduction in terms of electron gain 7.3.1.3 define an oxidising agent as a substance that gains electrons from another substance 7.3.1.4 define a reducing agent as substance that losses electrons to another substance 7.3.1.5 use aqueous potassium iodide and acidified potassium manganate(VII) to test for oxidising and reducing agents 7.3.1.6 identify examples of commonly occurring redox reactions e.g. rusting
7.4. Electrolysis	7.4.1. understand the process of electrolysis of compounds	7.3.1.1 describe electrolysis as a process of decomposition of a substance using electrical energy 7.3.1.2 identify electrodes (anode and cathode) and electrolyte from an electrolytic cell 7.3.1.3 explain electrolysis in terms of migration and discharge of ions 7.3.1.4 carry out electrolysis of the following: concentrated aqueous sodium chloride and dilute sulphuric acid between inert electrodes; aqueous copper(II) sulphate using carbon electrodes and copper electrodes 7.3.1.5 carry out simple electroplating of metals using copper

7.5. Acids, bases and salts	7.5.1. investigate acids, bases and salts and their properties	7.5.1.1 define an acid as an hydrogen ion, H^+, donor 7.5.1.2 define a base as a hydrogen ion, H^+, acceptor 7.5.1.3 describe the meaning of weak and strong acids and alkalis 7.5.1.4 investigate the properties of strong and weak acids 7.5.1.5 investigate properties of strong and weak alkalis 7.5.1.6 explain the difference between strength and concentration 7.5.1.7 investigate the effect of acids and alkalis on indicators such as methyl orange, universal indicator, litmus 7.5.1.8 describe pH as a measure of the degree of acidity or alkalinity of a solution 7.5.1.9 determine the pH of a solution using universal indicator 7.5.1.10 investigate the characteristic properties of acids in reactions with metals and bases (including alkalis and carbonates) 7.5.1.11 test for and identify hydrogen and carbon dioxide 7.5.1.12 investigate the characteristic properties of bases in reactions with ammonium salts 7.5.1.13 give applications of acid / base reactions in daily life e.g. treatment of indigestion, treatment of acidic soils, brushing teeth with toothpaste 7.5.1.14 classify oxides as acidic, basic, neutral or amphoteric 7.5.1.15 prepare soluble salts from acid / base, acid / metal reactions 7.5.1.16 prepare insoluble salts by precipitation 7.5.1.17 purify salts by filtration and crystallisation 7.5.1.18 investigate the existence of water of crystallisation 7.5.1.19 suggest a method of preparing a given salt from suitable starting materials, given appropriate information 7.5.1.20 conduct tests for the following ions: SO_4^{2-}, Cl^-, CO_3^{2-}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, and NH_4^+ 7.5.1.21 conduct tests for the following ions: I^-, NO_3^-, Ca^{2+} and Al^{3+}

8.0 STOICHIOMETRY

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
8.1. Chemical formulae and equations	8.1.1. understand the stoichiometry of chemical formulae and equations	8.1.1.1 represent elements, ions and the formulae of compounds with symbols 8.1.1.2 determine formulae of compounds from the charges of ions or from models and diagrams 8.1.1.3 interpret symbolic equations 8.1.1.4 construct balanced chemical equations with state symbols 8.1.1.5 construct balanced ionic equations with state symbols
8.2. Chemical calculations	8.2.1. perform simple chemical calculations	8.2.1.1 define the relative atomic mass, A_r, and the relative molecular mass, M_r 8.2.1.2 define one mole of a substance as the amount of that substance containing 6.02×10^{23} particles (Avogadro's number, N) 8.2.1.3 calculate the relative molecular mass of a compound with known formula 8.2.1.4 convert moles into other units (and vice versa) like grams (mostly for solids) 8.2.1.5 convert moles into other units (and vice versa) like cm^3 and dm^3 for gases (knowing that the molar gas volume at room temperature and pressure = 24 dm^3) 8.2.1.6 carry out experiments to determine the formula of a binary compound e.g. CuO. MgO 8.2.1.7 calculate stoichiometric reacting volumes of matter 8.2.1.8 deduce empirical and molecular formulae, given the relevant information 8.2.1.9 calculate percentages like composition, purity and yield 8.2.1.10 calculate stoichiometric reacting masses of matter 8.2.1.11 measure volumes of liquids using a volumetric flask, pipette and burette 8.2.1.12 make solutions of different concentrations by dilution from a given standard solution 8.2.1.13 calculate concentrations (mol / dm^3) in aqueous solutions 8.2.1.14 calculate the amount of solute present in a solution of given concentration

9.0 METALS AND NON METALS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
9.1. Properties of metals	9.1.1 investigate general physical and chemical properties of metals and their uses	9.1.1.1 describe the general physical and chemical properties of metals 9.1.1.2 describe the reactivity series as related to the ease of a metal to form its positive ion 9.1.1.3 carry out simple displacement reactions to demonstrate the relative reactivities of metals 9.1.1.4 use the reactions of these metals with water and dilute hydrochloric acid to place potassium, sodium, calcium, magnesium, aluminium, zinc, iron, copper, silver, gold in order of reactivity 9.1.1.5 place and justify the position of carbon and hydrogen in the reactivity series 9.1.1.6 identify the methods of extraction of the metals listed above depending on their position in the reactivity series 9.1.1.7 describe the chemical reactions (symbol equations) involved in the extraction of iron from Iron Ore (Haematite) 9.1.1.8 outline the general principles of steel making 9.1.1.9 explain the existence in nature of some metals as “free elements” e.g. gold 9.1.1.10 investigate the action of heat on the carbonates of sodium, calcium, zinc and copper 9.1.1.11 account for the apparent unreactivity of aluminium as it forms a film of oxide 9.1.1.12 describe alloys as a mixture of metals or of metals and non-metals 9.1.1.13 explain why metals are often used in the form of alloys by reference to mild steel, brass, solder, bronze and stainless steel 9.1.1.14 list the uses and the constituent elements of the alloys listed above 9.1.1.15 list the uses of the following metals: zinc, copper, and aluminium

9.2. Non-metals	9.2.1. investigate properties of non-metals	9.2.1.1 describe the general physical properties of non-metals
Chlorine	9.2.2. acquire an understanding of the preparation, properties and uses of chlorine	9.2.2.1 describe the preparation of chlorine from concentrated hydrochloric acid using an oxidising agent 9.2.2.2 state the test for chlorine 9.2.2.3 state the uses of chlorine (sterilising water, manufacturing plastics, making domestic bleaches) 9.2.2.4 describe properties of chlorine 9.2.2.5 describe the bleaching action of chlorine
	9.2.3. understand the uses of some important compounds of chlorine and its manufacture	9.2.3.1 name some sources of sodium chloride e.g. sea water, salt pans (give examples of some places in Botswana) 9.2.3.2 state the importance of sodium chloride as a source for chlorine, sodium hydroxide 9.2.3.3 describe extraction of sodium chloride from brine (focus on local process at Botswana Ash in Sowa Town)
Carbon and carbonates	9.2.4. acquire knowledge of the different forms of carbon	9.2.4.1 define allotropes 9.2.4.2 state diamond and graphite as allotropes of carbon 9.2.4.3 relate the properties and uses of diamond and graphite to their structures 9.2.4.4 describe the processes involved in the extraction of diamond in Botswana 9.2.4.5 list the uses of sodium carbonate and calcium carbonate
Nitrogen	9.2.5. acquire knowledge of sources and uses of nitrogen	9.2.5.1 name the sources of nitrogen and hydrogen in making ammonia 9.2.5.2 state the uses of ammonia (solvent, manufacture of fertilisers, nitric acid, bleach and explosives)

10.0 CHEMISTRY IN THE ENVIRONMENT

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	*Candidates should be able to:*
10.1. Water	10.1.1. acquire knowledge about the physical and chemical properties of water	10.1.1.1 investigate physical properties of pure water 10.1.1.2 carry out a chemical test for water
	10.1.2. know the effect of dissolving property of water in producing hard water and pollution	10.1.2.1 describe the process that results in hard water (name salts causing hard water) 10.1.2.2 distinguish temporary hardness of water and permanent hardness of water 10.1.2.3 measure the hardness of water 10.1.2.4 describe physical and chemical process of softening hard water 10.1.2.5 describe how a detergent works 10.1.2.6 describe pollution of water in terms of dissolved substances, accumulation of toxic substances and effect of detergents 10.1.2.7 investigate effects of pollutants in water 10.1.2.8 describe pollution of water in terms of biological oxygen demand (BOD)
10.2. Air	10.2.1. recognise the delicate balance of air in volume and quality	10.2.1.1 state the proportions of different components of clean air by percentage volume 10.2.1.2 describe the separation of oxygen and nitrogen from air by fractional distillation 10.2.1.3 explain the effect of increased carbon dioxide concentration in the atmosphere 10.2.1.4 name the uses of oxygen in health and in industry 10.2.1.5 state the importance of the ozone layer
	10.2.2. be aware that people's action on the environment can result in air pollution and appreciate the need to control it	10.2.2.1 name the common pollutants and their sources in the air as carbon monoxide, sulphur dioxide, oxides of nitrogen and lead compounds 10.2.2.2 state uses of catalytic converters and unleaded petrol in reducing pollution from car exhausts 10.2.2.3 explain the danger (include chemical reactions) of burning carbon compounds in an enclosed area 10.2.2.4 describe the adverse effects of common pollutants on buildings, health, vegetation, ozone layer 10.2.2.5 describe methods of controlling pollution such as acid rain, toxic waste

10.3. Recycling	10.3.1. appreciate the role of recycling in conservation of natural resources and reducing the problem of pollution	10.3.1.1 describe some of the problems caused by the chemical industry 10.3.1.2 explain the importance of recycling 10.3.1.3 identify recyclable materials
10.4. Sources of energy	10.3.2. appreciate the finite nature of fossil fuels and the need to find alternative sources of energy	10.3.2.1 relate the use of fossil fuels to their natural reserves 10.3.2.2 use data and information to compare two fuels 10.3.2.3 explain energy conservation methods used in the home 10.3.2.4 discuss the advantages and disadvantages of various energy sources 10.3.2.5 describe the use of plant and animal waste in producing fuel

11 CARBON CHEMISTRY

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
11.1. Homologous Series	11.1.1. understand the importance of carbon in organic compounds	11.1.1.1 explain the ability of carbon atoms to form chains, branched chains 11.1.1.2 describe the general characteristics of an homologous series 11.1.1.3 name and draw the structures of unbranched alkanes, alkenes and alkanols containing up to four carbon atoms 11.1.1.4 identify alkanes, alkenes, alkanols and alkanoic acids given their structural formulae 11.1.1.5 identify structural isomerism up to four carbon alkanes
Alkanes	11.1.2. be aware of the sources of alkanes and their impact in our everyday life	11.1.2.1 describe burning and substitution reactions (with chlorine) of alkanes (exemplified by methane) and name the products 11.1.2.2 name fossil fuels, natural gas and petroleum as the main sources of alkanes 11.1.2.3 describe fractional distillation of petroleum 11.1.2.4 name the uses of the fractions as: petrol fraction as fuel in cars; paraffin / kerosene fraction as fuel in stoves, lamps, aircraft, diesel fraction for fuel in engines, lubricating fraction for lubricants and making waxes and polishes and bitumen / asphalt for making roads
Alkenes	11.1.3. know uses of alkenes and how they are manufactured	11.1.3.1 describe the manufacture of alkenes by cracking 11.1.3.2 describe properties of alkenes in terms of burning, addition reactions with bromine, hydrogen and steam 11.1.3.3 distinguish unsaturated hydrocarbons e.g. alkenes from saturated hydrocarbons e.g. alkanes by molecular structures and by using aqueous bromine 11.1.3.4 describe the formation of polythene as an example of addition polymerisation of monomer units 11.1.3.5 list some uses of polythene e.g. plastic bags

Alkanols	11.1.4. acquire basic knowledge about alkanols including formation, properties and uses	11.1.4.1 describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) and its importance in brewing and baking 11.1.4.2 prepare ethanol by fermentation 11.1.4.3 describe formation of ethanol by catalytic addition of steam to ethene 11.1.4.4 describe the properties of ethanol in terms of burning and partial oxidation 11.1.4.5 relate physical properties of alkanols to the number of C atoms e.g. boiling point 11.1.4.6 list some uses of ethanol as solvent, as fuel and as constituent of alcoholic beverages
Alkanoic acids	11.1.5. acquire basic knowledge about alkanoic acids including properties and uses	11.1.5.1 name some commonly occurring alkanoic acids, their sources and uses e.g. tartaric acid, ethanoic acid, ascorbic acid, citric acid 11.1.5.2 describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate)
11.2 Macromolecules	11.2.1. be aware of macromolecules as large molecules built from small units	11.2.1.1 explain that different macromolecules have different units 11.2.1.2 describe formation of macromolecules from small units e.g. starch, fat, nylon and polyester
Synthetic macro molecules	11.2.2. be aware of the formation of synthetic polymers and their impact in everyday life	11.2.2.1 describe the pollution problems caused by non-biodegradable polymers e.g. plastics 11.2.2.2 list some typical uses of man-made fibres 11.2.2.3 investigate advantages and disadvantages of synthetic and natural fibres 11.2.2.4 describe uses of different macromolecules as related to their general structure and properties e.g. PVC, polystyrene, polypropene 11.2.2.5 interpret simple polymerisation reactions 11.2.2.6 describe the formation of nylon and terylene using simplified structure
Natural macromolecules	11.2.3. understand the impact of natural macromolecules in our daily life	11.2.3.1 name proteins, fats and carbohydrates as the main constituent of food 11.2.3.2 describe the hydrolysis of proteins to amino acids 11.2.3.3 describe proteins as possessing the same linkage (amide) as nylon but with different units 11.2.3.4 describe complex carbohydrates as macromolecules formed by the condensation polymerisation of smaller carbohydrate units called sugars 11.2.3.5 describe the hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars

BIOLOGY

12.0 LIVING THINGS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
12.1. Cell processes and maintenance	12.1.1. acquire knowledge and understanding of plant and animal cells	12.1.1.1 identify different parts of plant and animal cells 12.1.1.2 identify from fresh preparations and diagrams or on photomicrographs cell membrane, cytoplasm, cell organelles: nucleus, mitochondrion and ribosome of an animal cell 12.1.1.3 identify from fresh preparations and diagrams or on photomicrographs the cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts of a plant cell 12.1.1.4 state the functions of the nucleus 12.1.1.5 state the functions mitochondrion, ribosome, cell wall and cell membrane
	12.1.2. acquire knowledge on cell specialisation and organisation	12.1.2.1 describe the relationship between cell structure and function using a red blood cell and nerve cell in animals and root hair cell and xylem in plant cells 12.1.2.2 define tissue, organ, system and organism
	12.1.3. acquire knowledge and understanding of the process of diffusion	12.1.3.1 define diffusion as movement of molecules from a region where they are at a higher concentration to a region where they are at a lower concentration i.e. down a concentration gradient
	12.1.4. acquire knowledge and understanding of the process of osmosis and its role in living things	12.1.4.1 define osmosis (a special form of diffusion) as movement of water molecules from a region of their higher concentration to a region of their lower concentration through a selectively permeable membrane 12.1.4.2 describe the effect of concentration gradient in the uptake of water by plants 12.1.4.3 describe the effect of osmosis on plant tissues, in terms of flaccid cells, turgid cells and plasmolysis 12.1.4.4 describe the effect of osmosis on animal tissues [refer to bursting and shrinking] 12.1.4.5 conduct experiments using solutions of varying concentration to demonstrate the process of osmosis

13.0 OBTAINING ESSENTIALS OF LIFE

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	*Candidates should be able to:*
13.1. Nutrition	13.1.1. appreciate different ways of how organisms obtain their nutrients	13.1.1.1 describe autotrophic and heterotrophic modes of nutrition
	13.1.2. acquire knowledge and understanding of the structure and functions of a leaf	13.1.2.1 describe the significance of the cellular and tissue structures of a dicotyledon leaf in terms of: distribution of chloroplasts - photosynthesis; stomata and mesophyll cells - gaseous exchange; vascular bundles - transport 13.1.2.2 identify and label the cellular and tissue structure of a dicotyledonous leaf, as seen in cross section using diagrams or photomicrographs
	13.1.3. acquire knowledge and understanding of nutrition in plants	13.1.3.1 describe the intake of carbon dioxide and water by plants, the trapping of light energy by chlorophyll, the conversion of light energy into chemical energy, the formation of carbohydrates, their subsequent storage, and the release of oxygen 13.1.3.2 state both the word and symbol equation for photosynthesis 13.1.3.3 investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis using appropriate controls
	13.1.4. understand the need for mineral nutrients in plants	13.1.4.1 state the importance of nitrates for protein synthesis and magnesium ions for chlorophyll synthesis
	13.1.5. appreciate how diet relates to energy intake	13.1.5.1 explain why diet, especially energy intake, should be related to age and physical activity of an individual
	13.1.6. acquire knowledge on the procedure of carrying out food tests	13.1.6.1 list the chemical elements which make up: carbohydrates, fats and proteins 13.1.6.2 carry out tests for starch (iodine solution), reducing sugars (Benedict's solution), protein (Biuret test) and fats (ethanol)
	13.1.7. acquire knowledge and understanding of enzymes	13.1.7.1 define the term enzyme as proteins which function as biological catalysts 13.1.7.2 describe properties of enzymes 13.1.7.3 investigate and describe the effect of temperature and pH on enzyme activity

13.1. Nutrition	13.1.8. acquire knowledge on parts and functions of the human digestive system.	13.1.8.1 using diagrams and models identify the main regions of the digestive system and the associated organs: mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum and anus 13.1.8.2 describe the main functions of the identified parts of the digestive system in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate
	13.1.9. acquire knowledge on the physical and chemical processes of digestion	13.1.9.1 describe physical digestion with reference to chewing, emulsification and peristalsis 13.1.9.2 describe chemical digestion with reference to the functions of amylase, protease and lipase in digestion 13.1.9.3 investigate digestion of macromolecules such as amylase
	13.1.10. acquire knowledge on the absorption process and some possible uses of the end-products of digestion	13.1.10.1 state the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestines 13.1.10.2 describe the role of the liver in the metabolism of glucose, as a storage organ, deamination and detoxification 13.1.10.3 describe absorption of nutrients in the ileum (structure of villus not necessary) 13.1.10.4 describe the uses of glucose, amino acids and fatty-acids
13.2. Respiration	13.2.1. acquire knowledge and understanding of respiration	13.2.1.1 describe respiration as the release of energy from food substances in all living cells 13.2.1.2 list uses of energy in the body (muscle contraction, protein synthesis, cell division, active transport etc.)
	13.2.2. acquire knowledge and understanding of aerobic respiration	13.2.2.1 describe aerobic respiration as the release of a relatively large amount of energy by the breakdown of carbohydrates in the presence of oxygen 13.2.2.2 state the equation for aerobic respiration, using words and symbols
	13.2.3. acquire knowledge and understanding of anaerobic respiration	13.2.3.1 describe anaerobic respiration as the release of a relatively small amount of energy by the breakdown of carbohydrates in the absence of oxygen 13.2.3.2 state the equation for anaerobic respiration in plants and animals using words and symbols 13.2.3.3 describe fermentation process as a form of anaerobic respiration 13.2.3.4 describe production of lactic acid in muscles (details of oxygen debt not required) 13.2.3.5 demonstrate anaerobic respiration (using yeast)

13.3. Transport and circulation	13.3.1. acquire knowledge and understanding of the process of transpiration and translocation	13.3.1.1 define transpiration as loss of water vapour from stomata 13.3.1.2 investigate the effect of temperature, humidity and wind on the rate of transpiration 13.3.1.3 describe absorption of mineral ions in terms of active transport 13.3.1.4 describe transpiration stream as a process of water movement through xylem vessels [related theories not required] 13.3.1.5 define translocation as movement of organic materials through phloem
	13.3.2. acquire knowledge and understanding of the role of the circulatory system	13.3.2.1 describe the circulatory system as consisting of tubes (blood vessels) with a pump (heart) and valves to ensure one-way flow of blood 13.3.2.2 describe circulation as consisting of pulmonary and systemic circuits 13.3.2.3 identify and name the main blood vessels to and from the heart, lungs, liver, and kidney 13.3.2.4 describe the structure and function of the heart 13.3.2.5 compare the structure and function of arteries, veins and capillaries 13.3.2.6 locate pulse points and count the pulse rate 13.3.2.7 investigate the effect of physical activity on pulse rate 13.3.2.8 describe coronary heart disease in terms of the occlusion of coronary arteries 13.3.2.9 discuss possible causes of coronary heart diseases (diet, stress, smoking) 13.3.2.10 discuss preventative measures of coronary heart diseases
	13.3.3. acquire knowledge on the different components of blood and their functions	13.3.3.1 list the components of blood as red blood cells, white blood cells, platelets, and plasma 13.3.3.2 identify red and white blood cells as seen in diagrams and/or photomicrographs 13.3.3.3 describe the functions of blood: *red blood cells* - haemoglobin and oxygen transport; *white blood cells* - phagocytosis and antibody formation; *platelets*- fibrinogen to fibrin causing clotting; *plasma* - transport of blood cells , ions, vitamins, end products of digestion, carbon dioxide, urea, hormones, plasma proteins 13.3.3.4 describe the transfer of materials between capillaries and tissue fluid

14.0 CONTROL OF THE INTERNAL ENVIRONMENT

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
14.1. Homeostasis	14.1.1. acquire knowledge and understanding of the importance of maintaining a constant internal environment	14.1.1.1 define homeostasis as the maintenance of a constant internal environment 14.1.1.2 identify and label on a diagram of the skin: hairs, sweat glands receptors and blood vessels 14.1.1.3 describe the maintenance of a constant body temperature in Man, in terms of role of temperature receptors in the skin, shivering, sweating, blood vessels near the skin surface and the coordinating role of the brain
14.2. Excretion	14.2.1. acquire knowledge and understanding of the importance of removing waste from the body	14.2.1.1 define excretion as the removal of waste products of metabolism and/or toxic materials from organisms 14.2.1.2 identify parts of the urinary system: kidneys, ureter, bladder, urethra 14.2.1.3 describe the functions of kidneys, ureter, bladder and urethra 14.2.1.4 describe dialysis in kidney machines as the diffusion of waste products and salts (small molecules) through a semi-permeable membrane 14.2.1.5 draw and label a cross section of a mammalian kidney

15.0 RESPONSE AND CO-ORDINATION

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
15.1. Nervous system	15.1.1. acquire knowledge of functional parts of the nervous system and their relationship	15.1.1.1 discuss the relationship of sensory (receptor) cells, sense organs and the effector organs 15.1.1.2 describe the functions of a sensory neurone, a motor neurone and a relay neurone 15.1.1.3 draw a labelled diagram of a sensory neurone, a motor neurone and a relay neurone
	15.1.2. appreciate how a reflex action occurs	15.1.2.1 demonstrate and describe a reflex action
	15.1.3. understand the general function of the central nervous system	15.1.3.1 describe the functions of the pituitary gland and spinal cord
15.2. Hormonal co-ordination	15.2.1. understand and appreciate the function of hormones in body co-ordination	15.2.1.1 define a hormone as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs 15.2.1.2 identify and label on diagram the endocrine glands of the human body 15.2.1.3 name the hormones produced by the glands in the body 15.2.1.4 discuss the main functions of hormones insulin, glucagon and adrenalin 15.2.1.5 compare the nervous and endocrine systems
15.3. The use and abuse of drugs	15.3.1. understand drugs and their medicinal use	15.3.1.1 define a drug as any substance taken in from an external source to affect or modify chemical reactions in the body 15.3.1.2 distinguish between medicinal and non-medicinal drugs 15.3.1.3 describe the medicinal use of drugs e.g. antibiotics, painkillers, antacids etc. 15.3.1.4 discuss dependence (emotional and physical) and tolerance of medicinal drugs 15.3.1.5 discuss allergic reactions to drugs (penicillin), pollen, dust and food substances
	15.3.2. be aware of the dangers of abusing drugs	15.3.2.1 discuss the dangers of drug abuse e.g. damage to body tissues 15.3.2.2 describe non-medicinal (abusive) drugs according to their effect on the central nervous system: depressants, stimulants, hallucinogens 15.3.2.3 describe the dangers of consumption of alcohol: reduced self-control, depressant, effect on reaction time, damage to liver, social implications

16.0 REPRODUCTION

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
16.1. Forms of reproduction	16.1.1. acquire knowledge of asexual and sexual reproduction	16.1.1.1 describe asexual reproduction as the process resulting in the production of genetically identical offspring from one parent 16.1.1.2 give examples of asexual reproduction in plants and animals 16.1.1.3 describe commercially important applications of asexual reproduction in plants [include stem cuttings in sweet potatoes and grapes, grafting in oranges] 16.1.1.4 describe sexual reproduction as the process involving the fusion of nuclei from two different gametes to form a zygote and resulting in offspring's that are genetically dissimilar to parents
16.2. Sexual reproduction in flowering plants	16.2.1. acquire knowledge of reproductive parts of flowering plants	16.2.1.1 observe using a hand lens the sepals, petals, stamens, and carpels of the flower and draw the parts
	16.2.2. acquire knowledge and understanding of the processes of pollination, fertilisation and seed dispersal	16.2.2.1 describe types of pollination 16.2.2.2 compare functions of fruits and seeds in terms of dispersal and protection of seeds 16.2.2.3 describe the growth of the pollen tube and its entry into the ovule followed by fertilisation 16.2.2.4 describe the structure and function of parts of a non-endospermic seed in terms of embryo, (radicle and plumule) cotyledons and testa 16.2.2.5 investigate the environmental conditions (oxygen water and temperature) which affect germination of seeds 16.2.2.6 describe the role of enzymes in seed germination

16.3. Sexual reproduction in mammals	16.3.1. acquire knowledge about human reproductive parts and their functions	16.3.1.1 use a diagram of the male reproductive system to identify testes, scrotum, sperm ducts, prostate gland, seminal vesicle, Cowper's gland, urethra and penis 16.3.1.2 describe the functions of the testes, scrotum, sperm ducts, prostate gland, urethra and penis 16.3.1.3 use a diagram of the female reproductive system to identify ovaries, oviducts, uterus, cervix, vagina and bladder 16.3.1.4 describe the functions of the ovaries, oviducts, uterus, cervix and vagina
	16.3.2. acquire knowledge about the menstrual cycle, fertilisation and development of the zygote	16.3.2.1 discuss the menstrual cycle and factors affecting it 16.3.2.2 describe fertilisation and early development of the zygote in terms of the formation of a ball of cells which becomes implanted in the wall of the uterus 16.3.2.3 discuss the functions of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and waste products
	16.3.4. acquire knowledge about the use of birth control methods	16.3.4.1 discuss the following methods of birth control: natural, mechanical / physical, chemical / hormonal and surgical
	16.3.5. acquire knowledge of sexually transmitted diseases and be aware of their prevalence and seriousness	16.3.5.1 describe the causes, transmission, symptoms / signs, effects and treatment of gonorrhoea, syphilis and AIDS 16.3.5.2 discuss the control of the spread of sexually transmitted diseases [gonorrhoea, syphilis and AIDS

17.0 LIVING THINGS AND THE ENVIRONMENT

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
17.1. Ecology	17.1.1. acquire knowledge and understanding of the importance of energy flow through ecosystems	17.1.1.1 describe the importance of the sun as the principal source of energy for biological systems 17.1.1.2 describe energy transfer through an ecosystem
	17.1.2. be aware of the impact of man's activities on the environment	17.1.2.1 discuss how poor agricultural practices result in destruction of the ecosystem e.g. monoculture, excessive use of fertilisers and pesticides, overstocking, deforestation 17.1.2.2 describe eutrophication 17.1.2.3 discuss the problems which contribute to famine such as unequal distribution of food, natural disasters (such as floods and drought) and increase in population
	17.1.3. acquire knowledge of managing problems associated with pollution	17.1.3.1 describe the undesirable effects of water pollution by sewage and inorganic wastes, air pollution by sulphur dioxide and land by chemicals and litter
17.2. Conservation	17.1.4. be aware of and appreciate the need to conserve our natural resources	17.1.4.1 discuss conservation of species with reference to local plants, e.g. *mosukujane, sengaparile*, *monepenepe, mowana* and animals, rhinos, wild dogs, cheetahs 17.1.4.2 discuss the importance of plant and animal species conservation for food, medicine and tourist attraction 17.1.4.3 discuss reasons for recycling of materials including sewage water, paper, bottles and tins

18.0 BIOTECHNOLOGY

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
18.1. Biotechnology	18.1.1. appreciate biotechnology as an approach to solving day to day problems and its role in the provision of food, fuels, medicines and new raw materials for industry	18.1.1.1 define biotechnology as the application of biological organisms, systems or processes to manufacturing and service industries 18.1.1.2 discuss the role of living organisms in the production of medicine such as antibiotics and vaccines 18.1.1.3 discuss how industry in Botswana can benefit from biotechnology e.g. bread, drugs *madila*, *chibuku (bojalwa ja Setswana)*

5. OTHER INFORMATION

5.1 GRADING AND REPORTING

BGCSE results are reported on a scale of A* – G, A* being the highest and G the lowest. Ungraded (U) indicates that the candidate's performance fell short of the standard required for grade G. Ungraded (U) will be reported on the statement of results but not on the certificate. The letters Q (result pending) and X (no result) may also appear on the statement of results.

5.2 GRADE DESCRIPTORS

As a guide to what might be expected of a candidate, Grade Descriptors are given as follows.

A **Grade A** candidate should be able to:

- recall a wide range of scientific facts, concepts, principles and theories and use complex scientific knowledge
- understand the relationship between complex scientific concepts and relate them to scientific principles and theories in real life situations
- apply appropriate scientific knowledge and understanding, identify complex patterns, and report trends from given information and draw appropriate conclusions and give recommendations to novel situations
- translate abstract information from one form to another: process information from graphs, tables and charts; represent information in the form of graphs, tables and charts
- make concise and complete experimental procedures (plan); critically discuss the plan; generate hypotheses to solve a scientific problem, identify and deal with a wide range of variables
- demonstrate understanding of the correct and safe use of appropriate apparatus and techniques; follow / evaluate all the given instructions to an experiment
- make accurate observations; decide the level of precision needed in measurements and record detailed experimental data; process data, make appropriate conclusions and generalisations; identify and explain anomalous observation

A **Grade C** candidate should be able to:

- recall a range of scientific facts, concepts, principles and theories and use scientific knowledge
- understand the relationship between scientific concepts and relate them to scientific principles and theories in real life situations
- apply scientific knowledge and understanding, identify patterns, and report trends from given information and draw relevant conclusions and give recommendation to simple situations
- translate information from one form to another: process information from graphs, tables and charts; represent information in the form of graphs, tables and charts
- make concise and complete experimental procedures (plan); generate hypotheses to solve a scientific problem and identify some key factors to vary and control
- demonstrate understanding of the correct and safe use of appropriate apparatus and techniques; follow / evaluate most of the given instructions to an experiment
- make accurate observations, measurements and record experimental data; process data, make conclusions and generalisations; recognise when it is necessary to repeat observation and measurement

A **Grade E** candidate should be able to:

- recall simple scientific facts, concepts, principles and theories and use simple scientific knowledge
- understand the relationship between simple scientific concepts and relate them to simple scientific principles and theories in real life situations
- apply simple scientific knowledge and understanding, identify patterns, and report trends from given information and draw conclusions and give recommendation to familiar situations
- translate simple information from one form to another: process information from graphs, tables and charts with some assistance; represent information in the form of graphs, tables and charts
- make simple and complete experimental procedures (plan); devise a fair test which only involves a few factors, generate hypotheses
- demonstrate understanding of the correct and safe use of some apparatus and techniques; follow / evaluate some of the given instructions to an experiment
- make simple observations; measurements and record experimental data; process data, make conclusions where appropriate

6. Appendices

A. MATHEMATICAL SKILLS

Candidates will be required to perform quantitative work, including calculations.
They should be able to use scientific calculators and mathematical instruments.

The mathematical requirements, which form part of this syllabus, are listed below.

add, subtract, multiply and divide numbers
recognize and use expression in decimal form
use simple formulae
understand and use averages
read, interpret and draw simple inferences from tables and statistical diagrams
find fractions or percentages of quantities
construct and interpret pie-charts
calculate with fractions, decimals, percentage or ratios
manipulate and solve simple equations
substitute numbers in simple equations
recognize and use expressions in standard form
interpret and use graphs
choose by simple inspection and then draw the best smooth curve through a set of points on a graph
select appropriate axes and scales for plotting a graph
determine the intercept of a linear graph
understand and use direct and indirect proportion

B. PHYSICAL QUANTITIES, SYMBOLS AND UNITS

Candidates will be required to demonstrate an understanding of the physical quantities, and their corresponding SI units, listed below. They will be required to use them in quantitative work and calculations.

physical quantity	**symbols**	**SI unit(s)**	**other unit(s)**
length	*l, h*	metre (m)	kilometre(km); centimetre (cm); millimetre (mm)
mass	*M, m*	kilogram (kg)	gram (g); milligram (mg)
time	*t*	seconds (s)	milliseconds (ms), minutes (min), hours (h)
temperature	*θ, T*	Kelvin (K)	degree Celsius (^{o}C)
current	*I*	ampere (A)	milliampere (mA)

DERIVED QUANTITIES AND UNITS

physical quantity	**symbols**	**unit(s)**
area	*A*	cm^2; m^2
volume	*V*	cm^3; m^3
density	ρ	kg/m^3; g/cm^3
force	*F*	newton (N)
pressure	*P*	pascal (Pa); N/m^2; N/cm^2
speed	*u, v*	m/s; km/h
acceleration	*a*	m/s^2
energy	*E*	joule (J); kilojoule (kJ); megajoule (MJ)
power	*P*	watt (W); kilowatt (kW); megawatt(MW)
frequency	*f*	hertz (Hz); kilohertz (kHz)
electrical charge	*Q, q*	coulomb (C)
potential difference	*V*	volt (V)
resistance	*R*	ohm (Ω)
weight	*W*	newton (N)
acceleration of free fall	*g*	m/s^2, N/kg
work	*W*	joule (J)
specific heat capacity	*c*	J/(g °C), J/(kg °C)
specific latent heat	*l*	J/kg, J/g
wavelength	λ	m, cm
electromotive force	*E*	V

NOTE

Units, significant figures. Candidates would be advised in each question on the number of significant figures or decimal places they have to express their answers to. If there is no advice on such, answers can be given to any number of significant figures. Candidates should be aware that misuse of units that is, failure to code units where necessary or the inclusion of units in quantities defined as ratios is liable to be penalised.

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

C. GLOSSARY OF TERMS

Learning objectives in the content section of the syllabus are expressed in terms of what candidates **know**, **understand** and **can do**. The words used on the examination papers in connection with the assessment of these learning outcomes are contained in this glossary. This is neither exhaustive nor definitive but is meant to provide some useful guidance.

1. Writing questions about what candidates are expected to know

About 25 % of the marks are involved with *recall.* Words used on examination papers in connection with such questions may include:

"State...", "List...", "Give...", "Name....", "Define...", "Draw…", "Write…", "What…", "How…..", What is meant by….."

State or Name… implies a concise answer with little or no supporting argument.

List… requires a number of points generally each of one word, with no elaboration.

Define… is intended literally, only a formal statement or equivalent paraphrase being required.

What is meant by... normally implies that a definition should be given together with some relevant comment on the significance or context of the term(s) concerned, especially when 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.

2. Writing questions about understanding

"***Understand***" may be associated with simple factual recall. In this sense the candidate is required to recall the relevant part of the defined syllabus and to use this recalled information to amplify, extend or expand this in a wider context. This wider context will include situations or materials with which the candidates are familiar.

Questions may include such words as:

"*Explain…" "Complete..." "Why.", "Construct...", "Which…*

Explain… may imply reasoning or some of reference to theory, depending on the context.

"**Understand**" may also be associated with skills other than factual recall. It can be used to assess the candidate's abilities in problem solving, interpretation and evaluation, data handling and in communication of scientific ideas, principles and concepts. Words such as "*Suggest...", "Work out…", "How would you know that*…" may be used in questions.

Suggest… Is used in two main contexts: either to imply that there is no unique answer or to imply that candidates are expected to apply their general knowledge to a situation that may not formally be in the syllabus. This would be related to the Assessment Objective 2.

3. Writing questions about "be able to".

The use of this phrase is always associated with higher-order skills of interpretation, evaluation, calculation and communication. It involves the ability to recall the appropriate material from the content and apply this knowledge.

Questions may include *"Be able to…", "deduce…", "relate….", "interpret…", "explain…", "carry out…", "evaluate…" "predict….", "discuss…", "construct…", "suggest…", "calculate…", "find…", "demonstrate…", "estimate…", "determine..".*

deduce… is used in a similar way as predict except that some supporting statement is required, e.g., reference to a law or principle, or the necessary reasoning to be included in the answer.

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 early part of the question.

calculate… is used when a numerical answer is required. In general, working should be shown when two or more steps are involved.

find… is general term that may be interpreted as calculate, measure, determine, etc.

measure… implies that the quantity concerned can be directly obtained from suitable measuring instruments.

estimate… implies a reasoned order of magnitude statement or calculation of the quantity concerned making such implying assumptions as may be necessary about points of principle and about the values of quantities not otherwise used in the question.

discuss… requires the candidates to give critical account of the points involved in the topic.

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 standard formula.

D. PRESENTATION OF DATA

Tables

- Each column of a table will be headed with the physical quantity and the appropriate SI units, e.g., time / s, rather than time (s)
  There are two acceptable methods of stating units, e.g., m / s or ms^{-1}
- Candidates should use the number of significant figures appropriate to the precision of the measuring instrument.
- The column headings of the table can then be directly transferred to the axes of a constructed graph.

Graphs

- The independent variable will be plotted on the x-axis (horizontal axis) and the dependent variable plotted on the y-axis (vertical axis).
- The graph is the whole diagrammatic presentation. It may have one or several curves / lines plotted on it.
- Points on the curve / line should be clearly marked as crosses (**×**) or encircled dot (ʘ).
  If a further curve / line is included, vertical crosses (**+**) may be used to mark the points.
- Plots of points should have an accuracy of better than 1mm and all read-offs.
  Plots should be made with a sharp pencil.

E. Notes for use in Qualitative Analysis

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 lead(II) nitrate or aqueous silver nitrate	white precipitate
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide then aluminium foil; warm carefully	ammonia produced
sulphate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium chloride or aqueous barium nitrate	white precipitate

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
ammonium (NH_4^+)	ammonia produced on warming	–
copper(II) (Cu^{2+})	light blue precipitate, insoluble in excess	light blue precipitate, soluble in excess giving a dark blue solution
iron(II) (Fe^{2+})	dirty green precipitate, insoluble in excess	dirty green precipitate, insoluble in excess
iron(III) (Fe^{3+})	red brown precipitate, insoluble in excess	red brown precipitate, insoluble in excess
zinc (Zn^{2+})	white precipitate, soluble in excess forming colourless solution	white precipitate, soluble in excess forming colourless solution

gas	test and test result
ammonia (NH_3)	turns dump red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	“pops” with a lighted splint
oxygen (O_2)	relights a glowing splint

F. The Periodic Table

The Periodic Table of Elements

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

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

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

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

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