BOTSWANA
EXAMINATIONS
COUNCIL

BOTSWANA GENERAL CERTIFICATE
OF SECONDARY EDUCATION

ASSESSMENT SYLLABUS

CHEMISTRY

CODE 0570

Effective for examination from 2020

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: Practical Test

Paper 4: 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The grade descriptors for F have been replaced by grade descriptors for E.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 Chemistry Assessment Syllabus is designed to assess the outcome of instruction for candidates who have completed a course based on the Senior Secondary Chemistry 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 Chemistry Assessment Syllabus should be read in conjunction with the Senior Secondary Chemistry 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 or Paper 4, which are described below.
The questions will be based on the whole syllabus.

2.1 The components

<table>
<tr><th colspan="2">All candidates must take:</th></tr>
<tr><td>Paper 1 1 hour
Multiple Choice

A multiple-choice paper consisting of 40 items each with 4 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</td><td>Paper 2 1 hour 15 minutes
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.

70 marks.

The paper will be weighted at 50% of the final total marks</td></tr>
<tr><th>either:</th><th>or:</th></tr>
<tr><td>Paper 3 1 hour
Practical Test

This paper will test Assessment Objective 3 (AO 3). It is a laboratory based paper with questions covering experimental and observational skills.

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

30 marks.

The paper will be weighted at 20% of final total mark</td><td>Paper 4 1 hour
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.

40 marks.

The paper will be weighted at 20% of the final total mark.</td></tr>
</table>

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
- 0569 Science Double Award

3. Syllabus Aims and Assessment Objectives

3.1 Aims

According to the Chemistry 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. handle instruments, apparatus and materials safely;
4. make and record observations, measurements and estimates;
5. interpret and evaluate observations and data;
6. plan investigations and / or evaluate methods and suggest possible improvements;
7. convert acquired skills into creative innovations;
8. 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	Paper 4	
AO1: Knowledge with Understanding	recall	12 ± 2 (30 %)	22 ± 2 (30 %)	–	–	50 %
	understanding	13 ± 2 (33 %)	22 ± 2 (33 %)	–	–	
AO2: Handling Information and Problem Solving		15 (37 %)	26 (37 %)	–	–	30 %
AO3: Experimental Skills		–	–	100 %	100%	20 %
Total Marks		40	70	30	40	
Weighting of paper in overall qualification		30 %	50 %	20 %	20 %	100 %

4. CONTENT

This section presents the content as prescribed in the Chemistry Teaching Syllabus.

EXPERIMENTAL / INVESTIGATION SKILLS

TOPIC	GENERAL OBJECTIVES	SPECIFIC OBJECTIVES
	Learners should	*Learners should*
Experimental / Investigation Skills	apply basic skills for scientific investigation:	- follow a sequence of instructions
	• using and organising apparatus and materials:	- 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
	• 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

1. MATTER

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
1.1. Particulate nature of matter	1.1.1 understand the nature of matter in terms of particles	1.1.1.1. explain states of matter in terms of particle arrangement and movement 1.1.1.2. explain changes of state of matter in terms of the Kinetic Particle Theory 1.1.1.3. describe diffusion of particles in fluids 1.1.1.4. describe the dependence of rate of diffusion on molecular mass (treated quantitatively) 1.1.1.5. demonstrate diffusion in gases
1.2. Atomic structure	1.2.1. acquire an understanding of the structure and characteristics of atoms	1.2.1.1. describe the structure of an atom in terms of neutrons, protons and electrons 1.2.1.2. state the relative charges and approximate relative masses of protons, neutrons and electrons 1.2.1.3. define atomic number (proton number). 1.2.1.4. define Mass number (nucleon number). 1.2.1.5. use and interpret symbols such as $^{12}_{6}C$ 1.2.1.6. describe the build up of electrons in “shells” 1.2.1.7. draw the structure of atoms of elements 1 to 20 in the periodic table showing the electron arrangement and the nucleus 1.2.1.8. explain the significance of valency electrons and the noble gas configuration 1.2.1.9. define isotopes (give examples of hydrogen, carbon and chlorine isotopes)
1.3. Periodic Table	1.3.1. be aware of the periodic table as a method of classifying elements	1.3.1.1. extract information from the periodic table 1.3.1.2. translate from element name to symbol and vice versa 1.3.1.3. describe periodic trends like the change from metallic to non-metallic character, electronegativity across a period (use period III to illustrate this), include trend of atomic radius across a period 1.3.1.4. state the relationship between Group number and number of valency electrons 1.3.1.5. state the relationship between period number and number of main shells

1.3. Periodic Table	1.3.2. use trends in the periodic table to acquire knowledge and understanding of properties of elements	1.3.2.1. describe lithium, sodium and potassium as a collection of relatively soft metals showing a trend in melting point, density and in reaction with water 1.3.2.2. predict the properties of other elements in Group I, given data, where appropriate 1.3.2.3. describe chlorine, bromine and iodine 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 1.3.2.4. predict the properties of other elements in Group VII, given data, where appropriate 1.3.2.5. describe the transition elements as a collection of metals having high densities, high melting points, variable valencies, forming coloured compounds and which, as elements and compounds, often used as catalysts 1.3.2.6 describe elements in Group VIII or 0 as being unreactive 1.3.2.7 describe the uses of the Noble Gases in providing an inert atmosphere e.g. argon in lamps, helium for filling balloons, etc. 1.3.2.8 predict trends in Groups other than I, VII and VIII or 0 given information about elements concerned
1.4. Chemical Bonding	1.4.1. acquire knowledge and understanding of the structure of matter in terms of bonding between particles	1.5.1.1. state the significance of valency electrons 1.5.1.2. describe the formation of ions by electron loss or gain 1.5.1.3. define an ionic bond as an electrostatic force of attraction between oppositely charged ions 1.5.1.4. describe the formation of ionic bonds between metallic and non-metallic elements, e.g. in NaCl, $CaCl_2$, 1.5.1.5. describe properties and uses of ionic compounds 1.5.1.6. describe the formation of covalent bonds between non-metallic elements leading to the noble gas electron configuration, e.g. . H_2, Cl_2, HCl, H_2O, CH_4, C_2H_4, N_2, CO_2, CH_3OH etc 1.5.1.7. define a single covalent bond as a shared pair of electrons 1.5.1.8. deduce the electron arrangement in other covalent molecules 1.5.1.9. construct ‘dot’ and ‘cross’ diagrams of other covalent molecules 1.5.1.10. represent an electron pair by a dash in structural formulae 1.5.1.11. describe properties of covalent compounds 1.5.1.12. describe metallic bonding as a lattice of positive ions in a ‘sea of electrons’ 1.5.1.13. explain electrical conductivity and malleability of metals 1.5.1.14. describe the lattice structure of sodium chloride 1.5.1.15. distinguish between intra/inter molecular forces

2 CHEMICAL REACTIONS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
2.1. Energy changes	2.1.1 understand chemical reactions and explore their nature using the investigative approach	2.1.1.1. state that substances contain a certain amount of energy stored in bonds 2.1.1.2. describe the meaning of exothermic and endothermic reactions 2.1.1.3. carry out experiments which show exothermic and endothermic reactions (including chemical equations) 2.1.1.4. describe examples of endothermic reactions e.g. photosynthesis and the use of silver salts in photography 2.1.1.5. describe examples of exothermic reactions e.g. respiration, combustion of fuels, reaction of reactive metals with water
	2.1.2. be familiar with the energy changes that take place during chemical reactions	2.1.2.1. make simple calculations involving energy changes (including energy diagrams) 2.1.2.2. describe bond breaking as endothermic ΔH (+ve) 2.1.2.3. describe bond formation as exothermic ΔH (-ve) 2.1.2.4. describe activation energy as the energy required by some particles to break bonds for reactions to occur 2.1.2.5. demonstrate the production of electrical energy from simple cells
2.2 Rate of reaction	2.2.1. investigate the qualitative effect of several variables on the rate of chemical reaction.	2.2.1.1. devise a suitable method of investigating the effect of a given variable on the rate of a chemical reaction 2.2.1.2. represent and interpret data obtained from experiments concerned with rates of reaction 2.2.1.3. describe and explain the effect of concentration, temperature, surface area, use of catalyst and pressure on the rate of chemical reactions 2.2.1.4. explain the effects of the above factors in terms of collisions between the reacting particles 2.2.1.5. explain how explosive combustion with fine powders (e.g. in flour mills) and combustible gases (e.g. in mines) occur 2.2.1.6. list some everyday instances of speeding up or slowing down reactions and identify the changing variable in each of the reactions 2.2.1.7. compare enzymes with other catalysts 2.2.1.8. state uses of enzymes in baking, brewing, dairy industry 2.2.1.9. describe practical applications of the effect of temperature on rates of enzyme-catalysed reactions in food preservation e.g. freezing, refrigeration, cooking 2.2.1.10. conduct an experiment to illustrate catalysis

2.3. Reversible reactions	2.3.1. understand that some reactions can be reversed by changing reaction conditions	2.3.1.1. describe the concept of equilibrium 2.3.1.2. state the idea that some reversible reactions reach a state of dynamic equilibrium 2.3.1.3. represent a reversible reaction using symbols 2.3.1.4. predict the effect of changing pressure, temperature and concentration on a reversible reaction at equilibrium
2.4. Redox Reactions	2.4.1 understand concept of oxidation and reduction	2.4.1.1. define oxidation in terms of electron loss and increase in oxidation number 2.4.1.2. define reduction in terms of electron gain and decrease in oxidation number 2.4.1.3. define an oxidising agent as a substance that gains electrons from another substance 2.4.1.4. define a reducing agent as substance that losses electrons to another substance 2.4.1.5. use the test for oxidising agents and reducing agents using aqueous potassium iodide, acidified potassium chromate(VI) and acidified potassium manganate(VII), including chemical equations 2.4.1.6. identify and describe examples of commonly occurring redox equations 2.4.1.7. identify a redox reaction; reducing agent and an oxidising agent in a redox reaction equation

2.5. Electrolysis	2.5.1. understand the process of electrolysis of compounds in the molten state or in aqueous solution	2.5.1.1. describe electrolysis as a process of decomposition of a substance using electrical energy 2.5.1.2. identify electrodes (anode and cathode) and electrolyte from an electrolytic cell 2.5.1.3. explain electrolysis in terms of migration and discharge of ions 2.5.1.4. carry out electrolysis of the following: concentrated hydrochloric acid, concentrated aqueous sodium chloride, dilute sulphuric acid between inert electrodes; aqueous copper(II) sulphate using carbon electrodes and copper electrodes; molten lead(II) bromide 2.5.1.5. state importance of electroplating 2.5.1.6. describe the factors influencing preferential discharge of ions at the electrodes 2.5.1.7. describe the electrolytic refining of copper and gold. 2.5.1.8. carry out simple electroplating of metals using copper 2.5.1.9. state and use Faraday constant 2.5.1.10. calculate the quantity of charge passed during electrolysis 2.5.1.11. calculate the mass/volume of substance liberated during electrolysis

2.6. Acids, bases and salts	2.6.1. acquire information about acids, bases and salts and investigate their properties	2.6.1.1. define an acid as an hydrogen ion, H^+, donor 2.6.1.2. define a base as an hydrogen ion, H^+, acceptor 2.6.1.3. describe the meaning of weak and strong acids and alkalis 2.6.1.4. investigate the properties of strong and weak acids 2.6.1.5. investigate properties of strong and weak alkalis 2.6.1.6. explain the difference between strength and concentration 2.6.1.7. describe the effect of acids and alkalis on indicators such as methyl orange, universal indicator, litmus 2.6.1.8. describe pH as a measure of the degree of acidity or alkalinity of a solution 2.6.1.9. describe how the pH of a solution is measured using universal indicator 2.6.1.10. investigate (including equations) the characteristic properties of acids in reactions with metals and bases (including alkalis and carbonates) 2.6.1.11. test for and identify hydrogen using a lighted splint and carbon dioxide using lime water 2.6.1.12. investigate the characteristic properties of bases in reactions with acids and ammonium salts (including reaction equations) 2.6.1.13. give applications of acid/base reactions in daily life e.g. treatment of indigestion, treatment of acidic soils, brushing teeth with toothpaste 2.6.1.14. classify and give examples of oxides as acidic, basic, neutral or amphoteric 2.6.1.15. prepare soluble from acid/base, acid/metal reactions 2.6.1.16. prepare insoluble salts by precipitation 2.6.1.17. purify salts by filtration and crystallisation 2.6.1.18. suggest a method of preparing a given salt from suitable starting materials, given appropriate information 2.6.1.19. conduct tests for the following cations: Cu^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, NH_4^+, Ca^{2+} and Al^{3+} using aqueous sodium hydroxide and aqueous ammonium hydroxide (include equations) 2.6.1.20. conduct tests for the following anions: SO_4^{2-},(by reaction under acidic conditions with barium ions); Cl^-, (by reaction under acidic conditions with silver ions); CO_3^{2-},$^-$(by reaction with dilute acid and then with lime water); I^{--},(by reaction under acidic conditions with lead (II) nitrate), NO_3^{--},(by reaction with aluminium)

3. STOICHIOMETRY

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
3.1. Chemical formulae and equations	3.1.1. understand the stoichiometry of chemical formulae and equations	3.1.1.1. represent elements, ions and the formulae of compounds with symbols 3.1.1.2. determine formulae of compounds from the charges of ions or from models and diagrams 3.1.1.3. interpret symbolic equations 3.1.1.4. construct balanced chemical equations with state symbols including ionic equations.
3.2 The Mole	3.2.1. understand the mole concept	3.2.1.1. define one mole of a substance as the amount of that substance containing 6.02×10^{23} particles (Avogadro's number, N_A) 3.2.1.2. define the relative atomic mass, A_r, and the relative molecular mass, M_r 3.2.1.3. calculate the relative molecular mass of a compound with known formula. 3.2.1.4. convert moles into other units (and vice versa) like grams (mostly for solids), cm^3 (mostly for liquids) and dm^3 for gases (knowing that the molar gas volume at room temperature and pressure = 24 dm^3
3.3 Chemical calculations	3.3.1. perform simple chemical calculations	3.3.1.1. deduce empirical and molecular formulae, given the relevant information 3.3.1.2. calculate percentages like composition, purity and yield 3.3.1.3. calculate stoichiometric reacting masses and volumes of matter 3.3.1.4 collect and measure the volume of a gaseous product of a chemical reaction 3.3.1.5 carry out experiments to determine the formula of a binary compound e.g. MgO, CuO
3.4. Quantitative analysis	3.4.1. perform simple quantitative analysis	3.4.1.1. measure volumes of liquids using a volumetric flask, pipette and burette 3.4.1.2. make solutions of different concentrations by dilution from a given standard solution 3.4.1.3. calculate concentrations (mol/ dm^3) in aqueous solutions. 3.4.1.4 calculate the amount of solute present in a solution of given concentration 3.4.1.5. carry out simple acid-base titrations and titration calculations (including volumetric analysis to solve simple problems) 3.4.1.6. prepare standard solutions of different concentrations using pipettes and/or graduated flasks

4. METALS AND NON-METALS

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
4.1. Properties of metals	4.1.1. acquire practical skills and knowledge of general physical and chemical properties of metals.	4.1.1.1. describe the general physical and chemical properties of metals 4.1.1.2. describe the reactivity series as related to the tendency of a metal to form its positive ion 4.1.1.3. describe the reactivity series of metals in relation to displacement reactions (including chemical equations) 4.1.1.4. place the common metals (potassium, sodium, calcium, magnesium, aluminium, *carbon*, zinc, iron, lead, *hydrogen*, copper, silver, gold) in order of reactivity 4.1.1.5. use the series to show the pattern in the reactions of these metals with water or steam, dilute hydrochloric acid (including chemical equations) 4.1.1.6. explain the position of carbon and hydrogen in the reactivity series 4.1.1.7. explain the existence in nature of some metals as “free elements” e.g. gold 4.1.1.8. investigate the action of heat on the oxides, hydroxides, carbonates and nitrates of the listed metals (including chemical equations) 4.1.1.9. account for the apparent unreactivity of aluminium as it forms a film of oxide 4.1.1.10. describe alloys as a mixture of metals or of metals and non-metals 4.1.1.11. explain why metals are often used in the form of alloys by reference to steel, brass, duralumin, solder, alnico and bronze 4.1.1.12. name the constituent elements of the alloys listed above 4.1.1.13. state percentages of constituent elements of the alloys
4.2. Extraction of metals	4.2.1. acquire understanding and knowledge of the chemical processes involved in the extraction of aluminium, zinc, iron and copper.	4.2.1.1. name the important ores of the metals aluminium, zinc, iron and copper 4.2.1.2.- identify the methods of extraction of the metals listed above depending on their position in the reactivity series 4.2.1.3.- describe the chemical reactions involved in the extraction of iron and aluminium 4.2.1.4.- outline the general principles of steel making

4.3. Uses of metals and alloys	4.3.1. be aware of the uses of common metals and alloys in terms of their properties and availability.	4.3.1.1. list the uses of aluminium e.g. in the manufacture of aircraft because of its strength and low density, in food containers because of its resistance to corrosion 4.3.1.2. list the uses of zinc (galvanizing iron, in cells) 4.3.1.3. list the uses of copper (electrical wires and cooking utensils) 4.3.1.4. list the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)
4.4. Chlorine	4.4.1. understand the concept of electro-motive force	4.4.1.1. describe the preparation of chlorine from concentrated hydrochloric acid using an oxidising agent 4.4.1.2. state the test for chlorine as bleachine a litmus paper 4.4.1.3. state the uses of chlorine (sterilising water, manufacturing plastics, making domestic bleaches etc. 4.4.1.4. describe properties of chlorine 4.4.1.5. describe the bleaching action of chlorine
	4.4.2. understand the uses of some important compounds of chlorine and its manufacture	4.4.2.1. name some sources of sodium chloride e.g. sea water, salt pans (give examples of some places in Botswana) 4.4.2.2.- describe the importance of sodium chloride as a source for chlorine, sodium hydroxide and common salt 4.4.2.3.- describe extraction of sodium chloride from soda ash (focus on local process at Botswana Ash in Sowa Town)
4.5. Sulphur	4.5.1. acquire knowledge of sources and uses of sulphur and properties of its important compounds	4.5.1.1. list the sources of sulphur 4.5.1.2. describe the preparation of sulphur dioxide 4.5.1.3. state the important uses of sulphur dioxide (bleach in the manufacture of wood pulp, food preservative by killing bacteria) 4.5.1.4. describe the manufacture of sulphuric acid from sulphur by Contact process (conditions and reactions) 4.5.1.5. state the important uses of sulphuric acid (in the manufacture of detergent and fertilisers, car batteries and as a dehydrating agent

4.5. Carbon and carbonates	4.5.1. acquire knowledge of the different forms of carbon	4.2.6.1. state and identify diamond and graphite as allotropes of carbon 4.2.6.2. relate the structures of diamond and graphite to their uses 4.2.6.3. describe the processes involved in the extraction and refining of diamond in Botswana 4.2.6.4. describe the similarity in structure of graphite, diamond and silica [silicon (IV) oxide] and of their properties related to their structures.
	4.5.2. acquire knowledge of formation and uses of important carbonates	4.5.2.1. list the uses of sodium carbonate and calcium carbonate
4.6. Nitrogen	4.6.1. acquire knowledge of sources and uses of nitrogen	4.6.1.1. name the sources of nitrogen and hydrogen in making ammonia 4.6.1.2. state the uses of ammonia 4.6.1.3. describe the essential conditions for making ammonia by the Haber process

5. CHEMISTRY IN THE ENVIRONMENT

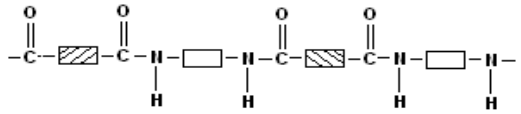
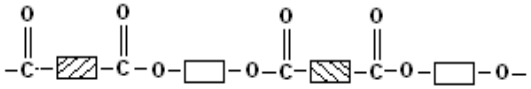
Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
5.1. Water	5.1.1. acquire knowledge about the physical and chemical properties of water	5.1.1.1. describe physical properties of pure water 5.1.1.2. carry out a chemical test for water 5.1.1.3. explain the following terms hydration, hydrolysis, drying, dehydration deliquescence, efflorescence and hygroscopic 5.1.1.4. investigate the existence of water of crystallisation
	5.1.2. appreciate the effect of dissolving property of water in producing hard water and pollution	5.1.2.1. describe the process that results in hard water (name salts causing hard water) 5.1.2.2. distinguish temporary hardness of water and permanent hardness of water 5.1.2.3. measure the hardness of water 5.1.2.4. describe physical and chemical process of softening hard water 5.1.2.5. describe how a detergent works 5.1.2.6. describe pollution of water in terms of dissolved substances, accumulation of toxic substances and effect of detergents 5.1.2.7. investigate effects of pollutants in water 5.1.2.8. explain the consequence of water pollution 5.1.2.9. describe pollution of water in terms of biological oxygen demand (BOD)
5.2. Air	5.2.1. appreciate the delicate balance of air in volume and quality	5.2.1.1. state the proportions of different components of clean air by percentage volume 5.2.1.2. describe the separation of oxygen and nitrogen from air by fractional distillation 5.2.1.3. explain the effect of increased carbon dioxide concentration in the atmosphere 5.2.1.4. name the uses of oxygen in health and in industry 5.2.1.5. state the importance of the ozone layer

	5.2.2. be aware that people's action on the environment can result in air pollution and appreciate the need to control it	5.2.2.1. name the common pollutants in the air as carbon monoxide, sulphur dioxide, oxides of nitrogen and lead compounds 5.2.2.2. state the source of each of the common pollutants 5.2.2.3. explain why it is dangerous to run a petrol engine in a closed garage or use a coal fire in a closed room 5.2.2.4. explain the presence of oxides of nitrogen in car exhausts 5.2.2.5. explain the problems caused by burning coal 5.2.2.6. describe the adverse effects (include chemical reactions) of common pollutants on buildings, health, vegetation, ozone layer, etc. 5.2.2.7. describe methods controlling pollution such as acid rain, toxic waste, etc. 5.2.2.8. state uses of catalytic converters and unleaded petrol in reducing pollution from car exhausts
5.3. Recycling	5.3.1. appreciate the role of recycling in conservation of natural resources and reducing the problem of pollution	4.5.2.1. describe some of the problems caused by the chemistry industry 4.5.2.2.- explain the importance of recycling 4.5.2.3.- identify methods of recycling of various substances (e.g. paper, metals, glass, water) 4.5.2.4.- find out advantages of using recyclable materials
5.4. Sources of energy	5.4.1. be aware of the chemical processes taking place when fuels are burned	5.4.1.1. state that fuel releases energy when it is burnt 5.4.1.2. state that fuel burning is an exothermic reactions 5.4.1.3. state that energy released was stored in the bonds of the fuel molecules 5.4.1.4. state that carbon monoxide is produced when carbon-containing fuels burn in a limited supply of oxygen 5.4.1.5. describe how charcoal can be made from wood 5.4.1.6. use data and information to compare two fuels
	5.4.2. appreciate the finite nature of fossil fuels and the need to find alternative sources of energy	5.4.2.1. explain energy conservation methods used in the home 5.4.2.2. discuss the advantages and disadvantages of various energy sources 5.4.2.3. describe one use of plants in producing a fuel 5.4.2.4. describe the use of plant and animal waste in producing fuel 5.4.2.5. relate the structure of silicon to its ability to trap solar energy

6. CARBON CHEMISTRY

Topic	General Objectives	Specific Objectives
	Candidates should be able to:	***Candidates should be able to:***
6.1. Homologous Series	6.1.1. understand the importance of carbon and organic compounds	6.1.1.1. explain the ability of carbon atoms to form chains, branched chains and rings 6.1.1.2. describe the general characteristics of an homologous series 6.1.1.3. name and draw the structures of unbranched alkanes, alkenes, alkanols and organic acids containing up to five carbon atoms 6.1.1.4. identify alkanes, alkenes, alkanols and organic acids given their structural formulae 6.1.1.5. identify structural isomerism in molecules containing up to five carbon alkanes and relate it to their physical properties
6.2. Alkanes	6.2.1. be aware of the sources of alkanes and their impact in our every day life	6.2.1.1. describe burning and substitution reaction with chlorine of alkanes (exemplified by methane) and name the products (including reactions equations) 6.2.1.2. name fossil fuels, natural gas and petroleum as the main sources of alkanes 6.2.1.3. describe fractional distillation of petroleum 6.2.1.4. name the main alkane constituents in the fractions 6.2.1.5. name the uses of the fractions as: petrol fraction as fuel in cars: paraffin/kerosene fraction as fuel in stoves, lamps; diesel fraction for fuel in engines; kerosene as fuel in aircraft; lubricating fraction for lubricants and making waxes and polishes; bitumen/asphalt for making roads
6.3. Alkenes	6.3.1. know uses of alkenes and how they are manufactured	6.3.1.1. describe the manufacture of alkenes by cracking 6.3.1.2. describe properties of alkenes in terms of burning, polymerisation, addition reactions with bromine, hydrogen and steam (including reaction equations) 6.3.1.3. distinguish unsaturated hydrocarbons e.g. alkenes from saturated hydrocarbons, alkanes by molecular structures and by using aqueous bromine 6.3.1.4. describe the formation of poly(ethene) as an example of addition polymerisation of monomer units 6.3.1.5. list some uses of poly(ethene) e.g. plastic bags

6.4. Alkanols	6.4.1. acquire basic knowledge about alkanols including formation, properties and uses	6.4.1.1. describe the fermentation of simple sugars to produce ethanol and carbon dioxide and its importance in brewing and baking (including symbol equations) 6.4.1.2. describe formation of ethanol by catalytic addition of steam to ethene 6.4.1.3. relate physical properties of alkanols to number of carbon atoms e.g. boiling point 6.4.1.4. describe the properties of ethanol in terms of burning and oxidation 6.4.1.5. list some uses of alcohols as solvents, as fuels and as constituents of alcoholic beverages
6.5. Alkanoic acids	6.5.1. acquire basic knowledge about organic acids including properties and uses	6.5.1.1. describe the formation of alkanoic acids [exemplified by the formation of ethanoic acid during the oxidation of ethanol by atmospheric oxygen and by acidified potassium chromate(VI) / potassium manganate(VII)] 6.5.1.2. explain properties of ethanoic acid as a typical weak acid 6.5.1.3. name some commonly occurring alkanoic acids, their sources and uses e.g. tartaric acid, ethanoic acid, ascorbic acid, citric acid 6.5.1.4. describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate (include reaction equations)
6.6. Macro-molecules	6.6.1. be aware of macromolecules as large molecules built from small units	6.6.1.1. explain that different macromolecules have different units and/or different linkages 6.6.1.2. describe formation of macromolecules from small units (monomers)

6.7. Synthetic condesation polymers	6.7.1. be aware of the formation of synthetic polymers and their impact in everyday life	6.7.1.1. list some typical uses of condensation polymers and link their properties to uses 6.7.1.2. describe the pollution problems caused by non-biodegradable polymers e.g. plastics, nylon 6.7.1.3. list some typical uses of man-made fibres 6.7.1.4. investigate advantages and disadvantages of synthetic and natural fibres 6.7.1.5. describe uses of different macromolecules as related to their general structure and properties e.g. PVC, Polystyrene, Polypropene 6.7.1.6. interpret polymerisation reactions in terms of simple graphical formulae 6.7.1.7. describe the formation of nylon using simplified structure:  and for terylene 
6.8. Natural macromolecules	6.8.1. understand the impact of natural macromolecules in our daily life	6.8.1.1. name proteins, fats and carbohydrates as the main constituent of food 6.8.1.2. describe the hydrolysis of proteins to amino acids 6.8.1.3. prepare soap by hydrolysis of fats 6.8.1.4. describe complex carbohydrates as macromolecules formed by the condensation polymerisation of smaller carbohydrate units called sugars 6.8.1.5. describe the hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars 6.8.1.6. describe proteins as possessing the same linkage (amide) as nylon but with different units 6.8.1.7. describe fats as esters possessing the same linkage as Terylene but with different units 6.8.1.8. demonstrate how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (refer to R_f factor) or UV light 6.8.1.9. describe, in outline, the usefulness of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

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 ASSESSMENT CRITERIA FOR PRACTICALS SKILLS

By its nature Chemistry is an experimental discipline. Accordingly, it is important that the practical work and experimental skills, identified in Assessment Objective 3, are made a central part of the assessment. However, it is recognised that, in certain circumstances, it will not be possible for some centres to provide the facilities and materials required for a laboratory-based experiment. Thus, at present, this syllabus provides two methods of assessing practical skills.

Paper 3: A practical test, administred in the centre and externally marked.

Or, for candidates in those centres which do not have the facilities properly to administer Paper 4 **and** which have been granted written permission to it,

Paper 4: An alternative to pratical test, a written paper, administered in the centre and externally marked.

Criteria for Assessing Practicals Skills

These criteria describe what a candidate will be expected to do and will provide the basis for making the papers.

Paper 3, Practical test

This paper is designed to assess a candidate's familiarity with appropriate chemistry laboratory apparatus and techniques. The candidate will be required to perform given tasks, which will be based on the requirements of Assessment Objective 3.

Questions in this paper may include

(a) A volumetric analysis problem, based on one set of tirations. Knowledge of acid/alkali titrations using methyl orange or screened methyl orange will be assumed. Simple titrations involving other reagents may be set but full instructions and other necessary information will be given.

(b) An experiment that may involve the determination of some quantity e.g. temperature change and rate/speed of reactions. Such experiments will depend on the use laboratory apparatus.

(c) An observation problem in which the candidate will be asked to investigate, by specified experiments an unknown substance or mixture. The exercise may include simple chromatorgraphy, tests of oxidising and reducing agents and filtration.

(d) Systematic analysis will not be required but it will assumed that candidates will be familiar with reactions of identifying gases as specified in the Curriculum. The question papers will include notes on qualitative analysis for the use by candidates see appendix.

(e) Exercise involving organic substances and ions not in the Curriculum may be set but candidates will only be required to record observations and draw general conclusions.

(f) Candidates will not be required to carry out any weighing during the practical test.

(h) Candidates can take notebooks, textbooks or any other information for reference during the practical test.

(i) Candidates may also be required to carry out simple calculations as determined in the Curriculum.

Practical Test Techniques

The following notes are intended to give schools and candidates indication of accuracy that is expected in quantitative exercises and general instructions for qualitative exercises.

(a) Candidates should normally record burette readings to the nearest 0.1 cm^3 and they should ensure that they have carried sufficient number of titrations, e.g. in an experiment with a good end-point, two titres within 0.2 cm^3.

(b) Candidates should normally record temperatures to the nearest ten and times to the nearest second.

(c) In qualitative analysis candidates should use approximately 1 cm depth of a solution (1-2 cm) for each test and add reagents slowly, ensuring good mixing, until no further change is seen. Candidates should indicate at what stage a change occurs. Answers should include details of colour changes and precipitates formed and the names and chemical tests of any gases evolved. Equations are not required and marks for deductions or conclusions can only be gained if the appropriate observations are recorded.

Apparatus list

The list given below has been drawn up in order to give guidance to schools concerning the apparatus that is expected to be generally available for examinations purposes. The list is not intended to be exhaustive in particular, items (such as Bunsen burners, tripods) that are commonly regarded as standard equipment in a chemical laboratory are not included. The rate of allocation is per candidate.

One burette, 50 cm^3
One pipette, 25 cm^3
A pipette filler

Two conical flasks with the range of 150 cm^3 to 250 cm^3
A measuring cylinder, 50 cm^3 or 25 cm^3
A filter funnel
A beaker, squat form with lip
A thermometer, -10^0 C to + 110^0 C t 1^0 C
A polystyrene, or other plastic beaker of approximate capacity 150 cm^3
Clocks (or a wall clock) to measure the accuracy of about 1 s. Candidates can use their own wrist watches
Wash bottle
Test tubes (a mixture of pyrex and hard glass) approximately 125 mm X 16 mm
Boiling tubes, approximately 150 mm X 25 mm
String rod

Reagents List

The list given has been drawn up in order to give guidance to schools concerning the standard reagents that are expected to be available for examination purposes. The list is not intended to be exhaustive and the Instructions to the Supervisors issued several weeks in advance of the examination will give a full list of all the reagents that are required for each practical examination. These instructions also contain advise about colour blind candidates.

Aqueous sodium hydroxide (approximately 1.0 mol dm^{-3})
Aqueous ammonia) approximately 1.0 mol dm^{-3})
Hydrochloric acid (approximately 1.0 mol dm^{-3})
Nitric acid (approximately 1.0 mol dm^{-3})
Sulphuric acid (approximately 0.5 mol dm^{-3})
Aqueous silver nitrate (approximately 0.05 mol dm^{-3})
Aqueous barium nitrate or aqueous barium chloride (approximately 0.2 mol dm^{-3})
Aqueous lead (ii) nitrate (approximately 0.2 mol dm^{-3})
Lime water (a saturated solution of calcium hydroxide)
Aqueous potassium dichromate (approximately 0.1 mol dm^{-3})

5.3 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
- use appropriate apparatus and techniques safely and correctly; follow all given instructions to perform 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
- use appropriate apparatus and techniques safely and correctly; follow most given instructions to perform 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
- use basic apparatus and techniques safely and correctly; follow a few given instructions to perform an experiment involving a few steps
- make simple observations; measurements and record experimental data; process data, make conclusions where appropriate

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

- recall basic scientific facts, concepts, principles and theories and use simple scientific knowledge
- understand the relationship between basic scientific concepts and relate them to basic scientific principles and theories in real life situations
- apply basic scientific knowledge and understanding, identify simple patterns, and report trends from given information on familiar situations
- translate basic 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 experimental procedures (plan); devise a test which only involves a few factors, generate hypotheses
- use basic apparatus and techniques; follow a few given instructions to perform an experiment
- make simple observations; measurements and record experimental data.

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
make approximations and estimates to obtain reasonable answers
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-and bar 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)

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, then add aqueous lead(II) nitrate or aqueous silver nitrate	white precipitate
nitrate (NO_3^-)	add iron(II) sulphate, then add concentrated sulphuric acid or	brown ring forms at the junction of the two liquids or
	add sodium hydroxide, then aluminium foil and warm gently	ammonia gas produced
sulphate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium chloride or aqueous barium nitrate	white precipitate
iodide (I^-) [in solution]	acidify, then add aqueous lead(II) nitrate or aqueous silver nitrate	yellow precipitate

cation	***effect of aqueous sodium hydroxide***	***effect of aqueous ammonia***
aluminium (Al^{3+})	white precipitate, soluble in excess giving a colourless solution	white precipitate, insoluble in excess
ammonium (NH_4^+)	smelly ammonia released, damp red litmus turns blue	-
calcium (Ca^{2+})	white precipitate, insoluble in excess	no change
copper (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, giving a colourless solution	white precipitate, soluble in excess, giving a colourless solution

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

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.).