Republic of Namibia

MINISTRY OF EDUCATION, ARTS AND CULTURE

NAMIBIA SENIOR SECONDARY CERTIFICATE (NSSC)

CHEMISTRY SYLLABUS

ORDINARY LEVEL

SYLLABUS CODE: 6117

GRADE 10 - 11

FOR IMPLEMENTATION IN 2019
FOR FIRST EXAMINATION IN 2020

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Chemistry Syllabus Ordinary Level Grade 10-11

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1. INTRODUCTION

The Namibia Senior Secondary Certificate Ordinary (NSSCO) level syllabus is designed as a two-year course leading to examination after completion of the Junior Secondary phase. The syllabus is designed to meet the requirements of the *National Curriculum for Basic Education (NCBE)* and has been approved by the National Examination, Assessment and Certification Board (NEACB).

The Namibia National Curriculum Guidelines, applicable at the stage of senior secondary education (Grades 10 and 11) and at equivalent stages of non-formal education, as a part of life-long learning, recognise the uniqueness of the learner and adhere to the philosophy of learner-centred education.

The Namibia National Curriculum Guidelines:

- recognise that learning involves developing values and attitudes as well as knowledge and skills
- promote self-awareness and an understanding of the attitudes, values and beliefs of others in a multilingual and multicultural society
- encourage respect for human rights and freedom of speech
- provide insight and understanding of crucial “global” issues in a rapidly changing world which affects quality of life: the AIDS pandemic, global warming, environmental degradation, distribution of wealth, expanding and increasing conflicts, the technological explosion and increased connectivity
- recognise that as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation and evaluation to use information effectively
- seek to challenge and to motivate learners to reach their full potential and to contribute positively to the environment, economy and society

Thus the Namibia National Curriculum Guidelines should provide opportunities for developing essential skills across the various fields of study. Such skills cannot be developed in isolation and they may differ from context to context according to a field of study. The skills marked with an * are relevant to this syllabus.

The skills are:

- communication skills*
- numeracy skills*
- information skills*
- problem-solving skills*
- self-management and competitive skills*
- social and cooperative skills
- physical skills
- work and study skills*
- critical and creative thinking*

2. RATIONALE

This syllabus describes the intended learning and assessment for Chemistry in the NSSC phase. As a subject, Chemistry is within the natural science area/areas of learning in the curriculum, but has thematic links to other subjects across the curriculum.

The subject Chemistry places strong emphasis on the learners' understanding of the physical and biological world around them at the local, regional and international levels. It thus includes how societies use natural resources to satisfy their needs, and how the environment may be changed in ecologically sustainable ways. At this phase and subject area, the application of scientific knowledge and attitudes to health is of special relevance for the individual, the family, and society as a whole as well as the environment around us including the sustainability of our natural resources. Critical thinking, investigating phenomena, interpreting data, and applying knowledge to practical (experimental and investigative) skills and abilities are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life. This requires advanced technology through the efficient and effective usage of equipment, materials and processes. Modern technology is required in order to assist our learners and society to solve problems through planning, design, realisation, and evaluation of activities and goals.

3. AIMS

The aims of the syllabus are the same for all learners. These are set out below and describe the educational purposes of a course in Chemistry for the NSSCO examination. They are not listed in order of priority.

Chemistry promotes the following aims in the curriculum:

1. Provide, through well designed studies of theoretical and practical science, a worthwhile educational experience for all learners, whether or not they go to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:
    - become confident citizens in a technological world
    - take or develop an informed interest in matters of scientific importance
    - recognise the usefulness and limitations of scientific method and to appreciate its applicability in other disciplines and in everyday life
    - be suitably prepared for studies beyond the NSSCO level in pure sciences, in applied sciences or in science-dependent vocational courses

2. Develop abilities and skills that:
    - are relevant to the study and practice of Chemistry
    - are useful in everyday life
    - encourage efficient and safe practice
    - encourage effective communication

3. Develop attitudes relevant to Chemistry such as: concern for accuracy and precision; objectivity, integrity, enquiry, initiative and inventiveness.

4. Stimulate interest in, and care for, the environment.

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

4. ADDITIONAL INFORMATION

4.1 Guided learning hours

The NSSCO level syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of two years, but this is for guidance only. The number of hours required to gain the qualification may vary according to local conditions and the learners' prior experience of the subject. The National Curriculum for Basic Education (NCBE) indicates that this subject will be taught for 8 periods of 40 minutes each per 7-day cycle, or 6 periods of 40 minutes each per 5-day cycle, over two years.

4.2 Prior learning

It is recommended that learners who are beginning this course should have previously studied Physical Science at Junior Secondary (JS) level.

4.3 Progression

NSSCO levels are general qualifications that enable learners to progress either directly to employment, or to proceed to further qualifications. Learners who are awarded grades C to A* in NSSCO are well prepared to follow courses leading to Namibia Senior Secondary Certificate Advanced Subsidiary (NSCCAS) level Chemistry.

4.4 Grading and reporting

NSSCO results are shown by one of the grades A, B, C, D, E, F or G indicating the standard achieved, grade A being the highest and grade G the lowest. 'Ungraded' indicates that the candidate has failed to reach the minimum standard required for a pass at NSSCO level.

4.5 Support materials and approved textbooks

NSSCO syllabuses, question papers and examiners reports are sent to all schools. Assessment manuals in subjects, where applicable are sent to schools. Approved learning support materials are available on the Senior Secondary Textbook Catalogue for Schools. The Senior Secondary Textbook Catalogue is available on the institution's (NIED) website (http://www.nied.edu.na).

5. LEARNING CONTENT

The content is divided into topics and sub-topics as follow:

Topic 1: Scientific processes

1.1 Mathematical requirements
1.2 Scientific skills
1.2.1 Planning and conducting investigations
1.2.2 Recording data
1.3 Basic units and derived units
1.4 Error, accuracy and uncertainty
1.5 Experimental techniques

Topic 2: Matter

2.1 Atoms, elements, molecules and compounds
2.1.1 The particle nature of matter
2.1.2 Atomic structure
2.2 Isotopes
2.3 Periodic table
2.3.1 Groups and periods
2.3.2 Periodicity
2.3.3 Group properties
2.4 Bonding: the structure of matter
2.4.1 Building blocks of matter
2.4.2 Ionic bonding / electrovalent bonds
2.4.3 Molecules and covalent bonds
2.4.4 Giant covalent structures
2.4.5 Metallic bonding
2.4.6 Writing and balancing equations

Topic 3: Materials

3.1 Types of materials
3.2 Building materials
3.3 Cleaning materials
3.4 Nano-materials

Topic 4: Stoichiometry

4.1 The mole concept
4.2 Mole calculations

Topic 5: Electrochemistry

5.1 Electrodes and electrolytes

Topic 6: Chemical reactions

6.1 Chemical and physical changes
6.2 Energetics of a reaction
6.3 Production of energy
6.4 Rate of reaction
6.5 Reversible reactions
6.6 Redox

Topic 7: Acids, bases and salts

7.1 The characteristic properties of acids and bases
7.2 Types of oxides
7.3 Neutralisation
7.4 Preparation of salts

Topic 8: Qualitative analysis
8.1 Identification of ions in solution
8.2 Identification of gases

Topic 9: Metals
9.1 Properties of metals
9.2 Reactivity series
9.3 Extraction of metals
9.4 Uses of metals

Topic 10: Organic chemistry
10.1 Names of compounds
10.2 Hydrocarbons
10.2.1 Fractional distillation of petroleum
10.2.2 Homologous series
10.3 Alkanes
10.4 Alkenes
10.5 Alcohols
10.6 Carboxylic acids
10.7 Esters
10.8 Polymers
10.8.1 Synthetic polymers
10.8.2 Natural macromolecules
10.8.3 Properties and uses of fibres

Topic 11: Environmental and industrial chemistry
11.1 Water
11.1.1 Physical and chemical properties of water
11.1.2 Availability, distribution and purification of water in Namibia
11.2 The air around us
11.3 The commercial preparation and uses of gases
11.4 Pollution of the air
11.5 Chemical industrial plants

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
1 Scientific processes		
1.1 Mathematical requirements	• know mathematical procedures which are required throughout the syllabus	• add, subtract, multiply and divide • use averages, decimals, fractions, percentages, ratios and reciprocals • use direct and inverse proportion • use positive and negative, whole number indices and exponents in calculations • make approximate evaluations of numerical expressions • solve equations of the form x = yz for any one term when the other two are known
1.2 Scientific skills		
1.2.1 Planning and conducting investigations	• know the scientific ways of planning and conducting an investigation	• make observations accurately; use appropriate techniques; handle apparatus/materials competently and have due regard to safety • distinguish between independent, dependent and control variables • predict the hypothesis and state the aim of the investigation • explain how to make a test fair (reliable and accurate) by identifying appropriate controls and the importance of a zero reading
1.2.2 Recording data	• know the scientific ways of presenting data	• locate, select and organise information from a variety of sources • record results of experimental investigations in a logical manner (tables or graphs) and explain the importance of units and recording results of experimental investigations • present each column of a table by heading it with the physical quantity and the appropriate unit, e.g. time/s (units should be in the heading of the column and not in the measurements in the column) • use column headings of a table to create the axes of a graph

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
1.3 Basic units and derived units	• understand scientific notation, prefixes and significant figures	• explain and use the relationships between length, surface area and volume and their units on metric scales • identify the correct SI unit, derived units and use the metric prefixes (tera, giga, mega, kilo, deci, centi, milli, micro, nano, pico) to convert between quantities • use standard (scientific) notation • use acceptable methods of stating units, e.g. metres per second or m per s be written as m/s or m s^{-1} (Note: The solidus (/) will be used for a quotient and also to indicate units in labels of tables and graphs e.g. distance/cm) • state the concept of absolute zero and the Kelvin scale of temperature • use the information that Celsius temperature is given by T/ºC + 273.15 = T/K (example: to convert 20ºC to K: 20ºC + 273.15 = 293.15 K)
1.4 Error, accuracy and uncertainty	• understand errors, sources of error, their rectification, accuracy, precision and uncertainty	• state and use the relationship between *precision*, *accuracy* and *uncertainty* of measurement and the appropriate number of significant figures used to record measurements and present calculated data • handle and process experimental observations and data, including dealing with anomalous (inconsistent) results • evaluate presented results or experimental data by applying scientific knowledge and interpret and draw appropriate conclusions from practical observations and data in relation to the hypotheses • analyse anomalous (inconsistent) results, discuss trends in results, identify sources of error and their margin of error (random and systematic errors) • suggest possible improvements to reduce errors

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
1.5 Experimental techniques	• understand the principles of experimental technique	• name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders • indicate that mixtures melt and boil over a range of temperatures • identify pure substances by distinctive melting and boiling points • outline the importance of purity in substances in everyday life, e.g. foodstuffs and drugs • describe methods of purification by the use of a suitable solvent, filtration, crystallisation, re-crystallisation, paper chromatography of coloured substances and distillation (including use of a fractionating column). (Refer to the fractional distillation of crude oil in section 10.2.1 and products of fermentation in section 10.5) • suggest suitable purification techniques, given information about the substances involved • suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurements of rates of reaction • outline how paper chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (knowledge of specific locating agents is not required) • interpret simple chromatograms including Rf values

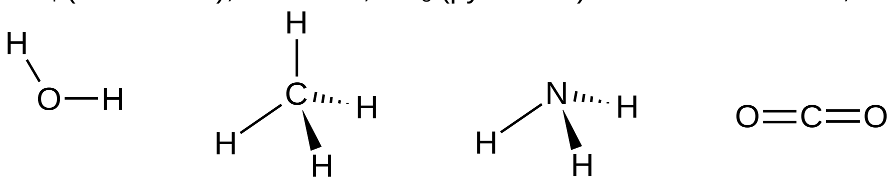
The practical activities, approaches or demonstrations required for Topic 1 Scientific processes are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *carry out crystallisation of a salt solution (cross reference to 7.4)* • *carry out distillation of fermented fruits/juice* • *carry out filtration e.g. muddy river water, water and sand mixture, filtration of an insoluble salt (precipitate) from solution (cross reference to 7.4)* • *investigate the components of coloured mixtures e.g. food colouring, OHP pens, ink, leaf or flower petal colour*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2 Matter		
2.1 Atoms, Elements, Molecules and Compounds		
2.1.1 The particle nature of matter	• know the kinetic particle theory and diffusion	• state and describe the distinguishing properties of solids, liquids and gases • describe the structure of solids, liquids and gases in terms of particle separation (spaces), arrangement and types of motion • describe changes of state in terms of melting, boiling, evaporation, freezing, condensation and sublimation • explain diffusion in liquids and gases • describe evidence for the movement of particles in gases and liquids • describe dependence of rate of diffusion on molecular mass and temperature • explain everyday effects of diffusion in terms of particles e.g. the spread of perfumes and cooking aromas, tea and coffee in water
2.1.2 Atomic structure	• know the development of the atomic model leading to the understanding of the atomic structure within the Periodic Table	• outline the development of the atomic model from the ancient Greek times, Dalton, Thomson, Rutherford, Bohr and Chadwick • use proton (atomic) number and the simple structure of atoms to explain the basis of the Periodic Table, with special reference to the elements of proton (atomic) number 1 to 20 • state the relative charge and approximate relative mass of a proton, a neutron and an electron and their positions in the atom • define proton (atomic) number (Z) of an element as the number of protons in the nucleus of each atom of that element • define nucleon (mass) number (A) of an element as the sum of the number of protons and neutrons (together called nucleons) in the nucleus • use the notation $^{A}_{Z}X$ for an atom • describe the build-up of electrons in 'shells' and draw the Bohr structure of the first 20 elements • analyse the structures of the first 20 elements in terms of: – proton (atomic) and nucleon (mass) numbers – electronic structures (electrons orbiting the nucleus and their arrangement) – the relative charges and masses of the protons, neutrons and electrons • deduce the structure of atoms and ions from given proton (atomic) and nucleon (mass) numbers and vice versa

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.2 Isotopes	• know about isotopes and radioactive isotopes and give examples of isotopes of the elements carbon, hydrogen, chlorine and uranium	• define isotopes as atoms with the same proton (atomic) number but different nucleon (mass) numbers • outline radioactive decay as the emission of radioactive particles (no need to identify particles) from unstable nuclei to make the nuclei more stable • discuss isotopes and radioactive isotopes and give examples of isotopes of the elements carbon, hydrogen, iodine, chlorine and uranium • relate isotopes to the different nucleon numbers of atoms of the same element • state some uses of radioactive isotopes e.g. in carbon-14 dating; radiotherapy (treatment of cancer); determination of thickness of material (e.g. the use of a beta-emitter to measure the thickness of aluminium foil during production); power generation
2.3 Periodic Table		
2.3.1 Groups and periods	• understand the relationship between the Periodic Table and atomic structure	• describe the build-up of electrons in 'shells' and analyse their structures in terms of: – the relationship between group number of the Periodic Table and number of electrons in the outer shell – the relationship between period number of the Periodic Table and number of shells in atoms • explain the significance of the noble gas electron arrangements and of outer electrons (The ideas of the distribution of electrons in s- and p-orbitals and in d-block elements are not required. Note that a copy of the Periodic Table will be provided in Papers 1, 2 and 3)
2.3.2 Periodicity	• understand trends in electron and atomic structure of elements in Period 3 and in Groups on the Periodic Table	• describe the changes that occur in the electron arrangement of elements in Period 3 and relate that to the change from metallic to non-metallic character of the elements across the period, and to the trend in atomic radius • describe the electron arrangement, especially the outer electron arrangement, of elements of a group on the Periodic Table and use the information to explain the similarity in chemical properties of the elements in a group

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.3.3 Group properties	• know the nature, properties and uses of the elements in the groups of the Periodic Table	• interpret the Periodic Table as a method of classifying elements according to their properties (metallic and non-metallic, groups and periods) • deduce and/or describe the trends in chemical and physical properties of elements in groups (when given data about the elements concerned) – melting point, density, colour and state – reactivity (e.g. with water) • describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing trends in melting point, density, their reactions with water and their identification by flame tests • state that Group I metals form soluble hydroxides with water that cannot be precipitated • describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour, reactivity, state of matter • state the reactions of Group VII elements with other halide ions • describe the transition elements as a collection of metals having high densities, high melting points, forming coloured compounds, and which, as elements and compounds, often act as catalysts • describe the noble gases (group VIII) as being unreactive • describe the use of the noble gases in providing an inert atmosphere (argon in lamps and helium for filling weather balloons)

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.4 Bonding: the structure of matter		
2.4.1 Building blocks of matter	• understand the different building blocks of matter	• explain that atoms, molecules and ions are the building blocks of all material (an extension of the particle model) (NOTE: the term "molecule" will be used only for electrically neutral groups of atoms held together by covalent bonds, including macromolecules) • distinguish between elements, mixtures and compounds • explain that atoms combine to form molecules, or (compound) ions • explain that atoms, ions and molecules can form crystal lattices that are either molecular or giant • explain that giant lattices can be ionic, metallic or covalent • describe alloys, such as brass, bronze and steel, as mixtures of a metal with other metals or carbon
2.4.2 Ionic bonding / electrovalent bonds	• understand and know how to illustrate ionic bonding, as the attraction between positive and negative ions after electrons have been transferred between atoms	• describe how the reaction between a metal and a non-metal results in the transfer of electrons from metal atoms to non-metal atoms so that both achieve full outer shells and form positive ions (cations) and negative ions (anions) respectively • explain ionic bonding as the electrostatic attraction between the oppositely charged ions formed • differentiate between the naming of atoms versus ions (e.g. chlorine and chloride) • predict the positive and negative charges of ions (in terms of the attained noble gas electron arrangements) • describe the lattice of an ionic compound as a regular arrangement of alternating positive and negative ions

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.4.3 Molecules and covalent bonds	• understand and know how to illustrate covalent bonding as the sharing of electrons when atoms bind • understand inter and intra molecular forces	• describe how non-metal atoms combine with other non-metal atoms by sharing electrons in their outer shells with the result that both atoms achieve full outer shells • explain covalent bonding as the electrostatic attraction between the nuclei of a pair of atoms and the shared electrons between those atoms • state that molecules of elements are made up of atoms of the *same kind* and are called *homonuclear* molecules (examples H_2, Cl_2, F_2, Br_2, I_2 O_2, N_2, O_3) • state that molecules of compounds are made up of atoms of *different kinds* and are called *heteronuclear* molecules (examples H_2O, CH_4, NH_3, HCl, C_2H_4, CH_3OH, CO_2) • describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4, NH_3 and HCl as the sharing of pairs of electrons leading to a noble gas configuration • describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH, CO_2 • use Bohr, Lewis and Couper notations to illustrate ionic and covalent bonding (NOTE: Bohr and Lewis notations involve the use of dot-and-cross diagrams) • state the names of the shapes of the molecules: water, H_2O (V-shaped); methane CH_4 (tetrahedral); ammonia, NH_3 (pyramidal) and carbon dioxide, CO_2 (linear)  (diagrams of the shapes of these molecules may be required, using the style shown) • state that the forces between atoms in covalent molecules are stronger than the intermolecular forces between molecules • compare the differences in volatility, solubility, melting/boiling points and electrical conductivity between ionic and covalent compounds, in terms of their bonding and structure • state that Buckminsterfullerene, C_{60}, is a (homonuclear) molecular allotrope of carbon

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
NOTE (for 2.4.3) - *atoms which exist as single atoms are referred to as monoatoms (examples: Group VIII elements)* - *diatomic molecules are made up of two atoms bonded together covalently* - *diatomic molecules can either be homonuclear or heteronuclear* - *homonuclear diatomic molecules are made up of two atoms of the same element bonded together covalently (e.g. H_2, O_2, N_2, F_2, Cl_2, Br_2, I_2)* - *heteronuclear diatomic molecules are made up of two atoms of different kinds bonded together covalently (e.g: HF, HCl, CO)* - *polyatomic molecules are made up of more than two atoms bonded together covalently* - *polyatomic molecules such as CO_2 , CH_4 , NH_3 and NH_3 are heteronuclear* - *polyatomic molecules such as O_3 and S_8 are homonuclear* (Details of the structures of O_3 and S_8 are **not** required)		
2.4.4 Giant covalent structures	• know the structures of graphite, diamond and silicon(IV) oxide	• describe the structures of the common allotropes of carbon, graphite and diamond, as giant covalent lattices with high melting points • relate the structures to the use of graphite as a lubricant and of diamond in cutting • describe the giant covalent structure of silicon(IV) oxide (silicon dioxide) • describe the similarity in properties between diamond and silicon(IV) oxide, in terms of the similarity in their structures
2.4.5 Metallic bonding	• know about metallic bonding	• describe metallic bonding as a lattice of positive ions in a 'sea' of delocalised electrons • describe and explain the electrical conductivity, melting point, and malleability/ductility of metals in terms of their structure and bonding • sketch the generalised structure of a typical metal • distinguish between covalent, ionic and metallic bonding as different types of bonding and relate the type of bonding to the position (group) of elements in the Periodic Table

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.4.6 Writing and balancing equations	• know how to write word equations and balance simple equations	• use the symbols of the elements to write the formulae of simple compounds • deduce the formula of a simple compound from the relative numbers of atoms present • determine the formula of an ionic compound from the charges on the ions present • deduce the formula of simple compounds from a model • construct word equations and simple balanced chemical equations (including simple ionic equations) • deduce the formulae of compounds, molecules and compound ions – see hydroxides, phosphates, nitrate, (hydrogen) carbonate and sulfate as oxyanions that bond in the same ratios as anions of elements in Groups V, VI and VII – see the ammonium ion as a compound cation bonding in the same ratio as cations of metals in Group I

The practical activities, approaches or demonstrations required for Topic 2 Matter are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *investigate the rate of diffusion between hydrogen chloride gas and ammonia gas in a glass tube* • *investigate everyday examples of diffusion in terms of particles e.g. the spread of perfumes and cooking aromas, tea and coffee grains in hot and cold water* • *build models of atoms, mixtures, compounds (including giant covalent structures) by using little spheres of various sizes and colour* • *investigate reactions of lithium, sodium and potassium with water* • *investigate how Group I metals form soluble hydroxides with water and cannot be precipitated* • *test for the pH of the hydroxides of Group I metals (cross reference to 6.1, 6.2)* • *test for the hydrogen gas evolved from reactions of lithium and Group II metals with water (cross reference to 6.7)* • *identification of lithium, sodium and potassium by flame tests (cross reference to 8.1)* • *investigate the trend in reactivity of Cl, Br and I* • *investigate the reaction of Cl, Br and I with other halide ions* • *investigate the coloured nature of compounds of transition elements (eg.* $CuSO_4$*)* • *investigate the differences between elements, compounds and a mixtures (e.g. using iron filings and sulfur; table salt solution) (see 1.5)* • *investigate the differences in volatility, solubility, melting/boiling points, electrical conductivity between ionic and covalent compounds* • *investigate electrical conductivity, melting/boiling points, malleability/ductility of metals*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
3 Materials		
3.1 Types of materials	• know the differences between materials such as wood, metals, glasses, ceramics, concrete, plastics and fibres and realise that some materials occur naturally and others are synthetic	• classify materials into categories such as wood, metals, glasses, ceramics, concrete, plastics and fibres and identify examples of these materials in the local environment • distinguish between materials that occur naturally and those that are synthetic • identify the types of bonding in different materials: - metallic bonding in metals - concrete as a mixture containing both ionic and covalent bonds - glass as a giant structure with mainly covalent bonds - cellulose as a natural polymer in wood (covalent bonding) - polythene, nylon, polyurethane and melamine as examples of synthetic polymers (covalent bonding)
3.2 Building materials	• know that a building is made of a number of different materials: bricks (mud or ceramic), concrete, wood, metal, thatch and glass • understand how the use of materials depends on their properties	• describe the use of different building materials in the local environment: bricks (mud or ceramic), concrete, wood, metal, thatch and glass • explain how their uses depend on the properties of the materials • explain how concrete is made using cement, crushed stones and sand by adding water • state that cement is made from clay and limestone

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
3.3. Cleaning materials	• understand how the properties of soaps and detergents are related to their generalised structures and understand their impact on the environment	• outline and sketch the generalised structure of a soap or detergent • explain how the structure allows the soap or detergent to act as an emulsifying agent • identify common cleaning materials such as soaps or detergents • outline the preparation of soap through hydrolysis of fat or oil • interpret the meanings of the terms biodegradable and non-biodegradable in relation to the impact on the environment • outline the advantages and disadvantages of the use of soaps and detergents
3.4 Nano-materials	• know the role of nanotechnology in the formation of nano-materials • know some of the applications of nano-materials in modern technology	• state that nanotechnology is used to produce nano-materials such as graphene and fullerenes • state that nano-materials are materials in which the particle sizes range between approximately 1 and 100 nanometers (nm), in one dimension • state that the small size of the particles in nano-materials gives these materials properties that are different to those of bulk materials or of individual atoms or molecules e.g. silver nanoparticles have anti-microbial properties • state some examples of the applications of nanotechnology such as in medicine, electronics, environment, consumer products, and sporting goods

The practical activities, approaches or demonstrations required for Topic 3 Materials are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *design and conduct experiments to investigate the compressive and tensile strength of different building materials* • *carry out surveys in the local environment to identify the uses of different building materials* • *design and carry out an experiment to investigate the insulating properties of different roofing materials* • *investigate emulsifying effects of soaps and detergents* • *prepare soap through hydrolysis of fat or oil*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
4 Stoichiometry		
4.1 The mole concept	• know the terminology used in the mole concept	• define relative atomic mass, A_r , of an element as the ratio of the average mass of the atoms of the naturally occurring element to 1/12 of the mass of a carbon-12 atom • define relative formula mass, M_r, of a molecule or chemical compound as the sum of the relative atomic masses of all atoms present in that molecule or compound • state that 'a *mole*' is an amount of substance containing approximately 6.022 x 10^{23} particles • state that the number of particles in one mole of any substance (approx. 6.022 x 10^{23}) is called the Avogadro constant • state that one mole of any substance has a mass equal to the relative mass in grams of that substance • state that the empirical formula is the simplest whole number ratio of the elements in a compound • define empirical formula mass as the relative formula mass, M_r, of a molecule or chemical compound in its simplest form • define concentration as mass per volume or moles per volume (in g/dm^3 and mol/dm^3) (Note: The word molarity expresses the concentration of a solution only in mol/dm^3 and is no longer in use)
4.2 Mole calculations	• know and apply calculations used in quantitative chemistry	• calculate stoichiometric reacting masses of pure substances • carry out calculations involving the concentrations and volumes of solutions, solution concentrations may be expressed in either g/dm^3 or mol/dm^3 (calculations based on limiting reactants may be set) • use the molar gas volume, taken as 24 dm^3 at room temperature and pressure, in calculations of stoichiometric reacting masses and volumes of gases (questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set) • calculate empirical formulae, using composition by mass data • use empirical formulae and relative formula mass to calculate molecular formulae • calculate % composition, % yield and % purity

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Learners should be able to:</th></tr>
<tr><td colspan="3">5 Electrochemistry</td></tr>
<tr><td>5.1 Electrodes and electrolytes</td><td>• know the process of electrolysis
• understand electroplating</td><td>• describe the terms electrodes, electrolytes, anodes and cathodes in electrolysis
• draw diagrams of electrolytic cells
• describe the reactions at the electrodes during electrolysis of molten and aqueous electrolytes (the oxidation and reduction reactions) using half equations (cross reference to 6.6)
• state the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode)
• describe the electrode products, using inert electrodes, in the electrolysis of:
– molten lead(II) bromide
– dilute sulfuric acid
– concentrated hydrochloric acid
– concentrated aqueous sodium chloride
• predict the products of the electrolysis of a specified binary compound in the molten state
• recall the different anode reactions and the products of electrolysis during the electrolysis of copper(II) sulfate, using carbon or copper as the electrodes (cross reference to 9.3)
• describe the electroplating of metals
• name the uses of electroplating
• outline the manufacture of
– aluminium from pure aluminium oxide in molten cryolite (cross reference to 9.3)
– chlorine and sodium hydroxide from concentrated aqueous sodium chloride (Starting materials, essential conditions and equations for electrode reactions should be given but not technical details or diagrams.)</td></tr>
</table>

The practical activities, approaches or demonstrations required for Topic 5 Electrochemistry are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *investigate the conductivity of a salt solution such as table salt (NaCl) and an acidic solution such as a lemon juice* • *carry out the electroplating of zinc with copper sulfate solution*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
6 Chemical reactions		
6.1 Chemical and physical changes	• recall the distinction between chemical and physical changes and that chemical reactions involve an energy change	• distinguish between chemical and physical changes • recall that chemical reactions involve an energy change
6.2 Energetics of a reaction	• understand energetics of reactions	• explain the meanings of the terms *exothermic* and *endothermic* • describe the meaning of enthalpy change in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions (including the use of simple energy level diagrams – labelled to show energy change and activation energy) • describe bond breaking as endothermic and bond forming as exothermic • calculate energy changes for reactions using simple calorimetry and $q = mc\Delta T$ • calculate energy changes for simple reactions using bond energies • state that light can provide the energy needed for a chemical reaction to occur (e.g. photosynthesis and formation of silver from silver chloride) • state that photosynthesis leads to the production of glucose from carbon dioxide and water in the presence of chlorophyll and sunlight (energy)
6.3 Production of energy	• understand the production of heat energy from fuels and electrical energy from simple cells	• describe the production of heat energy by burning fuels • describe radioactive isotopes, such as ${}^{235}_{92}U$, as a source of energy (cross reference to 2.2) • describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte (cross reference to 5.1; 8.2) • describe sources of clean energy • state that electrical energy can be produced from sunlight using solar cells • describe the use of hydrogen as a fuel reacting with oxygen to generate electricity in a fuel cell (details of the construction and operation of a fuel cell are not required)

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
6.4 Rate of reaction	• know the factors affecting rate of reaction	• explain the meaning of the term rate of reaction • define a *catalyst* as a substance that increases the rate of a chemical reaction. (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically) • state that a catalyst increases the rate of reaction by reducing the activation energy of a reaction • define an inhibitor as a substance that reduces the rate of a chemical reaction • describe, in terms of collision theory, the effects of – concentration – pressure – particle size (surface area) – catalysts (including inorganic or organic) – temperature – light on the rate of reactions (**NB**: an increase in temperature causes an increase in collision rate **and** more of the colliding molecules have sufficient energy – activation energy - to react whereas an increase in concentration only causes an increase in collision rate) • state that proteins that catalyse organic reactions are called enzymes • describe the application of the effect of surface area to the danger of explosive combustion with fine powders (e.g. flour mills, coal mines) • describe experiments for the investigation of the effects of given variables on the rate of reaction • interpret data obtained from experiments concerned with rate of reaction
6.5 Reversible reactions	• understand reversible reactions	• describe the idea that some chemical reactions can be reversed by changing the reaction conditions (including the effects of heat on hydrated salts, e.g. hydrated copper(II) sulfate and hydrated cobalt(II) chloride (cross reference to 11.1.1) • define dynamic equilibrium • describe that reversible reactions can reach dynamic equilibrium in a closed system • predict the effect of changing the conditions (concentration, temperature and pressure) on equilibria

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
6.6 Redox	• know simple redox reactions	• define oxidation and reduction in terms of oxygen gain/loss and in terms of the transfer of electrons • identify redox reactions by changes in ionic charge • identify reducing and oxidising agents (including in the context of the extraction of metals)

The practical activities, approaches or demonstrations required for Topic 6 Chemical reactions are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.

- *investigate how much energy can be obtained from the burning of methylated spirits*
- *investigate factors determining rate of reaction between metal or metal carbonate and diluted acid*
- *investigate the dehydration of hydrated copper(II) sulfate and hydrated cobalt(II) chloride*
- *Investigate the decomposition of H_2O_2 using MnO_2 as the catalyst; and the decomposition of tartaric acid ($C_4H_6O_6$) using Co salt as the catalyst*
- *Investigate the decomposition of AgCl in the presence of light*

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
7 Acids, bases and salts		
7.1 The characteristic properties of acids and bases	• understand characteristics and properties of acids and bases	• define acids and bases in terms of proton transfer (limited to aqueous solutions) • explain the difference between alkalis and bases • compare the properties of acids and bases (alkalis) such as their effects on indicators e.g. litmus and Universal Indicator (liquid or paper) • describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator (liquid or paper) • distinguish between weak alkalis such as soap water and limewater and strong alkalis such as sodium hydroxide, using Universal Indicator and by referring to the pH scale (range from 0 to 14) • distinguish between weak acids such as lemon juice and strong acids such as hydrochloric acid, using Universal Indicator and by referring to the pH scale (range from 0 to 14) • describe the characteristic properties of acids as in their reactions with metals, bases and carbonates • use these ideas to explain given reactions as acid-base • explain the difference between weak/strong acids and alkalis in terms of the dissociation into ions • explain the difference between concentrated/dilute acids and alkalis in terms of the number of H^+ or OH^- ions in 1 dm^3 of solution • explain that the pH value depends on the *strength* of the acid or the alkali as well as on its *concentration*
7.2 Types of oxides	• recognise the different types of oxides	• classify oxides as basic (e.g. Na_2O and MgO), acidic (e.g. SO_2, SO_3 and NO_2) or amphoteric (e.g. Al_2O_3), related to the metallic, non-metallic or metalloid character of the element forming the oxide

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
7.3 Neutralisation	• understand neutralisation as a reaction between bases (metal oxides, metal hydroxides, metal carbonates, ammonia) and acids and test any gas released	• describe the reaction of a base/alkali with an acid as neutralisation • describe the neutralisation reaction of an acid with an alkali as $H^+ + OH^- \rightarrow H_2O$ • describe neutralisation as one method of preparing soluble salts, e.g. sodium chloride • suggest methods of preparation of examples of well-known soluble salts (such as copper(II) sulfate or sodium chloride) by neutralisation reactions • describe the reactions of acids with metal oxides and metal hydroxides • describe the reaction of acids with metal carbonates and the test for the carbon dioxide evolved • write word and balanced equations for the neutralisation reactions: – between metal oxides and acids – between metal (Group I and II) hydroxides and acids – between metal carbonates and acids

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
7.4 Preparation of salts	• know the preparation methods of common salts	• describe the preparation, separation and purification of soluble and insoluble salts as examples of the application of some of the techniques specified in section 1.5 and the reactions specified in section 7.3 • recall and apply solubility rules: – all common sodium, potassium and ammonium salts are soluble – all nitrates are soluble – lead compounds are insoluble (except the nitrate and ethanoate) – hydroxides are insoluble (except for Group I hydroxides and barium hydroxide. Calcium hydroxide is slightly soluble) – carbonates are insoluble (except for sodium, potassium and ammonium carbonates) – common chlorides are soluble (except silver and lead chloride) – common sulfates are soluble (except barium sulfate, lead sulfate) • suggest a method of making a given salt from suitable starting materials, given appropriate information, including precipitation

The practical activities, approaches or demonstrations required for Topic 7 Acids, bases and salts are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *measure the pH of a variety of solutions and place them on a pH scale* • *use solutions of equal concentration to classify them as strong or weak acids or alkalis by measurement of pH* • *investigate the reactions of acids with metal oxides, metal hydroxides and carbonates and test any gas released* • *observe with a magnifying glass the crystals of the salt formed after crystallisation* • *carry out titration of an acid and an alkali using a suitable indicator to determine the end-point as a method of salt preparation* • *prepare NaCl and $CuSO_4$ salts through neutralisation* • *prepare insoluble salts*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
8 Qualitative analysis (**NOTE**: From Topic 8, flame tests and the tests for gases may be tested in Papers 1, 2 and 3. Tests for cations with sodium hydroxide or ammonia and tests for anions will only be tested in Paper 3. The notes for use in qualitative analysis (Annexe B) **will NOT** be supplied with Paper 3).		
8.1 Identification of ions in solution	• realise the importance of chemical identifications of ions in solution	• describe the use of the following tests to identify: *aqueous cations:* – ammonium, aluminium, zinc, calcium, copper(II), iron(II) and iron(III) using aqueous sodium hydroxide and aqueous ammonia as appropriate (formulae of complex ions are not required) – lithium, sodium, potassium, calcium, barium by flame tests *aqueous anions:* carbonate (by reaction with dilute acid and then with limewater), chloride (by reaction under acidic conditions with aqueous silver nitrate), bromide (by reaction under acidic conditions with aqueous silver nitrate), iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium to ammonia), sulfate (by reaction under acidic conditions with aqueous barium ions)
8.2 Identification of gases	• know the identification of gases	• describe the use of the following tests to identify: ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using a lighted splint), oxygen (using a glowing splint)

The practical activities, approaches or demonstrations required for Topic 8 Qualitative analysis are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *obtain samples of carbon dioxide, oxygen and hydrogen in the laboratory* • *carry out all tests as listed in annexe B of the syllabus* • *carry out some tests to identify the cation and anion in an unknown sample of a soluble salt* • *carry out all tests to identify the unknown gas released in a certain reaction*

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
9 Metals		
9.1 Properties of metals	• know the properties of metals	• compare the general physical and chemical properties of metals and non-metals • identify metals and alloys from diagrams • represent metals and alloys using diagrammatic representations
9.2 Reactivity series	• place the metals in order of their reactivity by using experimental data	• place in order of reactivity: potassium, sodium, calcium, magnesium, aluminium, (carbon), zinc , iron, tin, lead, (hydrogen), copper, silver, gold and platinum by reference to the reactions, if any and where relevant, of the metals with: – water or steam (**Note** potassium and sodium should only be placed in cold water) – dilute hydrochloric acid (**Note** potassium and sodium must **not** be added to dilute acids) – the aqueous ions of other metals • deduce an order of reactivity from a given set of experimental results
9.3 Extraction of metals	• know that most metals occur combined with other elements in compounds known as ores and know the methods of extraction of aluminium (electrolysis), copper, zinc and iron (reduction with carbon)	• state that most metals occur combined with other elements in compounds, as part of mixtures known as ores • identify ores of copper, zinc, uranium and tin as important ores that occur in Namibia and name the uses of the metals extracted from these ores (cross reference to 9.4) • name metals that occur 'native' e.g. gold, platinum • explain how the method of extraction of a metal from its ore depends on the position of the metal in the reactivity series • name the main ores of aluminium (Bauxite) and iron (Haematite) • name the main Namibian ores of copper (Chalcopyrite), lead (Galena) and uranium (uranium oxide) • describe the essential reactions in the extraction of iron from Haematite in the Blast Furnace • describe the conversion of iron into steel by basic oxygen steelmaking (using molten iron from a Blast Furnace) and by using an electric arc furnace (using scrap iron and steel) • explain that the properties and uses of steel depend on the amount of carbon or other elements in it

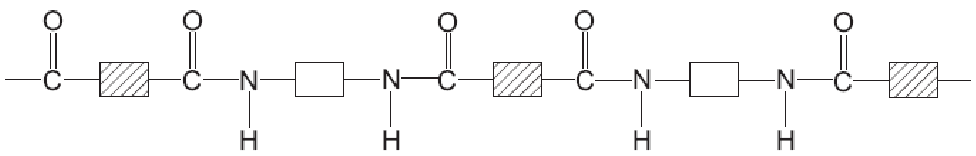
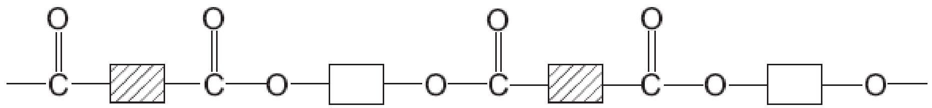
TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
9.3 Extraction of metals (continued)	• know that most metals occur combined with other elements in compounds known as ores and know the methods of extraction of aluminium (electrolysis), copper, zinc and iron (reduction with carbon)	• describe the extraction of zinc from zinc blende (zinc sulfide) • describe the methods of extraction of aluminium (electrolysis) and copper (reduction/roasting) • describe metal ores as a finite resource and hence the need to recycle metals • discuss the advantages and disadvantages of recycling metals (iron/steel and aluminium)
9.4 Uses of metals	• know the uses of metal	• explain that alloys are mixtures of metals and that the properties of metals can be changed, often to make them more useful • describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys • name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery) • state the uses of zinc in galvanising and making brass • state the uses of tin in tin-plating and making bronze • name the uses, related to their properties, of copper (electrical wiring and in cooking utensils) and of aluminium (aircraft parts and food containers) • name the uses of uranium (in nuclear power stations and nuclear weapons) • describe methods of rust prevention: paint and other coatings to exclude oxygen, galvanising (with zinc), plating (with tin) and sacrificial protection (with reference to the reactivity series) • account for the apparent unreactivity of aluminium and zinc in terms of the oxide layer adhering to the metal

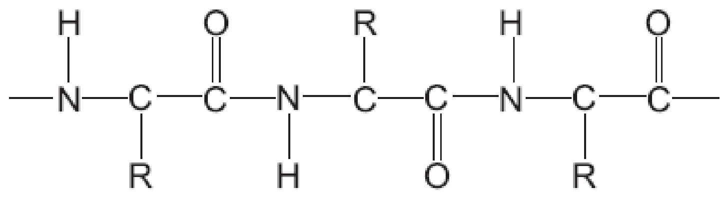
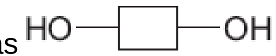
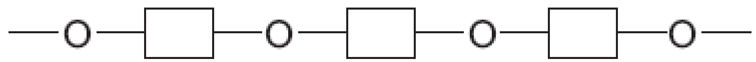
The practical activities, approaches or demonstrations required for Topic 9 Metals are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.

- *investigate the reaction of the metals with water, steam or dilute acid in order to place them in order of reactivity*
  ***NB**: Li, Na, K and Ca should only be tested with cold water, Mg and Zn with dilute acid, Fe, Pb and Cu can be used with more concentrated acid.*
  ***NB**: For Li, Na, and K only small, freshly cut pieces should be added to a trough of cold water behind safety screens*
- *investigate the displacement reaction between aqueous metal ions and metals*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
10 Organic chemistry		
10.1 Names of compounds	• know the names of simple organic compounds	• use the International Union of Pure and Applied Chemistry (IUPAC) system to name and draw the structures of the unbranched alkanes, alkenes (not cis and trans), alcohols and carboxylic acids containing up to four carbon atoms per molecule and ethyl ethanoate and the products of the reactions stated in section 10.4 to 10.5 • state the type of compound (functional group) present given a chemical name, ending in –ane, -ene, -ol, or –oic acid or a molecular structure
10.2 Hydrocarbons		
10.2.1 Fractional distillation of petroleum	• know the names and uses of fractional distillation	• name the fuels coal, natural gas and petroleum (crude oil) • name methane as the main constituent of natural gas • describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation • name the uses of the fractions as: – refinery gas for bottled gas for heating and cooking – gasoline fraction for fuel (petrol) in cars – naphtha fraction for making chemicals – kerosene/paraffin fraction for jet fuel – diesel oil/gas oil for fuel in diesel engines – fuel oil fraction for fuel for ships and home heating systems – lubricating fraction for lubricants, waxes and polishes – bitumen for making tar for roads
10.2.2 Homologous series	• understand the naming and basic chemistry of homologous series and isomers	• describe the concept of homologous series as a 'family' of similar compounds with similar chemical properties due to the presence of the same functional group and a trend in physical properties • recall that all members of a homologous series have the same general formula • identify and describe structural isomerism (restricted to): – isomers of C_4H_{10}: butane and (2-)methyl propane – isomers of C_5H_{12}: pentane, 2-methylbutane and 2-2 dimethylpropane – isomers of C_3H_7OH: propan-1-ol and propan-2-ol

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
10.3 Alkanes	• understand the basic chemistry of alkanes	• describe alkanes as saturated hydrocarbons with the general formula C_nH_{2n+2} • describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of combustion (both complete and incomplete reaction) to produce CO_2 and CO) • describe substitution reactions of alkanes with chlorine (details of the mechanism of reaction are **not** required)
10.4 Alkenes	• understand the basic chemistry of alkenes	• describe alkenes as unsaturated hydrocarbons with the general formula C_nH_{2n} • describe the properties of alkenes in terms of addition reactions with bromine, hydrogen and steam (details of the mechanism of reaction are **not** required) • describe the manufacture of alkenes by catalytic cracking • distinguish between saturated and unsaturated hydrocarbons from molecular structures and by simple chemical tests (bromine water and potassium manganate (VII))
10.5 Alcohols	• understand the basic chemistry of alcohols	• describe alcohols as saturated compounds with a hydroxyl functional group and the general formula $C_nH_{2n+1}OH$ • describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethene (details of the mechanism of reaction are **not** required) • describe the properties of ethanol in terms of burning • name the uses of ethanol as a solvent, as a fuel and as a constituent of alcoholic drinks
10.6 Carboxylic acids	• understand the basic chemistry of carboxylic acids	• describe carboxylic acids as compounds with the carboxyl functional group (COOH) • describe the formation of ethanoic acid by the oxidation of ethanol by fermentation or with acidified potassium manganate(VII) (details of mechanisms and equations are not required)
10.7 Esters	• understand the basic chemistry of esters	• describe the formation of ethyl ethanoate by the reaction of ethanoic acid with ethanol • state uses of esters (e.g. flavours and fragrances)

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
10.8 Polymers		
10.8.1 Synthetic polymers	• understand polymers in terms of large molecules built up from monomers • know the names, uses and formation of plastics (e.g. poly(ethene)) and other man-made-fibres	• describe polymers in terms of large molecules built up from small units (monomers), different polymers having different units and/or different linkages • describe the two different types of polymerisation (addition and condensation) • deduce the structure of the polymer product from a given alkene monomer and vice versa • describe the formation of poly(ethene) as an example of addition polymerisation of monomer units • describe the formation of nylon (a polyamide) and Terylene (a polyester) by condensation polymerisation, the structure of nylon being represented as:  and the structure of Terylene as:  (Details of manufacture and mechanisms of these polymerisations are **not** required.) • outline some uses of plastics

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
10.8.2 Natural macromolecules	• know the names, structures and formation of proteins, fats and carbohydrates	• name proteins, fats and carbohydrates as the main constituents of food • describe proteins as possessing the same (amide) linkages as nylon but with different units • describe the structure of proteins as:  • describe the hydrolysis of proteins to amino acids (structures and names are not required) • describe fats as esters possessing the same linkage as Terylene but with different units • describe complex carbohydrates in terms of a large number of sugar units, considered as  , joined together by condensation polymerisation, e.g.  • describe the acid hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars • describe, in outline, the usefulness of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
10.8.3 Properties and uses of fibres	• know the properties and uses of natural and synthetic fibres	• classify fibre polymers as natural or synthetic, give examples of both and observe the different types of fibres used in the home • outline that fibres are made into fabrics/textiles and that fabrics/textiles have properties which are useful (e.g. insulation, water absorption) • describe the pollution problems caused by non-biodegradable plastics and man-made fibres

The practical activities, approaches or demonstrations required for Topic 10 Organic chemistry are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *carry out fractional distillation of a sample of wine/ fermented sugar solution/ fruit juice (cross reference to 1.5)* • *prepare a sample of soap from an alkali and a fat or oil* • *investigate saturated and unsaturated hydrocarbons by simple chemical tests (bromine water and potassium manganate (VII))* • *carry out an experiment to investigate the properties of fibres (e.g. insulation, water absorption)*

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
11 Environmental and industrial chemistry		
11.1 Water		
11.1.1 Physical and chemical properties of water	• know the physical and chemical tests for water	• describe a chemical test for the presence of water using (anhydrous copper(II) sulfate or cobalt(II) chloride) • describe how to test the purity of water using physical test (melting/boiling points or density)
11.1.2 Availability, distribution and purification of water in Namibia	• know the distribution, availability, purification, pollution and value of water in Namibia	• discuss the distribution and availability of water in Namibia, such as in dams, underground rivers and lakes • evaluate soft and hard water in terms of the ease with which they form a lather with soap • define scum as a product of soap and the calcium and magnesium salts in water • identify hard water as containing dissolved salts of calcium and magnesium • explain that temporary hardness of water is caused by the presence of calcium and/or magnesium hydrogen carbonate • explain that permanent hardness is caused by the presence of calcium and/or magnesium sulfate • describe the softening of permanent and temporary hard water by washing soda or ion exchange • describe the softening of temporary hard water by boiling and the formation of ‘scale’ in hot water kettles and geysers • describe the removal of scale from a kettle by reaction with dilute acid • state the sources of temporary and permanent hardness

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
11.1.2 Availability, distribution and purification of water in Namibia (continued)	• know the distribution, availability, purification, pollution and value of water in Namibia	• describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers • discuss the dangers of over use of fertilisers with reference to the effect on water resources (eutrophication) • discuss water pollution from sewage and landfill leachate • describe, in outline, the purification of the water supply (including treatment of water from sewage) in terms of filtration and chlorination • discuss the implications of an inadequate supply of safe water for drinking and water for irrigating crops in Namibia (**NB**: the process of desalination of sea water is expensive therefore is not a solution to water scarcity problem in Namibia)
11.2 The air around us	• know the composition of dry air • know how carbon dioxide is formed	• interpret the composition of dry air (78% N_2; 21% O_2; 1% other gases) with special reference to the high concentration of nitrogen • recall that combustion involves reaction with oxygen in the air • describe the formation of carbon dioxide: − as a product of complete combustion of carbon-containing substances (cross reference to 10.3) − as a product of aerobic respiration − as a product of fermentation − as a product of the reaction between an acid and a carbonate − from the thermal decomposition of a carbonate
11.3 The commercial preparation and uses of gases	• know the commercial preparation and uses of oxygen, nitrogen and carbon dioxide	• describe the commercial preparation of oxygen, nitrogen (from liquid air by fractional distillation) and carbon dioxide • describe the uses of: − oxygen e.g. for breathing in hospitals, for welding and for steel production − carbon dioxide e.g. as “dry ice”, in carbonated drinks, baking soda, fire extinguishers and as a cooling agent

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
11.4 Pollution of the air	• know the formation of carbon monoxide and its dangers to humans • understand that non-metal oxides are acidic oxides, some of which form acid rain, which in turn can have a serious impact on the environment	• investigate and describe the pollution of air by gases such as carbon monoxide, sulfur dioxide and nitrogen oxides • explain the incomplete combustion of carbon to form carbon monoxide as a particular problem in confined spaces and its dangers to humans • describe sulfur dioxide and nitrogen oxides as acidic oxides which combine with water in the air to form acid rain • outline the consequences of acid rain for the environment (cross reference to 7.3, 7.4) • state that carbon dioxide and methane are greenhouse gases and contribute to climate change when in excess • state the sources of methane, including decomposition of vegetation and waste gases from digestion in animals • describe the main pollutants resulting from vehicle exhausts: unburned hydrocarbons, carbon monoxide, nitrogen oxides • discuss the dangers of lead pollution and the use of unleaded petrol as one measure to reduce lead pollution of the air • describe the use of catalysts in the exhaust systems of vehicles to reduce the emission of harmful gases • describe the pollution of air by solid particles, such as smoke and dust (refer to mica dust in Namibia) using data of the emission of gases in both industrial and developing countries • identify the causes of air pollution in your area • discuss why air pollutants are of a global concern

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
11.5 Chemical industrial plants	• know the manufacturing, chemistry and uses of lime and limestone • know the processes of other chemical industrial plants	• describe the manufacture of calcium oxide (lime) from calcium carbonate (limestone) in terms of the chemical reactions involved • state some uses of lime and calcium hydroxide (slaked lime) e.g. in treating acidic soil and neutralising acidic industrial waste products (e.g. flue gas desulfurisation) • state the uses of calcium carbonate (e.g. Marble Mining at Karibib), and in the manufacturing of iron and of cement (e.g. Ohorongo Cement Works) • describe the extraction of salt and table salt in salt works (Swakopmund and Walvis Bay) • describe the essential conditions for the manufacture of ammonia by the Haber process (cross reference to 6.5) including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air • state the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria) • describe the manufacture of sulfuric acid by the Contact process, including essential conditions and raw materials (sulfur, air and water) • state the use of sulfuric acid in the manufacture of detergents and fertilisers and as a battery acid

The practical activities, approaches or demonstrations required for Topic 11 Environmental and industrial chemistry are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement.
• *investigate the chemical properties of limestone, lime and slaked lime* • *carry out tests for the presence of water* • *investigate hard water and soft water by mixing soap solutions with a variety of salt solutions, including solutions of calcium and magnesium salts to show that the lathers are not easily formed with these solutions* • *investigate the presence of carbon dioxide in exhaled air (aerobic respiration)* • *investigate the presence of carbon dioxide in fermented fruit juice/sugar (anaerobic respiration/fermentation)* • *analyse the water consumption of your family and your area due to spillage, leaking water pipes and taps* • *determine by experiments that temporary hardness can be removed by boiling the water* • *investigate the removal of scale from kettles and pots*

6. ASSESSMENT OBJECTIVES

The assessment will include, wherever appropriate, personal, social, environmental, economic and technological applications of Chemistry in modern society. Learners are required to demonstrate the Assessment Objectives in the context of the content and skills prescribed. Within each of the Assessment Objectives the assessment must take account of the learners' ability to communicate clearly and logically and apply conventions where appropriate.

The three Assessment Objectives in Chemistry are:

A Knowledge with understanding
B Handling information, application and solving problems
C Practical (experimental and investigative) skills and abilities

Following is a description of each Assessment Objective:

A Knowledge with understanding
Learners should be able to demonstrate knowledge and understanding in relation to:
A1 scientific phenomena, facts, laws, definitions, concepts and theories
A2 scientific vocabulary, terminology and conventions, (including symbols, quantities, units)
A3 scientific instruments and apparatus, including techniques of operation and aspects of safety
A4 scientific quantities and their determination
A5 scientific and technological applications with their social, economic and environmental implications

The Learning Content defines what learners may be required to recall and explain. Questions testing assessment objectives will often begin with one of the following words: *define, name, list, indicate, give examples, state, describe, compare, explain, distinguish, outline and give reasons.*

B Handling information, application and solving problems
Learners should be able to, in word or using other written forms of presentation (i.e. symbolic, graphical and numerical) to:
B1 locate, select, organise and present information from a variety of sources
B2 translate information from one form to another
B3 manipulate numerical and other data
B4 use information to identify patterns, report trends and draw inferences
B5 present reasoned explanations for phenomena, patterns and relationships
B6 make predictions and hypotheses
B7 solve quantitative and qualitative problems as they relate to everyday life

These skills cannot be precisely specified in the Learning Content, because questions testing such skills are often based on information that is unfamiliar to the learner. In answering such questions, learners are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *discuss, deduce, compare and discuss, find, estimate, interpret, evaluate, sketch, predict, identify, relate, suggest and calculate* or *determine.*

C Practical (experimental and investigative) skills and abilities
Learners should be able to:

C1 demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
C2 plan experiments and investigations
C3 make and record observations, measurements and estimates
C4 interpret and evaluate experimental observations and data, including dealing with anomalous or inconsistent results
C5 evaluate methods and suggest possible improvements

7. SCHEME OF ASSESSMENT

All learners should be entered for **Papers 1, 2** and **3** which are compulsory papers.

Paper	**Description of paper and types of questions**	**Duration of paper**	**Marks**
Paper 1: Theory: Multiple choice questions	This paper will consist of forty multiple-choice items of the four-choice type. The questions will be based on the content described in the specific objectives and will test abilities in assessment objectives A and B. Learners should attempt all questions	45 minutes	40
Paper 2: Theory: Structured questions	This paper will consist of compulsory short-answer, structured and free-response questions. The questions will test skills and abilities in Assessment Objectives A and B	1 hour 30 minutes	80
Paper 3: Alternative to practical: Assessment of practical skills and abilities	The purpose of this component is to test appropriate skills in Assessment Objective C. This paper is a written paper of compulsory questions designed to test familiarity with practical laboratory procedures and will test skills in assessment objective C. This implies that learners must be exposed to practical work and demonstrations The notes for use in qualitative analysis (*annexe B*) will **NOT** be supplied with paper 3.	1 hour 15 minutes	40
		TOTAL	**160**

Weighting of papers

All learners will be entered for Papers 1, 2 and 3 specified below.
Learners will be graded from A* - G depending on their abilities and achievements.

Weighting of papers	
Paper 1 Paper 2 Paper 3 (Alternative to Practical Paper)	30% 50% 20%

8. SPECIFICATION GRID

The approximate weightings allocated to each of the Assessment Objectives across the papers are summarised in the table below:

Assessment Objective	Weighting across all components	Paper 1	Paper 2	Paper 3
A Knowledge with understanding	50% (not more than 25% recall)	25 marks	50 marks	0 marks
B Handling information, application and solving problems	30%	15 marks	30 marks	0 marks
C Practical (experimental and investigative) skills and abilities	20%	0 marks	0 marks	40 marks
		40 marks	**80 marks**	**40 marks**
		160 marks		

9. GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all learners. Grade descriptions are therefore provided for judgmental Grades A, C and F to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades. The description must be interpreted in relation to the content specified by the Chemistry syllabus but are not designed to define that content. The grade awarded will depend in practice upon the extent to which the learner has met the assessment objective overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others. Grade descriptions for Science Subjects will range from A, C and F.

At ***Grade A*** *the learner is expected to:*

- recall a wide range of knowledge from all areas of the syllabus
- use detailed scientific knowledge and understanding in a range of applications relating to scientific systems or phenomena
- use a wide range of scientific and technical vocabulary throughout their work
- explain how theories can be changed by new evidence and identify some areas of uncertainty in science
- select and collate information from a number of sources and present it in a clear, logical form
- solve problems in situations that may involve a wide range of variables
- process data from a number of sources to identify patterns or trends
- generate a hypothesis to explain facts, or find facts to support a hypothesis.

At ***Grade C*** *the learner is expected to:*

- recall a range of scientific information from all areas of the syllabus
- use and apply scientific knowledge and understanding in some general contexts
- use appropriate scientific and technical vocabulary in a range of contexts
- explain how scientific theories can be modified by new scientific evidence
- select a range of information from a given source and present it in a clear, logical form
- identify patterns or trends in given information
- solve problems involving more than one step, but with a range of variables
- generate a hypothesis to explain a given set of facts or data

At ***Grade F*** *the learner is expected to:*

- recall and communicate limited knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply a limited range of scientific facts and concepts to give basic explanations of familiar phenomena, to solve straightforward problems and make simple predictions
- communicate and present simple scientific ideas, observations and data using a limited range of scientific terminology and conventions
- select a single piece of information from a given source, and use it to support a given conclusion, and to make links between scientific information and its scientific, technological, social, economic or environmental implications
- solve problems involving more than one step if structured help is given
- analyse data to identify a pattern or trend
- select, describe and evaluate techniques for a limited range of scientific operations and laboratory procedures.

10. GLOSSARY OF TERMS

Define (the term(s)...).	is intended literally. Only a formal statement or equivalent paraphrase is required
What do you understand by/What is meant by (the term(s)...)	normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
State	implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.
List	requires a number of points with no elaboration. If a specific number of points is requested, this number should not be exceeded.
Explain	may imply reasoning or some reference to theory, depending on the context.
Describe	requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. For particular phenomena, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. In other contexts, **describe and give an account of** should be interpreted more generally, i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer. **Describe and explain** may be coupled in a similar way to **state and explain**.
Discuss	requires candidates to give a critical account of the points involved in the topic.
Outline	implies brevity, i.e. restricting the answer to giving essentials.
Deduce/ predict	implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.
Comment	is intended as an open-ended instruction, inviting candidates to recall or infer points of interest relevant to the context of the question, taking account of the number of marks available.
Suggest	is used in two main contexts. It may imply either that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or that candidates are expected to apply their general knowledge to a new situation (one that may not formally be in the syllabus).
Find	is a general term that may variously be interpreted as calculate, measure, determine, etc.

Calculate	is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
Measure	implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.
Determine	often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. relative molecular mass.
Estimate	implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make any necessary simplifying assumptions about points of principle and about the values of quantities not otherwise included in the question.
Sketch	when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. In diagrams, sketch implies that a simple, freehand drawing is acceptable though care should be taken over proportions and the clear exposition of important details.
Construct	is often used in relation to chemical equations where a candidate is expected to write a balanced equation, not by factual recall but by analogy or by using information in the question.
Compare	requires candidates to provide both the similarities and differences between things or concepts.
Classify	requires candidates to group things based on common characteristics.

ANNEXE A: Assessment criteria for Paper 3, Alternative to Practical Paper

Scientific subjects are, by their nature, experimental. It is, accordingly, important that an assessment of a learner's knowledge and understanding of Chemistry should contain a component relating to practical work and experimental skills (as identified by assessment objective C).

1. Experimental contexts

Candidates may be asked questions on the following experimental contexts:

(a) simple quantitative experiments involving the measurement of volumes and/or masses

(b) rates (speeds) of reaction

(c) measurement of temperature based on a thermometer with 1°C graduations

(d) problems of an investigatory nature, possibly including suitable organic compounds

(e) filtration

(f) electrolysis

(g) identification of ions and gases (**NB:** Notes for use in qualitative analysis (*Annexe B)* **will NOT** be provided in the question paper)

2. Experimental skills and investigations requirements

Candidates may be required to do the following:

(a) take and record readings from apparatus, including:

- (i) reading a scale with appropriate accuracy and precision
- (ii) interpolating between scale divisions
- (iii) taking repeated measurements, where appropriate

(b) describe, explain or comment on experimental arrangements and techniques

(c) complete tables of data, and process data, using a calculator where necessary

(d) draw, complete and/or label diagrams of apparatus

(e) draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation

(f) interpret and evaluate observations and experimental data

(g) plot graphs and/or interpret graphical information

(h) identify sources of error and suggest possible improvements in procedures

(i) plan an experiment or investigation, including making reasoned predictions of expected results and
suggesting suitable apparatus and techniques.

(j) determine a gradient, intercept or intersection on a graph

(k) identify and/or select, with reasons, items of apparatus to be used for carrying out practical procedures

(l) explain, suggest and/or comment critically on precautions taken and/or possible improvements to techniques and procedures

(m) describe the tests for gases and ions, and/or draw conclusions from such tests

3. Teaching experimental skills
We expect you to look for suitable opportunities to embed practical techniques and investigative work throughout the course.

The best way to prepare candidates for these papers is to integrate practical work fully into the course so that it becomes a normal part of your teaching. Practical work helps candidates to:

- develop a deeper understanding of the syllabus topics
- learn to appreciate the way in which scientific theories are developed and tested
- develop experimental skills and positive scientific attitudes such as objectivity, integrity, cooperation, enquiry and inventiveness.

4. Apparatus list
This list contains the items you will need for teaching the experimental skills needed. It is not exhaustive. As far as possible, teachers should improvise and use easily accessible and familiar materials from the local environment.

- a burette, $50cm^3$
- a pipette, $25cm^3$
- a pipette filler
- two conical flasks, within the range $150cm^3$ to $250cm^3$
- measuring cylinder, $50cm^3$, $25cm^3$, $10cm^3$
- a filter funnel
- beaker, squat form with lip, $250cm^3$ and $100cm^3$
- a thermometer, –10°C to + 110°C at 1 °C graduations
- a polystyrene or other plastic beaker of approximate capacity $150cm^3$
- clocks (or wall-clock) to measure to an accuracy of 1 s (where clocks are specified, candidates may use their own wrist-watch if they prefer)
- wash bottle
- test-tubes (Pyrex or hard glass), approximately 125mm × 16mm
- boiling tubes, approximately 150mm × 25mm
- stirring rod

ANNEXE B: Notes for use in qualitative analysis

Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt. (soluble in dilute ammonia)
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt. (insoluble in dilute ammonia)
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium (Al^{3+})	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt., or very slight white ppt.
ammonium (NH_4^+)	ammonia produced on warming	
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Flame Tests

cation	flame colour
Li^+	red
Na^+	bright yellow
K^+	lilac
Ca^{2+}	brick-red
Ba^{2+}	green

Tests for gases

gas	test and test result
ammonia (NH_3)	turns damp 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

ANNEXE C: Data sheet: the Periodic Table of the elements

Group																	
I	II											III	IV	V	VI	VII	0
						1 H Hydrogen 1											4 He Helium 2
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 A*l* Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 C*l* Chlorine 17	40 Ar Argon 18
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 T*l* Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	- Po Polonium 84	- At Astatine 85	- Rn Radon 86
- Fr Francium 87	226 Ra Radium 88	227 Ac actinium 89 †															

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

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	- Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 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	- U Uranium 92	- Np Neptunium 93	- Pu Plutonium 94	- Am Americium 95	- Cm Curium 96	- Bk Berkelium 97	- Cf Californium 98	- Es Einsteinium 99	- Fm Fermium 100	- Md Mendelevium 101	- No Nobelium 102	- Lr Lawrencium 103

Key

A_r **X** Z

A_r = relative atomic mass
X = atomic symbol
Z = proton (atomic) number

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

ANNEXE D: Units of physical quantities

1. Numbers

The decimal point will be placed on the line, e.g. 52.35.
Numbers from 1000 to 9999 will be printed without commas or spaces.
Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

2. Units

Learners should be able to state the symbols for the following physical quantities and where indicated, state the units in which they are measured. The acceptable methods of stating units (e.g. metres per second or m per s) will be written as m/s or m s-1 (Note: the solidus (/) will be used for a quotient and indicate units in labels of tables and graphs e.g. distance/cm).

Quantity	Name of unit	Symbol for unit
length	kilometre	km
	metre	m
	centimetre	cm
	millimetre	mm
mass	tonne (1000 kg)	Mg
	kilogram	kg
	gram	g
	milligram	mg
weight	newton	N
time	year	y
	day	d
	hour	h
	minute	min
	second	s (not sec)
amount of substance	mole	mol
	square metre	m^2
	square decimetre	dm^2
	square centimetre	cm^2
	square millimetre	mm^2
volume	cubic kilometre	km^3
	cubic metre	m^3
	cubic decimetre (preferred to litre)	dm^3
	litre	dm^3 (**not** *l*)
	cubic centimetre	cm^3 (**not** m*l* or cc)
	cubic millimetre	mm^3
density	kilogram per cubic metre	kg/m^3
	gram per cubic centimetre	g/cm^3

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