ZIMSEC

For Performance Measurement

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL (ZIMSEC)

ZIMBABWE GENERAL CERTIFICATE OF EDUCATION (ZGCE)

For Examination in November 2013 – 2017

O-Level Syllabus

CHEMISTRY (5071)

CONTENTS

NOTES

Information for Teachers

This booklet relates to examinations taken in the year printed on the cover. It is the normal practice of ZIMSEC to print and distribute a new version of this booklet each period as changes occur. Centres should receive copies well in advance of them being required for teaching purposes.

Teachers who have not previously taught syllabus in this booklet are advised to obtain and study the relevant past examination papers and Subject Reports.

Units, significant figures

Candidates should be aware that misuse of units and/or significant figures, i.e. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.

REGULATIONS

Subject 5071 may not be taken with 5009.

The *International Syllabus Synopses* booklet should be consulted for a full list of subject exclusions.

DESPATCH OF EARLY MATERIALS

Centres, not entering through Ministry, who are likely to enter candidates in the November sessions and would like to ensure early receipt of Instructions of the practical examinations, should contact Question Paper Despatch before 1 June.

CHEMISTRY

5071

GCE ORDINARY LEVEL

SCHOOL CERTIFICATE

INTRODUCTION

This syllabus is designed to place less emphasis on factual material and greater emphasis on the understanding and application of scientific concepts and principles. This approach has been adopted in recognition of the need of students to develop skills that will be of long term value in an increasing technological world rather than focusing on large quantities of actual material which may have only short term relevance.

AIMS

These are not listed in order of priority.

The aims are to:

1. Provide, through well designed studies of experimental and practical chemistry, a worthwhile educational experiment for all students, whether or not they go on the study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:

    1.1. become confident citizens in a technological word, able to take or develop an informed interest in matters of scientific import;

    1.2. recognise the usefulness, and limitations, of scientific methods and to appreciate its applicability in other disciplines and in everyday life;

    1.3. be suitably prepared for studies beyond O/SC level in chemistry, in applied sciences or in science-dependant vocational courses.

2. develop abilities and skills that:

    2.1. are relevant to the study and practice of science;

    2.2. are useful in everyday life;

    2.3. encourage efficient and sage practice;

    2.4. encourage effective communication.

3. Develop attitude relevant to science such as: -

   3.1. accuracy and precision;

   3.2. objectivity;

   3.3. integrity;

   3.4. enquiry;

   3.5. initiative;

   3.6. inventiveness.

4. Stimulate interest in and care for the environment.

5. Promote an awareness that:

   5.1. the study and practice of science are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations;

   5.2. the applications of science may be both beneficial and detrimental to the individual, the community and the environment.

ASSESSMENT OBJECTIVES

A. Knowledge with understanding

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

1 scientific phenomena, facts, laws, definitions, concepts, theories;

2 scientific vocabulary, terminology, conventions (including symbols, quantities and units)

3 scientific instruments and apparatus, including techniques of operation and aspects of safety;

4 scientific quantities and their determination;

5 scientific and technological applications with their social, economic and environmental implications.

The Subject Content defines the factual knowledge that candidates may be required to recall and explain. Questions testing those objectives will often being with one of the following words: *define, state, describe, explain or outline*. (See the Glossary of Terms on page 97.)

B Handling information and solving problems

Students should be able – in orders or by using symbolic graphical and numerical forms of presentation – to:

1 locate, select, organise and present information from a variety of sources;

2 translate information from one form to another;

3 manipulate numerical and other data;

4 use information to identify patterns, report trends and draw inferences;

5 present reasoned explanations of phenomena, patterns and relationships;

6 make predictions propose hypothesis;

7 solve problems;

These assessment objectives cannot be precisely specified in the Subject Content because questions testing such skills may be based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *predict, suggest, construct, calculate or determine*. (See the Glossary of terms on page 32.)

C Experimental skills and investigations

Students should be able to:

1 follow a sequence of instructions;

2 use techniques, apparatus and materials;

3 make and record observations, measurements and estimates;

4 interpret and evaluate observations and experimental results;

5 plan and investigation, select techniques, apparatus and materials;

6 evaluate methods and suggest possible improvements.

The apparatus and techniques that candidates should be familiar with are given in Section 2 of the Subject Content and in the descriptions of Papers 3 and 4 below, see also page 27.

SCHEME OF ASSESSMENT

Candidates are required to enter for Papers 1, 2 and one other paper.

Paper	Type of Paper	Duration	Marks
1	Multiple Choice	1h	40
2	Theory	1½ h	75
3	Practical Test	1½ h	30
4	Alternative To Practical	1h	30

Paper 1 Theory (1h, 40 marks)

A paper consisting of 40 compulsory multiple-choice items of the simple 'direct choice' type. A copy of the data sheet (p.26) will be printed as part of this paper.

Paper 2 Theory (1½h, 75 marks)

A written paper consisting of two sections. Section a will carry 45 marks and will consist of a small number of compulsory, structured questions of variable mark value. Section B will carry 30 marks and will consist of 4 questions each of 10 marks with candidates being required to attempt 3 questions. A copy of the sheet (p.26) will be as part of this Paper.

Paper 3 Practical Test (1½h, 30 marks)

This paper will be marked out of 40 and the scaled to a mark out of 30.
Details of the syllabus and requirements for this paper are given on pages 27-30.
Candidates are NOT allowed to refer to notebooks, text books or any other information in the practical examination.

Paper 4 Alternative to Practical (1h, 30 marks)

This paper will be marked out of 60 and then scaled to a mark out of 30.
A written paper of compulsory short-answer and structured questions designed to test familiarity with laboratory practical procedures.

Questions may be set requiring candidates to:

(a) record readings from diagrams of apparatus;
(b) describe, explain, comment on or suggest experimental arrangements, techniques and procedures;

(c) complete table of data and/or plot graphs;
(d) interpret, draw conclusions from and evaluate observations and experimental (including graphical) data;
(e) describe tests for gases, ions, oxidising and reducing agents and/or draw conclusions from such tests.

Candidates may also be required to perform simple calculations.

WEIGHTINGS OF ASSESSMENT OBJECTIVES

Theory Papers (Papers 1 and 2)

A *Knowledge with understanding,* approximately 65% of the marks with approximately half allocated to recall.

B *Handling information,* approximately 35% of the marks.

Practical Assessment (Papers 3 and 4)

This is designed to test appropriate skills in C, Experimental Skills and Investigation, and carries about 25% of the marks for the subject.

SUBJECT CONTENT

It is important that, throughout the course, attention should be drawn to:

(i) the finite life of the world's economic considerations in the chemical industry, such as the availability and cost of raw materials and energy;

(ii) resources and hence the need for recycling and conservation;

(iii) the importance of chemicals in industry and in everyday life.

1 THE PARTICULATE NATURE OF MATTER

Candidates should be able to-

(a) describe the states of matter and explain their inter-conversion in terms of the kinetic particle theory;

(b) describe evidence for the movements of particles in gases and liquids (the treatment of Brownian motion is not required);

(c) describe and explain diffusion;

(d) describe the dependence of rate of diffusion on molecular mass (treated qualitatively).

2 EXPERIMENTAL TECHNIQUES

2.1. Apparatus

Candidates should be able to:

(a) name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders;

(b) design arrangement of apparatus, given information about the substances involved;

(c) describe the use of volumetric apparatus and indicators including methyl orange and screened methyl orange;

2.2. (a) Criteria of purity

Candidates should be able to:

(i) describe paper chromatography and interpret chromatograms including comparison with 'known' samples and R_f values;

(ii) describe how chromatography techniques be applied to colourless substances (knowledge of the composition of particular locating agents is *not* required);

(iii) identify substances and test their purity by melting point and boiling point determination and by paper chromatography;

(iv) explain the importance of purity in substances in everyday life, e.g. in foodstuffs and drugs;

2.2. (b) Methods of purification

Candidates should be able to:

(i) describe methods of purification by the use of a suitable solvent, filtration, crystallisation, distillation (including use of fractionating column) (refer to the fractional distillation of : crude oil, liquid air, fermented liquor);

(ii) suggest suitable purification techniques, given information about the substances involved.

3 ATOMS, ELEMENTS AND COMPOUNDS

Candidates should be able to:

(a) state the relative charges and approximate relative masses o protons, neutrons and electrons;

(b) define proton (atomic) number and nucleon (mass) number;

(c) use and interpret such symbols as $^{12}_{6}C$;

(d) use proton number and the simple structure of atoms to explain the Periodic Table, with special references to the elements of proton number 1 to 20;

(e) define isotopes;

(f) state that some isotopes are radioactive;

(g) describe one medical, and one industrial, use of a radioactive isotope;

(h) describe the build-up of electrons in 'shells' and understand the significance of valency electrons and the noble gas electronic structures. (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, as shown on page 26, will be available in the examination in Paper 1 and Paper 2).

3.1. Bonding: the structure of matter

Candidates should be able to:-

(a) describe the differences between elements, compounds and mixtures and between metals and non-metals;
(b) describe alloys, such as brass, as mixture of a metal with other elements

3.2. (a) Ions and ionic bonds

Candidates should be able to:

(i) describe the formation of ions by electrons loss or grain

(ii) describe the formations of ionic bonds between metallic and non-metallic elements, e.g. in NaCl, CaCl_2;

(iii) describe the lattice structure of sodium chloride

(iv) describe some ionic compounds as refractory materials, e.g. MgO as a lining in furnaces.

3.2. (b) Molecule and covalent bonds

(i) describe the formation of covalent bonds between non-metallic elements leading to the noble gas configuration, e.g. H_2, Cl_2, N_2, HCl, H_2O, CH_4, $C_4H_4CO_2$

(ii) deduce the electron arrangement in other covalent molecules;

(iii) construct 'dot and cross' diagrams to show the valency electrons in covalent molecules;

3.2. (c) Macromolecules

(i) describe the structure of macromolecules such as graphite, diamond, silica (silcon (IV) oxide, silicon dioxide) and poly(ethene)

(ii) describe the similarity in structure of diamond and silicon, diamond and silica (silicon (IV) oxide) and of their properties related to their structures.

3.2. (d) Metallic bonding

Candidates should be able to:

describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and explain the electrical conductivity and malleability of metals.

3.2. (e) Physical Properties

Candidates should be able to:

relate the volatility, solubility and electrical conductivity of a compound to its structure to its structure and bonding.

4 STOICHIOMETRY AND THE MOLE CONCEPT

Candidates should be able to:

Relate the volatility, solubility and electrical conductivity of a compound to its structure to its structure and bonding.

(a) state the symbols of the elements and formulae of the compounds mentioned in the syllabus.;

(b) deduce the formula of a simple compound from the relative numbers of atoms present and vice versa;

(c) determine the formula of a ionic compound from the charges on the ions present and vice versa;

(d) construct equations with state symbols, including ionic equations;

(e) deduce the balanced chemical equation for a chemical reaction, given relevant information;

(f) define relative atomic mass, A_r;

(g) define relative molecular mass, M_r, and calculate it as the sum of relative atomic masses;

(h) use the mole concept to calculate empirical formulae and molecular formulae;

(i) calculate stoichiometric reacting masses and volumes of gasses and solutions, solution concentration being expressed in g/dm^3 and/or in mol/dm3; calculations involving h idea of limiting reactants may be set. Questions on the gas law and the conversion of gaseous volumes to different temperatures and pressures will not be set.

(j) Calculate % yield and % purity

5 ELECTRICITY AND CHEMISTRY

Candidates should be able to:-

(a) describe the electrode products in the electrolysis of:

(i) molten lead (II) bromide, concentrated hydrochloric acid, concentrated aqueous sodium chloride, dilute sulphuric acid (as essentially the electrolysis of water) between inert electrodes;

(ii) aqueous copper (II) sulphate using carbon electrodes and using copper electrodes (as used in the refining of copper);

(b) describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given;

(c) state the general principles that metals or hydrogen are formed at the negative electrode (cathode) an that non-metals (other than hydrogen) are formed at the positive electrode (anode);

(d) predict the likely products of the electrolysis of a specified binary compound in the molten state or in concentrated aqueous solution;

(e) describe, in outline, the manufacture of: -

(i) aluminium from pure aluminium oxide in molten cryolite

(ii) chlorine and sodium hydroxide from concentrated aqueous sodium chloride;

(f) describe the electroplating of metals exemplified by copper plating;

(g) state two uses of electroplating;

(h) describe the reasons for the use of copper and (steel-cored) aluminium in cables and why plastics and ceramics are used as insulators.

6 ENERGY CHANGES

Candidates should be able to:

(a) describe the meaning of enthalpy change in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions;

(b) use the kilojoules, KJ, as a unit of energy;

(c) describe bond breaking as endothermic and bond forming as exothermic;

(d) state that the burning of fuels, e.g. wood, coal, oil, is exothermic;

(e) describe hydrogen as a fuel, e.g. in rockets;

(f) describe radioactive isotopes, such as ^{235}U, as a source of nuclear energy;

(g) describe the production of electrical energy from simple cess, i.e. two electrodes in an electrolyte. This should be linked with the reactivity series;

(h) describe the use of batteries as a convenient, portable energy source;

(i) describe the use of solver salts in photography as an endothermic process involving reduction of silver ions to silver;

(j) describe photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and using sunlight (energy) to produce glucose.

7 CHEMICAL REACTIONS

7.1. Speed of Reaction

Candidates should be able to:

(a) describe the effect of concentration, pressure, particle size and temperature on the speeds of reactions and explain these effects in terms of collision between reacting particles.;

(b) describe the effect of catalysts (including enzymes) on the speeds of reactions;

(c) describe how the above factors are used to explain the danger of explosive combustion with fine powders (e.g. in flour mills) and combustible gases (e.g. in mines);

(d) devise a suitable method for investigating the effect of a given variable on the speed of a reaction;

(e) interpret data obtained from experiments concerned with speed of reaction.

7.2. Reversible reactions

Candidates should be able to:

(a) describe the idea that some chemical reactions can be reversed by changing the reaction conditions;

(b) state the idea that some reversible chemical reactions reach a state of dynamic equilibrium;

(c) predict the effect of changing the conditions of a reversible reaction at equilibrium.

7.3. Redox

Candidates should be able to:-

(a) define oxidation and reduction in terms of oxygen/hydrogen gain/loss;

(b) define redox in terms of electron transfer and changes in oxidation state;

(c) identify redox reactions in terms of hydrogen/oxygen, and/or electron, gain/loss;

(d) describe the use of aqueous potassium iodine, acidified potassium dichromate (IV) and acidified potassium manganate (VII) in testing for oxidising and reducing agents from the colour changes produced;

8 ACIDS, BASES AND SALTS

8.1. The characteristic properties of acids and bases

Candidates should be able to:-

(a) describe the meaning of the terms acid and alkali in terms of the ions they contain or produce in aqueous solution and their effects on indicator paper;

(b) describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator paper;

(c) describe the characteristics properties of acids as in reactions with metals, bases, alkalis, carbonates

(d) describe the characteristic properties o bases as in reactions with acids and with ammonium salts;

(e) describe and explain the importance of controlling the pH of soil;

8.2. Types of oxides

Candidates should be able to:

Classify oxides as either acidic, basic or atmospheric relate to metallic/non-metallic character.

8.3. Preparation of salts

Candidates should be able to:-

(a) describe the preparation, separation and purification of salts as examples of some of the techniques in Section 2.2.(b);
(Methods of preparing salts to illustrate the practical techniques should include the action of acids with metals, insoluble base and insoluble carbonates).

(b) describe the preparation of salts by titration method;

(c) suggest a method of preparing a given salt from suitable starting materials, given appropriate information.

8.4. Identification of ions and gases

Candidates should be able to:

describe and explain the use of the following tests to identify:

(i) aqueous cations;
aluminium, ammonium, calcium, copper (ii), iron (ii), iron (iii) and zinc using aqueous sodium hydroxide and aqueous ammonia, as appropriate (formulae of complex ions are not required);

(ii) anions;
carbonate (by reaction with dilute acid and then limewater); chloride (by reaction, under acidic conditions, with aqueous silver nitrate); iodide (by reaction, under acidic conditions, with aqueous lead (ii) nitrate); nitrate (by reduction with aluminium to ammonia) and sulphate (by reaction, under acidic conditions, with aqueous barium ions);

(iii) gases;
ammonia (using damp red litmus paper); carbon dioxide (using limewater); chloride (using damp litmus paper); hydrogen (using lighted splint); oxygen (using glowing splint) and sulphur dioxide (using acidified potassium dichromate (IV)).

9 THE PERIODIC TABLE

Candidates should be able to:

describe the Periodic Table as a method of classifying elements and its use to predict properties of elements.

9.1. Periodic Trends

Candidates should be able to:

(a) describe the changes from metallic to non-metallic character across a period;

(b) describe the relationship between Group number, number of valency electrons and metallic/non-metallic character;

9.2. Group properties

Candidates should be able to:

(a) describe lithium, sodium and potassium in Group 1 (the alkali metals) as a collection of relative soft, low density metals showing a trend in melting points and in reaction with water;

(b) predict the properties of elements in Group 1, given data, where appropriate;

(c) describe chlorine, bromine and iodine in Group VII (the halogens) as a collection of diatomic non-metals showing a trend in colour, state and their displacement reactions with other halide ions;

(d) predict the properties of elements in Group VII, given data, where appropriate;

(e) identify trends in other Groups given information about the elements concerned;

9.3. Noble gases

Candidates should be able to:

(a) describe the noble gases as being uncreative;

(b) describe the uses of the noble gases in providing an inert atmosphere, e.g. argon in lamps; helium for filling balloons;

10 METALS

10.1. Properties of metals

10.2. Reactivity series

Candidates should be able to:-

(a) place calcium, copper, (hydrogen), iron, magnesium, potassium, silver, sodium and zinc in order to reactivity by reference to:

(i) the reactions, if any, of the metals with water or steam, dilute hydrochloric acid;

(ii) the reduction, if any, of their oxides with carbon and with oxygen;

(b) describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction with:

(i) the aqueous ions of the other listed metals;

(ii) the oxides of the other listed metals;

(c) describe the action of heat on the carbonates of the listed metals

(d) account of the apparent unreactivity of aluminium in terms of the presence of an oxide layer which adheres to the metal;

(e) deduce an order or reactivity from a given set of experimental results.

10.3. Extraction and uses of metals

Candidates should be able to:

(a) describe the ease of obtaining metals from their ores by relating the elements the reactivity series;

(b) describe the essential reactions in the extraction of iron from haematite in the blast furnace;

(c) describe the ideas of changing the properties of iron by the controlled use of additives to form alloys called steels;

(d) state the use of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)

(e) describe, in outline, the extraction of aluminium from pure aluminium oxide;

(f) state the uses of aluminium: in the manufacture of aircraft because of it strength and low density;

(g) state the uses of zinc fro galvanising and for making brass (with copper);

(h) state the uses of copper related to its properties, e.g. electrical wiring.

11 NON-METALS

11.1. Hydrogen

Candidates should be able to:

(a) describe the formation of hydrogen as a product of the reaction between:-

(i) reactive metals and water;

(ii) metals and acids.

(b) describe the formation of hydrogen as a product of electrolysis of certain aqueous solutions related to the ions present and their position in the reactivity series;

(c) describe, in outline, the manufacture of hydrogen from the reaction between methane and steam;

(d) state the uses of hydrogen in the manufacture of ammonia, and of margarine from unsaturated vegetable oils, and as a fuel in rockets;

(e) describe, in outline, he purification of the water supply in terms of filtration and chlorination;

(f) state some of the uses of water in industry and in the home;

(g) describe a chemical test for water.

11.2. Oxygen

Candidates should be able to:

(a) describe, in simple terms, the ideas of respiration, combustion and rusting;

(b) describe the volume composition of clean air in terms of 79% nitrogen, 20% oxygen, with the remainder being noble gases (with argon as the main constituent), carbon dioxide and variable amounts of water vapour;

(c) name common pollutants of air (carbon monoxide, sulphur dioxide, oxides of nitrogen, e.g. NO_2, and led compounds);

(d) state the source of each of these pollutants:

(i) carbon monoxide from the incomplete combustion of carbon – containing substances;

(ii) sulphur dioxide from the combustion of fossil fuels which contain sulphur compounds (leading to ‘acid rain’);

(iii) oxides of nitrogen and lead compounds from car exhausts;

(e) state the adverse effect of acidic pollutants on buildings and plants, and of carbon monoxide;

(f) describe the separation of oxygen and nitrogen from liquid air by fractional distillation;

(g) name the uses of oxygen in making steel, oxygen tents in hospitals, and with acetylene (hydrocarbon) in welding;

(h) describe paint and other coatings, including galvanising, as methods of rust prevention;

(i) describe sacrificial protection in terms of the reactivity series of metals.

11.3. Nitrogen

Candidates should be able to:

(a) state the use of nitrogen in the manufacture of ammonia;

(b) describe the essential conditions for the manufacture of ammonia by the Harber process;

(c) describe the displacement of ammonia from its salts;

(d) state the need for nitrogen, phosphorus and potassium compounds in plant life;

(e) name the uses of ammonia in the manufacture of fertilisers such as ammonium sulphate and nitrate;

11.4. Sulphur

Candidates should be able to:

(a) state the uses of sulphur dioxide as a bleach in the manufacture of wood pulp for papers; as a food preservative (by killing bacteria);

(b) describe the manufacture of sulphuric acid as a typical acid from sulphur by the Contact process;

(c) describe the properties of dilute sulphuric acid;

(d) state the uses of sulphuric acid as in the manufacture of detergents and fertilisers.

11.5. Chlorine

Candidates should be able to:

(a) name some sources of sodium chloride;

(b) describe the importance of sodium chloride as a source for chlorine and sodium hydroxide;

(c) state the main uses of chlorine in sterilising water; manufacturing plastics, e.g. pvc; making domestic bleaches.

11.6. Silicon

Candidates should be able to:

(a) describe silicon as a common element in most rocks (being combined with oxygen);

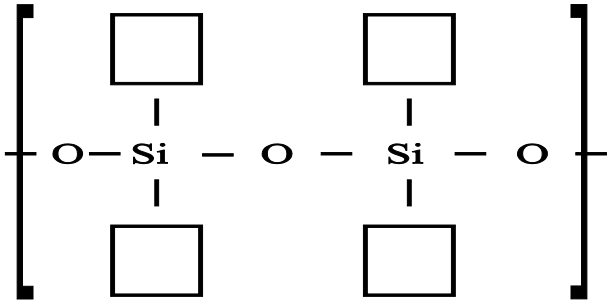
(i) as silicon (IV) oxide (silicon dioxide), e.g. quartz

(ii) as complex silicates, e.g. mica

(b) describe sand as impure form of silicon (IV) oxide;

(c) state the use of sand in making glass (a mixture of silicates) and as a source of silicon (by reduction);

(d) state the uses of silicon in semiconductors (for electronics) and for making silicones, their structure being represented as:



(e) state that different silicones are able to exist as oils, waxes or plastics

(f) explain the fire resistance o a silicone plastic to the nature of the combustion product and compare this to carbon-based polymers;

11.7. Carbon and carbonates

Candidates should be able to:

(a) name the allotropes of carbon as graphite and diamond

(b) state use of relate their structures to the uses of graphite e.g. as a lubricant and diamond in cutting

(c) describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reaction involved

(d) state some uses of lime and slaked lime as in treating acidic soil and neutralizing acidic industrial waste products

(e) state the uses of calcium carbonate in the manufacture of iron, glass and of cement

12 ORGANIC CHEMISTRY

12.1. Name of compounds

Candidates should be able to:

(a) name, and draw the structure of, the unbranched alkanes, alkenes (not *cis-trans*), alcohols and acids containing up to four carbon atoms per molecule and the products of the reactions stated in Sections 12.4 to 12.6

(b) state the type of compound present, given a chemical name ending in –ane, -ene, -ol, -oic acid, or given a molecular structure.

12.2. Fuels

Candidates should be able to:

(a) name natural gas and petroleum as sources of fuels;

(b) name methane as the main constituent of natural gas;

(c) describe petroleum as a mixture of hydrocarbons and its separation into useful fraction b fractional distillation;

(d) name the uses of the fractions: petrol (gasoline) fraction for fuel in cars; paraffin (kerosene) fraction for oil stoves and aircraft fuel for fuel in diesel engines: lubricating fraction for lubricants and making waxes and polishes: bitumen for making roads.

12.3. Homologous series

Candidates should be able to:

(a) describe the general characteristics of a homologous series

(b) describe and identify (given molecular structures) isomerism.

12.4. Alkanes

Candidates should be able to:

(a) describe the properties of alkenes (exemplified by methane) as being generally unreactive expect in terms of burning and substitution by chlorine;

(b) draw the structures of branched and unbranched alkanes containing four or five carbon atoms per molecule.

12.5. Alkenes

Candidates should be able to:

(a) describe the manufacture of alkenes and of hydrogen by cracking;

(b) describe the properties of alkenes in terms of burning; polymerisation; addition reactions with bromine, steam and hydrogen (margarine manufacture, considered as the addition of hydrogen to unsaturated vegetable oils in order to give a solid product);

(c) distinguish between saturated and unsaturated hydrocarbons from molecular structures; by using aqueous bromine;

(d) describe the formation of poly(ethene) as an example of addition polymerisation of monomer units;

(e) name some uses of poly(ethene) as a typical plastic, e.g. plastic bags.

12.6. Alcohol

Candidates should be able to:

(a) describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethane;

(b) describe the properties of ethanol in terms of burning and of oxidation;

(c) name the uses of ethanol as a solvent; as a fuel.

12.7. Acids

Candidates should be able to:

(a) describe the formation of ethanoic acid by the oxidation of ethanol by

(i) the action of atmospheric oxygen

(ii) acidified potassium dichromate (VI)

(b) describe ethanoic acid as an acid

(c) describe the reaction of ethanoic acid ethanol to give an ester (ethyl ethanoate)

12.8. Macromolecules

Candidates should be able to:

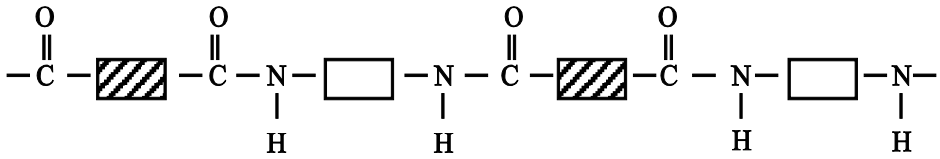
Describe macromolecules in terms of large molecules built up form small units, different macromolecules having different units and/or different linkages.

12.8. (a) Synthetic Polymers

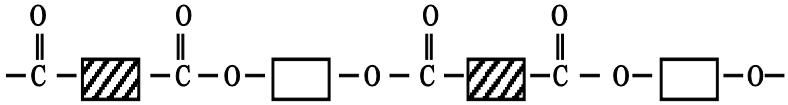
Candidates should be able to:

(i) deduce the structure of the polymer product from a given alkene and vice versa

(ii) describe the formation of nylon (a polyamide) and *Terylene (*a polyester) by condensation polymerization, the structure of nylon being represented as:



and the structure of *Terylene* as



(details of manufacture and mechanism of these polymerization are **not** required)

(iii) name some typical uses of man-made fibres such as nylon and Terylene, e.g. clothing

(iv) describe the pollution problems caused by non-biodegradable plastics

12.8. (b) Natural macromolecules

Candidates should be able to:

(i) name proteins, fats and carbohydrates as the main constituents of food

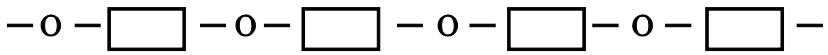
(ii) describe proteins as possessing the same (amide) linkages as nylon but with different units

(iii) describe the hydrolysis of protein to amino acids (structures and names not required)

(iv) describe fats (and vegetable oils) as esters possessing the same linkages as Terylene but with different structures

(v) describe soap as a product of hydrolysis of fat

(vi) describe the carbohydrate starch as a macromolecule represented as:



being formed by the condensation polymerization of smaller carbohydrate units called sugars, represented as

(vii) describe the acid hydrolysis of carbohydrates such as starch to given simple sugars

(viii) describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) (Candidates will not be expected to give the molecular formulae of sugars)

(ix) describe, in outline, the uses of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

MATHEMATICAL REQUIREMENTS

Calculators may be used in all papers of the examination, provided they are in accordance with the regulations stated in the "ZIMSEC Handbook for Centres" (General Certificate of Education).

Candidates should be able to:

1 add, subtract, multiply and divide;

2 use averages, decimals;

3 recognise and use standard notation;

4 use direct and inverse proportion

5 use positive, whole number indices;

6 draw charts and graphs;

7 interpret charts and graphs;

8 select suitable scales and axes for graphs;

9 make appropriate evaluations of numerical expressions;

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

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

12 comprehend and use the symbols/notations <, >, ≠, /, α;

13 comprehend how to handle numerical work so that significant figures are neither lost unnecessarily nor used beyond what is justified.

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 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulphur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **At** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Polonium 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	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

Key

a
X
b

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

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

Practical Syllabus for Paper 5071/3

The questions in the practical paper may include:

(a) a volumetric analysis problem, based on one set of titrations.

A knowledge of acid/alkali titrations using methyl orange or screened methyl orange will be assumed. Simple titrations involving other reagents may be set but full instructions and other necessary information will be given.

(b) an experiment that may involve the determination of some quantity, e.g. a temperature change or the rate of a reaction. Such experiments will depend on the use of usual laboratory apparatus.

(c) an observational problem in which the candidate will be asked to investigate, by specified experiments, an unknown substance or mixture. The exercise may include simple chromatography, tests for oxidizing and reducing agents and filtration.

Systematic analysis will **not** be required but it will be assumed that candidates will be familiar with the reactions of the following cations with aqueous sodium hydroxide and aqueous ammonia (aluminium, ammonium, calcium, copper, iron (II), iron (III) and inc), and with the tests for the anions (carbonate, chloride, iodine, nitrate, and sulphate) and gases (ammonium, carbon dioxide, chlorine, hydrogen, oxygen and sulphur dioxide) as detailed in the qualitative analysis notes which will be included with the question paper and are reproduced on page 30.

Exercise involving organic substances and ions not on the list above may be set but candidates will only be required to record observations and to draw general conclusions.

Candidates are **not** allowed to refer to note books, text books or nay other information in the Practical Examination.

Candidates may also be required to carry out simple calculations as detailed in the theory syllabus.

Practical Techniques for 5071/3

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

(a) Candidates should normally record burette readings to the nearest 0.05cm^3 and they should ensure that they have carried out a sufficient number of titrations, e.g. in an experiment with a good end-point, two titres within 0.2cm^3.

(b) Candidates should normally record: temperature readings to the nearer 0.1°C time to the nearest second.

(c) In qualitative exercises candidates should use approximately 1cm depth of a solution (1-2cm^3) for each test and add reagents slowly, ensuring good mixing, until no further change is seen. Candidates should indicate at what stage a change occurs. Answers should include details of colour changes and precipitates formed and the names and chemical tests for any gases evolved. Equations are **not** required and marks for deductions or conclusions can only be gained if the appropriate observations are recorded.

Apparatus List for 5071/3

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

One burette, 50cm^3
One pipette, 25cm^3
A pipette filler
Two conical flasks within the range 150cm^3 to 250cm^3
A measuring cyclinder, 50cm^3 or 25cm^3
A filter funnel
A beaker, squat form with lip: 250cm^3
A thermometer, -10°C to +110°C at 0.2°C
A polystyrene, or other plastic beaker of approximate capacity 150cm^3
Clocks (or wall-clock) to measure to an accuracy of about 1 s. (Where clocks are specified, candidates may use their own wrist watch if they prefer)
Wash bottle
Test tubes (some of which should be Pyrex or hard glass), approximately 125mm x 16mm
Boiling tubes, approximately 150mm x 25mm
Stirring rod

Reagents List for 5017/3

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

Aqueous sodium hydroxide (approximately 1.0 mol dm^{-3})
Aqueous ammonia (approximately 1.0 mol dm^{-3})

Hydrocloric acid (approximately 1.0 mol dm^{-3})
Nitric acid (approximately 1.0 mol dm^{-3})
Sulphuric acid (approximately 0.5 mol dm^{-3})

Aqueous silver nitrate (approximately 0.05 mol dm^{-3})
Aqueous barium nitrate or aqueous barium chloride (approximately 2.0 mol dm^{-3})
Aqueous lead (II) nitrate (approximately 2.0 mol dm^{-3})
Limewater (a saturated solution of calcium hydroxide)
Aqueous potassium dichromate (VI) (approximately 0.1 mol dm^{-3})
Aqueous potassium manganate (VII) (approximately 0.02 mol dm^{-3})
Aqueous potassium iodine (approximately 0.1 mol dm^{-3})

Aluminium foil
Red and blue litmus paper or Universal Indicator paper
Supervisors are reminded of their responsibilities of supplying the Examiners with the information specified in the Instructions. Failure to supply such information may cause candidates to be unavoidably penalised.

Te attention of Centres is drawn to the Handbooks for Centres which contain a section on science Syllabuses which includes information about arrangements for practical examinations.

QUALITATIVE ANALYSIS NOTES (5071/3)

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
iodine (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous lead (ii) nitrate	yellow ppt
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide then aluminium foil; warm carefully/dervada's alloy	ammonia produced
sulphate (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
ammonium (NH_4^+)	ammonia produced on warming	-
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt
copper (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution
iron (ii) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron (iii) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess giving a colourless solution	white ppt., soluble in excess giving a colourless solution

Tests for aqueous cations

gas	test and test results
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
sulphur dioxide (SO_2)	Turns aqueous potassium dichromate (VI) from orange to green

CHEMISTRY TEXTBOOKS – 5071

Teachers may find reference to the following books helpful.

- Chemistry for IGCSE by A. Glegg, published by Heinemann (ISBN 0-435-96675-8)
- Chemistry for IGCSE by E.N. Ramsden, published by ?Simon and Schuster (ISBN 0-7501-0681-6)
- Chemistry Counts by G. Hill, published by Hodder and Stoughton (ISBN 0-340-63934-2)
- Thinking Chemistry (GCSE Edition) by Lewis an Waller, published by Oxford University Press (ISBN 0-19-914257-2)
- Chemistry by B. Earl and L.D.R. Wilford, published by John Murray (ISBN 0-7195-5303-2)
- Caribbean Chemistry b J A Hunt, A Sykes with J George and A Maund, published by Longman (ISBN 0-582-02949-X

The titles represent some of the texts available at the time of printing this booklet. Teachers are encouraged to choose texts for class use which they feel will be of interest to their students and will support their own teaching style.

GLOSSARY OF TERMS USED IN SCIENCE PAPERS

It is hoped that the glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor defective. The glossary as been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1 *Define (the term(s) …*) is intended literally. Only a formal statement or equivalent paraphrased being required.

2 *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.

3 *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can obtained 'by inspection'.

4 *List* requires a number of points, generally each of own word, with no elaboration. Where a given number of points is specified, this should not be exceeded.

5 *Explain* may imply reasoning or some reference to theory, depending on the context.

6 *Describe* requires candidates to state in words (using diagrams whee appropriate) the main pints of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena.

In other context, *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.*

7 *Discuss* requires candidates to give a critical account of the points involved in the topic.

8 *Outline* implies brevity, i.e. restricting the answer to given essentials.

9 *Predict or deduce* implies that the candidates is not expected to produce the required answer by recall but by making a local connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an early part of the question.

10 *Comment* is intended as an open-ended instruction, inviting candidates or recall or infer points of interest relevant to the context of the question, taking account of the number of marks available.

11 *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown'),

12 *Find* is a generic term that may variously be interpreted as calculate, measure determine, etc.

13 *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

14 *Measure* implies that the quantity concerned can be directly obtained from a suitable measurement instrument, e.g. length, using a ruler, or angle, using a protractor.

15 *Determine* often implies that the quantity concerned cannot be measured directly but is obtained but calculation, substituting measured or known values of other quantities into a standard formula, e.g. relative molecular mass.

16 *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned; making such simplifying assumptions as may be necessary bout points of principle and about the values of quantities not otherwise included in the question.

17 *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only to 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 as a particular value.

In diagrams, *sketch* implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important details.

18 *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.

Special Note

Units, significant figures. Candidates should be aware that misuse of units and/or significant figures, i.e. failure to quo units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.