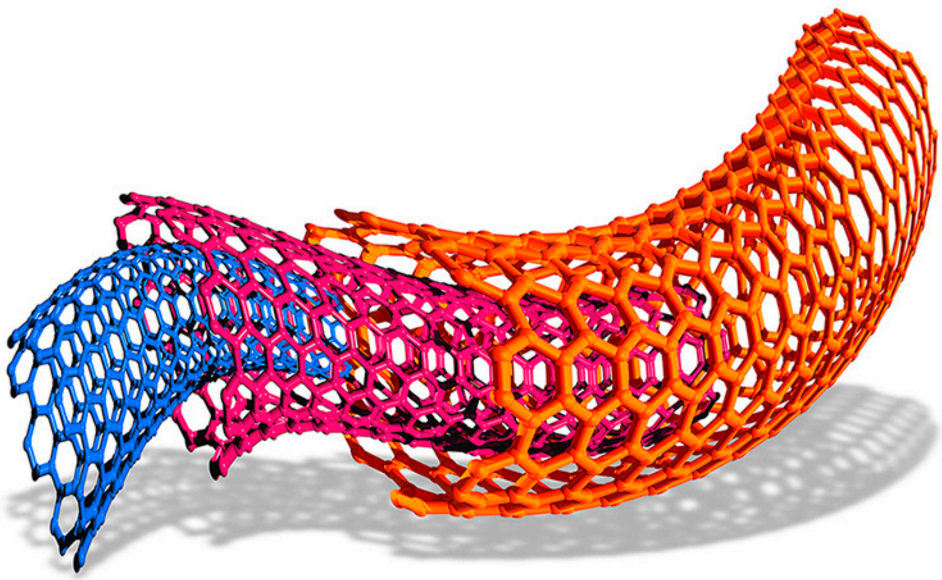
Cambridge Secondary 2

Syllabus

Cambridge IGCSE® (9–1)
Chemistry **0971**

For Centres in the UK

For examination in June and November 2018 and 2019.



Version 1

Please check the syllabus page at **www.cie.org.uk/igcse** to see if this syllabus is available in your administrative zone.

CAMBRIDGE
International Examinations

Why choose Cambridge?

Cambridge International Examinations prepares school students for life, helping them develop an informed curiosity and a lasting passion for learning. We are part of Cambridge Assessment, a department of the University of Cambridge.

Our international qualifications are recognised by the world's best universities and employers, giving students a wide range of options in their education and career. As a not-for-profit organisation, we devote our resources to delivering high-quality educational programmes that can unlock students' potential.

Our programmes and qualifications set the global standard for international education. They are created by subject experts, rooted in academic rigour and reflect the latest educational research. They provide a strong platform for learners to progress from one stage to the next, and are well supported by teaching and learning resources.

Our mission is to provide educational benefit through provision of international programmes and qualifications for school education and to be the world leader in this field. Together with schools, we develop Cambridge students who are confident, responsible, reflective, innovative and engaged – equipped for success in the modern world.

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Christoph Guttentag, Dean of Undergraduate Admissions, Duke University, USA

Quality management

Our systems for managing the provision of international qualifications and education programmes for students aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at **cie.org.uk/ISO9001**

Contents

Changes to this syllabus

The latest syllabus is version 1, published September 2016.

Any textbooks endorsed to support IGCSE Chemistry (0620) for examination from 2016 are suitable for use with this syllabus.

1 Why choose this syllabus?

Key benefits

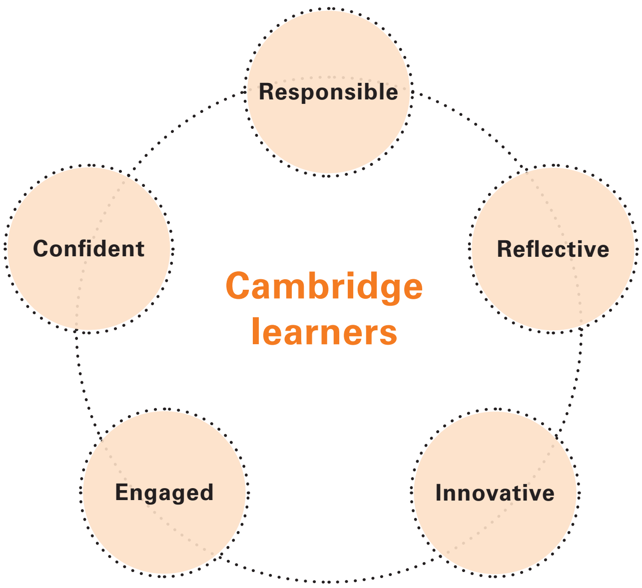
Cambridge IGCSE® syllabuses are created especially for international students. For over 25 years, we have worked with schools and teachers worldwide to develop syllabuses that are suitable for different countries, different types of schools and for learners with a wide range of abilities.

Cambridge IGCSE (9–1) Chemistry enables learners to:

- increase their understanding of the technological world
- take an informed interest in scientific matters
- recognise the usefulness (and limitations) of scientific method, and how to apply this to other disciplines and in everyday life
- develop relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness
- develop an interest in, and care for, the environment
- better understand the influence and limitations placed on scientific study by society, economy, technology, ethics, the community and the environment
- develop an understanding of the scientific skills essential for both further study and everyday life.

Our programmes balance a thorough knowledge and understanding of a subject and help to develop the skills learners need for their next steps in education or employment.

Our approach encourages learners to be:



‘The strength of Cambridge IGCSE qualifications is internationally recognised and has provided an international pathway for our students to continue their studies around the world.’

Gary Tan, Head of Schools and CEO, Raffles International Group of Schools, Indonesia

Recognition and progression

The combination of knowledge and skills in Cambridge IGCSE (9–1) Chemistry gives learners a solid foundation for further study. Candidates who achieve grades 4 to 9 are well prepared to follow a wide range of courses including Cambridge International AS & A Level Chemistry.

Cambridge IGCSEs are accepted and valued by leading universities and employers around the world as evidence of academic achievement. Many universities require a combination of Cambridge International AS & A Levels and Cambridge IGCSEs to meet their entry requirements.

Learn more at **www.cie.org.uk/recognition**

Supporting teachers

We provide a wide range of practical resources, detailed guidance and innovative training and professional development so that you can give your learners the best possible preparation for Cambridge IGCSE.

Support for Cambridge IGCSE

Teaching resources

- Syllabus
- Scheme of work
- Learner guide
- Endorsed textbooks and digital resources
- Teacher support **teachers.cie.org.uk**
- Discussion forum
- Resource List

Exam preparation resources

- Question papers
- Mark schemes
- Example candidate responses to understand what examiners are looking for at key grades
- Examiner reports to improve future teaching

Training

- Face-to-face workshops around the world
- Online self-study training
- Online tutor-led training
- Professional development qualifications

Community

Community forum **teachers.cie.org.uk**

LinkedIn **linkd.in/cambridgeteacher**

Twitter **@cie_education**

Facebook **facebook.com/cie.org.uk**

‘Cambridge IGCSE is one of the most sought-after and recognised qualifications in the world. It is very popular in Egypt because it provides the perfect preparation for success at advanced level programmes.’

Mrs Omnia Kassabgy, Managing Director of British School in Egypt BSE

2 Syllabus overview

Aims

The syllabus aims summarise the context in which you should view the syllabus content and describe the purposes of a course based on this syllabus. They are not listed in order of priority.

You can deliver some of the aims using suitable local, international or historical examples and applications, or through collaborative experimental work.

The aims are:

- to provide an enjoyable and worthwhile educational experience for all learners, whether or not they go on to study science beyond this level
- to enable learners to acquire sufficient knowledge and understanding to:
  - become confident citizens in a technological world and develop an informed interest in scientific matters
  - be suitably prepared for studies beyond Cambridge IGCSE
- to allow learners to recognise that science is evidence based and understand the usefulness, and the limitations, of scientific method
- to develop skills that:
  - are relevant to the study and practice of chemistry
  - are useful in everyday life
  - encourage a systematic approach to problem solving
  - encourage efficient and safe practice
  - encourage effective communication through the language of science
- to develop attitudes relevant to chemistry such as:
  - concern for accuracy and precision
  - objectivity
  - integrity
  - enquiry
  - initiative
  - inventiveness
- to enable learners to appreciate that:
  - 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.

Content

Candidates study the following topics:

1 The particulate nature of matter
2 Experimental techniques
3 Atoms, elements and compounds
4 Stoichiometry
5 Electricity and chemistry
6 Chemical energetics
7 Chemical reactions
8 Acids, bases and salts
9 The Periodic Table
10 Metals
11 Air and water
12 Sulfur
13 Carbonates
14 Organic chemistry

Teacher support for Cambridge IGCSE (9–1) Chemistry

We provide a wide range of support resources to give your learners the best possible preparation for Cambridge programmes and qualifications. Support for IGCSE (9–1) Chemistry includes a Teacher Guide, Example Candidate Responses and a Scheme of Work. These and other resources are available online through Teacher Support at **https://teachers.cie.org.uk**

Assessment

All candidates take three papers.

Candidates who have studied the Core subject content, or who are expected to achieve a grade 3 or below should be entered for Paper 1, Paper 3 and either Paper 5 or Paper 6. These candidates will be eligible for grades 1 to 5.

Candidates who have studied the Extended subject content (Core and Supplement), and who are expected to achieve a grade 4 or above should be entered for Paper 2, Paper 4 and either Paper 5 or Paper 6. These candidates will be eligible for grades 1 to 9.

Core candidates take:

Paper 1 45 minutes
Multiple Choice 30%
40 marks
40 four-choice multiple-choice questions
Questions will be based on the Core subject content
Assessing grades 1–5
Externally assessed

Extended candidates take:

Paper 2 45 minutes
Multiple Choice 30%
40 marks
40 four-choice multiple-choice questions
Questions will be based on the Extended subject content (Core and Supplement)
Assessing grades 1–9
Externally assessed

and Core candidates take:

Paper 3 1 hour 15 minutes
Theory 50%
80 marks
Short-answer and structured questions
Questions will be based on the Core subject content
Assessing grades 1–5
Externally assessed

and Extended candidates take:

Paper 4 1 hour 15 minutes
Theory 50%
80 marks
Short-answer and structured questions
Questions will be based on the Extended subject content (Core and Supplement)
Assessing grades 1–9
Externally assessed

All candidates take either:

Paper 5 1 hour 15 minutes
Practical Test 20%
40 marks
Questions will be based on the experimental skills in Section 4
Assessing grades 1–9
Externally assessed

or:

Paper 6 1 hour
Alternative to Practical 20%
40 marks
Questions will be based on the experimental skills in Section 4
Assessing grades 1–9
Externally assessed

3 Subject content

All candidates should be taught the Core subject content. Candidates who are only taught the Core subject content can achieve a maximum of grade 5. Candidates aiming for grades 4 to 9 should be taught the Extended subject content. The Extended subject content includes both the Core and the Supplement.

Scientific subjects are, by their nature, experimental. Learners should pursue a fully integrated course which allows them to develop their practical skills by carrying out practical work and investigations within all of the topics listed.

1 The particulate nature of matter

1.1 The particulate nature of matter

Core	Supplement
• State the distinguishing properties of solids, liquids and gases	
• Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion	
• Describe changes of state in terms of melting, boiling, evaporation, freezing, condensation and sublimation	• Explain changes of state in terms of the kinetic theory
• Describe qualitatively the pressure and temperature of a gas in terms of the motion of its particles	
• Show an understanding of the random motion of particles in a suspension (sometimes known as Brownian motion) as evidence for the kinetic particle (atoms, molecules or ions) model of matter	• Describe and explain Brownian motion in terms of random molecular bombardment • State evidence for Brownian motion
• Describe and explain diffusion	• Describe and explain dependence of rate of diffusion on molecular mass

2 Experimental techniques

2.1 Measurement

Core

- Name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders

2.2 Purity

2.2.1 Criteria of purity

Core

- Demonstrate knowledge and understanding of paper chromatography
- Interpret simple chromatograms
- Identify substances and assess their purity from melting point and boiling point information
- Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs

Supplement

- Interpret simple chromatograms, including the use of R_f values
- Outline how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents. (Knowledge of *specific* locating agents is **not** required.)

2.2.2 Methods of purification

Core

- Describe and explain methods of purification by the use of a suitable solvent, filtration, crystallisation and distillation (including use of a fractionating column). (Refer to the fractional distillation of petroleum in section 14.2 and products of fermentation in section 14.6.)
- Suggest suitable purification techniques, given information about the substances involved

3 Atoms, elements and compounds

3.1 Atomic structure and the Periodic Table

Core

- State the relative charges and approximate relative masses of protons, neutrons and electrons
- Define *proton number* (atomic number) as the number of protons in the nucleus of an atom
- Define *nucleon number* (mass number) as the total number of protons and neutrons in the nucleus of an atom
- Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see section 9), with special reference to the elements of proton number 1 to 20
- Define *isotopes* as atoms of the same element which have the same proton number but a different nucleon number
- State the two types of isotopes as being radioactive and non-radioactive

Supplement

- Understand that isotopes have the same properties because they have the same number of electrons in their outer shell

continued

3.1 Atomic structure and the Periodic Table continued

Core

- State one medical and one industrial use of radioactive isotopes
- Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of the outer shell electrons. (The ideas of the distribution of electrons in s and p orbitals and in d block elements are **not** required.)

Note: a copy of the Periodic Table, as shown in the Appendix, will be available in Papers 1, 2, 3 and 4.

3.2 Structure and bonding

3.2.1 Bonding: the structure of matter

Core

- Describe the differences between elements, mixtures and compounds, and between metals and non-metals
- Describe an alloy, such as brass, as a mixture of a metal with other elements

3.2.2 Ions and ionic bonds

Core

- Describe the formation of ions by electron loss or gain
- Describe the formation of ionic bonds between elements from Groups I and VII

Supplement

- Describe the formation of ionic bonds between metallic and non-metallic elements
- Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions

3.2.3 Molecules and covalent bonds

Core

- 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 the noble gas configuration
- Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds

Supplement

- Describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH and CO_2
- Explain the differences in melting point and boiling point of ionic and covalent compounds in terms of attractive forces

3.2.4 Macromolecules

Core

- Describe the giant covalent structures of graphite and diamond
- Relate their structures to their uses, e.g. graphite as a lubricant and a conductor, and diamond in cutting tools

Supplement

- Describe the macromolecular structure of silicon(IV) oxide (silicon dioxide)
- Describe the similarity in properties between diamond and silicon(IV) oxide, related to their structures

3.2.5 Metallic bonding

Supplement

- Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to describe the electrical conductivity and malleability of metals

4 Stoichiometry

4.1 Stoichiometry

Core

- Use the symbols of the elements and write the formulae of simple compounds
- Deduce the formula of a simple compound from the relative numbers of atoms present
- Deduce the formula of a simple compound from a model or a diagrammatic representation
- Construct word equations and simple balanced chemical equations
- Define *relative atomic mass*, A_r, as the average mass of naturally occurring atoms of an element on a scale where the ^{12}C atom has a mass of exactly 12 units
- Define *relative molecular mass*, M_r, as the sum of the relative atomic masses. (*Relative formula mass* or M_r will be used for ionic compounds.)

  (Calculations involving reacting masses in simple proportions may be set. Calculations will **not** involve the mole concept.)

Supplement

- Determine the formula of an ionic compound from the charges on the ions present
- Construct equations with state symbols, including ionic equations
- Deduce the balanced equation for a chemical reaction, given relevant information

4.2 The mole concept

Supplement

- Define the *mole* and the *Avogadro constant*
- Use the molar gas volume, taken as 24 dm^3 at room temperature and pressure
- Calculate stoichiometric reacting masses, volumes of gases and solutions, and concentrations of solutions expressed in g/dm^3 and mol/dm^3. (Calculations involving the idea of limiting reactants may be set. Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.)
- Calculate empirical formulae and molecular formulae
- Calculate percentage yield and percentage purity

5 Electricity and chemistry

5.1 Electricity and chemistry

Core

- Define electrolysis as the breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity
- Describe the electrode products and the observations made during the electrolysis of:
  - molten lead(II) bromide
  - concentrated hydrochloric acid
  - concentrated aqueous sodium chloride
  - dilute sulfuric acid

  between inert electrodes (platinum or carbon)
- 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)
- Predict the products of the electrolysis of a specified binary compound in the molten state
- Describe the electroplating of metals
- Outline the uses of electroplating

Supplement

- Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper)
- Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given
- Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution
- Construct ionic half-equations for reactions at the cathode

continued

5.1 Electricity and chemistry continued

Core

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

Supplement

- Describe the transfer of charge during electrolysis to include:
  – the movement of electrons in the metallic conductor
  – the removal or addition of electrons from the external circuit at the electrodes
  – the movement of ions in the electrolyte
- Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte. (This should be linked with the reactivity series in section 10.2 and redox in section 7.4.)
- Describe, in outline, the manufacture of:
  – aluminium from pure aluminium oxide in molten cryolite (refer to section 10.3)
  – chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride

  (Starting materials and essential conditions should be given but not technical details or diagrams.)

6 Chemical energetics

6.1 Energetics of a reaction

Core

- Describe the meaning of *exothermic* and *endothermic* reactions
- Interpret energy level diagrams showing exothermic and endothermic reactions

Supplement

- Describe bond breaking as an endothermic process and bond forming as an exothermic process
- Draw and label energy level diagrams for exothermic and endothermic reactions using data provided
- Calculate the energy of a reaction using bond energies

6.2 Energy transfer

Core

- Describe the release of heat energy by burning fuels
- State the use of hydrogen as a fuel
- Describe radioactive isotopes, such as ^{235}U, as a source of energy

Supplement

- 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.)

7 Chemical reactions

7.1 Physical and chemical changes

Core

- Identify physical and chemical changes, and understand the differences between them

7.2 Rate (speed) of reaction

Core

- Describe and explain the effect of concentration, particle size, catalysts (including enzymes) and temperature on the rate of reactions
- Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. methane in mines)
- Demonstrate knowledge and understanding of a practical method for investigating the rate of a reaction involving gas evolution
- Interpret data obtained from experiments concerned with rate of reaction

Note: Candidates should be encouraged to use the term *rate* rather than *speed*.

Supplement

- Devise and evaluate a suitable method for investigating the effect of a given variable on the rate of a reaction
- Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles. (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.)
- Describe and explain the role of light in photochemical reactions and the effect of light on the rate of these reactions. (This should be linked to section 14.4.)
- Describe the use of silver salts in photography as a process of reduction of silver ions to silver; and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose and oxygen

7.3 Reversible reactions

Core

- Understand that some chemical reactions can be reversed by changing the reaction conditions. (Limited to the effects of heat and water on hydrated and anhydrous copper(II) sulfate and cobalt(II) chloride.) (Concept of equilibrium is **not** required.)

Supplement

- Predict the effect of changing the conditions (concentration, temperature and pressure) on other reversible reactions
- Demonstrate knowledge and understanding of the concept of equilibrium

7.4 Redox

Core

- Define *oxidation* and *reduction* in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII).)

Supplement

- Define *redox* in terms of electron transfer
- Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving $KMnO_4$ is **not** required.)
- Define *oxidising agent* as a substance which oxidises another substance during a redox reaction. Define *reducing agent* as a substance which reduces another substance during a redox reaction.
- Identify oxidising agents and reducing agents from simple equations

8 Acids, bases and salts

8.1 The characteristic properties of acids and bases

Core

- Describe the characteristic properties of acids as reactions with metals, bases, carbonates and effect on litmus and methyl orange
- Describe the characteristic properties of bases as reactions with acids and with ammonium salts and effect on litmus and methyl orange
- Describe neutrality and relative acidity and alkalinity in terms of pH measured using Universal Indicator paper (whole numbers only)
- Describe and explain the importance of controlling acidity in soil

Supplement

- Define *acids* and *bases* in terms of proton transfer, limited to aqueous solutions
- Describe the meaning of weak and strong acids and bases

8.2 Types of oxides

Core

- Classify oxides as either acidic or basic, related to metallic and non-metallic character

Supplement

- Further classify other oxides as neutral or amphoteric

8.3 Preparation of salts

Core

- Demonstrate knowledge and understanding of preparation, separation and purification of salts as examples of some of the techniques specified in section 2.2.2 and the reactions specified in section 8.1

Supplement

- Demonstrate knowledge and understanding of the preparation of insoluble salts by precipitation
- Suggest a method of making a given salt from a suitable starting material, given appropriate information

8.4 Identification of ions and gases

Core

- Describe the following tests to identify:

  aqueous cations:

  aluminium, ammonium, calcium, chromium(III), copper(II), iron(II), iron(III) and zinc (using aqueous sodium hydroxide and aqueous ammonia as appropriate). (Formulae of complex ions are **not** required.)

  cations:

  use of the flame test to identify lithium, sodium, potassium and copper(II)

  anions:

  carbonate (by reaction with dilute acid and then limewater), chloride, bromide and iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium), sulfate (by reaction under acidic conditions with aqueous barium ions) and sulfite (by reaction with dilute acids and then aqueous potassium manganate(VII))

  gases:

  ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using lighted splint), oxygen (using a glowing splint), and sulfur dioxide (using aqueous potassium manganate(VII))

9 The Periodic Table

9.1 The Periodic Table

Core

- Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements

9.2 Periodic trends

Core

- Describe the change from metallic to non-metallic character across a period

Supplement

- Describe and explain the relationship between Group number, number of outer shell electrons and metallic/non-metallic character

9.3 Group properties

Core

- Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and reaction with water
- Predict the properties of other elements in Group I, given data, where appropriate
- Describe the halogens, chlorine, bromine and iodine in Group VII, as a collection of diatomic non-metals showing a trend in colour and density and state their reaction with other halide ions
- Predict the properties of other elements in Group VII, given data where appropriate

Supplement

- Identify trends in Groups, given information about the elements concerned

9.4 Transition elements

Core

- Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts

Supplement

- Know that transition elements have variable oxidation states

9.5 Noble gases

Core

- Describe the noble gases, in Group VIII or 0, as being unreactive, monoatomic gases and explain this in terms of electronic structure
- State the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons

10 Metals

10.1 Properties of metals

Core

- List the general physical properties of metals
- Describe the general chemical properties of metals, e.g. reaction with dilute acids and reaction with oxygen
- Explain in terms of their properties why alloys are used instead of pure metals
- Identify representations of alloys from diagrams of structure

10.2 Reactivity series

Core

- Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with:
  - water or steam
  - dilute hydrochloric acid

  and the reduction of their oxides with carbon
- Deduce an order of reactivity from a given set of experimental results

Supplement

- Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with:
  - the aqueous ions
  - the oxides

  of the other listed metals
- Describe and explain the action of heat on the hydroxides, carbonates and nitrates of the listed metals
- Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal

10.3 Extraction of metals

Core	Supplement
• Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series • Describe and state the essential reactions in the extraction of iron from hematite • Describe the conversion of iron into steel using basic oxides and oxygen • Know that aluminium is extracted from the ore bauxite by electrolysis	• Describe in outline, the extraction of zinc from zinc blende
• Discuss the advantages and disadvantages of recycling metals, limited to iron/steel and aluminium	• Describe in outline, the extraction of aluminium from bauxite including the role of cryolite and the reactions at the electrodes

10.4 Uses of metals

Core	Supplement
• Name the uses of aluminium: – in the manufacture of aircraft because of its strength and low density – in food containers because of its resistance to corrosion • Name the uses of copper related to its properties (electrical wiring and in cooking utensils)	• Explain the uses of zinc for galvanising and for making brass
• Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)	• Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys

11 Air and water

11.1 Water

Core	Supplement
• Describe chemical tests for water using cobalt(II) chloride and copper(II) sulfate • Describe, in outline, the treatment of the water supply in terms of filtration and chlorination • Name some of the uses of water in industry and in the home	• Discuss the implications of an inadequate supply of water, limited to safe water for drinking and water for irrigating crops

11.2 Air

Core

- State the composition of clean, dry air as being approximately 78% nitrogen, 21% oxygen and the remainder as being a mixture of noble gases and carbon dioxide
- Name the common pollutants in the air as being carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds
- State the source of each of these pollutants:
  - carbon monoxide from the incomplete combustion of carbon-containing substances
  - sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to 'acid rain')
  - oxides of nitrogen from car engines
  - lead compounds from leaded petrol
- State the adverse effect of these common pollutants on buildings and on health and discuss why these pollutants are of global concern
- State the conditions required for the rusting of iron
- Describe and explain methods of rust prevention, specifically paint and other coatings to exclude oxygen

Supplement

- Describe the separation of oxygen and nitrogen from liquid air by fractional distillation
- Describe and explain the presence of oxides of nitrogen in car engines and their catalytic removal
- Describe and explain sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention

11.3 Nitrogen and fertilisers

Core

- Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers
- Describe the displacement of ammonia from its salts

Supplement

- Describe and explain the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air

11.4 Carbon dioxide and methane

Core

- State that carbon dioxide and methane are greenhouse gases and explain how they may contribute to climate change
- State the formation of carbon dioxide:
  - as a product of complete combustion of carbon-containing substances
  - as a product of respiration
  - as a product of the reaction between an acid and a carbonate
  - from the thermal decomposition of a carbonate
- State the sources of methane, including decomposition of vegetation and waste gases from digestion in animals

Supplement

- Describe the carbon cycle, in simple terms, to include the processes of combustion, respiration and photosynthesis

12 Sulfur

12.1 Sulfur

Core

- Name some sources of sulfur
- Name the use of sulfur in the manufacture of sulfuric acid
- 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)

Supplement

- Describe the manufacture of sulfuric acid by the Contact process, including essential conditions and reactions
- Describe the properties and uses of dilute and concentrated sulfuric acid

13 Carbonates

13.1 Carbonates

Core

- Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of thermal decomposition
- Name some uses of lime and slaked lime such as in treating acidic soil and neutralising acidic industrial waste products, e.g. flue gas desulfurisation
- Name the uses of calcium carbonate in the manufacture of iron and cement

14 Organic chemistry

14.1 Names of compounds

Core

- Name and draw the structures of methane, ethane, ethene, ethanol, ethanoic acid and the products of the reactions stated in sections 14.4–14.6
- State the type of compound present, given a chemical name ending in -*ane*, -*ene*, -*ol*, or -*oic acid* or a molecular structure

Supplement

- Name and draw the structures of the unbranched alkanes, alkenes (not *cis-trans*), alcohols and acids containing up to four carbon atoms per molecule
- Name and draw the structural formulae of the esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms

14.2 Fuels

Core

- Name the fuels: coal, natural gas and petroleum
- 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
- Describe the properties of molecules within a fraction
- 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 roads

14.3 Homologous series

Core

- 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

Supplement

- Describe the general characteristics of a homologous series
- Recall that the compounds in a homologous series have the same general formula
- Describe and identify structural isomerism

14.4 Alkanes

Core

- Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning
- Describe the bonding in alkanes

Supplement

- Describe substitution reactions of alkanes with chlorine

14.5 Alkenes

Core

- Describe the manufacture of alkenes and of hydrogen by cracking
- Distinguish between saturated and unsaturated hydrocarbons:
  - from molecular structures
  - by reaction with aqueous bromine
- Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units

Supplement

- Describe the properties of alkenes in terms of addition reactions with bromine, hydrogen and steam

14.6 Alcohols

Core

- Describe the manufacture of ethanol by fermentation and by the catalytic addition of steam to ethene
- Describe the properties of ethanol in terms of burning
- Name the uses of ethanol as a solvent and as a fuel

Supplement

- Outline the advantages and disadvantages of these two methods of manufacturing ethanol

14.7 Carboxylic acids

Core

- Describe the properties of aqueous ethanoic acid

Supplement

- Describe the formation of ethanoic acid by the oxidation of ethanol by fermentation and with acidified potassium manganate(VII)
- Describe ethanoic acid as a typical weak acid
- Describe the reaction of a carboxylic acid with an alcohol in the presence of a catalyst to give an ester

14.8 Polymers

14.8.1 Polymers

Core

- Define polymers as large molecules built up from small units (monomers)

Supplement

- Understand that different polymers have different units and/or different linkages

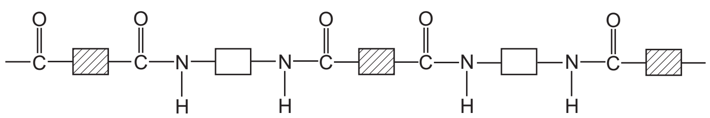
14.8.2 Synthetic polymers

Core

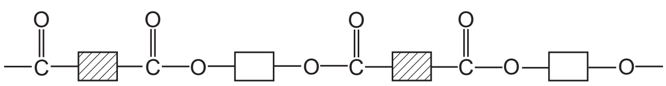
- Name some typical uses of plastics and of man-made fibres such as nylon and *Terylene*
- Describe the pollution problems caused by non-biodegradable plastics

Supplement

- Explain the differences between condensation and addition polymerisation
- Deduce the structure of the polymer product from a given alkene and *vice versa*
- 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.)

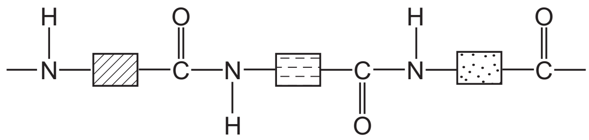
14.8.3 Natural polymers

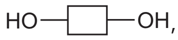
Core

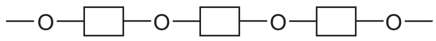
- Name proteins and carbohydrates as constituents of food

Supplement

- 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 complex carbohydrates in terms of a large number of sugar units, considered as , joined together by condensation polymerisation, e.g.



- Describe the hydrolysis of complex carbohydrates (e.g. starch), by acids or enzymes to give simple sugars
- Describe the fermentation of simple sugars to produce ethanol (and carbon dioxide). (Candidates will **not** be expected to give the molecular formulae of sugars.)
- Describe, in outline, the usefulness of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

4 Details of the assessment

For information on the Assessment objectives (AOs), see section 5.

All candidates take three papers.

Core Assessment

Core candidates take the following papers that have questions based on the Core subject content only:

Paper 1 – Multiple Choice (Core)

45 minutes, 40 marks

Forty compulsory multiple-choice items of the four-choice type. This paper tests assessment objectives AO1 and AO2.

Paper 3 – Theory (Core)

1 hour 15 minutes, 80 marks

Short-answer and structured questions testing assessment objectives AO1 and AO2.

Extended Assessment

Extended candidates take the following papers that have questions based on the Core and Supplement subject content:

Paper 2 – Multiple Choice (Extended)

45 minutes, 40 marks

Forty compulsory multiple-choice items of the four-choice type. This paper tests assessment objectives AO1 and AO2.

Paper 4 – Theory (Extended)

1 hour 15 minutes, 80 marks

Short-answer and structured questions testing assessment objectives AO1 and AO2.

Practical Assessment

All candidates take one practical component from a choice of two:

Paper 5 – Practical Test

1 hour 15 minutes, 40 marks

This paper tests assessment objective AO3 in a practical context.

or

Paper 6 – Alternative to Practical Test

1 hour, 40 marks

This paper tests assessment objective AO3 in a written paper.

Whichever practical paper you choose please be aware that:

- they test the same assessment objective, AO3
- they require the same experimental skills to be learned and developed
- the same sequence of practical activities is appropriate.

Candidates must not use textbooks or any of their course notes in the practical component.

Questions in the practical papers are structured to assess performance across the grade range 1 to 9. The information candidates need to answer the questions is in the question paper itself or the experimental context and skills listed below. The questions do not assess specific syllabus content.

Experimental skills tested in Paper 5 Practical Test and Paper 6 Alternative to Practical

Candidates may be asked questions on the following experimental contexts:

- simple quantitative experiments involving the measurement of volumes and/or masses
- rates (speeds) of reaction
- measurement of temperature based on a thermometer with 1°C graduations
- problems of an investigatory nature, possibly including suitable organic compounds
- filtration
- electrolysis
- identification of ions and gases (Paper 5 will include notes on qualitative analysis for the use of candidates in the examination).

Candidates may be required to do the following:

- take and record readings from apparatus, including:
  - reading a scale with appropriate accuracy and precision
  - interpolating between scale divisions
  - taking repeated measurements, where appropriate

- describe, explain or comment on experimental arrangements and techniques
- complete tables of data, and process data, using a calculator where necessary
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- interpret and evaluate observations and experimental data
- plot graphs and/or interpret graphical information
- identify sources of error and suggest possible improvements in procedures
- plan an experiment or investigation, including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

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, co-operation, enquiry and inventiveness.

Apparatus list

This list contains the items you will need for teaching the experimental skills needed for both practical papers, as well as the Paper 5 exam. It is not exhaustive and does not include standard equipment such as Bunsen burners or tripods. The Confidential Instructions we send you before the Paper 5 exam will give the detailed requirements for the exam.

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

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.
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
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, then add aqueous barium nitrate	white ppt.
sulfite (SO_3^{2-})	add dilute hydrochloric acid, warm gently and test for the presence of sulfur dioxide	sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless

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. or very slight white ppt.
chromium(III) (Cr^{3+})	green ppt., soluble in excess	grey-green ppt., insoluble in excess
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	'pops' with a lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns acidified aqueous potassium manganate(VII) from purple to colourless

Flame tests for metal ions

metal ion	flame colour
lithium (Li^+)	red
sodium (Na^+)	yellow
potassium (K^+)	lilac
copper(II) (Cu^{2+})	blue-green

5 Assessment objectives

The assessment objectives (AOs) are:

AO1 Knowledge with understanding

AO2 Handling information and problem solving

AO3 Experimental skills and investigations

AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

- scientific phenomena, facts, laws, definitions, concepts and theories
- scientific vocabulary, terminology and conventions (including symbols, quantities and units)
- scientific instruments and apparatus, including techniques of operation and aspects of safety
- scientific and technological applications with their social, economic and environmental implications.

Subject content defines the factual material that candidates may be required to recall and explain. Candidates will also be asked questions which require them to apply this material to unfamiliar contexts and to apply knowledge from one area of the syllabus to another.

Questions testing this objective will often begin with one of the following words: *define*, *state*, *describe*, *explain* (*using your knowledge and understanding*) or *outline* (see the *Glossary of terms used in science papers*).

AO2 Handling information and problem solving

Candidates should be able, in words or using other written forms of presentation (i.e. symbolic, graphical and numerical), to:

- locate, select, organise and present information from a variety of sources
- translate information from one form to another
- manipulate numerical and other data
- use information to identify patterns, report trends and draw inferences
- present reasoned explanations for phenomena, patterns and relationships
- make predictions and hypotheses
- solve problems, including some of a quantitative nature.

Questions testing these skills may be based on information that is unfamiliar to candidates, requiring them to apply the principles and concepts from the syllabus to a new situation, in a logical, deductive way.

Questions testing these skills will often begin with one of the following words: *predict*, *suggest*, *calculate* or *determine* (see the *Glossary of terms used in science papers*).

AO3 Experimental skills and investigations

Candidates should be able to:

- demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- make and record observations, measurements and estimates
- interpret and evaluate experimental observations and data
- evaluate methods and suggest possible improvements.

Weighting for assessment objectives

The approximate weightings allocated to each of the assessment objectives (AOs) are summarised below.

Assessment objectives as a percentage of the qualification

Assessment objective	Weighting in IGCSE %
AO1 Knowledge with understanding	50
AO2 Handling information and problem solving	30
AO3 Experimental skills and investigations	20

Assessment objectives as a percentage of each component

Assessment objective	Weighting in components %		
	Papers 1 and 2	**Papers 3 and 4**	**Papers 5 and 6**
AO1 Knowledge with understanding	63	63	0
AO2 Handling information and problem solving	37	37	0
AO3 Experimental skills and investigations	0	0	100

6 Appendix

The Periodic Table

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			**Key** atomic number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

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

Safety in the laboratory

Responsibility for safety matters rests with Centres. Further information can be found from the following UK associations, publications and regulations.

Associations

CLEAPSS is an advisory service providing support in practical science and technology.
http://www.cleapss.org.uk

Publications

CLEAPSS Laboratory Handbook, updated 2009 (available to CLEAPSS members only)
CLEAPSS Hazcards, 2007 update of 1995 edition (available to CLEAPSS members only)

UK regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002 and subsequent amendment in 2004
http://www.legislation.gov.uk/uksi/2002/2677/contents/made
http://www.legislation.gov.uk/uksi/2004/3386/contents/made

a brief guide may be found at
http://www.hse.gov.uk/pubns/indg136.pdf

Glossary of terms used in science papers

This glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, but it is neither exhaustive nor definitive. The glossary has 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 paraphrase 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. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

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

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

5 (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons. The candidate needs to leave the examiner in no doubt why something happens.

(b) *Give a reason*/*Give reasons* is another way of asking candidates to explain why something happens.

6 *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points.

Describe and *explain* may be coupled, as may *state* and *explain*.

7 *Discuss* requires the candidate to give a critical account of the points involved.

8 *Outline* implies brevity (i.e. restricting the answer to giving essentials).

9 *Predict* implies that the candidate is expected to make a prediction not by recall but by making a logical connection between other pieces of information.

10 *Deduce* 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.

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'), or to imply that candidates are expected to apply their general knowledge of the subject to a 'novel' situation, one that may be formally 'not in the syllabus' – many data response and problem solving questions are of this type.

12 *Find* is a general 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 measuring instrument (e.g. length using a rule, or mass using a balance).

15 *Determine* often implies that the quantity concerned cannot be measured directly but is obtained from a graph or by calculation.

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

17 *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept).

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

Mathematical requirements

Calculators may be used in all parts of the examination.

Candidates should be able to:

- add, subtract, multiply and divide
- use averages, decimals, fractions, percentages, ratios and reciprocals
- use standard notation, including both positive and negative indices
- understand significant figures and use them appropriately
- recognise and use direct and inverse proportion
- use positive, whole number indices in algebraic expressions
- draw charts and graphs from given data
- interpret charts and graphs
- determine the gradient and intercept of a graph
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, rectangle and diagonal
- solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known.

Presentation of data

The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts, e.g. time / s for time in seconds.

(a) Tables

- Each column of a table should be headed with the physical quantity and the appropriate unit, e.g. time / s.
- The column headings of the table can then be directly transferred to the axes of a constructed graph.

(b) Graphs

- Unless instructed otherwise, the independent variable should be plotted on the *x*-axis (horizontal axis) and the dependent variable plotted on the *y*-axis (vertical axis).
- Each axis should be labelled with the physical quantity and the appropriate unit, e.g. time / s.
- Unless instructed otherwise, the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable.
- The graph is the whole diagrammatic presentation, including the best-fit line when appropriate. It may have one or more sets of data plotted on it.
- Points on the graph should be clearly marked as crosses (x) or encircled dots (⊙).
- Large 'dots' are penalised. Each data point should be plotted to an accuracy of better than one half of each of the smallest squares on the grid.
- A best-fit line (trend line) should be a single, thin, smooth straight-line or curve. The line does not need to coincide exactly with any of the points; where there is scatter evident in the data, Examiners would expect a roughly even distribution of points either side of the line over its entire length. Points that are clearly anomalous should be ignored when drawing the best-fit line.
- The gradient of a straight line should be taken using a triangle whose hypotenuse extends over at least half of the length of the best-fit line, and this triangle should be marked on the graph.

(c) Numerical results

- Data should be recorded so as to reflect the precision of the measuring instrument.
- The number of significant figures given for calculated quantities should be appropriate to the least number of significant figures in the raw data used.

(d) Pie charts

- These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie charts should preferably contain no more than six sectors.

(e) Bar charts

- These should be drawn when one of the variables is not numerical. They should be made up of narrow blocks of equal width that do **not** touch.

(f) Histograms

- These are drawn when plotting frequency graphs with continuous data. The blocks should be drawn in order of increasing or decreasing magnitude and they **should** touch.

ICT opportunities

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This syllabus provides candidates with a wide range of opportunities to use ICT in their study of chemistry.

Opportunities for ICT include:

- gathering information from the internet, DVDs and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using software to present ideas and information on paper and on screen.

Conventions (e.g. signs, symbols, terminology and nomenclature)

Syllabuses and question papers conform with generally accepted international practice. In particular, the following document, produced by the Association for Science Education (ASE), should be used as a guideline.

- *Signs, Symbols and Systematics: The ASE Companion to 16–19 Science (2000).*

Litre/dm^3

To avoid any confusion concerning the symbol for litre, **dm^3** will be used in place of l or litre.

Decimal markers

In accordance with current ASE convention, decimal markers in examination papers will be a single dot on the line. Candidates are expected to follow this convention in their answers.

Numbers

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.

7 What else you need to know

This section is an overview of other information you need to know about this syllabus. It will help to share the administrative information with your exams officer so they know when you will need their support. Find more information about our administrative processes at **www.cie.org.uk/examsofficers**

Before you start

Previous study

We recommend that learners starting this course should have studied a chemistry curriculum such as the Cambridge Secondary 1 programme or equivalent national educational framework. Learners in England will normally have followed the Key Stage 3 programme of study within the National Curriculum for England.

Guided learning hours

Cambridge IGCSE syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of the course, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

Availability and timetables

You can enter candidates in the June and November exam series. You can view the timetable for your administrative zone at **www.cie.org.uk/timetables**

All Cambridge schools are allocated to one of six administrative zones. Each zone has a specific timetable. This syllabus is not available in all administrative zones. To find out about the availability visit the syllabus page at **www.cie.org.uk/igcse**

Private candidates can enter for this syllabus.

Combining with other syllabuses

Candidates can take this syllabus alongside other Cambridge syllabuses in a single exam series. The only exceptions are:

- Cambridge IGCSE Chemistry (0620)
- Cambridge IGCSE Physical Science (0652)
- Cambridge IGCSE Combined Science (0653)
- Cambridge IGCSE Co-ordinated Sciences (Double Award) (0654)
- Cambridge O Level Combined Science (5129)
- syllabuses with the same title at the same level.

Cambridge IGCSE, Cambridge IGCSE (9–1) (Level 1/Level 2 Certificates) and Cambridge O Level syllabuses are at the same level.

Making entries

Exams officers are responsible for submitting entries to Cambridge. We encourage them to work closely with you to make sure they enter the right number of candidates for the right combination of syllabus components. Entry option codes and instructions for submitting entries are in the *Cambridge Guide to Making Entries*. Your exams officer has a copy of this guide.

Option codes for entries

To keep our exams secure we allocate all Cambridge schools to one of six administrative zones. Each zone has a specific timetable. The majority of option codes have two digits:

- the first digit is the component number given in the syllabus
- the second digit is the location code, specific to an administrative zone.

Support for exams officers

We know how important exams officers are to the successful running of exams. We provide them with the support they need to make your entries on time. Your exams officer will find this support, and guidance for all other phases of the Cambridge Exams Cycle, at **www.cie.org.uk/examsofficers**

Retakes

Candidates can retake the whole qualification as many times as they want to. This is a linear qualification so candidates cannot re-sit individual components.

Equality and inclusion

We have taken great care to avoid bias of any kind in the preparation of this syllabus and related assessment materials. In compliance with the UK Equality Act (2010) we have designed this qualification to avoid any direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. We can put arrangements in place for these candidates to enable them to access the assessments and receive recognition of their attainment. We do not agree access arrangements if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who cannot access the assessment of any component may be able to receive an award based on the parts of the assessment they have completed.

Information on access arrangements is in the *Cambridge Handbook (UK)* at **www.cie.org.uk/examsofficers**

Language

This syllabus and the related assessment materials are available in English only.

After the exam

Grading and reporting

Grades 1, 2, 3, 4, 5, 6, 7, 8 or 9 indicate the standard a candidate achieved at Cambridge IGCSE (9–1).

9 is the highest and 1 is the lowest. 'Ungraded' means that the candidate's performance did not meet the standard required for grade 1. 'Ungraded' is reported on the statement of results but not on the certificate. In specific circumstances your candidates may see one of the following letters on their statement of results:

- Q (result pending)
- X (no result)
- Y (to be issued)

These letters do not appear on the certificate.

Grade descriptions

Grade descriptions are provided to give an indication of the standards of achievement candidates awarded particular grades are likely to show. Weakness in one aspect of the examination may be balanced by a better performance in some other aspect.

A **Grade 7** Cambridge IGCSE (9–1) Chemistry candidate will be able to:

- recall and communicate precise knowledge and display comprehensive understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present reasoned explanations of familiar and unfamiliar phenomena, to solve complex problems involving several stages, and to make reasoned predictions and hypotheses
- communicate and present complex scientific ideas, observations and data clearly and logically, independently using scientific terminology and conventions consistently and correctly
- independently select, process and synthesise information presented in a variety of ways, and use it to draw valid conclusions and discuss the scientific, technological, social, economic and environmental implications
- devise strategies to solve problems in complex situations which may involve many variables or complex manipulation of data or ideas through multiple steps
- analyse data to identify any patterns or trends, taking account of limitations in the quality of the data and justifying the conclusions reached
- select, describe, justify and evaluate techniques for a large range of scientific operations and laboratory procedures.

A **Grade 4** Cambridge IGCSE (9–1) Chemistry candidate will be able to:

- recall and communicate secure knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present simple explanations of familiar and some unfamiliar phenomena, to solve straightforward problems involving several stages, and to make detailed predictions and simple hypotheses
- communicate and present scientific ideas, observations and data using a wide range of scientific terminology and conventions
- select and process information from a given source, and use it to draw simple conclusions and state the scientific, technological, social, economic or environmental implications
- solve problems involving more than one step, but with a limited range of variables or using familiar methods
- analyse data to identify a pattern or trend, and select appropriate data to justify a conclusion
- select, describe and evaluate techniques for a range of scientific operations and laboratory procedures.

A **Grade 1** Cambridge IGCSE (9–1) Chemistry candidate will be able 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.

‘While studying Cambridge IGCSE and Cambridge International A Levels, students broaden their horizons through a global perspective and develop a lasting passion for learning.’

Zhai Xiaoning, Deputy Principal, The High School Affiliated to Renmin University of China

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