Syllabus

Cambridge IGCSE™
Chemistry 0620

Use this syllabus for exams in 2022.
Exams are available in the June and November series.
Exams are also available in the March series in India only.
Why choose Cambridge International?

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

Our Cambridge Pathway gives students a clear path for educational success from age 5 to 19. Schools can shape the curriculum around how they want students to learn – with a wide range of subjects and flexible ways to offer them. It helps students discover new abilities and a wider world, and gives them the skills they need for life, so they can achieve at school, university and work.

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 learners who are confident, responsible, reflective, innovative and engaged – equipped for success in the modern world.

Every year, nearly a million Cambridge students from 10 000 schools in 160 countries prepare for their future with the Cambridge Pathway.

'We think the Cambridge curriculum is superb preparation for university.'

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

Quality management

Cambridge International is committed to providing exceptional quality. In line with this commitment, our quality management system for the provision of international qualifications and education programmes for students aged 5 to 19 is independently certified as meeting the internationally recognised standard, ISO 9001:2015. Learn more at www.cambridgeinternational.org/ISO9001
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Changes to this syllabus
For information about changes to this syllabus for 2022, go to page 42.
The latest syllabus is version 1, published September 2019. There are no significant changes which affect teaching.
Any textbooks endorsed to support the syllabus for examination from 2016 are still suitable for use with this syllabus.
1 Why choose this syllabus?

Key benefits

Cambridge IGCSE is the world’s most popular international qualification for 14 to 16 year olds, although it can be taken by students of other ages. It is tried, tested and trusted.

Students can choose from 70 subjects in any combination – it is taught by over 4700 schools in 150 countries.

**Cambridge IGCSE 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 in Cambridge IGCSE Chemistry encourages learners to be:

![Cambridge learner](image-url)

‘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
International recognition and acceptance

Our expertise in curriculum, teaching and learning, and assessment is the basis for the recognition of our programmes and qualifications around the world. The combination of knowledge and skills in Cambridge IGCSE Chemistry gives learners a solid foundation for further study. Candidates who achieve grades A* to C 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 or equivalent to meet their entry requirements.

UK NARIC, the national agency in the UK for the recognition and comparison of international qualifications and skills, has carried out an independent benchmarking study of Cambridge IGCSE and found it to be comparable to the standard of GCSE in the UK. This means students can be confident that their Cambridge IGCSE qualifications are accepted as equivalent to UK GCSEs by leading universities worldwide.

Learn more at www.cambridgeinternational.org/recognition

Cambridge Assessment International Education is an education organisation and politically neutral. The content of this syllabus, examination papers and associated materials do not endorse any political view. We endeavour to treat all aspects of the exam process neutrally.

‘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.’

Managing Director of British School in Egypt BSE
Supporting teachers

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

Teaching resources
- School Support Hub
  www.cambridgeinternational.org/support
- Syllabuses
- Schemes of work
- Learner guides
- Discussion forums
- Endorsed resources

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
- Introductory – face-to-face or online
- Extension – face-to-face or online
- Enrichment – face-to-face or online
- Coursework – online
- Cambridge Professional Development Qualifications
Find out more at
www.cambridgeinternational.org/profdev

Community
You can find useful information, as well as share your ideas and experiences with other teachers, on our social media channels and community forums.
Find out more at
www.cambridgeinternational.org/social-media
2 Syllabus overview

Aims

The aims describe the purposes of a course based on this syllabus.

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
• 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
• allow learners to recognise that science is evidence-based and understand the usefulness, and the limitations, of scientific method
• 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
• develop attitudes relevant to chemistry such as:
  – concern for accuracy and precision
  – objectivity
  – integrity
  – enquiry
  – initiative
  – inventiveness
• 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 overview

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

Support for Cambridge IGCSE Chemistry

The School Support Hub is our secure online site for Cambridge teachers where you can find the resources you need to deliver our programmes, including schemes of work, past papers, mark schemes and examiner reports. You can also keep up to date with your subject and the global Cambridge community through our online discussion forums.

www.cambridgeinternational.org/support
Assessment overview

All candidates take three papers.

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

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

<table>
<thead>
<tr>
<th>Core candidates take:</th>
<th>Extended candidates take:</th>
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<tbody>
<tr>
<td><strong>Paper 1</strong></td>
<td><strong>Paper 2</strong></td>
</tr>
<tr>
<td>45 minutes</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Multiple Choice (Core) 30%</td>
<td>Multiple Choice (Extended) 30%</td>
</tr>
<tr>
<td>40 marks</td>
<td>40 marks</td>
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<tr>
<td>40 four-option multiple-choice questions</td>
<td>40 four-option multiple-choice questions</td>
</tr>
<tr>
<td>Questions will be based on the Core subject content</td>
<td>Questions will be based on the Extended subject content (Core and Supplement)</td>
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<tr>
<td>Externally assessed</td>
<td>Externally assessed</td>
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<th>and Core candidates take:</th>
<th>and Extended candidates take:</th>
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<tr>
<td><strong>Paper 3</strong></td>
<td><strong>Paper 4</strong></td>
</tr>
<tr>
<td>1 hour 15 minutes</td>
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<tr>
<td>Theory (Core) 50%</td>
<td>Theory (Extended) 50%</td>
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<tr>
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<td>Short-answer and structured questions</td>
<td>Short-answer and structured questions</td>
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<tr>
<td>Questions will be based on the Core subject content</td>
<td>Questions will be based on the Extended subject content (Core and Supplement)</td>
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<tr>
<td>Externally assessed</td>
<td>Externally assessed</td>
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<table>
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<tr>
<th>All candidates take either:</th>
<th>or:</th>
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<tbody>
<tr>
<td><strong>Paper 5</strong></td>
<td><strong>Paper 6</strong></td>
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<tr>
<td>1 hour 15 minutes</td>
<td>1 hour</td>
</tr>
<tr>
<td>Practical Test 20%</td>
<td>Alternative to Practical 20%</td>
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<tr>
<td>40 marks</td>
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</tr>
<tr>
<td>Questions will be based on the experimental skills in Section 4</td>
<td>Questions will be based on the experimental skills in Section 4</td>
</tr>
<tr>
<td>Externally assessed</td>
<td>Externally assessed</td>
</tr>
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</table>

Information on availability is in the Before you start section.
Assessment objectives

The assessment objectives (AOs) are:

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

<table>
<thead>
<tr>
<th>Assessment objective</th>
<th>Weighting in IGCSE %</th>
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<tbody>
<tr>
<td>AO1 Knowledge with understanding</td>
<td>50</td>
</tr>
<tr>
<td>AO2 Handling information and problem-solving</td>
<td>30</td>
</tr>
<tr>
<td>AO3 Experimental skills and investigations</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
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Assessment objectives as a percentage of each component

<table>
<thead>
<tr>
<th>Assessment objective</th>
<th>Weighting in components %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Papers 1 and 2</td>
</tr>
<tr>
<td>AO1 Knowledge with understanding</td>
<td>63</td>
</tr>
<tr>
<td>AO2 Handling information and problem-solving</td>
<td>37</td>
</tr>
<tr>
<td>AO3 Experimental skills and investigations</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>
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 C. Candidates aiming for grades A* to C 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

- 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
- 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 diffusion

Supplement

- Explain changes of state in terms of the kinetic theory
- Describe and explain Brownian motion in terms of random molecular bombardment
- State evidence for Brownian motion
- 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 $\text{H}_2$, $\text{Cl}_2$, $\text{H}_2\text{O}$, $\text{CH}_4$, $\text{NH}_3$ and $\text{HCl}$ 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 $\text{N}_2$, $\text{C}_2\text{H}_4$, $\text{CH}_3\text{OH}$ and $\text{CO}_2$
- 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 $^{12}\text{C}$ atom has a mass of exactly 12 units
- Define relative molecular mass, $M_r$, as the sum of the relative atomic masses. ($\text{Relative formula mass or } M_r$ 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 KMnO₄ 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))
### The Periodic Table

#### The Periodic Table

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

#### 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

#### 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

#### 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**
- 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
- Discuss the advantages and disadvantages of recycling metals, limited to iron/steel and aluminium

**Supplement**
- Describe in outline, the extraction of zinc from zinc blende
- 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**
- 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)
- Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)

**Supplement**
- Explain the uses of zinc for galvanising and for making brass
- 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**
- 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

**Supplement**
- 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 desulphurisation
- 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:

```
\[\text{C} = \text{O} - \text{N} = \text{C} = \text{O} - \text{N} = \text{C} = \text{O}\]
```

and the structure of Terylene as:

```
\[\text{C} = \text{O} - \text{O} - \text{C} = \text{O} - \text{O} - \text{O} - \text{C} = \text{O}\]
```

(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:

\[
\begin{align*}
\text{H} & \text{N} \quad \text{C} \quad \text{O} \\
\text{N} & \text{C} \quad \text{O} \quad \text{N} \\
\text{H} & \text{C} \quad \text{O}
\end{align*}
\]

- 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 Ho—OH, joined together by condensation polymerisation, e.g.

\[
\begin{align*}
\text{O} & \text{O} \quad \text{O} \\
\text{O} & \text{O} \quad \text{O}
\end{align*}
\]

- 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

All candidates take three papers.

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

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

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-option 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-option 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**

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 full grade range. 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, cooperation, 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 1 s (where clocks are specified, candidates may use their own wrist-watch if they prefer)
• wash bottle
• test-tubes (Pyrex or hard glass), approximately 125 mm × 16 mm
• boiling tubes, approximately 150 mm × 25 mm
• stirring rod
### Notes for use in qualitative analysis

#### Tests for anions

<table>
<thead>
<tr>
<th>anion</th>
<th>test</th>
<th>test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbonate (CO₃²⁻)</td>
<td>add dilute acid</td>
<td>effervescence, carbon dioxide produced</td>
</tr>
<tr>
<td>chloride (Cl⁻)</td>
<td>acidify with dilute nitric acid, then add aqueous silver nitrate</td>
<td>white ppt.</td>
</tr>
<tr>
<td>bromide (Br⁻)</td>
<td>acidify with dilute nitric acid, then add aqueous silver nitrate</td>
<td>cream ppt.</td>
</tr>
<tr>
<td>iodide (I⁻)</td>
<td>acidify with dilute nitric acid, then add aqueous silver nitrate</td>
<td>yellow ppt.</td>
</tr>
<tr>
<td>nitrate (NO₃⁻)</td>
<td>add aqueous sodium hydroxide, then aluminium foil; warm carefully</td>
<td>ammonia produced</td>
</tr>
<tr>
<td>sulfate (SO₄²⁻)</td>
<td>acidify, then add aqueous barium nitrate</td>
<td>white ppt.</td>
</tr>
<tr>
<td>sulfite (SO₃²⁻)</td>
<td>add dilute hydrochloric acid, warm gently and test for the presence of sulfur dioxide</td>
<td>sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless</td>
</tr>
</tbody>
</table>
Tests for aqueous cations

<table>
<thead>
<tr>
<th>Cation</th>
<th>Effect of aqueous sodium hydroxide</th>
<th>Effect of aqueous ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium (Al(^{3+}))</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
<td>White ppt., insoluble in excess</td>
</tr>
<tr>
<td>Ammonium (NH(_4^+))</td>
<td>Ammonia produced on warming</td>
<td>–</td>
</tr>
<tr>
<td>Calcium (Ca(^{2+}))</td>
<td>White ppt., insoluble in excess</td>
<td>No ppt. or very slight white ppt.</td>
</tr>
<tr>
<td>Chromium(III) (Cr(^{3+}))</td>
<td>Green ppt., soluble in excess</td>
<td>Grey-green ppt., insoluble in excess</td>
</tr>
<tr>
<td>Copper(II) (Cu(^{2+}))</td>
<td>Light blue ppt., insoluble in excess</td>
<td>Light blue ppt., soluble in excess, giving a dark blue solution</td>
</tr>
<tr>
<td>Iron(II) (Fe(^{2+}))</td>
<td>Green ppt., insoluble in excess</td>
<td>Green ppt., insoluble in excess</td>
</tr>
<tr>
<td>Iron(III) (Fe(^{3+}))</td>
<td>Red-brown ppt., insoluble in excess</td>
<td>Red-brown ppt., insoluble in excess</td>
</tr>
<tr>
<td>Zinc (Zn(^{2+}))</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
</tr>
</tbody>
</table>

Tests for gases

<table>
<thead>
<tr>
<th>Gas</th>
<th>Test and test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (NH(_3))</td>
<td>Turns damp red litmus paper blue</td>
</tr>
<tr>
<td>Carbon dioxide (CO(_2))</td>
<td>Turns limewater milky</td>
</tr>
<tr>
<td>Chlorine (Cl(_2))</td>
<td>Bleaches damp litmus paper</td>
</tr>
<tr>
<td>Hydrogen (H(_2))</td>
<td>'Pops' with a lighted splint</td>
</tr>
<tr>
<td>Oxygen (O(_2))</td>
<td>Relights a glowing splint</td>
</tr>
<tr>
<td>Sulfur dioxide (SO(_2))</td>
<td>Turns acidified aqueous potassium manganate(VII) from purple to colourless</td>
</tr>
</tbody>
</table>

Flame tests for metal ions

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>Flame colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium (Li(^{+}))</td>
<td>Red</td>
</tr>
<tr>
<td>Sodium (Na(^{+}))</td>
<td>Yellow</td>
</tr>
<tr>
<td>Potassium (K(^{+}))</td>
<td>Lilac</td>
</tr>
<tr>
<td>Copper(II) (Cu(^{2+}))</td>
<td>Blue-green</td>
</tr>
</tbody>
</table>
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, free-hand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.
The Periodic Table

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>H</td>
<td>He</td>
</tr>
<tr>
<td>II</td>
<td>Li</td>
<td>Be</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>Mg</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>Ca</td>
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<tr>
<td></td>
<td>Rb</td>
<td>Sr</td>
</tr>
<tr>
<td></td>
<td>Cs</td>
<td>Ba</td>
</tr>
<tr>
<td></td>
<td>Fr</td>
<td>Ra</td>
</tr>
<tr>
<td>lanthanoids</td>
<td>La</td>
<td>Ce</td>
</tr>
<tr>
<td></td>
<td>Pr</td>
<td>Nd</td>
</tr>
<tr>
<td></td>
<td>Sm</td>
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<td></td>
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</tr>
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<td>Ho</td>
<td>Er</td>
</tr>
<tr>
<td></td>
<td>Lu</td>
<td></td>
</tr>
<tr>
<td>actinoids</td>
<td>Ac</td>
<td>Th</td>
</tr>
<tr>
<td></td>
<td>Pa</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Np</td>
<td>Pu</td>
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<tr>
<td></td>
<td>Es</td>
<td>Fm</td>
</tr>
<tr>
<td></td>
<td>Md</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Lr</td>
<td></td>
</tr>
</tbody>
</table>

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.
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

A brief guide may be found at
www.hse.gov.uk/pubns/indg136.pdf

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 (×) 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 should be 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/dm³**

To avoid any confusion concerning the symbol for litre, dm³ 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.
6 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.cambridgeinternational.org/eoguide

Before you start

Previous study
We recommend that learners starting this course should have studied a chemistry curriculum such as the Cambridge Lower Secondary programme or equivalent national educational framework.

Guided learning hours
We design Cambridge IGCSE syllabuses based on learners having about 130 guided learning hours for each subject during the course but this is for guidance only. The number of hours a learner needs to achieve the qualification may vary according to local practice and their previous experience of the subject.

Availability and timetables
All Cambridge schools are allocated to one of six administrative zones. Each zone has a specific timetable.

You can view the timetable for your administrative zone at www.cambridgeinternational.org/timetables

You can enter candidates in the June and November exam series. If your school is in India, you can also enter your candidates in the March exam series.

Check you are using the syllabus for the year the candidate is taking the exam.

Private candidates can enter for this syllabus.
Combining with other syllabuses

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

- Cambridge IGCSE (9–1) Chemistry (0971)
- Cambridge IGCSE Physical Science (0652)
- Cambridge IGCSE Combined Science (0653)
- Cambridge IGCSE Co-ordinated Sciences (Double Award) (0654)
- Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973)
- Cambridge O Level Combined Science (5129)
- syllabuses with the same title at the same level.

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

Group awards: Cambridge ICE

Cambridge ICE (International Certificate of Education) is a group award for Cambridge IGCSE. It allows schools to offer a broad and balanced curriculum by recognising the achievements of learners who pass examinations in a range of different subjects.

Learn more about Cambridge ICE at www.cambridgeinternational.org/cambridgeice

Making entries

Exams officers are responsible for submitting entries to Cambridge International. 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.

Exam administration

To keep our exams secure, we produce question papers for different areas of the world, known as administrative zones. We allocate all Cambridge schools to one administrative zone determined by their location. Each zone has a specific timetable. Some of our syllabuses offer candidates different assessment options. An entry option code is used to identify the components the candidate will take relevant to the administrative zone and the available assessment options.

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.cambridgeinternational.org/eoguide
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 at www.cambridgeinternational.org/eoguide

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

After the exam
Grading and reporting
Grades A*, A, B, C, D, E, F or G indicate the standard a candidate achieved at Cambridge IGCSE.

A* is the highest and G is the lowest. ‘Ungraded’ means that the candidate's performance did not meet the standard required for grade G. ‘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 (pending)
- X (no result)
- Y (to be issued).

These letters do not appear on the certificate.
How students and teachers can use the grades

Assessment at Cambridge IGCSE has two purposes:

- to measure learning and achievement
  The assessment:
  - confirms achievement and performance in relation to the knowledge, understanding and skills specified in the syllabus, to the levels described in the grade descriptions.
- to show likely future success
  The outcomes:
  - help predict which students are well prepared for a particular course or career and/or which students are more likely to be successful
  - help students choose the most suitable course or career.

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.

Grade descriptions for Cambridge IGCSE Chemistry will be published after the first assessment of the syllabus in 2020. Find more information at www.cambridgeinternational.org/igcse
Changes to this syllabus for 2022

The syllabus has been updated. This is version 1, published September 2019.

There are no significant changes which affect teaching.

You are strongly advised to read the whole syllabus before planning your teaching programme.

Any textbooks endorsed to support the syllabus for examination from 2016 are still suitable for use with this syllabus.
’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