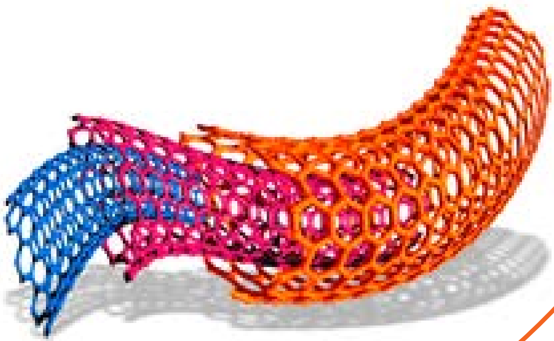
Cambridge Assessment International Education

Syllabus

Cambridge IGCSE™ Physical Science 0652

Use this syllabus for exams in 2022.
Exams are available in the November series.



Version 1
Please check the syllabus page at **www.cambridgeinternational.org/igcse** to see if this syllabus is available in your administrative zone.

Cambridge Pathway

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**

Contents

Changes to this syllabus

For information about changes to this syllabus for 2022, go to page 57.

The latest syllabus is version 1, published September 2019.

Any textbooks endorsed to support the syllabus for examination from 2019 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.

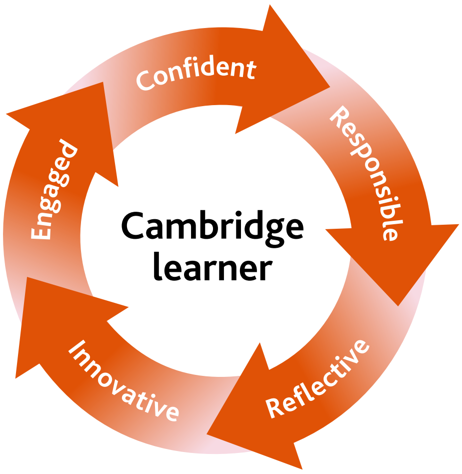
Students can choose from 70 subjects in any combination – it is taught by over 4700 schools in 150 countries.

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.

Cambridge IGCSE Physical Science 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 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

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 Physical Science 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 science subjects.

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.

Support 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 science
  - 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 science 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.

Support for Cambridge IGCSE Physical Science

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

Content overview

The subject content is divided into two sections: Chemistry (C1–C12) and Physics (P1–P5).
Candidates must study both sections.

Chemistry

C1 The particulate nature of matter
C2 Experimental techniques
C3 Atoms, elements and compounds
C4 Stoichiometry
C5 Electricity and chemistry
C6 Energy changes in chemical reactions
C7 Acids, bases and salts
C8 The Periodic Table
C9 Metals
C10 Air and water
C11 Carbonates
C12 Organic chemistry

Physics

P1 General physics
P2 Thermal physics
P3 Properties of waves, including light and sound
P4 Electricity and magnetism
P5 Atomic physics

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.

Core candidates take:	Extended candidates take:
Paper 1 45 minutes Multiple Choice (Core) 30% 40 marks 40 four-option multiple-choice questions Questions will be based on the Core subject content. Externally assessed	**Paper 2** 45 minutes Multiple Choice (Extended) 30% 40 marks 40 four-option multiple-choice questions Questions will be based on the Extended subject content (Core and Supplement). Externally assessed

and Core candidates take:	and Extended candidates take:
Paper 3 1 hour 15 minutes Theory (Core) 50% 80 marks Short-answer and structured questions Questions will be based on the Core subject content. Externally assessed	**Paper 4** 1 hour 15 minutes Theory (Extended) 50% 80 marks Short-answer and structured questions Questions will be based on the Extended subject content (Core and Supplement). Externally assessed

All candidates take either:	or:
Paper 5 1 hour 15 minutes Practical Test 20% 40 marks Questions will be based on the experimental skills in section 4. Externally assessed	**Paper 6** 1 hour Alternative to Practical 20% 40 marks Questions will be based on the experimental skills in section 4. Externally assessed

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 assessment 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
Total	100

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
Total	100	100	100

3 Subject content

The subject content that follows is divided into two sections: Chemistry (C1–C12) and Physics (P1–P5). **Candidates must study both sections**.

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.

Chemistry

C1 The particulate nature of matter

C1.1 The particulate nature of matter

Core	Supplement
1 State the distinguishing properties of solids, liquids and gases	
2 Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion	
	3 Explain changes of state in terms of the kinetic particle theory and the energy changes involved
4 Describe and explain diffusion in terms of the movement of particles (atoms, molecules or ions)	
	5 Describe and explain dependence of rate of diffusion on molecular mass

C2 Experimental techniques

C2.1 Measurement

Core	Supplement
1 Name and suggest appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders	

0652 Chemistry

C2.2 Criteria of purity

Core

1 Interpret simple chromatograms

3 Recognise that mixtures melt and boil over a range of temperatures

Supplement

2 Interpret simple chromatograms, including the use of R_f values

4 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.)

5 Identify substances and assess their purity from melting point and boiling point information

C2.3 Methods of purification

Core

1 Describe and explain methods of separation and purification by the use of a suitable solvent, filtration, crystallisation, distillation, fractional distillation and paper chromatography

2 Suggest suitable separation and purification techniques, given information about the substances involved

C3 Atoms, elements and compounds

C3.1 Physical and chemical changes

Core

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

C3.2 Elements, compounds and mixtures

Core

1 Describe the differences between elements, mixtures and compounds, and between metals and non-metals

2 Define the terms *solvent*, *solute*, *solution* and *concentration*

0652 Chemistry

C3.3 Atomic structure and the Periodic Table

Core

1 Describe the structure of an atom in terms of a central nucleus, containing protons and neutrons, and 'shells' of electrons

2 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.)

3 State the relative charge and approximate relative mass of a proton, a neutron and an electron

4 Define and use *proton number* (atomic number) as the number of protons in the nucleus of an atom

5 Define and use *nucleon number* (mass number) as the total number of protons and neutrons in the nucleus of an atom

6 Use proton number and the simple structure of atoms to explain the basis of the Periodic Table, with special reference to the elements of proton numbers 1 to 20

7 Define *isotopes* as atoms of the same element which have the same proton number but a different nucleon number

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

Supplement

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

C3.4 Ions and ionic bonds

Core

1 Describe the formation of ions by electron loss or gain

2 Use dot-and-cross diagrams to describe the formation of ionic bonds between Group I and Group VII

Supplement

3 Describe the formation of ionic bonds between metallic and non-metallic elements to include the strong attraction between ions because of their opposite electrical charges

4 Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions, exemplified by the sodium chloride structure

0652 Chemistry

C3.5 Molecules and covalent bonds

Core

1 State that non-metallic elements form simple molecules with covalent bonds between atoms

2 Describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4, NH_3 and HCl as the sharing of pairs of electrons leading to the noble gas configuration including the use of dot-and-cross diagrams

4 Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds

Supplement

3 Use and draw dot-and-cross diagrams to represent the bonding in the more complex covalent molecules such as N_2, C_2H_4, CH_3OH, and CO_2

5 Explain the differences in melting point and boiling point of ionic and covalent compounds in terms of attractive forces

C3.6 Macromolecules

Core

1 State that there are several different forms of carbon, including diamond and graphite

2 Describe the giant covalent structures of diamond and graphite

Supplement

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

0652 Chemistry

C4 Stoichiometry

C4.1 Stoichiometry

Core

1 Use the symbols of the elements and write the formulae of simple compounds

3 Deduce the formula of a simple compound from the relative numbers of atoms present

4 Deduce the formula of a simple compound from a model or a diagrammatic representation

5 Construct and use word equations

6 Interpret and balance simple symbol equations

Supplement

2 Determine the formula of an ionic compound from the charges on the ions present

7 Construct and use symbol equations, with state symbols, including ionic equations

8 Deduce the balanced equation of a chemical reaction, given relevant information

9 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

10 Define *relative molecular mass*, M_r and calculate it as the sum of the relative atomic masses (the term *relative formula mass* or M_r will be used for ionic compounds)

11 Calculate stoichiometric reacting masses, volumes of gases and solutions and solution concentrations expressed in g/dm^3 and mol/dm^3

(Calculations based on 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.)

C5 Electricity and chemistry

C5.1 Electricity and chemistry

Core

1 Define *electrolysis* as the breakdown of an ionic compound when molten or in aqueous solution by the passage of electricity

2 Use the terms *inert electrode*, *electrolyte*, *anode* and *cathode*

4 Describe the electrode products and the observations made, using inert electrodes (platinum or carbon), in the electrolysis of:
- molten lead(II) bromide
- concentrated aqueous sodium chloride
- dilute sulfuric acid

Supplement

3 Describe electrolysis in terms of the ions present and the reactions at the electrodes, in terms of gain of electrons by cations and loss of electrons by anions to form atoms

5 Predict the products of the electrolysis of a specified molten binary compound

0652 Chemistry

C6 Energy changes in chemical reactions

C6.1 Energetics of a reaction

Core

1 Describe the meaning of *exothermic* and *endothermic* reactions

Supplement

2 Describe bond breaking as an endothermic process and bond forming as an exothermic process

3 Draw and label energy level diagrams for exothermic and endothermic reactions using data provided

4 Interpret energy level diagrams showing exothermic and endothermic reactions and the activation energy of a reaction

C6.2 Energy transfer

Core

1 Describe the release of thermal energy by burning fuels

2 State the use of hydrogen as a fuel

C6.3 Rate (speed) of reaction

Core

1 Describe practical methods for investigating the rate of a reaction which produces a gas

2 Interpret data obtained from experiments concerned with rate of reaction

3 Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the rate of reactions

6 Describe how concentration, temperature and surface area create a danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. methane in mines)

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

Supplement

4 Describe and explain the effect of concentration in terms of frequency of collisions between reacting particles

5 Describe and explain the effect of changing temperature in terms of the frequency of collisions between reacting particles and more colliding particles possessing the minimum energy (activation energy) to react

0652 Chemistry

C6.4 Redox

Core	Supplement
1 Describe oxidation and reduction in chemical reactions in terms of oxygen loss / gain (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II).)	2 Define and identify an *oxidising agent* as a substance which oxidises another substance during a redox reaction, and a *reducing agent* as a substance which reduces another substance during a redox reaction

C7 Acids, bases and salts

C7.1 The characteristic properties of acids and bases

Core	Supplement
1 Describe the characteristic properties of acids (exemplified by dilute hydrochloric acid and dilute sulfuric acid) including their effect on litmus paper and their reactions with metals, bases and carbonates	
2 Describe the characteristic properties of bases including their effect on litmus paper and their reactions with acids and ammonium salts	3 Define *acids* and *bases* in terms of proton transfer, limited to aqueous solutions
4 Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using universal indicator	
5 Describe and explain the importance of controlling acidity in soil	

C7.2 Types of oxides

Core	Supplement
1 Classify oxides as either acidic or basic, related to the metallic and non-metallic character	2 Further classify other oxides as neutral or amphoteric

C7.3 Preparation of salts

Core	Supplement
1 Describe the preparation, separation and purification of salts using techniques specified in Section C2 and the reactions specified in Section C7.1	2 Suggest a method of making a given salt from suitable starting material, given appropriate information, including precipitation

0652 Chemistry

C7.4 Identification of ions and gases

Core

1 Describe and use the following tests to identify:

aqueous cations:

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

cations:

flame tests to identify lithium, sodium, potassium and copper(II)

anions:

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

gases:

ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using a lighted splint), oxygen (using a glowing splint)

C8 The Periodic Table

C8.1 The Periodic Table

Core

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

C8.2 Periodic Trends

Core

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

Supplement

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

0652 Chemistry

C8.3 Group properties

Core

1 Describe lithium, sodium and potassium in Group I (the alkali metals) as a collection of relatively soft metals showing a trend in melting point, density and reaction with water

3 Describe the halogens, chlorine, bromine and iodine in Group VII, as a collection of diatomic non-metals showing a trend in colour and physical state

Supplement

2 Predict the properties of other elements in Group I given data, where appropriate

4 State the reaction of chlorine, bromine and iodine with other halide ions

5 Predict the properties of other elements in Group VII, given data where appropriate

6 Identify trends in other groups, given data about the elements concerned

C8.4 Transition elements

Core

1 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

C8.5 Noble gases

Core

1 Describe the noble gases, in Group VIII or 0, as being unreactive, monoatomic gases and explain this in terms of electronic structure

2 State the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons

C9 Metals

C9.1 Properties of metals

Core

1 Describe the general physical properties of metals as solids with high melting and boiling points, malleable and good conductors of heat and electricity

3 Describe alloys, such as brass, as mixtures of a metal with other elements

4 Explain in terms of their properties why alloys are used instead of pure metals

Supplement

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

5 Describe how the properties of iron are changed by the controlled use of additives to form steel alloys, such as mild steel and stainless steel

0652 Chemistry

C9.2 Reactivity series

Core

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

3 Deduce an order of reactivity from a given set of experimental results

Supplement

2 Describe the reactivity series in terms of the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with the aqueous ions of other listed metals

C9.3 Extraction of metals

Core

1 Describe the use of carbon in the extraction of some metals from their ores

2 Know that aluminium is extracted from the ore bauxite by electrolysis

Supplement

3 Describe and explain the essential reactions in the extraction of iron from hematite in the blast furnace

$C + O_2 \rightarrow CO_2$

$C + CO_2 \rightarrow 2CO$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

C9.4 Uses of metals

Core

1 Describe the uses of aluminium:
- in aircraft parts because of its strength and low density
- in food containers because of its resistance to corrosion

3 State the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)

Supplement

2 Describe and explain the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal

4 Explain the uses of zinc for galvanising steel and for making brass

C10 Air and water

C10.1 Water

Core

1 Describe a chemical test for water using copper(II) sulfate and cobalt(II) chloride

3 Describe, in outline, and explain the purification treatment of the water supply in terms of filtration and chlorination

Supplement

2 Describe how hydration can be reversed (e.g. by heating hydrated copper(II) sulfate or hydrated cobalt(II) chloride)

0652 Chemistry

C10.2 Air

Core

1 State the composition of clean air as being a mixture of 78% nitrogen, 21% oxygen and small quantities of noble gases, water vapour and carbon dioxide

2 Name the common pollutants in air as being carbon monoxide, sulfur dioxide and oxides of nitrogen

3 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

6 State the adverse effect of these common air pollutants on buildings and on health

7 State the conditions required for the rusting of iron (presence of oxygen and water)

8 Describe and explain barrier methods of rust prevention, including paint and other coatings

Supplement

4 Describe some approaches to reducing emissions of sulfur dioxide, including the use of low sulfur petrol and flue gas desulfurisation by calcium oxide

5 Describe, in outline, how a catalytic converter removes nitrogen monoxide and carbon monoxide from exhaust emissions by reaction over a hot catalyst

$2CO + O_2 \rightarrow 2CO_2$

$2NO + 2CO \rightarrow N_2 + 2CO_2$

$2NO \rightarrow N_2 + O_2$

9 Describe and explain sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention

C10.3 Carbon dioxide and methane

Core

1 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
- as a product of thermal decomposition of calcium carbonate

2 State that carbon dioxide and methane are greenhouse gases

0652 Chemistry

C11 Carbonates

C11.1 Carbonates

Core

1 Describe the manufacture of lime (calcium oxide) from limestone (calcium carbonate) in terms of the chemical reactions involved, and the use of limestone in treating acidic soil and neutralising acidic industrial waste products

2 Describe the thermal decomposition of calcium carbonate (limestone)

C12 Organic chemistry

C12.1 Names of compounds

Core

1 Name and draw the structures of methane, ethane, ethene and ethanol

2 State the type of compound present, given a chemical name ending in *-ane*, *-ene* and *-ol*, or a molecular structure

C12.2 Fuels

Core

1 State that coal, natural gas and petroleum are fossil fuels that produce carbon dioxide on combustion

2 Name methane as the main constituent of natural gas

3 Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation

5 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 as a feedstock for making chemicals
- diesel oil / gas oil for fuel in diesel engines
- bitumen for road surfaces

Supplement

4 Describe the properties of molecules within a fraction

0652 Chemistry

C12.3 Homologous series

Supplement

1 Describe the homologous series of alkanes and alkenes as families of compounds with the same general formula and similar chemical properties

C12.4 Alkanes

Core

1 Describe alkanes as saturated hydrocarbons whose molecules contain only single covalent bonds

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

3 Describe the complete combustion of hydrocarbons to give carbon dioxide and water

C12.5 Alkenes

Core

1 Describe alkenes as unsaturated hydrocarbons whose molecules contain one double covalent bond

2 State that cracking is a reaction that produces alkenes

4 Recognise saturated and unsaturated hydrocarbons:
- from molecular structures
- by their reaction with aqueous bromine

6 Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units

Supplement

3 Describe the formation of smaller alkanes, alkenes and hydrogen by the cracking of larger alkane molecules and state the conditions required for cracking

5 Describe the properties of alkenes in terms of addition reactions, with bromine, hydrogen and steam, exemplified by ethene

C12.6 Alcohols

Core

1 State that ethanol may be formed by fermentation and by reaction between ethene and steam

3 Describe the complete combustion of ethanol to give carbon dioxide and water

4 State the uses of ethanol as a solvent and as a fuel

Supplement

2 Describe the formation of ethanol by fermentation and the catalytic addition of steam to ethene

Physics

P1 General physics

P1.1 Length and time

Core

1 Use and describe the use of rules and measuring cylinders to find a length or a volume

3 Use and describe the use of clocks and devices, both analogue and digital, for measuring an interval of time

4 Obtain an average value for a small distance and for a short interval of time by measuring multiples (including the period of a pendulum)

Supplement

2 Understand that a micrometer screw gauge is used to measure very small distances

P1.2 Motion

Core

1 Define *speed* and calculate average speed from

$$\frac{\text{total distance}}{\text{total time}}$$

4 Plot and interpret a speed–time graph and a distance–time graph

6 Recognise from the shape of a speed–time graph when a body is:
- at rest
- moving with constant speed
- moving with changing speed

8 Calculate the area under a speed–time graph to work out the distance travelled for motion with constant acceleration

9 Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed–time graph

10 State that the acceleration of free fall *g* for a body near to the Earth is constant

Supplement

2 Distinguish between *speed* and *velocity*

3 Define and calculate acceleration using

$$\frac{\text{change in velocity}}{\text{time taken}}$$

5 Calculate acceleration from the gradient of a speed–time graph

7 Recognise linear motion for which the acceleration is not constant

11 Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance including reference to terminal velocity

0652 Physics

P1.3 Mass and weight

Core	Supplement
1 Show familiarity with the idea of the mass of a body	2 Demonstrate an understanding that mass is a property which 'resists' change in motion
3 State that weight is a gravitational force 4 Distinguish between *mass* and *weight* 5 Demonstrate understanding that weights (and hence masses) may be compared using a balance	6 Describe, and use the concept of, weight as the effect of a gravitational field on a mass
7 Recognise that g is the gravitational force on unit mass and is measured in N / kg 8 Recall and use the equation $W = mg$	

P1.4 Density

Core	Supplement
1 Recall and use the equation $\rho = \frac{m}{V}$ 2 Describe an experiment to determine the density of a liquid and of a regularly-shaped solid and make the necessary calculation	3 Describe the determination of the density of an irregularly-shaped solid by the method of displacement and make the necessary calculation

P1.5 Forces

P1.5.1 Effects of forces

Core	Supplement
1 Recognise that a force may produce a change in the size, shape and motion of a body	2 Plot and interpret extension–load graphs and describe the associated experimental procedure 3 State Hooke's law and recall and use the equation $F = kx$ where k is the spring constant 4 Recognise the significance of the term 'limit of proportionality' for an extension–load graph 5 Recall and use the relationship between resultant force, mass and acceleration, $F = ma$
6 Understand friction as the force between two surfaces which impedes motion and results in heating 7 Recognise air resistance as a form of friction 8 Find the resultant of two or more forces acting along the same line 9 Recognise that if there is no resultant force on a body it either remains at rest or continues at constant speed in a straight line	

continued

0652 Physics

P1.5 Forces continued

P1.5.2 Turning effect

Core

1. Describe the moment of a force as a measure of its turning effect, and give everyday examples
2. Calculate moment using the product force × perpendicular distance from the pivot
4. Recognise that, when there is no resultant force and no resultant turning effect, a system is in equilibrium

Supplement

3. Apply the principle of moments to the balancing of a weightless beam about a pivot

P1.5.3 Centre of mass

Core

1. Perform and describe an experiment to determine the position of the centre of mass of a plane lamina
2. Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects

P1.5.4 Pressure

Core

1. Relate qualitatively pressure to force and area, using appropriate examples

Supplement

2. Recall and use the equation $p = F / A$

P1.6 Work, energy and power

P1.6.1 Work

Core

1. Relate (without calculation) work done to the magnitude of a force and distance moved in the direction of the force

Supplement

2. Recall and use $W = Fd = \Delta E$

continued

0652 Physics

P1.6 Work, energy and power continued

P1.6.2 Energy

Core

1. Demonstrate an understanding that work done = energy transferred
2. Demonstrate understanding that an object may have energy due to its motion (kinetic energy, KE) or its position (potential energy, PE) and that energy may be transferred and stored
3. Give and identify examples of changes in kinetic, gravitational potential, chemical potential, elastic (strain), nuclear and thermal energy that have occurred as a result of an event or process
5. Recognise that energy is transferred during events and processes, including examples of transfer by forces (mechanical working), by electric currents (electrical working), by heating and by waves
6. Apply the principle of conservation of energy to simple examples

Supplement

4. Recall and use the expressions KE = $\frac{1}{2}mv^2$ and gravitational potential energy (GPE) = mgh or change in GPE = $mg\Delta h$

P1.6.3 Power

Core

1. Relate (without calculation) power to work done and time taken, using appropriate examples

Supplement

2. Recall and use the equation $P = \Delta E / t$ in simple systems

continued

0652 Physics

P1.6 Work, energy and power continued

P1.6.4 Energy resources

Core

1. Distinguish between renewable and non-renewable sources of energy
2. Describe how electricity or other useful forms of energy may be obtained from:
   - chemical energy stored in fuel
   - energy from water, including the energy stored in waves, in tides, and in water behind hydroelectric dams
   - geothermal resources
   - nuclear fission
   - heat and light from the Sun (solar cells and panels)
   - wind energy
3. Give advantages and disadvantages of each method in terms of renewability, cost, reliability, scale and environmental impact
4. Show a qualitative understanding of efficiency

Supplement

5. Understand that the Sun is the source of energy for all our energy resources except geothermal, nuclear and tidal
6. Understand that the source of tidal energy is mainly the moon
7. Show an understanding that energy is released by nuclear fusion in the Sun
8. Recall and use the equations:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}} \times 100\%$$

0652 Physics

P2 Thermal physics

P2.1 Thermal properties and temperature

P2.1.1 Thermal expansion of solids, liquids and gases

Core

1. State the distinguishing properties of solids, liquids and gases
2. Describe qualitatively the molecular structure of solids, liquids and gases in terms of the arrangement, separation, and motion of the molecules
3. Describe qualitatively the pressure of a gas and the temperature of a gas, liquid or solid in terms of the motion of its particles
4. Describe qualitatively the thermal expansion of solids, liquids and gases at constant pressure
5. Identify and explain some of the everyday applications and consequences of thermal expansion
6. Know the relative order of the magnitude of the expansion of solids, liquids and gases

P2.1.2 Measurement of temperature

Core

1 Describe how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties

3 Recognise the need for and identify fixed points

4 Describe and explain the structure and action of liquid-in-glass thermometers

Supplement

2 Demonstrate understanding of *sensitivity*, *range* and *linearity*

5 Use and describe the use of thermometers to measure temperature on the Celsius scale

6 Describe the structure of a thermocouple, and show understanding of its use as a thermometer for measuring high temperatures and those which vary rapidly

continued

0652 Physics

P2.1 Thermal properties and temperature continued

P2.1.3 Melting and boiling

Core

1. Describe melting and boiling in terms of energy input without a change in temperature
2. State the meaning of *melting point* and *boiling point*, and recall the melting and boiling points for water

Supplement

3. Distinguish between *boiling* and *evaporation*

P2.2 Thermal processes

P2.2.1 Conduction

Core

1. Recognise and name typical good and bad thermal conductors
2. Describe experiments to demonstrate the properties of good and bad thermal conductors

Supplement

3. Explain conduction in solids in terms of molecular vibrations and transfer by electrons

P2.2.2 Convection

Core

1. Recognise convection as the main method of energy transfer in fluids
3. Interpret and describe experiments designed to illustrate convection in liquids and gases (fluids)

Supplement

2. Relate convection in fluids to density changes

P2.2.3 Radiation

Core

1. Recognise radiation as the method of energy transfer that does not require a medium to travel through
2. Identify infrared radiation as the part of the electromagnetic spectrum often involved in energy transfer by radiation

Supplement

3. Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation
4. Interpret and describe experiments to investigate the properties of good and bad emitters and good and bad absorbers of infrared radiation

continued

0652 Physics

P2.2 Thermal processes continued

P2.2.4 Consequences of energy transfer

Core

1 Identify and explain some of the everyday applications and consequences of conduction, convection and radiation

P3 Properties of waves, including light and sound

P3.1 General wave properties

Core

1 Demonstrate understanding that waves transfer energy without transferring matter

2 Describe what is meant by *wave motion* as illustrated by vibration in ropes, springs and by experiments using water waves

3 Use the term *wavefront*

4 State the meaning of *speed*, *frequency*, *wavelength* and *amplitude*

6 Describe how waves can undergo:
- reflection at a plane surface
- refraction due to a change of speed

7 Describe the use of water waves to demonstrate reflection and refraction

Supplement

5 Distinguish between *transverse* and *longitudinal* waves and give suitable examples

8 Recall and use the equation $v = f\lambda$

9 Understand that refraction is caused by a change in speed as a wave moves from one medium to another

10 Describe how waves can undergo diffraction through a narrow gap

11 Describe the use of water waves to demonstrate diffraction

0652 Physics

P3.2 Light

P3.2.1 Reflection of light

Core

1. Describe the formation of an optical image by a plane mirror and give its characteristics
2. Recall and use the law
   angle of incidence i = angle of reflection r
   recognising these angles are measured to the normal
3. Give the meaning of *critical angle*
4. Describe internal and total internal reflection
5. Perform simple constructions, measurements and calculations for reflection by plane mirrors

Supplement

6. Recall that the image in a plane mirror is virtual
7. Describe and explain the action of optical fibres particularly in medicine and communications technology

P3.2.2 Refraction of light

Core

1. Interpret and describe an experimental demonstration of the refraction of light
3. Use the terminology for the angle of incidence i and angle of refraction r and describe the passage of light through parallel-sided transparent material

Supplement

2. Recall and use the definition of refractive index n in terms of speed
4. Recall and use the equation for refractive index

$$n = \frac{\sin i}{\sin r}$$

P3.2.3 Thin converging lens

Core

1. Describe the action of a thin converging lens on a beam of light
2. Use the terms *principal focus* and *focal length*
3. Draw ray diagrams for the formation of a real image by a single lens
6. Describe the nature of an image using the terms enlarged / same size / diminished and upright / inverted

Supplement

4. Show understanding of the terms *real image* and *virtual image*
5. Draw and use ray diagrams for the formation of a virtual image by a single converging lens
7. Use and describe the use of a single lens as a magnifying glass

continued

0652 Physics

P3.2 Light continued

P3.2.4 Electromagnetic spectrum

Core

1 Describe the main features of the electromagnetic spectrum in order of frequency, from radio waves to gamma radiation (γ)

2 State that all electromagnetic waves travel with the same high speed in a vacuum

4 Describe typical properties and uses of radiations in all the different regions of the electromagnetic spectrum including:
- radio and television communications (radio waves)
- satellite television and telephones (microwaves)
- electrical appliances, remote controllers for televisions and intruder alarms (infrared)
- medicine and security (X-rays)

Supplement

3 State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m / s and is approximately the same in air

P3.3 Sound

Core

1 Describe how vibrating objects produce sound waves, and how sound waves can cause objects to vibrate, including the eardrum

4 State that the approximate range of audible frequencies for a healthy human ear is 20 Hz to 20 000 Hz

5 Show an understanding that a medium is needed to transmit sound waves

Supplement

2 Describe the longitudinal nature of sound waves

3 Describe the transmission of sound waves in air in terms of compressions and rarefactions

0652 Physics

P4 Electricity and magnetism

P4.1 Simple phenomena of magnetism

Core	Supplement
1 Describe the forces between magnets, and between magnets and magnetic materials	2 Give an account of induced magnetism
3 Distinguish between magnetic and non-magnetic materials	
4 Draw and describe the pattern and direction of magnetic field lines around a bar magnet	
5 Distinguish between the magnetic properties of soft iron and steel	
6 Recognise that an electric current has an associated magnetic field	
7 Distinguish between the design and use of permanent magnets and electromagnets	
8 Describe methods of magnetisation to include stroking with a magnet, use of d.c. in a coil and hammering in a magnetic field	9 Describe methods of demagnetisation, to include hammering, heating and use of alternating current (a.c.) in a coil

P4.2 Electrical quantities

P4.2.1 Electric charge

Core	Supplement
1 State that there are positive and negative charges	
2 State that unlike charges attract and that like charges repel	
3 Describe and interpret simple experiments to show the production and detection of electrostatic charges by friction	
4 State that charging a body involves the addition or removal of electrons	5 Describe an electric field as a region in which an electric charge experiences a force
6 Distinguish between electrical conductors and insulators and give typical examples	

P4.2.2 Current

Core	Supplement
1 State that current is related to the flow of charge	2 Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q / t$
	3 Distinguish between the direction of flow of electrons and conventional current
4 Use and describe the use of an ammeter, both analogue and digital	
5 State that current in metals is due to a flow of electrons	

continued

0652 Physics

P4.2 Electrical quantities continued

P4.2.3 Electromotive force (e.m.f.) and potential difference (p.d.)

Core

1 State that the potential difference (p.d.) across a circuit component is measured in volts

3 Use and describe the use of a voltmeter, both analogue and digital

4 State that the electromotive force (e.m.f.) of an electrical source of energy is measured in volts

Supplement

2 Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge around a complete circuit

5 Recall that 1 V is equivalent to 1 J / C

P4.2.4 Resistance

Core

1 State that resistance = p.d. / current and understand qualitatively how changes in p.d. or resistance affect current

2 Recall and use the equation $R = V / I$

3 Describe an experiment to determine resistance using a voltmeter and an ammeter

4 Relate (without calculation) the resistance of a wire to its length and to its diameter

5 Demonstrate understanding of *current*, *potential difference*, *e.m.f.* and *resistance*

Supplement

6 Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire

P4.3 Electric circuits

P4.3.1 Circuit diagrams

Core

1 Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters and fuses

(Symbols for other common circuit components will be provided in questions.)

continued

0652 Physics

P4.3 Electric circuits continued

P4.3.2 Series and parallel circuits

Core

1 Understand that the current at every point in a series circuit is the same

2 Calculate the combined resistance of two or more resistors in series

4 State that, for a parallel circuit, the current from the source is larger than the current in each branch

6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself

8 State the advantages of connecting components in parallel in a circuit

Supplement

3 Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply

5 Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit

7 Calculate the combined resistance of two resistors in parallel

9 Draw and interpret circuit diagrams containing NTC thermistors and light-dependent resistors (LDRs)

10 Describe the action of NTC thermistors and LDRs and show understanding of their use as input transducers

P4.4 Electrical energy

Supplement

1 Recall and use the equations $P = IV$ and $E = IVt$

P4.5 Dangers of electricity

Core

1 State the hazards of:
- damaged insulation
- overheating of cables
- damp conditions

2 State that a fuse protects a circuit

3 Explain the use of fuses and circuit breakers and choose appropriate fuse ratings and circuit-breaker ratings

4 Explain the benefits of earthing metal cases

0652 Physics

P4.6 Electromagnetic effects

P4.6.1 Electromagnetic induction

Supplement

1 Show understanding that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an electromotive force (e.m.f.) in the conductor
2 Describe an experiment to demonstrate electromagnetic induction
3 State the factors affecting the magnitude of an induced e.m.f.
4 Show understanding that the direction of an induced e.m.f. opposes the change causing it

P4.6.2 a.c. generator

Supplement

1 Distinguish between direct current (d.c) and alternating current (a.c)
2 Describe and explain the operation of a rotating-coil generator and the use of slip rings
3 Sketch a graph of voltage output against time for a simple a.c. generator

P4.6.3 Transformers

Supplement

1 Describe the construction of a basic transformer with a soft-iron core, as used for voltage transformations
2 Describe the principle of operation of a transformer
3 Use the terms step-up and step-down
4 Recall and use the equation $(V_p / V_s) = (N_p / N_s)$ (for 100% efficiency)
5 Recall and use the equation $I_p V_p = I_s V_s$ (for 100% efficiency)
6 Describe the use of the transformer in high-voltage transmission of electricity
7 Explain why power losses in cables are lower when the voltage is high

continued

0652 Physics

P4.6 Electromagnetic effects continued

P4.6.4 Force on a current-carrying conductor

Core

1 Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing:
- the current
- the direction of the field

P4.6.5 d.c.motor

Core

1 State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by:
- increasing the number of turns on the coil
- increasing the current
- increasing the strength of the magnetic field

Supplement

2 Relate this turning effect to the action of an electric motor including the action of a split-ring commutator

P5 Atomic physics

P5.1 The nuclear atom

Core

1 Describe the composition of the nucleus in terms of protons and neutrons

2 Use the terms *proton number Z* and *nucleon number A*

3 Use and interpret the term *nuclide* and use the nuclide notation $^{A}_{Z}X$

4 Use and explain the term *isotope*

P5.2 Radioactivity

P5.2.1 Detection of radioactivity

Core

1 Demonstrate understanding of background radiation

2 Describe the detection of α-particles, β - particles and γ-rays (β^+ are not included, β - particles will be taken to refer to β^-)

continued

0652 Physics

P5.2 Radioactivity continued

P5.2.2 Characteristics of the three kinds of emission

Core

1. Describe the random nature of radioactive emission
2. Identify alpha-, beta- and gamma- (α-, β- and γ-emissions) by recalling:
   - their nature
   - their relative ionising effects
   - their relative penetrating abilities

Supplement

3. Describe deflection of α-, β- and γ-emissions in electric fields and in magnetic fields
4. Give and explain examples of practical applications of α-, β- and γ-emissions

P5.2.3 Radioactive decay

Core

1. State the meaning of *radioactive decay*
2. Use word equations to represent changes in the composition of the nucleus when particles are emitted

Supplement

3. Use nuclide notation in equations to show the effect on the nucleus of α- and β-decay

P5.2.4 Half-life

Core

1. Show an understanding of the term *half-life* and use the term in context
2. Use the term half-life in simple calculations which may involve information in tables or decay curves

Supplement

3. Calculate half-life from data or decay curves, including curves from which background radiation has not been subtracted

P5.2.5 Safety precautions

Core

1. Recall the effects of ionising radiations on living things
2. Describe how radioactive materials are handled, used and stored in a safe way

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.

These papers are based on testing experimental skills. One question on each paper assesses the skill of planning. This question will be based on any one of the sciences, which could be: Chemistry or Physics.

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 subject content.

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

Candidates may be required to do the following:

- carefully follow a sequence of instructions
- describe, explain or comment on experimental arrangements and techniques
- select the most appropriate apparatus or method for a task and justify the choice made
- draw, complete or label diagrams of apparatus
- perform simple arithmetical calculations
- take readings from an appropriate measuring device or from an image of the device (e.g. thermometer, rule, protractor, measuring cylinder, ammeter, stop-watch), including:
  - reading analogue and digital scales with accuracy and appropriate precision
  - interpolating between scale divisions when appropriate
  - correcting for zero errors when appropriate
- plan to take a sufficient number and range of measurements, repeating where appropriate to obtain an average value
- describe or explain precautions taken in carrying out a procedure to ensure safety or the accuracy of observations and data, including the control of variables and repetition of measurements
- identify key variables and describe how, or explain why, certain variables should be controlled

- record observations systematically, for example in a table, using appropriate units and to a consistent and appropriate degree of precision
- process data, using a calculator where necessary
- present and analyse data graphically, including the use of best-fit lines where appropriate, interpolation and extrapolation, and the determination of a gradient, intercept or intersection
- interpret and evaluate observations and experimental data
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- comment critically on a procedure or point of practical detail, and suggest an appropriate improvement
- evaluate the quality of data, identifying and dealing appropriately with any anomalous results
- identify possible causes of uncertainty, in data or in a conclusion
- make estimates or describe outcomes which demonstrate their familiarity with an experiment, procedure or technique
- plan an experiment or investigation, including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

Chemistry

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 and energetics
- problems of an investigatory nature, possibly including suitable organic compounds
- filtration
- electrolysis
- identification of ions and gases
- metals and the reactivity series
- acids, bases, oxides and preparation of salts
- redox reactions and rusting.

Physics

Candidates may be asked questions on the following experimental contexts:

- measurement of physical quantities such as length or volume or force or density
- cooling and heating
- springs and balances
- timing motion or oscillations
- electrical circuits, circuit diagrams and electrical symbols
- optics equipment such as mirrors, prisms and lenses
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate
- use or describe the use of common techniques, apparatus and materials, e.g. ray-tracing equipment or the connection of electric circuits
- explain the manipulation of the apparatus to obtain observations or measurements, e.g.:
  - when determining a derived quantity, such as the extension per unit load for a spring
  - when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length
  - when comparing physical quantities, such as two masses, using a balancing method.

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.

Note on taking readings

When approximate volumes are used, e.g. about 2 cm^3, it is expected that candidates will estimate this and not use measuring devices.

A measuring instrument should be used to its full precision. Thermometers may be marked in 1 °C intervals but it is often appropriate to interpolate between scale divisions and record a temperature to the nearest 0.0 °C or 0.5 °C. Measurements using a rule require suitable accuracy of recording, such as 15.0 cm rather than 15 cm; the use of millimetres when appropriate should be encouraged. Similarly, when measuring current, it is often more appropriate to use milliamperes rather than amperes.

Apparatus list

This list contains the items you are likely to 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 equipment commonly regarded as standard in a science laboratory. The *Confidential Instructions* we send you before the Paper 5 exam will give the detailed requirements for that exam.

- rulers capable of measuring to 1 mm
- metre rule
- means of writing on glassware
- beakers, 100 cm^3, 250 cm^3
- polystyrene or other plastic beakers of approximate capacity 150 cm^3
- test-tubes (Pyrex or hard glass), approximately 125 mm × 16 mm
- boiling tubes, approximately 150 mm × 25 mm
- delivery tubes
- conical flasks, within the range 150 cm^3 to 250 cm^3
- measuring cylinders, 100 cm^3, 50 cm^3, 25 cm^3, 10 cm^3
- dropping pipettes
- white tiles
- large containers (e.g. plastic bowl) to hold cold water
- thermometers, –10 °C to +110 °C with 1 °C graduations
- stop-clocks (or wall-clock or wrist-watch), to measure to an accuracy of 1 s
- glass rods
- spatulas
- wooden splints
- indicators (e.g. litmus paper, universal indicator paper, full range universal indicator)

- common reagents for tests (e.g. limewater test)
- burettes, 50 cm^3
- pipettes, 25 cm^3
- pipette fillers
- filter funnels and filter paper
- wash bottle
- ammeter FSD 1 A, 1.5 A
- voltmeter FSD 1 V, 5 V
- electrical cells (batteries) and holders to enable several cells to be joined
- connecting leads and crocodile clips
- d.c. power supply, variable to 12 V
- low-voltage filament lamps in holders
- various resistors and resistance wire
- switches
- good supply of masses and holders
- 2 cm expendable springs
- clamps and stands
- pendulum bobs
- newton meters
- Plasticine or modelling clay
- wooden boards
- converging lens with $f = 15$ cm
- glass or Perspex block, rectangular and semi-circular
- glass or Perspex prism, triangular
- optics pins
- plane mirrors
- ray box

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.

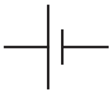
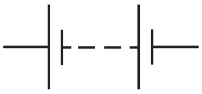
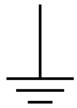
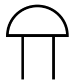
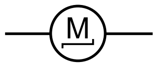
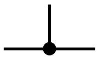
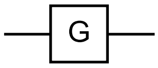
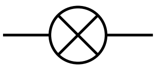
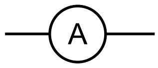
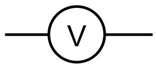
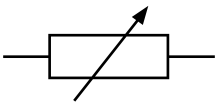
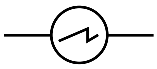
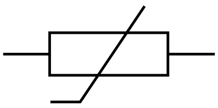
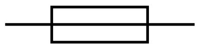
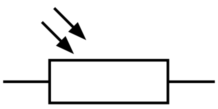
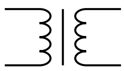
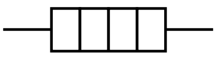
16 *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

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.

5 Appendix

Electrical symbols

cell		switch	
battery of cells	 or 	earth or ground	
power supply		electric bell	
a.c. power supply		motor	
junction of conductors		generator	
lamp		ammeter	
fixed resistor		voltmeter	
variable resistor		oscilloscope	
thermistor		fuse	
light dependent resistor		transformer	
heater			

Symbols and units for physical quantities

Candidates should be able to give the symbols for the following physical quantities and, where indicated, state the units in which they are measured. The list for the Extended syllabus content includes both the Core and the Supplement.

Candidates should be familiar with the following multipliers: M mega, k kilo, c centi, m milli.

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
length	*l*, *h* …	km, m, cm, mm			
area	*A*	m^2, cm^2			
volume	*V*	m^3, cm^3			
weight	*W*	N			
mass	*m*, *M*	kg, g	mass	*m*, *M*	mg
time	*t*	h, min, s	time	*t*	ms
density	ρ	g/cm^3, kg/m^3			
speed	*u*, *v*	km/h, m/s, cm/s			
acceleration	*a*		acceleration	*a*	m/s^2
acceleration of free fall	*g*		acceleration of free fall	*g*	m/s^2
force	*F*	N			
gravitational field strength	*g*	N/kg			
moment of a force		N m			
work done	*W*, *E*	J, kJ, MJ			
energy	*E*	J, kJ, MJ			
power	*P*	W, kW, MW			
pressure	*p*	N/m^2	pressure	*p*	Pa
temperature	θ, *T*	°C			
frequency	*f*	Hz, kHz			
wavelength	λ	m, cm			
focal length	*f*	cm			
angle of incidence	*i*	degree (°)			
angle of reflection, refraction	*r*	degree (°)			
critical angle	*c*	degree (°)			

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
			refractive index	n	
potential difference/voltage	V	V, mV			
current	I	A, mA			
e.m.f.	E	V			
resistance	R	Ω			
			charge	Q	C

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.
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.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt. or very slight white ppt.
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

Flame tests for metal ions

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

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.
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
www.legislation.gov.uk/uksi/2002/2677/contents/made
www.legislation.gov.uk/uksi/2004/3386/contents/made

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
- recall and use equations for the areas of a rectangle, triangle and circle and the volumes of a rectangular block and a cylinder
- use mathematical instruments (ruler, compassess, protracter and set square)
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and diagonal
- solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known
- recognise and use clockwise and anticlockwise directions
- recognise and use points of the compass (N, S, E, W)
- use sines and inverse signs (Extended candidates only).

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.
- 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 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 and physics.

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, $\mathbf{dm^3}$ 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.

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 science 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. This syllabus is **not** available in all administrative zones. To find out about availability check the syllabus page at **www.cambridgeinternational.org/igcse**

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

You can enter candidates in the November 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 Chemistry (0620)
- Cambridge IGCSE (9–1) Chemistry (0971)
- Cambridge IGCSE Physics (0625)
- Cambridge IGCSE (9–1) Physics (0972)
- 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 Physics (5054)
- Cambridge O Level Chemistry (5070)
- 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 Physical Science will be published after the first assessment of the syllabus in 2022. Find more information at **www.cambridgeinternational.org/igcse**

Changes to this syllabus for 2022

We have updated the look and feel of this document. The subject content remains the same.

Minor changes to the wording of some sections have been made to improve clarity.

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

Any textbooks endorsed to support the syllabus for examination from 2019 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

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