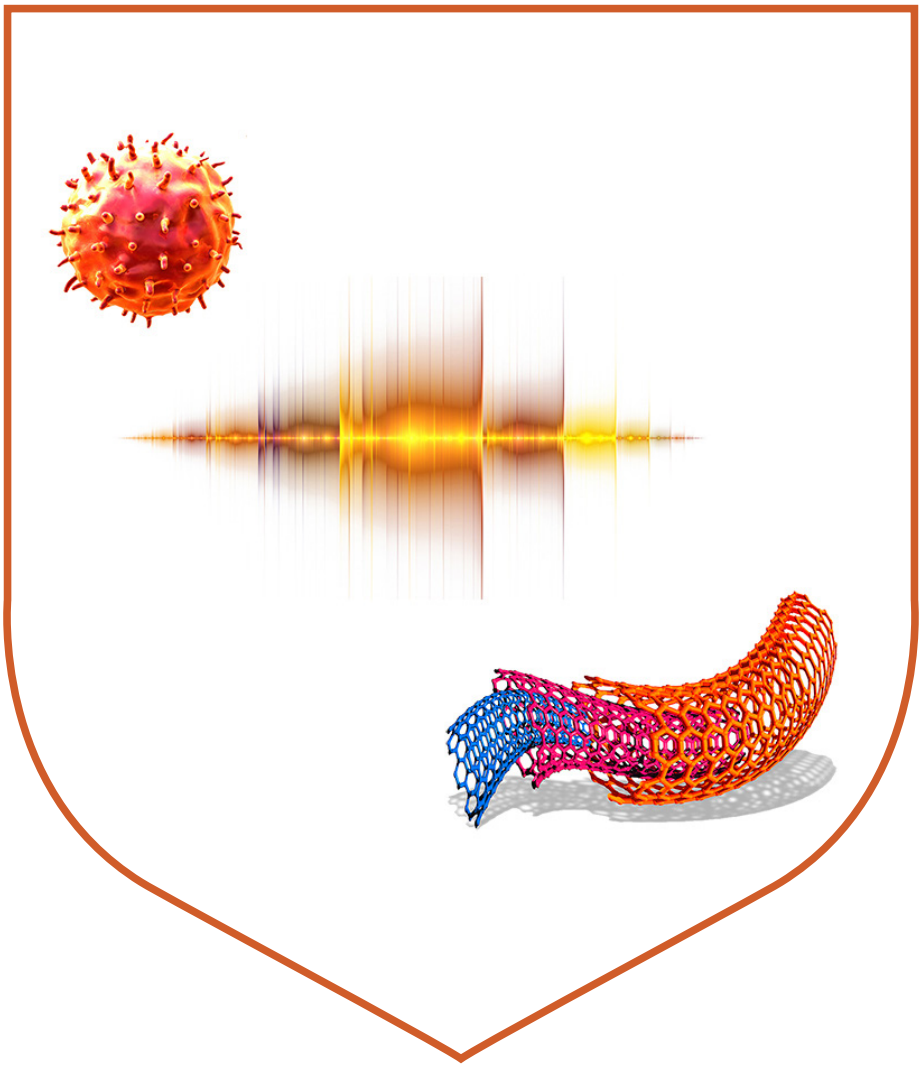
CAMBRIDGE
International Education

Syllabus

Cambridge IGCSE™
Combined Science 0653

Use this syllabus for exams in 2028 and 2029.
Exams are available in the June and November series.
Exams are also available in the March series in India.



Version 0.2

For the purposes of screen readers, any mention in this document of Cambridge IGCSE refers to Cambridge International General Certificate of Secondary Education.

Cambridge Pathway

Why choose Cambridge?

We work with schools worldwide to build an education that shapes knowledge, understanding and skills. Together, we give learners the confidence they need to thrive and make a positive impact in a changing world.

As part of the University of Cambridge, we offer a globally trusted and flexible framework for education from age 3 to 19, informed by research, experience, and listening to educators.

With recognised qualifications, high-quality resources, comprehensive support and valuable insights, we help schools prepare every student for the opportunities and challenges ahead.

Qualifications that are recognised and valued worldwide

From the world's top-ranked universities to local higher education institutions, Cambridge qualifications open doors to a world of opportunities.

Setting a global standard

With over 160 years of experience in delivering fair, valid and reliable assessments to students worldwide, we offer a global, recognised performance standard for international education.

Your path, your way

Schools can adapt our curriculum, high-quality teaching and learning resources and flexible assessments to their local context. Our aligned offer helps Cambridge schools support every learner to reach their potential and thrive.

Learning with lasting impact

Cambridge learners build subject knowledge and conceptual understanding, and develop a broad range of skills, learning habits and attributes to help make them ready for the world.

Improving learning outcomes through data-led insight and action

Our trusted baseline and diagnostic assessments, together with our insights and evaluation service, help schools turn data into knowledge and actionable insights, to inform teaching decisions and improve learner outcomes.

Bringing together a community of experts

We bring together the collective knowledge of experts and our diverse community of educators worldwide, supporting them to learn from one another and share ideas and information.

Tackling the climate crisis together

We believe that education is key to tackling the climate crisis. Together with Cambridge schools, we can empower young people with the skills and knowledge to take action on climate change, helping them be ready for the world.

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

Feedback from: Christoph Guttentag, Dean of Undergraduate Admissions, Duke University, USA

Contents

Important: Changes to this syllabus

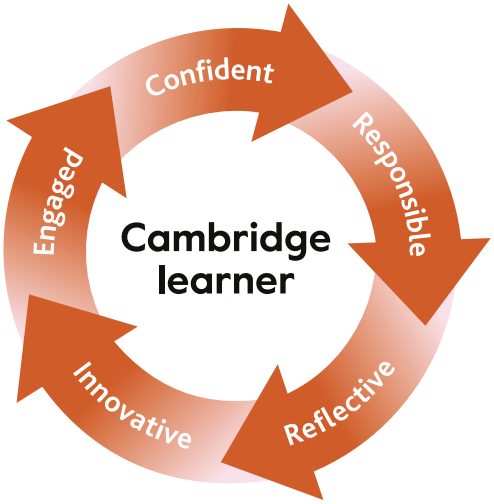
The latest syllabus is version 1, published September 2025. There are no significant changes which affect teaching.

Any textbooks endorsed to support the syllabus for examination from 2025 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 at any age. Taught by over 5000 schools in 150 countries, it is tried, tested and trusted.



Students can choose from 70 subjects in any combination, including 30 languages.

Our programmes promote 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 Combined Science develops a set of transferable skills including handling data, practical problem-solving and applying the scientific method. Learners develop relevant attitudes, such as concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness. They acquire the essential scientific skills required for progression to further studies or employment.

Our approach in Cambridge IGCSE Combined Science encourages learners to be:

confident, interested in learning about science, questioning ideas and using scientific language to communicate their views and opinions

responsible, working methodically and safely when working alone or collaboratively with others

reflective, learning from their experiences and interested in scientific issues that affect the individual, the community and the environment

innovative, solving unfamiliar problems confidently and creatively

engaged, keen to develop scientific skills, curious about scientific principles and their application in the world.

School feedback: '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.'

Feedback from: Gary Tan, Head of Schools and CEO, Raffles Group of Schools, Indonesia

Qualifications that are recognised and valued worldwide

Cambridge qualifications prepare and equip learners with the skills they need to thrive at university and beyond. The world's best higher education institutions recognise our qualifications and value the critical thinking skills, independent research abilities and deep subject knowledge that Cambridge learners bring.

We continually work with universities and colleges in every part of the world to ensure that they understand and accept our qualifications. Cambridge IGCSE provides a springboard to the Cambridge Advanced stage, as well as other post-16 routes. The combination of knowledge and skills in Cambridge IGCSE Combined 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 Cambridge International AS & A Level courses.

Many universities require a combination of Cambridge International AS & A Levels and Cambridge IGCSEs or equivalent to meet their entry requirements.

UK ENIC, 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 the 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**

School feedback: '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.'

Feedback from: Managing Director of British School of Egypt BSE

Supporting teachers

We believe education works best when teaching and learning are closely aligned to the curriculum, resources and assessment. Our high-quality teaching support helps to maximise teaching time and enables teachers to engage learners of all backgrounds and abilities.

We aim to provide the following support for each Cambridge qualification:

- Syllabus
- Specimen question papers and mark schemes
- Specimen paper answers
- Schemes of Work
- Example candidate responses
- Past papers and mark schemes
- Principal examiner reports for teachers

These resources are available on the School Support Hub at **www.cambridgeinternational.org/support**, our secure online site for Cambridge teachers. Your exams officer can provide you with a login.

Additional teaching & learning resources are also available for many syllabuses and vary according to the nature of the subject and the structure of the assessment of each syllabus. These can include ready-built lesson materials, digital resources and multimedia for the classroom and homework, guidance on assessment and much more. Beyond the resources available on the Schools Support Hub, a wide range of endorsed textbooks and associated teaching and learning support are available from Cambridge at **www.cambridge.org/education** and from other publishers. Resources vary according to the nature of the subject and the structure of the assessment of each syllabus.

You can also contact our global Cambridge community or talk to a senior examiner on our discussion forums.

Sign up for email notifications about changes to syllabuses, including new and revised products and services, at **www.cambridgeinternational.org/syllabusupdates**

Professional development

Find the next step on your professional development journey.

- **Introduction courses** – An introduction to Cambridge programmes and qualifications. For teachers who are new to Cambridge programmes or new to a specific syllabus.
- **Focus on Teaching courses** – These are for teachers who want to explore a specific area of teaching and learning within a syllabus or programme.
- **Focus on Assessment courses** – These are for teachers who want to understand the assessment of a syllabus in greater depth.
- **Marking workshops** – These workshops help you become more familiar with what examiners are looking for, and provide an opportunity to raise questions and share your experiences of the syllabus.
- **Enrichment Professional Development** – Transform your approach to teaching with our Enrichment workshops. Each workshop focuses on a specific area of teaching and learning practice.
- **Cambridge Professional Development Qualifications (PDQs)** – Practice-based programmes that transform professional learning for practicing teachers. Available at Certificate and Diploma level.

For more information visit **www.cambridgeinternational.org/support-and-training-for-schools**

Supporting exams officers

We provide comprehensive support and guidance for all Cambridge exams officers.
Find out more at: **www.cambridgeinternational.org/eoguide**

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.

Students following a course based on this syllabus will:

- acquire scientific knowledge and understanding of scientific theories and practice
- develop a range of experimental skills, including handling variables and working safely
- use scientific data and evidence to solve problems and discuss the limitations of scientific methods
- communicate effectively and clearly, using scientific terminology, notation and conventions
- understand that the application of scientific knowledge can benefit people and the environment
- enjoy science and develop an informed interest in scientific matters which support further study.

We are an education organisation and politically neutral. The contents 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.

Content overview

The subject content is divided into three sections: Biology (B1–B16), Chemistry (C1–C12) and Physics (P1–P5).

Candidates must study all three sections.

Biology

B1 Characteristics of living organisms
B2 Cells
B3 Movement into and out of cells
B4 Biological molecules
B5 Enzymes
B6 Plant nutrition
B7 Human nutrition
B8 Transport in plants
B9 Transport in animals
B10 Diseases and immunity
B11 Gas exchange in humans
B12 Respiration
B13 Drugs
B14 Reproduction
B15 Organisms and their environment
B16 Human influences on ecosystems

Chemistry

C1 States of matter
C2 Atoms, elements and compounds
C3 Stoichiometry
C4 Electrochemistry
C5 Chemical energetics
C6 Chemical reactions
C7 Acids, bases and salts
C8 The Periodic Table
C9 Metals
C10 Chemistry of the environment
C11 Organic chemistry
C12 Experimental techniques and chemical analysis

Physics

P1 Motion, forces and energy
P2 Thermal physics
P3 Waves
P4 Electricity
P5 Space physics

Assessment overview

All candidates take three papers.

Candidates who have studied the Core syllabus 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 syllabus 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 Paper 1 and Paper 3. The questions are based on the Core subject content only:

Paper 1: Multiple Choice (Core)	
45 minutes	
40 marks	30%
40 four-option multiple-choice questions	
Externally assessed	

Paper 3: Theory (Core)	
1 hour 15 minutes	
80 marks	50%
Short-answer and structured questions	
Externally assessed	

Extended assessment

Extended candidates take Paper 2 and Paper 4. The questions are based on the Core and Supplement subject content:

Paper 2: Multiple Choice (Extended)	
45 minutes	
40 marks	30%
40 four-option multiple-choice questions	
Externally assessed	

Paper 4: Theory (Extended)	
1 hour 15 minutes	
80 marks	50%
Short-answer and structured questions	
Externally assessed	

Practical assessment

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

Paper 5: Practical Test	
1 hour 15 minutes	
40 marks	20%
Questions will be based on the experimental skills in section 4	
Externally assessed	

OR

Paper 6: Alternative to Practical	
1 hour	
40 marks	20%
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.

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 form conclusions
- present reasoned explanations for phenomena, patterns and relationships
- make predictions based on relationships and patterns
- 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.

AO3 Experimental skills and investigations

Candidates should be able to:

- demonstrate knowledge of how to select and 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

This syllabus gives you the flexibility to design a course that will interest, challenge and engage your learners. Where appropriate you are responsible for selecting resources and examples to support your learners' study. These should be appropriate for the learners' age, cultural background and learning context as well as complying with your school policies and local legal requirements.

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 experimental skills by doing practical work and investigations.

Practical work helps students to:

- use equipment and materials accurately and safely
- develop observational and problem-solving skills
- develop a deeper understanding of the syllabus topics and the scientific approach
- appreciate how scientific theories are developed and tested
- transfer the experimental skills acquired to unfamiliar contexts
- develop positive scientific attitudes such as objectivity, integrity, cooperation, enquiry and inventiveness
- develop an interest and enjoyment in science.

Biology

B1 Characteristics of living organisms

B1.1 Characteristics of living organisms

Core	Supplement
1 Describe the characteristics of living organisms by defining: (a) movement as an action by an organism or part of an organism causing a change of position or place (b) respiration as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism (c) sensitivity as the ability to detect and respond to changes in the internal or external environment (d) growth as a permanent increase in size and dry mass (e) reproduction as the processes that make more of the same kind of organism (f) excretion as the removal of waste products of metabolism and substances in excess of requirements (g) nutrition as the taking in of materials for energy, growth and development	

B2 Cells

B2.1 Cell structure

Core

1 Describe and compare the structure of a plant cell with an animal cell, limited to: cell wall, cell membrane, nucleus, cytoplasm, chloroplasts, ribosomes, mitochondria, vacuoles

2 Describe the structure of a bacterial cell, limited to: cell wall, cell membrane, cytoplasm, ribosomes, circular DNA, plasmids

3 Identify the cell structures listed in 2.1.1 and 2.1.2 in diagrams and images of plant, animal and bacterial cells

4 Describe the functions of the structures listed in 2.1.1 in plant and animal cells

5 Describe the meaning of the terms cell, tissue, organ, organ system and organism as illustrated by examples given in the syllabus

Supplement

6 State that specialised cells have specific functions, limited to:

(a) root hair cells – absorption

(b) palisade mesophyll cells – photosynthesis

(c) red blood cells – transport of oxygen

B2.2 Size of specimens

Core

1 State and use the formula:

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$

2 Calculate magnification and size of biological specimens using millimetres as units

Supplement

3 Convert measurements between millimetres (mm) and micrometres (μm)

B3 Movement into and out of cells

B3.1 Diffusion

Core	Supplement
1 Describe diffusion as the net movement of particles from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement	
2 State that some substances move into and out of cells by diffusion through the cell membrane	
3 Describe the importance of diffusion of gases and solutes in living organisms	4 Investigate the factors that influence diffusion, limited to: surface area, temperature, concentration gradient and distance

B3.2 Osmosis

Core	Supplement
1 State that water diffuses through partially permeable membranes by osmosis	4 Describe osmosis as the net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane
2 State that water moves into and out of cells by osmosis through the cell membrane	
3 Investigate and describe the effects on plant tissues of immersing them in solutions of different concentrations	5 Explain the effects on plant cells of immersing them in solutions of different concentrations by using the terms: turgid, turgor pressure, plasmolysis, flaccid

B3.3 Active transport

Core	Supplement
	1 Describe active transport as the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration
	2 Explain the importance of active transport as a process for movement of molecules or ions across membranes, including ion uptake by root hairs

B4 Biological molecules

B4.1 Biological molecules

Core

1 List the chemical elements that make up: carbohydrates, fats and proteins

2 State that large molecules are made from smaller molecules, limited to:

- (a) starch, glycogen and cellulose from glucose
- (b) proteins from amino acids
- (c) fats and oils from fatty acids and glycerol

3 Describe the use of:

- (a) iodine solution test for starch
- (b) Benedict's solution test for reducing sugars
- (c) biuret test for proteins
- (d) ethanol emulsion test for fats and oils

Supplement

B5 Enzymes

B5.1 Enzymes

Core

1 Describe enzymes as proteins that are involved in all metabolic reactions, where they function as biological catalysts

2 Investigate and describe the effect of changes in temperature and pH on enzyme activity

Supplement

3 Describe and explain enzyme action with reference to: the active site, enzyme-substrate complex, substrate and product

4 Describe and explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate

5 Explain the effect of changes in temperature on enzyme activity in terms of kinetic energy, shape and fit, frequency of effective collisions and denaturation

6 Explain the effect of changes in pH on enzyme activity in terms of shape and fit and denaturation

B6 Plant nutrition

B6.1 Photosynthesis

Core		Supplement	
1	Describe photosynthesis as the process by which plants synthesise carbohydrates from raw materials using energy from light		
2	State the word equation for photosynthesis as: carbon dioxide + water → glucose + oxygen in the presence of light and chlorophyll	5	State the balanced symbol equation for photosynthesis as: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
3	State that chlorophyll is a green pigment that is found in chloroplasts		
		6	State that chlorophyll transfers energy from light into energy in chemicals, for the synthesis of carbohydrates
4	Investigate and understand the need for chlorophyll, light and carbon dioxide for photosynthesis	7	Understand and describe the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis
		8	Understand and describe the effect of light and dark conditions on gas exchange in an aquatic plant using hydrogencarbonate indicator solution

B6.2 Leaf structure

Core		Supplement
1	Identify in diagrams and images the following structures in the leaf of a dicotyledonous plant: chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, air spaces, vascular bundles, xylem and phloem	

B7 Human nutrition

B7.1 Diet

Core		Supplement
1	Describe what is meant by a balanced diet	
2	State the principal dietary sources and describe the importance of: (a) carbohydrates (b) fats and oils (c) proteins (d) vitamins, limited to C and D (e) mineral ions, limited to calcium and iron (f) fibre (roughage) (g) water	

B7.2 Digestive system

Core		Supplement
1	Identify in diagrams and images the main organs of the digestive system limited to: (a) alimentary canal; mouth, oesophagus, stomach, small intestine (duodenum and ileum) and large intestine (colon, rectum and anus) (b) associated organs; salivary glands, pancreas, liver and gall bladder	
2	Describe the functions of the organs of the digestive system listed in 7.2.1, in relation to: (a) ingestion – the taking of substances, e.g. food and drink, into the body (b) digestion – the breakdown of food (c) absorption – the movement of nutrients from the intestines into the blood (d) assimilation – uptake and use of nutrients by cells (e) egestion – the removal of undigested food from the body as faeces	

continued

B7 Human nutrition continued

B7.3 Digestion

Core

1 Describe physical digestion as the breakdown of food into smaller pieces without chemical change to the food molecules

2 Describe chemical digestion as the breakdown of large insoluble molecules into small soluble molecules

Supplement

3 State that physical digestion increases the surface area of food for the action of enzymes in chemical digestion

4 State the role of chemical digestion in producing small soluble molecules that can be absorbed

5 Describe the functions of enzymes as follows:

(a) amylase breaks down starch to simple reducing sugars

(b) proteases break down protein to amino acids

(c) lipase breaks down fats and oils to fatty acids and glycerol

6 State where, in the digestive system, amylase, protease and lipase are secreted and where they act

7 Describe the functions of hydrochloric acid in gastric juice, limited to killing harmful microorganisms in food and providing an acidic pH for optimum enzyme activity of proteases in the stomach

B8 Transport in plants

B8.1 Xylem and phloem

Core

1 State the functions of xylem and phloem:

(a) xylem – transport of water and mineral ions, and support

(b) phloem – transport of sucrose and amino acids

2 Identify in diagrams and images the position of xylem and phloem as seen in sections of roots, stems and leaves of non-woody dicotyledonous plants

Supplement

continued

B8 Transport in plants continued

B8.2 Water uptake

Core

1 Identify in diagrams and images root hair cells and state their functions

2 Outline the pathway taken by water through the root hair cells, root cortex cells, xylem and mesophyll cells

Supplement

3 State that the large surface area of root hairs increases the uptake of water and mineral ions

B8.3 Transpiration

Core

1 Describe transpiration as the loss of water vapour from leaves

Supplement

2 Investigate and describe the effects of variation of temperature and wind speed on transpiration rate

B9 Transport in animals

B9.1 Circulatory systems

Core

1 Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood

Supplement

B9.2 Heart

Core

1 Identify in diagrams and images the structures of the mammalian heart, limited to: muscular wall, septum, left and right ventricles, left and right atria, one-way valves and coronary arteries

2 State that blood is pumped away from the heart in arteries and returns to the heart in veins

3 State that the activity of the heart may be monitored by: ECG (electrocardiogram), pulse rate and listening to sounds of valves closing

Supplement

5 Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves

continued

B9 Transport in animals continued

B9.2 Heart continued

Core

4 Investigate and describe the effect of physical activity on heart rate

Supplement

6 Explain the effect of physical activity on the heart rate

7 Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors including: diet, lack of exercise, stress, smoking, genetic predisposition, age and sex

8 Discuss the roles of diet and exercise in reducing the risk of coronary heart disease

B9.3 Blood vessels

Core

1 Describe the structure of arteries, veins and capillaries, limited to: relative thickness of wall, diameter of the lumen and the presence of valves in veins

Supplement

2 Explain how the structure of arteries and veins is related to the pressure of the blood that they transport

B9.4 Blood

Core

1 List the components of blood as: red blood cells, white blood cells, platelets and plasma

2 Identify red and white blood cells in photomicrographs and diagrams

3 State the functions of the following components of blood:

- (a) red blood cells in transporting oxygen, including the role of haemoglobin
- (b) white blood cells in phagocytosis and antibody production
- (c) platelets in clotting (details are **not** required)
- (d) plasma in the transport of blood cells, ions, nutrients, urea, hormones and carbon dioxide

Supplement

4 State the roles of blood clotting as preventing: blood loss and the entry of pathogens

B10 Diseases and immunity

B10.1 Diseases and immunity

Core

1 Describe a pathogen as a disease-causing organism

2 Describe a transmissible disease as a disease in which the pathogen can be passed from one host to another

3 State that a pathogen is transmitted:
- (a) by direct contact, including through blood and other body fluids
- (b) indirectly, including from contaminated surfaces, food, animals and air

4 Describe the body defences against pathogens, limited to: skin, hairs in the nose, mucus, stomach acid and white blood cells

Supplement

5 State the features of viruses, limited to a protein coat and genetic material

6 Explain the importance of the following in controlling the spread of disease:
- (a) a clean water supply
- (b) hygienic food preparation
- (c) good personal hygiene
- (d) waste disposal
- (e) sewage treatment (details of the stages of sewage treatment are **not** required)

7 Describe active immunity as defence against a pathogen by antibody production in the body

8 State that active immunity is gained after an infection by a pathogen or by vaccination

B11 Gas exchange in humans

B11.1 Gas exchange in humans

Core

1 Identify in diagrams and images the following parts of the breathing system: lungs, diaphragm, ribs, intercostal muscles, larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries

2 Investigate and describe the effects of physical activity on the rate and depth of breathing

Supplement

3 Describe the features of gas exchange surfaces in humans, limited to: large surface area, thin surface, good blood supply and good ventilation with air

B12 Respiration

B12.1 Respiration

Core

1 State the uses of energy in living organisms, including: muscle contraction, protein synthesis, cell division, growth and the maintenance of a constant body temperature

2 Describe aerobic respiration as the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy

3 State the word equation for aerobic respiration as:
glucose + oxygen → carbon dioxide + water

Supplement

4 State the balanced symbol equation for aerobic respiration as:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

B13 Drugs

B13.1 Drugs

Core

1 Describe a drug as any substance taken into the body that modifies or affects chemical reactions in the body

2 Describe the use of antibiotics for the treatment of bacterial infections

3 State that some bacteria are resistant to antibiotics which reduces the effectiveness of antibiotics

4 State that antibiotics kill bacteria but do not affect viruses

Supplement

5 Explain how using antibiotics only when essential can limit the development of resistant bacteria such as MRSA

B14 Reproduction

B14.1 Sexual reproduction in plants

Core

1 Identify in diagrams and images and draw the following parts of an insect-pollinated flower: sepals, petals, stamens, filaments, anthers, carpels, style, stigma, ovary and ovules

2 State the functions of the structures listed in 14.1.1

3 Describe pollination as the transfer of pollen grains from an anther to a stigma

4 State that fertilisation occurs when a pollen nucleus fuses with a nucleus in an ovule

5 Investigate and describe the environmental conditions that affect germination of seeds, limited to the requirement for: water, oxygen and a suitable temperature

Supplement

6 Identify in diagrams and images and describe the anthers and stigmas of a wind-pollinated flower

continued

B14 Reproduction continued

B14.2 Sexual reproduction in humans

Core		Supplement
1	Identify on diagrams and state the functions of the following parts of the male reproductive system: testes, scrotum, sperm ducts, prostate gland, urethra and penis	
2	Identify on diagrams and state the functions of the following parts of the female reproductive system: ovaries, oviducts, uterus, cervix and vagina	
3	Describe fertilisation as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell)	
4	Describe the menstrual cycle in terms of changes in the ovaries and in the lining of the uterus (knowledge of sex hormones is **not** required)	

B15 Organisms and their environment

B15.1 Energy flow

Core		Supplement
1	State that the Sun is the principal source of energy input to biological systems	
2	Describe the flow of energy through living organisms including light energy from the Sun and chemical energy in organisms and its eventual transfer to the environment	

B15.2 Food chains and food webs

Core		Supplement
1	Describe a food chain as showing the transfer of energy from one organism to the next, beginning with a producer	
2	Construct and interpret simple food chains	
3	Describe a food web as a network of interconnected food chains and interpret food webs	
4	Describe a producer as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis	

continued

B15 Organisms and their environment continued

B15.2 Food chains and food webs continued

Core	Supplement
5 Describe a consumer as an organism that gets its energy by feeding on other organisms	
6 State that consumers may be classed as primary, secondary and tertiary according to their position in a food chain	
7 Describe a herbivore as an animal that gets its energy by eating plants	
8 Describe a carnivore as an animal that gets its energy by eating other animals	
9 Describe a decomposer as an organism that gets its energy from dead or waste organic material	
	10 Use food chains and food webs to describe the impact humans have through overharvesting of food species and through introducing foreign species to a habitat

B15.3 Carbon cycle

Core	Supplement
1 Describe the carbon cycle, limited to: photosynthesis, respiration, feeding, decomposition, formation of fossil fuels and combustion	

B16 Human influences on ecosystems

B16.1 Habitat destruction

Core	Supplement
1 Describe an ecosystem as a unit containing the community of organisms and their environment, interacting together	
2 Describe biodiversity as the number of different species that live in an area	
3 Describe the reasons for habitat destruction, including: (a) increased area for housing, crop plant production and livestock production (b) extraction of natural resources (c) freshwater and marine pollution (a detailed description of eutrophication is **not** required)	
4 State the undesirable effects of deforestation as an example of habitat destruction, to include: reducing biodiversity, extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere	5 Explain the undesirable effects of deforestation as an example of habitat destruction, to include: reducing biodiversity, extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere

B16.2 Conservation

Core	Supplement
1 Outline why organisms become endangered or extinct, including: climate change, habitat destruction, hunting, overharvesting, pollution and introduced species	
	2 Describe how endangered species can be conserved, limited to: (a) monitoring and protecting species and habitats (b) education (c) captive breeding programmes (d) seed banks

Chemistry

C1 States of matter

C1.1 Solids, liquids and gases

Core		Supplement	
1	State the distinguishing properties of solids, liquids and gases		
2	Describe the structures of solids, liquids and gases in terms of particle separation, arrangement and motion		
3	Describe changes of state in terms of melting, boiling, evaporating, freezing and condensing	5	Explain changes of state in terms of kinetic particle theory
4	Describe the effects of temperature and pressure on the volume of a gas		

C2 Atoms, elements and compounds

C2.1 Elements, compounds and mixtures

Core		Supplement
1	Describe the differences between elements, compounds and mixtures	

C2.2 Atomic structure and the Periodic Table

Core		Supplement
1	Describe the structure of the atom as a central nucleus containing neutrons and protons, surrounded by electrons in shells	
2	State the relative charges and relative masses of a proton, a neutron and an electron	
3	Define proton number/atomic number as the number of protons in the nucleus of an atom	
4	Define mass number/nucleon number as the total number of protons and neutrons in the nucleus of an atom	
5	Determine the electronic configuration of elements with proton number 1 to 20, e.g. 2,8,3	
6	State that: (a) Group VIII noble gases have a full outer shell (b) the number of outer-shell electrons is equal to the group number in Groups I to VII (c) the number of occupied electron shells is equal to the period number	

continued

C2 Atoms, elements and compounds continued

C2.3 Ions and ionic bonds

Core

1 Describe the formation of positive ions, known as cations, and negative ions, known as anions

2 State that an ionic bond is a strong electrostatic attraction between oppositely charged ions

3 Describe the formation of ionic bonds between elements from Group I and Group VII, including the use of dot-and-cross diagrams

4 Describe the properties of ionic compounds:
- (a) high melting points and boiling points
- (b) good electrical conductivity when aqueous or molten and poor when solid
- (c) generally soluble in water

Supplement

5 Describe the formation of ionic bonds between ions of metallic and non-metallic elements, including the use of dot-and-cross diagrams

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

C2.4 Simple molecules and covalent bonds

Core

1 State that a covalent bond is formed when a pair of electrons is shared between two atoms leading to noble gas electronic configurations

2 Describe the formation of covalent bonds in simple molecules, including H_2, Cl_2, H_2O, CH_4, NH_3 and HCl. Use dot-and-cross diagrams to show the electronic configurations in these molecules

3 Describe the properties of simple molecular compounds:
- (a) low melting points and boiling points
- (b) poor electrical conductivity

Supplement

4 Describe the formation of covalent bonds in simple molecules, including CH_3OH, C_2H_4, O_2, CO_2 and N_2. Use dot-and-cross diagrams to show the electronic configurations in these molecules

C3 Stoichiometry

C3.1 Formulas

Core

1 State the formulas of the elements and compounds named in the subject content

2 Define the molecular formula of a compound as the number and type of atoms in one molecule

3 Deduce the formula of a simple molecular compound from the relative numbers of atoms present in a model or a diagrammatic representation

4 Construct word equations to show how reactants form products

5 Balance and interpret simple symbol equations, including state symbols

Supplement

6 Deduce the formula of an ionic compound from the relative numbers of the ions present in a model or a diagrammatic representation or from the charges on the ions

7 Construct symbol equations with state symbols, including ionic equations

C4 Electrochemistry

C4.1 Electrolysis

Core

1 Define electrolysis as the decomposition of an ionic compound, when molten or in aqueous solution, by the passage of an electric current

2 Identify in simple electrolytic cells:

(a) the anode as the positive electrode

(b) the cathode as the negative electrode

(c) the electrolyte as the molten or aqueous substance that undergoes electrolysis

3 Identify the products formed at the electrodes and describe the observations, made during the electrolysis of:

(a) molten lead(II) bromide

(b) concentrated aqueous sodium chloride

(c) dilute sulfuric acid

using inert electrodes made of platinum or carbon/graphite

Supplement

4 State that metals or hydrogen are formed at the cathode and that non-metals (other than hydrogen) are formed at the anode

5 Predict the identity of the products at each electrode for the electrolysis of a binary compound in the molten state

C5 Chemical energetics

C5.1 Exothermic and endothermic reactions

Core

1 State that an exothermic reaction transfers thermal energy to the surroundings leading to an increase in the temperature of the surroundings

2 State that an endothermic reaction takes in thermal energy from the surroundings leading to a decrease in the temperature of the surroundings

Supplement

3 Interpret reaction pathway diagrams showing exothermic and endothermic reactions

4 Define activation energy, E_a, as the minimum energy that colliding particles must have to react

5 Draw and label reaction pathway diagrams for exothermic and endothermic reactions using information provided, to include:

(a) reactants

(b) products

(c) overall energy change of reaction

(d) activation energy, E_a

6 State that bond breaking is an endothermic process and bond making is an exothermic process

C6 Chemical reactions

C6.1 Physical and chemical changes

Core

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

Supplement

C6.2 Rate of reaction

Core

1 Describe the effect on the rate of reaction of:

(a) changing the concentration of solutions

(b) changing the surface area of solids

(c) changing the temperature

(d) adding or removing a catalyst

Supplement

5 Explain the effect on the rate of reaction of:

(a) changing the concentration of solutions

(b) changing the surface area of solids

(c) changing the temperature

(d) adding or removing a catalyst

using collision theory

continued

C6 Chemical reactions continued

C6.2 Rate of reaction continued

Core	Supplement
2 State that a catalyst increases the rate of a reaction and is unchanged at the end of a reaction	
3 Describe practical methods for investigating the rate of a reaction including change in mass of a reactant or product and the formation of a gas	
4 Interpret data, including graphs, from rate of reaction experiments	
	6 Describe collision theory in terms of: (a) number of particles per unit volume (b) frequency of collisions between particles (c) kinetic energy of particles (d) activation energy, E_a

C6.3 Redox

Core	Supplement
1 Define redox reactions as involving simultaneous oxidation and reduction	
2 Define oxidation as gain of oxygen and reduction as loss of oxygen	
3 Identify redox reactions as reactions involving gain and loss of oxygen	
4 Identify oxidation and reduction in redox reactions. (Oxidation number limited to its use to name ions, e.g. iron(II), iron(III), copper(II).)	

C7 Acids, bases and salts

C7.1 The characteristic properties of acids and bases

Core

1 Describe the characteristic properties of acids in terms of their reactions with:
   (a) metals
   (b) bases
   (c) carbonates

2 Describe acids in terms of their effect on the indicators:
   (a) litmus
   (b) methyl orange

3 State that bases are oxides or hydroxides of metals and that alkalis are soluble bases

4 Describe the characteristic properties of bases in terms of their reactions with acids

5 Describe alkalis in terms of their effect on the indicators:
   (a) litmus
   (b) methyl orange

6 Describe how to compare neutrality, relative acidity and relative alkalinity in terms of colour and pH using universal indicator

Supplement

C7.2 Oxides

Core

1 Classify oxides as either acidic, including SO_2 and CO_2, or basic, including CuO and CaO, related to metallic and non-metallic character

Supplement

C7.3 Preparation of salts

Core

1 Describe the preparation, separation and purification of soluble salts by reaction of an acid with:
   (a) an alkali by titration
   (b) excess metal
   (c) excess insoluble base
   (d) excess insoluble carbonate
   (candidates do **not** need to know general solubility rules for salts)

Supplement

2 Describe the preparation of insoluble salts by precipitation (candidates do **not** need to know general solubility rules for salts)

C8 The Periodic Table

C8.1 Arrangement of elements

Core

1 Describe the Periodic Table as an arrangement of elements in periods and groups and in order of increasing proton number/atomic number

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

Supplement

3 Identify trends in groups, given information about the elements

C8.2 Group I properties

Core

1 Describe the Group I alkali metals, lithium, sodium and potassium, as relatively soft metals with general trends down the group, limited to:

(a) decreasing melting point

(b) increasing density

(c) increasing reactivity with water

Supplement

2 Predict the properties of other elements in Group I, given information about the elements

C8.3 Group VII properties

Core

1 Describe the Group VII halogens, chlorine, bromine and iodine, as diatomic non-metals with general trends down the group, limited to:

(a) increasing density

(b) decreasing reactivity

2 State the appearance of the halogens at room temperature and pressure, r.t.p., as:

(a) chlorine, a pale yellow-green gas

(b) bromine, a red-brown liquid

(c) iodine, a grey-black solid

Supplement

3 Describe and explain the displacement reactions of halogens with other halide ions

4 Predict the properties of other elements in Group VII, given information about the elements

continued

C8 The Periodic Table continued

C8.4 Transition elements

Core	Supplement
1 Describe the transition elements as metals that: (a) have high densities (b) have high melting points (c) form coloured compounds (d) often act as catalysts as elements and in compounds	

C8.5 Noble gases

Core	Supplement
1 Describe the Group VIII noble gases as unreactive, monatomic gases and explain this in terms of electronic configuration	

C9 Metals

C9.1 Properties of metals

Core	Supplement
1 Compare the general physical properties of metals and non-metals, including: (a) thermal conductivity (b) electrical conductivity (c) malleability and ductility (d) melting points and boiling points 2 Describe the general chemical properties of metals, limited to their reactions with: (a) dilute acids (b) cold water and steam	

C9.2 Uses of metals

Core	Supplement
1 Describe the uses of metals in terms of their physical properties, including: (a) aluminium in the manufacture of aircraft because of its low density (b) aluminium in the manufacture of overhead electrical cables because of its low density and good electrical conductivity (c) aluminium in food containers because of its resistance to corrosion (d) copper in electrical wiring because of its good electrical conductivity	

continued

C9 Metals continued

C9.3 Alloys and their properties

Core

1 Describe alloys as mixtures of a metal with other elements, including:
   (a) brass as a mixture of copper and zinc
   (b) stainless steel as a mixture of iron and other elements such as chromium, nickel and carbon
2 State that alloys can be harder and stronger than the pure metals and are more useful
3 Describe the use of alloys in terms of their physical properties, including stainless steel in cutlery because of its hardness and resistance to rusting
4 Identify representations of alloys from diagrams of structure

Supplement

5 Explain in terms of structure how alloys can be harder and stronger than the pure metals because the different sized atoms in alloys mean the layers can no longer slide over each other

C9.4 Reactivity series

Core

1 State the order of the reactivity series as: potassium, sodium, calcium, magnesium, aluminium, carbon, zinc, iron, hydrogen, copper, silver, gold
2 Describe the reactions, if any, of:
   (a) potassium, sodium and calcium with cold water
   (b) magnesium with steam
   (c) magnesium, zinc, iron, copper, silver and gold with dilute hydrochloric acid

   and explain these reactions in terms of the position of the metals in the reactivity series
3 Deduce an order of reactivity from a given set of experimental results

Supplement

continued

C9 Metals continued

C9.5 Corrosion of metals

Core	Supplement
1 State the conditions required for the rusting of iron (presence of oxygen and water)	
2 State some common barrier methods, including painting, greasing and coating with plastic	
3 Describe how barrier methods prevent rusting by excluding oxygen and water	

C9.6 Extraction of metals

Core	Supplement
1 Describe the ease in obtaining metals from their ores, related to the position of the metal in the reactivity series	
2 State that iron from hematite is extracted by reduction of iron(III) oxide in the blast furnace	4 Describe the extraction of iron from hematite in the blast furnace, limited to: (a) the burning of carbon (coke) to provide heat and produce carbon dioxide $C + O_2 \rightarrow CO_2$ (b) the reduction of carbon dioxide to carbon monoxide $C + CO_2 \rightarrow 2CO$ (c) the reduction of iron(III) oxide by carbon monoxide $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
3 State that main ore of aluminium is bauxite and that aluminium is extracted by electrolysis	

C10 Chemistry of the environment

C10.1 Water

Core	Supplement
1 Describe chemical tests for the presence of water using anhydrous cobalt(II) chloride and anhydrous copper(II) sulfate	
2 State that distilled water is used in practical chemistry rather than tap water because it contains fewer chemical impurities	
3 Describe the treatment of the domestic water supply in terms of:	
(a) sedimentation and filtration to remove solids	
(b) use of carbon to remove tastes and odours	
(c) chlorination to kill microbes	

C10.2 Air quality and climate

Core	Supplement
1 State the composition of clean, dry air as approximately 78% nitrogen, N_2, 21% oxygen, O_2, and the remainder as a mixture of noble gases and carbon dioxide, CO_2	
2 State the source of each of these air pollutants, limited to:	
(a) carbon dioxide from the complete combustion of carbon-containing fuels	
(b) carbon monoxide and particulates from the incomplete combustion of carbon-containing fuels	
(c) methane from the decomposition of vegetation and waste gases from digestion in animals	
(d) oxides of nitrogen from car engines	
(e) sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds	

continued

C10 Chemistry of the environment continued

C10.2 Air quality and climate continued

Core

3 State the adverse effect of these air pollutants, limited to:

- (a) carbon dioxide: higher levels of carbon dioxide leading to increased global warming, which leads to climate change
- (b) carbon monoxide: toxic gas
- (c) particulates: increased risk of respiratory problems and cancer
- (d) methane: higher levels of methane leading to increased global warming, which leads to climate change
- (e) oxides of nitrogen: acid rain and respiratory problems
- (f) sulfur dioxide: acid rain

Supplement

4 State and explain strategies to reduce the effects of climate change:

- (a) planting trees
- (b) reduction in livestock farming,
- (c) decreasing use of fossil fuels
- (d) increasing use of renewable energy, e.g. wind, solar

5 State strategies to reduce the effects of acid rain: reducing emissions of sulfur dioxide by using low-sulfur fuels

6 Describe how the greenhouse gases carbon dioxide and methane cause global warming, limited to:

- (a) the absorption, reflection and emission of thermal energy
- (b) reducing thermal energy loss to space

C11 Organic chemistry

C11.1 Terminology

Core

1 State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds

2 State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds

Supplement

3 State that a homologous series is a family of similar compounds with similar chemical properties

4 Describe the general characteristics of a homologous series as:

(a) having the same general formula (recall of specific general formulas is **not** required)

(b) displaying a trend in physical properties

C11.2 Fuels

Core

1 Name the fossil fuels: coal, natural gas and petroleum

2 Name methane as the main constituent of natural gas

3 State that hydrocarbons are compounds that contain hydrogen and carbon only

4 State that petroleum is a mixture of hydrocarbons

5 Describe the separation of petroleum into useful fractions by fractional distillation

6 Name the uses of the fractions as:

(a) refinery gas fraction for gas used in heating and cooking

(b) gasoline/petrol fraction for fuel used in cars

(c) naphtha fraction as a chemical feedstock

(d) diesel oil/gas oil for fuel used in diesel engines

(e) bitumen for making roads

Supplement

7 Describe how the properties of fractions obtained from petroleum change from the bottom to the top of the fractionating column, limited to:

(a) decreasing chain length

(b) lower boiling points

continued

C11 Organic chemistry continued

C11.3 Alkanes

Core

1 State that the bonding in alkanes is single covalent and that alkanes are saturated hydrocarbons

2 Describe the properties of alkanes as being generally unreactive, except in terms of combustion

Supplement

C11.4 Alkenes

Core

1 State that the bonding in alkenes includes a double carbon–carbon covalent bond and that alkenes are unsaturated hydrocarbons

2 Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine

Supplement

3 Describe the manufacture of alkenes and hydrogen by the cracking of larger alkane molecules using a high temperature and a catalyst

4 Describe the properties of alkenes in terms of addition reactions with:

(a) bromine

(b) hydrogen in the presence of a nickel catalyst

(c) steam in the presence of an acid catalyst

C11.5 Polymers

Core

1 Define polymers as large molecules built up from many smaller molecules called monomers

2 State that the formation of poly(ethene) is an example of addition polymerisation using ethene (an alkene) monomers

Supplement

C12 Experimental techniques and chemical analysis

C12.1 Experimental design

Core

1 Name appropriate apparatus for the measurement of time, temperature, mass and volume, including:
   (a) stop-watches
   (b) thermometers
   (c) balances
   (d) burettes
   (e) volumetric pipettes
   (f) measuring cylinders
   (g) gas syringes

2 Describe a:
   (a) solvent as a substance that dissolves a solute
   (b) solute as a substance that is dissolved in a solvent
   (c) solution as a mixture of one or more solutes dissolved in a solvent
   (d) saturated solution as a solution containing the maximum concentration of a solute dissolved in the solvent at a specified temperature
   (e) residue as a solid substance that remains after evaporation, distillation, filtration or any similar process
   (f) filtrate as a liquid or solution that has passed through a filter

Supplement

C12.2 Chromatography

Core

1 Describe how paper chromatography is used to separate mixtures of soluble coloured substances, using a suitable solvent

2 Interpret simple chromatograms to identify:
   (a) unknown substances by comparison with known substances
   (b) pure and impure substances

Supplement

3 State and use the equation for R_f:

$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

continued

C12 Experimental techniques and chemical analysis continued

C12.3 Separation and purification

Core

1 Describe and explain methods of separation and purification using:
- (a) a suitable solvent
- (b) filtration
- (c) crystallisation
- (d) simple distillation
- (e) fractional distillation

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

Supplement

C12.4 Identification of ions and gases

Core

1 Describe tests to identify the anions:
- (a) carbonate, CO_3^{2-}, by reaction with dilute acid and then testing for carbon dioxide gas
- (b) chloride, Cl^-, bromide, Br^-, and iodide, I^-, by acidifying with dilute nitric acid then adding aqueous silver nitrate
- (c) sulfate, SO_4^{2-}, by acidifying with dilute nitric acid and then adding aqueous barium nitrate

2 Describe tests using aqueous sodium hydroxide and aqueous ammonia to identify the aqueous cations:
- (a) ammonium, NH_4^+
- (b) calcium, Ca^{2+}
- (c) copper(II), Cu^{2+}
- (d) iron(II), Fe^{2+}
- (e) iron(III), Fe^{3+}
- (f) zinc, Zn^{2+}

(formulas of complex ions are not required)

3 Describe tests to identify the gases:
- (a) ammonia, NH_3, using damp red litmus paper
- (b) carbon dioxide, CO_2, using limewater
- (c) chlorine, Cl_2, using damp litmus paper
- (d) hydrogen, H_2, using a lighted splint
- (e) oxygen, O_2, using a glowing splint

Supplement

continued

C12 Experimental techniques and chemical analysis continued

C12.4 Identification of ions and gases continued

Core	Supplement
4 Describe the use of a flame test to identify the cations: (a) lithium, Li^+ (b) sodium, Na^+ (c) potassium, K^+ (d) copper(II), Cu^{2+}	

Physics

P1 Motion, forces and energy

P1.1 Physical quantities and measurement techniques

Core		Supplement	
1	Describe the use of rulers and measuring cylinders to find a length or a volume		
2	Describe how to measure a variety of time intervals using clocks and digital timers		
3	Determine an average value for a small distance and for a short interval of time by measuring multiples (including the period of oscillation of a pendulum)		

P1.2 Motion

Core		Supplement	
1	Define speed as distance travelled per unit time; recall and use the equation $v = \frac{s}{t}$		
2	Recall and use the equation $\text{average speed} = \frac{\text{total distance travelled}}{\text{total time taken}}$		
3	Sketch, plot and interpret distance–time and speed–time graphs		
4	Know that an object moving with increasing speed is accelerating, and that an object moving with decreasing speed is decelerating		
5	Determine, qualitatively, from the shape of a distance–time graph when an object is: (a) at rest (b) moving with constant speed		
		8	Define acceleration for an object moving in a straight line as change in speed per unit time; recall and use the equation $a = \frac{\Delta v}{\Delta t}$
6	Determine, qualitatively, from the shape of a speed–time graph when an object is: (a) at rest (b) moving with constant speed (c) accelerating (d) decelerating	9	Determine from given data or the shape of a speed–time graph when an object is moving with constant acceleration
7	Calculate speed from the gradient of a straight-line section of a distance–time graph	10	Calculate acceleration from the gradient of a straight-line section of a speed–time graph

continued

P1 Motion, forces and energy continued

P1.2 Motion continued

Core

Supplement

11 Calculate the area under a speed–time graph to work out the distance travelled for motion with:
   (a) constant speed
   (b) constant acceleration

12 Know that deceleration is a negative acceleration and use this in calculations

13 Know that the acceleration of free fall g for an object near to the surface of the Earth is approximately constant and is approximately $9.8\,m/s^2$

P1.3 Mass and weight

Core

1 State that mass is a measure of the quantity of matter in an object

2 State that weight is the gravitational force on an object that has mass

3 Define gravitational field strength g as the gravitational force per unit mass; recall and use the equation

$$g = \frac{W}{m}$$

and know that near to the surface of the Earth, g is approximately $9.8\,N/kg$

Supplement

4 Describe, and use the concept of, weight as the effect of a gravitational field on a mass

5 Know that gravitational field strength is equivalent to the acceleration of free fall

P1.4 Density

Core

1 Define density as mass per unit volume; recall and use the equation

$$\rho = \frac{m}{V}$$

2 Describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in a liquid (volume by displacement), including appropriate calculations

3 Determine whether an object floats or sinks based on density data

Supplement

continued

P1 Motion, forces and energy continued

P1.5 Forces

P1.5.1 Effects of forces

Core

1 Know that forces may produce changes in the size, shape and motion of an object

2 Determine the resultant of two or more forces acting along the same straight line

3 Describe friction as the force between two surfaces that may impede relative motion and produce heating

4 Know that friction (drag) acts on an object moving through a liquid

5 Know that friction (drag) acts on an object moving through a gas (e.g. air resistance)

6 Know that an object either remains at rest or continues in a straight line at constant speed unless there is a resultant force on the object

Supplement

7 Recall and use the equation

$F = ma$ and know that the resultant force and the acceleration are in the same direction

P1.6 Energy, work and power

P1.6.1 Energy

Core

1 State that energy may be stored as kinetic, gravitational potential, chemical, elastic (strain), nuclear, electrostatic and internal (thermal)

2 Describe how energy is transferred between stores during events and processes, including examples of transfer by forces (mechanical work done), electrical currents (electrical work done), heating and by electromagnetic, sound and other waves

3 Know the principle of conservation of energy and apply this principle to simple examples including the interpretation of simple flow diagrams (Sankey diagrams are **not** required)

Supplement

4 Recall and use the equation for kinetic energy

$E_k = \frac{1}{2}mv^2$

5 Recall and use the equation for the change in gravitational potential energy

$\Delta E_p = mg\Delta h$

continued

P1 Motion, forces and energy continued

P1.6 Energy, work and power continued

P1.6.2 Work

Core

1 Understand that mechanical or electrical work done is equal to the energy transferred

2 Recall and use the equation for mechanical working
$W = Fd = \Delta E$

Supplement

P1.6.3 Energy resources

Core

1 Describe how useful energy may be obtained, or electrical power generated, from:

(a) fossil fuels

(b) biofuels

(c) water, including waves, tides, and hydroelectric dams

(d) geothermal resources

(e) nuclear fission

(f) light from the Sun (solar cells)

(g) infrared and other electromagnetic waves from the Sun to heat water (solar thermal collectors)

(h) wind (wind turbines)

including references to a boiler, turbine and generator where they are used

2 Understand, qualitatively, the concept of efficiency of energy transfer

Supplement

3 Know that radiation from the Sun is the main source of energy for all our energy resources except geothermal, nuclear and tidal

4 Know that energy is released by nuclear fusion in the Sun (detailed knowledge of the process of fusion is **not** required)

5 Know that energy is released by nuclear fission in nuclear reactors (detailed knowledge of the process of fission is **not** required)

6 Define efficiency as:

(a) $\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$

(b) $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100\%$

recall and use the equations

continued

P1 Motion, forces and energy continued

P1.6 Energy, work and power continued

P1.6.4 Power

Core	Supplement
1 Define power as work done per unit time and also as energy transferred per unit time; recall and use the equations (a) $P = \frac{W}{t}$ (b) $P = \frac{\Delta E}{t}$	

P1.7 Pressure

Core	Supplement
1 Describe how pressure varies with force and area in the context of everyday examples	
2 Define pressure as force per unit area; recall and use the equation $p = \frac{F}{A}$	

P2 Thermal physics

P2.1 Kinetic particle model of matter

P2.1.1 States of matter

Core	Supplement
1 State the distinguishing properties of solids, liquids and gases	
2 Know the terms for the changes in state between solids, liquids and gases (gas to solid and solid to gas changes are **not** required)	

P2.1.2 Particle model

Core	Supplement
1 Describe the structure of solids, liquids and gases in terms of the arrangement, separation and motion of the particles and represent these states using simple particle diagrams	3 Know that the forces and distances between particles and the motion of the particles affect the properties of solids, liquids and gases
2 Describe the relationship between the motion of particles and temperature	4 Describe the pressure of a gas in terms of the forces exerted by particles colliding with surfaces, creating a force per unit area

continued

P2 Thermal physics continued

P2.1 Kinetic particle model of matter continued

P2.1.3 Pressure changes

Core

Supplement

1 Describe qualitatively, in terms of particles, the effect on the pressure of a fixed mass of gas of:
   (a) a change of temperature at constant volume
   (b) a change of volume at constant temperature

P2.2 Thermal properties and temperature

P2.2.1 Thermal expansion of solids, liquids and gases

Core

1 Describe, qualitatively, the thermal expansion of solids, liquids and gases at constant pressure

Supplement

2 Explain some of the everyday applications and consequences of thermal expansion

P2.2.2 Evaporation

Core

1 Describe evaporation in terms of the escape of the more energetic particles from the surface of a liquid

2 Know that evaporation causes cooling of a liquid

Supplement

3 Describe how temperature, surface area and air movement over a surface affect evaporation

P2.3 Transfer of thermal energy

P2.3.1 Conduction

Core

1 Identify and give examples of typical good thermal conductors and bad thermal conductors (thermal insulators)

Supplement

2 Describe thermal conduction in solids in terms of atomic or molecular lattice vibrations and also in terms of the movement of delocalised (mobile) electrons in metallic conductors

P2.3.2 Convection

Core

1 Know that convection is an important method of energy transfer in liquids and gases

2 Describe convection in liquids and gases

Supplement

3 Explain convection in liquid and gases in terms of density changes

continued

P2 Thermal physics continued

P2.3 Transfer of thermal energy continued

P2.3.3 Radiation

Core

1 Know that thermal energy transfer by thermal radiation does **not** require a medium and is mainly due to infrared radiation

2 Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of thermal radiation

Supplement

3 Know that the temperature of the Earth is affected by the radiation absorbed by the Earth and the radiation emitted by the Earth

4 Describe experiments to distinguish between good and bad emitters of thermal radiation

5 Describe experiments to distinguish between good and bad absorbers of thermal radiation

P2.3.4 Consequences of thermal energy transfer

Core

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

Supplement

P3 Waves

P3.1 General properties of waves

Core

1 Know that waves transfer energy without transferring matter

2 Describe what is meant by wave motion as illustrated by vibration (oscillation) in ropes and springs and by experiments using water waves

3 Describe the features of a wave in terms of wavelength, frequency, crest (peak), trough, amplitude and wave speed

4 Describe how waves can undergo:

(a) reflection at a plane surface

(b) refraction due to a change of speed

5 Recall and use the equation for wave speed $v = f\lambda$

Supplement

6 Know that for a transverse wave, the direction of vibration is at right angles to the direction of propagation and understand that electromagnetic radiation, water waves and seismic S-waves (secondary) are transverse

7 Know that for a longitudinal wave, the direction of vibration is parallel to the direction of propagation and understand that sound waves and seismic P-waves (primary) are longitudinal

P3.2 Light

P3.2.1 Reflection of light

Core

1 Use ray diagrams to define the terms normal, angle of incidence and angle of reflection

2 Describe the formation of an optical image by a vertical plane mirror and give its characteristics compared with the object, i.e. same size, same distance from mirror, laterally inverted

3 State that for reflection, the angle of incidence is equal to the angle of reflection; recall and use this relationship

Supplement

4 Describe the formation of an optical image by a plane mirror and explain why it is virtual

5 Use simple diagrams, measurements and calculations for reflection by plane mirrors

continued

P3 Waves continued

P3.2 Light continued

P3.2.2 Refraction of light

Core		Supplement
1	Define refraction as the change in direction of a light ray passing from one medium to another	
2	Define and use the terms normal, angle of incidence and angle of refraction using ray diagrams	
3	Describe the passage of light through a transparent material (limited to the boundaries between two media only)	

P3.2.3 Thin converging lens

Core		Supplement
1	Describe the action of a thin converging lens on a parallel beam of light and know that rays of light from an object at distance can be assumed to be parallel	
2	Define and use the terms principal axis, principal focus (focal point) and focal length	
3	Interpret ray diagrams for the formation of an image by a thin converging lens, limited to real images	
4	Describe the characteristics of an image using the terms enlarged/same size/diminished and upright/inverted	

P3.2.4 Dispersion of light

Core		Supplement
1	Describe the dispersion of light as illustrated by the refraction of white light by a glass prism	
2	Know the seven colours (red, orange, yellow, green, blue, indigo, violet) of the visible spectrum in order of frequency and in order of wavelength	

continued

P3 Waves continued

P3.3 Electromagnetic spectrum

Core

1 Know the main regions of the electromagnetic spectrum (radio, microwave, infrared, visible, ultraviolet, X-ray, gamma) in order of frequency and in order of wavelength

2 Know that all electromagnetic waves travel at the same high speed in a vacuum and at approximately the same speed in air

3 Know some applications of the different regions of the electromagnetic spectrum including:

- (a) radio waves; radio and television transmissions, radar
- (b) microwaves; satellite television, mobile (cell) phone, microwave ovens
- (c) infrared; remote controllers for televisions, thermal imaging
- (d) visible light; vision, photography
- (e) ultraviolet; detecting fake bank notes
- (f) X-rays; medical scanning, security scanners
- (g) gamma rays; detection of cancer and its treatment

4 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:

- (a) ultraviolet; damage to surface cells and eyes, leading to skin cancer and eye conditions
- (b) X-rays and gamma rays; mutation or damage to cells in the body

Supplement

5 Know that the speed of electromagnetic waves in a vacuum is $3.0 \times 10^8 \text{ m/s}$

continued

P3 Waves continued

P3.4 Sound

Core

1 Describe the production of sound by vibrating sources

2 State the approximate range of frequencies audible to humans as 20 Hz to 20 kHz

3 Know that a medium is needed to transmit sound waves

4 Determine the speed of sound in air using a method involving a measurement of distance and time

5 Describe how changes in amplitude and frequency affect the loudness and pitch of sound waves

6 Describe an echo as the reflection of sound waves

7 Define ultrasound as sound with a frequency higher than 20 kHz

Supplement

8 Describe the longitudinal nature of sound waves in air as a series of compressions and rarefactions

9 Describe, qualitatively, compressions as regions of higher pressure due to particles being closer together and rarefactions as regions of lower pressure due to particles being spread further apart

10 Know that, in general, sound travels faster in solids than in liquids and faster in liquids than in gases

P4 Electricity

P4.1 Electrical quantities

P4.1.1 Electrical charge

Core

1 State that there are positive and negative charges

2 State that positive charges repel other positive charges, negative charges repel other negative charges, but positive charges attract negative charges

3 Distinguish between electrical conductors and insulators and give typical examples

Supplement

4 State that charge is measured in coulombs

continued

P4 Electricity continued

P4.1 Electrical quantities continued

P4.1.2 Electric current

Core	Supplement
1 Know that electric current is related to the flow of charge	5 Define electric current as the charge passing a point per unit time; recall and use the equation $I = \frac{Q}{t}$
2 Know that electric current in metals is related to the flow of electrons	6 Describe electrical conduction in metals in terms of the movement of delocalised (mobile) electrons
3 Describe the use of ammeters (analogue and digital) with different ranges	7 State that conventional current is from positive to negative and that the flow of electrons is from negative to positive
4 Know the difference between direct current (d.c.) and alternating current (a.c.)	

P4.1.3 Voltage (electromotive force and potential difference)

Core	Supplement
1 Describe the voltage of the source as the cause of current in the circuit	4 Define electromotive force (e.m.f.) as the electrical work done by a source in moving a unit charge around a complete circuit
2 Know that the voltage of the source is shared between the components in a series circuit	5 Know that e.m.f. is measured in volts (V)
3 Describe the use of voltmeters (analogue and digital) with different ranges	6 Define potential difference (p.d.) as the work done by a unit charge passing between two points in a circuit
	7 Know that the p.d. between two points is measured in volts (V)

P4.1.4 Resistance

Core	Supplement
1 Recall and use the equation for resistance $R = \frac{V}{I}$	2 Recall and use the following relationship for a metallic electrical conductor: (a) resistance is directly proportional to length (b) resistance is inversely proportional to cross-sectional area

continued

P4 Electricity continued

P4.1 Electrical quantities continued

P4.1.5 Electrical energy and electrical power

Core	Supplement
1 Understand that electric circuits transfer energy from a source of electrical energy, such as an electrical cell or mains supply, to the circuit components and then into the surroundings	
2 Recall and use the equation for electrical power $P = IV$	
3 Recall and use the equation for electrical energy $E = IVt$	
4 Define the kilowatt-hour (kW h) and calculate the cost of using electrical appliances where the energy unit is the kW h	

P4.2 Electrical circuits

P4.2.1 Circuit diagrams and circuit components

Core	Supplement
1 Draw and interpret circuit diagrams containing cells, batteries, power supplies, switches, resistors (fixed and variable), heaters, lamps, motors, ammeters, voltmeters and fuses, and know how these components behave in the circuit	2 Draw and interpret circuit diagrams containing generators and light-emitting diodes (LEDs), and know how these components behave in the circuit

P4.2.2 Series and parallel circuits

Core	Supplement
1 Know that the current at every point in a series circuit is the same	
2 Know how to construct and use series and parallel circuits	

continued

P4 Electricity continued

P4.2 Electrical circuits continued

P4.2.2 Series and parallel circuits continued

Core	Supplement
3 Calculate the combined resistance of two or more resistors in series	7 Recall and use in calculations, the fact that (a) the sum of the currents entering a junction in a parallel circuit is equal to the sum of the currents that leave the junction (b) the total p.d. across the components in a series circuit is equal to the sum of the individual p.d.s across each component (c) the p.d. across each branch of a parallel arrangement of components is the p.d. across the whole arrangement
4 Know the advantages of connecting lamps in parallel in a circuit	
5 Know that, for a parallel circuit, the current from the source is larger than the current in each branch	
6 Know that the combined resistance of two resistors in parallel is less than that of either resistor by itself	8 Calculate the combined resistance of two resistors in parallel

P4.3 Electrical safety

Core	Supplement
1 Describe the heating effect of current	
2 State the hazards of: (a) damaged insulation (b) overheating cables (c) damp conditions (d) excess current from overloading of plugs, extension leads, single and multiple sockets when using a mains supply	
3 Explain the use and operation of trip switches and fuses and choose appropriate fuse ratings and trip switch settings (knowledge of RCDs (Residual Current Devices) is **not** required)	
4 Explain why the outer casing of an electrical appliance must be either non-conducting (double-insulated) or earthed	

continued

P4 Electricity continued

P4.4 Cells, batteries, generators and motors

Core	Supplement
1 Know that cells and batteries transfer chemical energy into electrical energy	
2 Know that generators transfer kinetic energy into electrical energy	
3 Know that electric motors transfer electrical energy into kinetic energy	

P5 Space physics

P5.1 The Solar System

P5.1.1 The Solar System

Core	Supplement
1 Describe the Solar System as containing: (a) one star, the Sun (b) the eight named planets and know their order from the Sun (c) minor planets that orbit the Sun, including dwarf planets such as Pluto and asteroids in the asteroid belt (d) moons, that orbit the planets	

P5.2 Stars and the Universe

P5.2.1 The Sun as a star

Core	Supplement
1 Know that: (a) the Sun is the closest star to the Earth (b) astronomical distances can be measured in light-years, where one light-year is the distance travelled in (the vacuum of) space by light in one year	
2 Calculate the time it takes light to travel a significant distance such as between objects in the Solar System	
3 Know that the Sun contains most of the mass of the Solar System and this explains why the planets orbit the Sun	6 Define orbital speed from the equation $v = \frac{2\pi r}{T}$ where r is the radius of the orbit and T is the orbital period; recall and use this equation

continued

P5 Space physics continued

P5.2 Stars and the Universe continued

P5.2.1 The Sun as a star continued

Core

4 Know that the force that keeps an object in orbit around the Sun is due to the gravitational attraction of the Sun

5 Know that the Sun is a star of medium size, consisting mostly of hydrogen and helium, and that it radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum

Supplement

7 Know that the strength of the Sun's gravitational field decreases and that the orbital speeds of the planets decrease as the distance from the Sun increases

8 Know that stars are powered by nuclear reactions that release energy and that in stable stars the nuclear reactions involve the fusion of hydrogen into helium

P5.2.2 Life cycle of stars

Core

1 Know that stable stars are formed as protostars from interstellar clouds of gas and dust due to gravitational attraction

2 Know that the next stages of the life cycle of a star depend on its mass:

(a) a small mass star (about the same mass as the Sun): red giant → white dwarf + planetary nebula

(b) a large mass star: red supergiant → supernova → neutron star

(c) a very large mass star: red supergiant → supernova → black hole

Supplement

3 Know that the nebula from a supernova may form new stars with orbiting planets

P5.2.3 Galaxies and the Universe

Core

1 Know that:

(a) galaxies are each made up of many billions of stars

(b) the Sun is a star in the galaxy known as the Milky Way

(c) other stars that make up the Milky Way are much further away from the Earth than the Sun is from the Earth

2 Know that the Milky Way is one of many billions of galaxies making up the Universe and that the diameter of the Milky Way is approximately 100 000 light-years

Supplement

3 Know that the Big Bang Theory is supported by many astronomical observations and states that:

(a) the Universe expanded from a single point of high density and temperature

(b) the Universe is still expanding

(c) the Universe is approximately 13.8 billion years old

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. The questions are based on the Core subject content only.

Paper 1: Multiple Choice (Core)		Paper 3: Theory (Core)
45 minutes		1 hour 15 minutes
40 marks		80 marks
40 compulsory multiple-choice items of the four-choice type		Compulsory short-answer and structured questions
This paper tests assessment objectives AO1 and AO2	**AND**	This paper tests assessment objectives AO1 and AO2
This paper assesses grades C to G		This paper assesses grades C to G
Externally assessed		Externally assessed

Extended assessment

Extended candidates take the following papers. The questions are based on the Core and Supplement subject content.

Paper 2: Multiple Choice (Extended)		Paper 4: Theory (Extended)
45 minutes		1 hour 15 minutes
40 marks		80 marks
40 compulsory multiple-choice items of the four-choice type		Compulsory short-answer and structured questions
This paper tests assessment objectives AO1 and AO2	**AND**	This paper tests assessment objectives AO1 and AO2
This paper assesses grades A* to G		This paper assesses grades A* to G
Externally assessed		Externally assessed

Practical assessment

All candidates take one practical paper from a choice of two.

Paper 5: Practical Test		Paper 6: Alternative to Practical
1 hour 15 minutes		1 hour
40 marks		40 marks
All items are compulsory		All items are compulsory
This paper tests assessment objective AO3	**OR**	This paper tests assessment objective AO3
Candidates will be required to do experiments in a laboratory as part of this test		Candidates will **not** be required to do experiments as part of this test
This paper assesses grades A* to G		This paper assesses grades A* to G
Externally assessed		Externally assessed

Questions in the practical papers are structured to assess performance across the full grade range.

Notes for use in qualitative analysis are provided for both Paper 5 and Paper 6.

The Practical Test and Alternative to Practical:

- require the same experimental skills to be developed and learned
- require an understanding of the same experimental contexts
- test the same assessment objective, AO3.

Candidates are expected to be familiar with and may be asked questions on the following experimental contexts:

Biology

- simple quantitative experiments, including the measurement of:
  - volumes of gases and liquids
  - masses
  - temperatures
  - times
  - lengths
- diffusion
- osmosis
- food tests
- rates of enzyme-catalysed reactions, including judging end-points, e.g. colour changes
- pH and the use of hydrogencarbonate indicator, litmus and universal indicator
- photosynthesis (rate and limiting factors)
- transpiration
- heart rate and breathing rate
- respiration
- observation and dissection of seeds and flowers
- germination
- observe, record and measure images of familiar and unfamiliar biological specimens
- make clear line drawings of biological specimens, calculating the magnification or actual size and adding labels as required
- procedures using simple apparatus in situations where the method may not be familiar to the candidate.

Chemistry

- simple quantitative experiments, including the measurement of:
  - volumes of gases or solutions/liquids
  - masses
  - temperatures
  - times
  - lengths
- rates of reaction
- salt preparation
- separation and purification techniques, including:
  - filtration
  - crystallisation
  - simple distillation
  - fractional distillation
  - chromatography
- electrolysis
- identification of metal ions, non-metal ions and gases
- chemical tests for water
- test-tube reactions of dilute acids
- tests for oxidising and reducing agents
- heating and cooling curves
- titrations
- solubility
- melting points and boiling points
- displacement reactions of metals and halogens
- temperature changes during reactions
- conditions under which iron rusts or other metals corrode
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate.

Physics

- measurement of physical quantities such as length, volume or force
- measurement of small distances or short intervals of time
- determining a derived quantity such as the value of a known resistance or the acceleration of an object
- testing and identifying the relationship between two variables such as between the potential difference across a wire and its length
- comparing measured quantities such as angles of reflection
- comparing derived quantities such as density
- cooling and heating, including measurement of temperature
- experiments using springs and balances
- timing motion or oscillations
- electric circuits, including the connection and reconnection of these circuits, and the measurement of current and potential difference
- optics experiments using equipment such as optics pins, mirrors, prisms, lenses, glass or Perspex blocks (both rectangular and semicircular), including the use of transparent, translucent and opaque substances to investigate the transmission of light
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate.

Candidates may be required to do the following:

- **demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate):**
  - identify apparatus from diagrams or descriptions
  - draw, complete or label diagrams of apparatus and biological specimens
  - use, or explain the use of, common techniques, apparatus and materials
  - select the most appropriate apparatus or method for the task and justify the choice made
  - describe tests (food tests, gas tests, qualitative tests, other tests)
  - describe and explain hazards and identify safety precautions
  - describe and explain techniques used to ensure the accuracy of observations and data
- **plan experiments and investigations:**
  - identify the independent variable and dependent variable
  - describe how and explain why variables should be controlled
  - suggest an appropriate number and range of values for the independent variable
  - suggest the most appropriate apparatus or technique and justify the choice made
  - describe experimental procedures, including a suitable control experiment
  - identify risks and suggest appropriate safety precautions
  - describe how to record the results of an experiment
  - describe how to process the results of an experiment to form a conclusion or to evaluate a prediction
  - make reasoned predictions of expected results
- **make and record observations, measurements and estimates:**
  - take readings from apparatus (analogue and digital) or from diagrams of apparatus
  - take readings with appropriate precision, reading to the nearest half-scale division where required
  - correct for zero errors where required
  - make observations, measurements or estimates that are in agreement with expected results or values
  - take sufficient observations or measurements, including repeats where appropriate
  - record qualitative observations from tests (including chemical tests, food tests, other tests)
  - record observations and measurements systematically, for example in a suitable table, to an appropriate degree of precision and using appropriate units
- **interpret and evaluate experimental observations and data:**
  - process data, including for use in further calculations or for graph plotting, using a calculator as appropriate
  - present data graphically, including the use of best-fit lines where appropriate
  - analyse and interpret observations and data, including data presented graphically
  - use interpolation and extrapolation graphically to determine a gradient or intercept
  - form conclusions justified by reference to observations and data and with appropriate explanation
  - evaluate the quality of observations and data, identifying any anomalous results and taking appropriate action
  - comment on and explain whether results are equal within the limits of experimental accuracy (assumed to be ± 10% at this level of study)
- **evaluate methods and suggest possible improvements:**
  - evaluate experimental arrangements, methods and techniques, including the control of variables
  - identify sources of error, including measurement error, random error and systematic error
  - identify possible causes of uncertainty in data or in a conclusion
  - suggest possible improvements to the apparatus, experimental arrangements, methods or techniques

Language of measurement

The following definitions have been taken or adapted from *The Language of Measurement* (2010), a guide from the Association for Science Education (ASE).

www.ase.org.uk

The definitions in the table below should be used by teachers during the course to encourage students to use the terminology correctly and consistently.

Candidates will **not** be required to recall the specific definition of these terms in the examinations.

true value	the value that would be obtained in an ideal measurement
measurement error	the difference between a measured value and the true value of a quantity
accuracy	a measurement result is described as accurate if it is close to the true value
precision	how close the measured values of a quantity are to each other
repeatability	a measurement is repeatable if the same or similar result is obtained when the measurement is repeated under the same conditions, using the same method, within the same experiment
reproducibility	a measurement is reproducible if the same or similar result is obtained when the measurement is made under either different conditions or by a different method or in a different experiment
validity of experimental design	an experiment is valid if the experiment tests what it says it will test. The experiment must be a fair test where only the independent variable and dependent variable may change, and controlled variables are kept constant
range	the maximum and minimum value of the independent or dependent variables
anomaly	an anomaly is a value in a set of results that appears to be outside the general pattern of the results, i.e. an extreme value that is either very high or very low in comparison to others
independent variable	independent variables are the variables that are changed in a scientific experiment by the scientist. Changing an independent variable may cause a change in the dependent variable
dependent variable	dependent variables are the variables that are observed or measured in a scientific experiment. Dependent variables may change based on changes made to the independent variables

Apparatus, materials and reagents

This list gives items that candidates should be familiar with using, whether they are taking the Practical Test or the Alternative to Practical. The list is divided into general apparatus for use across the syllabus, and then specific apparatus and materials for each of biology, chemistry and physics. Any queries on apparatus or materials can be sent to **info@cambridgeinternational.org**

These items should be available for use in the Practical Test. This list is not exhaustive and we may also require other items to be sourced for specific examinations. The Confidential Instructions we send before the Practical Test will give the detailed requirements for the examination.

Every effort is made to minimise the cost to and resources required by centres. Experiments will be designed around basic apparatus and materials which should be available in most school laboratories and are easily obtainable.

Hazard codes are used where relevant and in accordance with information provided by CLEAPSS (**www.cleapss.org.uk**). Students should be familiar with the meanings of these codes and terms but will **not** be assessed on them.

C corrosive
HH health hazard
F flammable
N hazardous to the aquatic environment
MH moderate hazard
T acutely toxic
O oxidising

The attention of centres is also drawn to any national and local regulations relating to safety, first aid and disposal of chemicals. 'Hazard data sheets' should be available from your chemical supplier.

Candidates must be provided with appropriate safety equipment, such as suitable eye protection and gloves, during practical work.

The Confidential Instructions will indicate which hazard symbols are applicable for the materials required for each Practical Test exam.

General apparatus

Other materials may be required for examinations.

- adhesive putty (e.g. Patafix, Blu Tack®)
- adhesive tape (e.g. Sellotape®)
- aluminium foil
- balance to measure up to 500 g, with precision of at least 0.1 g
- beakers or cups made of an insulating material such as polystyrene, approximately 200 cm^3
- beakers, squat form with lip, 100 cm^3, 250 cm^3, 400 cm^3, 1 dm^3
- bungs/stoppers to fit small test-tubes and large test-tubes/boiling tubes
- bungs/stoppers with delivery tubes to fit small test-tubes and boiling tubes/large test-tubes
- Bunsen burners
- card
- filter funnels
- filter paper

- forceps
- glass rods/stirring rods
- means of writing on glassware (e.g. wax pencils or water-resistant markers)
- measuring cylinders, 250 cm^3, 100 cm^3, 50 cm^3 or 25 cm^3, 10 cm^3 (ISO6706 or ISO4788 or grade B)
- metre ruler, graduated in mm
- Pasteur or dropping pipette (2.5 cm^3) or small plastic syringe (e.g. 5 cm^3)
- racks for test-tubes and boiling tubes
- test-tube holders for test-tubes and boiling tubes
- red and blue litmus paper
- retort stands, bosses and clamps
- ruler, 30 cm, graduated in mm
- S-hook
- scissors
- small dropping pipettes or teat pipettes
- stirring thermometers, –10 °C to +110 °C, with 1 °C graduations
- stop-clocks/stop-watches, reading to 0.1 s or better
- string
- syringes (without needles, various sizes, 1 cm^3, 5 cm^3, 10 cm^3)
- test-tubes (Pyrex or hard glass) – small test-tubes (125 mm × 16 mm) and large test-tubes/boiling tubes (150 mm × 25 mm)
- thread
- tracing paper
- tripods and gauzes
- universal indicator paper or solution
- wash bottles containing distilled or deionised water
- white tiles or other suitable cutting surfaces such as wooden board (rigid, 150 cm × 20 cm × 1.5 cm)

Biology

Apparatus

As well as the general apparatus, you may also need the following for biology.

- hand lenses (at least ×6 magnification)
- lamps for photosynthesis experiments
- means of cutting biological materials (e.g. scalpels or sharp knives)
- mounted needles or seekers or long pins with large heads
- partially permeable membrane (e.g. Visking® or dialysis tubing)
- Petri dishes
- spotting tiles

Chemicals, reagents and indicators

The list below is not meant to be comprehensive but shows the types of chemicals, reagents and indicators that the candidates should be familiar with.

- Benedict's solution
- biuret reagent (sodium or potassium hydroxide solution and copper sulfate solution)
- carbohydrates (starch, glucose, sucrose), proteins, lipids
- DCPIP (for use in Paper 5 and Paper 6 only)
- dilute acid
- dilute alkali
- distilled or deionised water
- enzymes (e.g. amylase, a protease, lipase)
- ethanol
- hydrogen peroxide solution
- indicators (universal indicator solution, hydrogencarbonate indicator, litmus solution)
- iodine in potassium iodide solution (iodine solution)
- limewater
- methylene blue dye
- petroleum jelly (Vaseline® or similar)
- sodium chloride
- sodium hydrogencarbonate (sodium bicarbonate)

Chemistry

Apparatus

As well as the general apparatus, you may also need the following for chemistry.

- burettes, 50 cm^3 (ISO385 or grade B)
- conical flasks, within the range 50 cm^3 to 250 cm^3
- flame test wires or alternative apparatus
- pipette fillers
- small funnels for filling burettes
- spatulas
- volumetric pipettes, 25 cm^3 (ISO648 or grade B)

Preparation of reagents

Detailed guidance on preparing the standard bench reagents and indicators listed here will **not** be given in the Confidential Instructions. The Confidential Instructions will refer supervisors to the preparations in this list.

Candidates are **not** expected to be familiar with the preparation of these reagents.

Please note, hazard symbols were accurate at the time of publication and may change.

Hazard	Label	Identify	Instructions
	dilute hydrochloric acid	1.0 mol / dm^3 HCl	Dilute 85 cm^3 of concentrated (35–37%; approximately 11 mol / dm^3) HCl **[C] [MH]** to 1 dm^3.
[C]	**dilute nitric acid**	1.0 mol / dm^3 HNO_3	Dilute 64 cm^3 of concentrated (70%) HNO_3 **[C] [O]** to 1 dm^3.
[MH]	**dilute sulfuric acid**	0.5 mol / dm^3 H_2SO_4	Cautiously pour 28 cm^3 of concentrated (98%) H_2SO_4 **[C]** into 500 cm^3 of distilled water with continuous stirring. Make the solution up to 1 dm^3 with distilled water. **Care:** concentrated H_2SO_4 is very corrosive.
[MH] [N]	**aqueous ammonia**	1.0 mol / dm^3 NH_3	Dilute 66 cm^3 of concentrated (35%) NH_3 **[C] [MH] [N]** to 1 dm^3.
[C]	**aqueous sodium hydroxide**	1.0 mol / dm^3 NaOH	Dissolve 40.0 g of NaOH **[C]** in each dm^3 of solution. **Care:** the process of solution is exothermic and any concentrated solution is very corrosive.
	aqueous barium nitrate	0.1 mol / dm^3 $Ba(NO_3)_2$	Dissolve 26.1 g of $Ba(NO_3)_2$ **[MH] [O]** in each dm^3 of solution.
	aqueous silver nitrate	0.05 mol / dm^3 $AgNO_3$	Dissolve 8.5 g of $AgNO_3$ **[C] [N] [O]** in each dm^3 of solution.
[MH]	**limewater**	saturated aqueous calcium hydroxide, $Ca(OH)_2$	Prepare fresh limewater by leaving distilled water to stand over solid $Ca(OH)_2$ **[C] [MH]** for several days, shaking occasionally. Decant or filter the solution.
	aqueous potassium iodide	0.1 mol / dm^3 KI	Dissolve 16.6 g of KI in each dm^3 of solution.
[C] [F] [HH] [MH] [N] [T]	**methyl orange indicator**	methyl orange indicator (pH range 3.1–4.4)	Use commercially produced solution or dissolve 0.4 g of solid methyl orange indicator **[C] [HH] [MH] [N] [T]** in 200 cm^3 of 95% ethanol **[F] [HH] [MH]** and make up to 1 dm^3 with distilled water.

Hazard	Label	Identify	Instructions
[C] [HH] [MH] [N] [T]	**screened methyl orange indicator**	screened methyl orange indicator (pH range 3.2–4.2)	Use commercially produced solution or dissolve 1 g of solid methyl orange indicator **[C] [HH] [MH] [N] [T]** and 2.6 g of xylene cyanol **[HH] [MH] [N]** in 1 dm^3 of water.
	starch indicator	freshly prepared aqueous starch indicator (approximately 2% solution)	Mix 2 g of soluble starch with a little cold water until a smooth paste is obtained. Add 100 cm^3 boiling water and stir. Boil until a clear solution is obtained (about 5 minutes).

Physics

Apparatus

As well as the general apparatus, you may also need the following for physics. The following suggested equipment has been categorised, but equipment can be used in any topic.

Mechanics

- expendable steel springs, with spring constant of approx. 0.25 N / cm
- force meter, with maximum reading or full scale deflection of between 1.0 N and 3.0 N
- G-clamp
- glass ball (marble), ball bearing (approx. 10 mm in diameter) and table tennis ball
- masses, 10 × 10 g, 10 × 100 g, including holders
- pendulum bob
- pivots (e.g. 15 cm nails, triangular wooden blocks)

Optics

- converging lens, spherical, +6.7 D (f = 15 cm)
- glass or Perspex 60° prism
- glass or Perspex blocks, rectangular and semicircular
- optics pins, minimum length 75 mm
- pin board
- plane mirror, approx. 75 mm × 25 mm
- protractor

Electricity

Candidates or centres may need to join components, meters and cells together to make circuits. Connectors used will be 3.5 mm or 4 mm in diameter.

- ammeter, with full scale deflection 1 A or 1.5 A and precision of at least 0.05 A (analogue, dedicated digital or multimeter)
- cells, 1.5 V and holders to enable several cells to be joined
- connecting leads, 3.5 mm or 4 mm connectors

- crocodile clips
- d.c. power supply, variable to 12 V
- filament lamps, low voltage (e.g. 2.5 V) and holders
- filament lamp, 12 V, 24 W and holder
- switches
- selection of resistors, values within range 5–50 Ω, power rating of 1–2 W
- set square
- voltmeter, with full scale deflection 5 V and precision of at least 0.1 V (analogue, dedicated digital or multimeter)
- wire, constantan (eureka), 0.38 mm diameter (28 swg), 0.32 mm diameter (30 swg)
- wire, nichrome, 0.38 mm diameter (28 swg), 0.32 mm diameter (30 swg)

Safety in the laboratory

Teachers should make sure that they do not contravene any school, education authority or government regulations. 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 2015 (available to CLEAPSS members only)

CLEAPSS Hazcards, 2019 update of 2016 edition (available to CLEAPSS members only)

UK regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002 and subsequent amendment in 2004

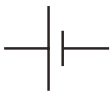
www.legislation.gov.uk/uksi/2002/2677/contents/made

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

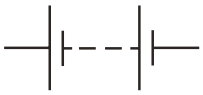
A brief guide may be found at

www.hse.gov.uk/pubns/indg136.pdf

Electrical symbols

cell 

battery of cells 

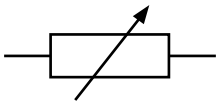
or 

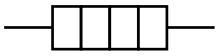
power supply 

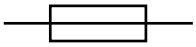
d.c. power supply 

a.c. power supply 

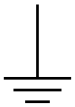
fixed resistor 

variable resistor 

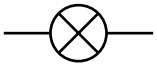
heater 

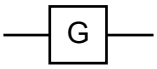
fuse 

switch 

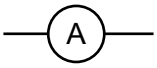
earth or ground 

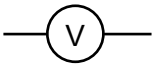
junction of conductors 

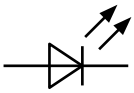
lamp 

generator 

motor 

ammeter 

voltmeter 

light-emitting diode 

electric bell 

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.

All candidates should be able to use the following multipliers: M mega, k kilo, c centi, m milli. Extended candidates should also be able to use the following multipliers: G giga, μ micro, n nano.

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
length	*l, h, d, s, x*	km, m, cm, mm			
area	*A*	m^2, cm^2			
volume	*V*	m^3, cm^3, dm^3			
weight	*W*	N			
mass	*m, M*	kg, g	mass	*m, M*	mg
time	*t*	h, min, s	time	*t*	ms, μs
density	*ρ*	g/cm^3, kg/m^3			
speed	*u, v*	km/h, m/s, cm/s			
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			
work done	*W*	J, kJ, MJ			
energy	*E*	J, kJ, MJ, kWh			
power	*P*	W, kW, MW			
pressure	*p*	N/m^2, N/cm^2	pressure	*p*	Pa
temperature	*θ*, ***T***	°C, K			
frequency	*f*	Hz, kHz			
wavelength	*λ*	m, cm	wavelength	*λ*	nm
focal length	*f*	m, cm			

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
angle of incidence	*i*	degree (°)			
angle of reflection	*r*	degree (°)			
angle of refraction	*r*	degree (°)			
potential difference/ voltage	*V*	V, mV, kV			
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, then test for carbon dioxide gas	effervescence, carbon dioxide produced
chloride, Cl^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide, Br^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide, I^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
sulfate, SO_4^{2-} [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
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, ppt. turns brown near surface on standing	green ppt., insoluble in excess, ppt. turns brown near surface on standing
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

Conventional abbreviations, such as ppt. for precipitate, may be used in the assessment.

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 of Elements

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											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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

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.).

Mathematical requirements

It is expected that these requirements will be covered as part of a mathematics curriculum at this level of study.

Calculators may be used in all parts of the examination.

Number

- add, subtract, multiply and divide
- use decimals, fractions, percentages, ratios and reciprocals
- convert between decimals, fractions and percentages
- calculate and use percentages and percentage change
- understand and use the symbols: =, <, >
- understand the meaning of sum, difference and product
- use standard form (scientific notation)
- understand that only the final answer in a calculation should be rounded
- use decimal places and significant figures appropriately
- make approximations and estimates to obtain reasonable answers

Algebra

- use positive, whole number indices in algebraic expressions
- substitute values of quantities into formulas, equations, using consistent units
- solve simple algebraic equations for any one term when the other terms are known
- recognise and use direct and inverse proportion
- set up simple algebraic equations as mathematical models of physical situations and to represent information given in words
- use Δ (delta) in algebraic expressions and equations to represent changes in a variable

Geometry and trigonometry

- apply Pythagoras' theorem to the calculation of a side of a right-angled triangle
- convert between metric units, e.g. cm^3, m^3 and dm^3; mg, g and kg; μm, mm, cm and m; J and kJ; Pa and kPa
- select and use the most appropriate units for recording data and the results of calculations
- recall and use the equation for the circumference of a circle
- recall and use the equations for the area of a rectangle, area of a triangle and area of a circle
- recall and use the equations for the volume of a rectangular block and volume of a cylinder
- recognise and use the points of the compass (N, S, E, W) and clockwise and anticlockwise directions
- make estimates of numbers, quantities and lengths
- understand surface area and use surface area : volume ratio
- use scale diagrams
- understand that a right angle is 90° and that the sum of the angles on a straight line is 180°
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and diagonal
- use mathematical instruments (ruler, compasses, protractor, set square)
- use trigonometric functions (sine, cosine, tangent and their inverses) (Extended physics only)

Graphs, charts and statistics

- draw graphs and charts from data
- interpret line graphs, bar charts, pie charts and histograms with equal intervals
- interpolate and extrapolate from data
- determine the gradient (slope) of a line on a graph, including by drawing a tangent to a curved line
- determine the intercept of the line on a graph, extending the line graphically (extrapolating) where appropriate
- select suitable scales and axes for graphs
- recognise direct and inverse proportionality from a graph
- calculate and use the average (mean) for a set of data
- use simple probability
- understand that $y = mx + c$ represents a linear relationship
- use and interpret Venn diagrams to show groupings and sets

Presentation of data

Taking readings

- Data values should be read from an instrument or from a diagram of an instrument to an accuracy of one half of one of the smallest divisions on the scale.
- Interpolation between scale divisions should be to an accuracy of one half of a division. That is, where a reading lies between two scale marks, it should be interpolated to the nearest half division.

Recording readings

- Data should be recorded so as to reflect the precision of the measuring instrument, i.e. the smallest difference that can reliably be detected on the measuring instrument scale should be reflected by the number of decimal places and unit given in the measurement.
- A measurement or calculated quantity must be accompanied by a correct unit, where appropriate.
- Each column of a table should be headed with the name or symbol of the measured or calculated quantity and the appropriate unit, e.g. time/s. The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts.
- Units should not be included with data in the body of a table.
- Each reading should be repeated, where appropriate, and recorded.
- The number of significant figures given for measured quantities should be appropriate to the measuring instrument used.
- The number of significant figures given for calculated quantities should be the same as the least number of significant figures in the raw data used in that specific calculation.
- A ratio should be expressed as $x : y$.

Drawing and analysing graphs

- The column headings of a table can be directly transferred to the axes of a constructed graph.
- A graph should be drawn with a sharp pencil.
- The axes should be labelled with the observation or name or symbol of the measured or calculated quantity and the appropriate unit, e.g. time/s.
- 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).
- Unless instructed otherwise, the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable (or 10, 20 or 50, etc.). The axes do not have to include (0, 0).
- Points on the graph should be clearly marked as plus signs (+), crosses (×) or encircled dots (⊙) of appropriate size.
- Each data point should be plotted to an accuracy of one half of one of the smallest squares on the grid.
- A best-fit line (trend line) should be a single, thin, smooth straight-line or curve, drawn by inspection. Mathematical or least-squares method of obtaining a best-fit line are **not** required. 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 and identified by the candidate should be ignored when drawing the best-fit line.
- A best-fit line or curve should only be drawn if there is good reason to believe that the intermediate values can be predicted.
- Candidates should be able to take readings from the graph by extrapolation or interpolation and indicate on the graph how they determined the reading.
- Data values should be read from a line on a graph to an accuracy of one half of one of the smallest squares on the grid. The same accuracy should be used in reading off an intercept.
- The gradient of a straight line should be taken using a triangle whose hypotenuse extends over at least half the length of the candidate's best-fit line, and this triangle should be marked on the graph.
- Calculation of the gradient should be to two or three significant figures.
- When the gradient or intercept of a graph is used in subsequent calculations, it will be assumed to have units consistent with the graph axes.

Drawings

- Drawings should be drawn using a sharp pencil to give fine lines that are clear and unbroken.
- Drawings should use most of the available space and show all the features observed in the specimen, with no shading or use of colour.
- Label lines should be drawn with a ruler and touch the object or feature labelled.

Charts

- Pie charts are generally used to show percentage or proportionality.
- Bar charts should be drawn for categorical or discrete data. They should be made up of bars of equal width that do **not** touch.
- Histograms should be drawn for continuous data. They should have bars that touch.

Further guidance can be found in the following publications:

ASE, The Language of Mathematics in Science: A Guide for Teachers of 11–16 Science (2016).

ASE, The Language of Mathematics in Science: Teaching Approaches (2016).

www.ase.org.uk/mathsinscience

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

Candidates are expected to be familar with the nomenclature in the syllabus.

The 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).

The traditional names sulfate, nitrate, sulfuric acid and nitric acid will be used in question papers. Candidates will be credited for traditional or systematic names in their answers.

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 digits, e.g. 4 256 789.

Variables

Independent variables are the variables that are changed in a scientific experiment by the scientist. Changing an independent variable may cause a change in the dependent variable.

Dependent variables are the variables that are observed or measured in a scientific experiment. Dependent variables may change based on changes made to the independent variables.

Units

To avoid any confusion concerning the symbol for litre, the equivalent quantity, the cubic decimetre (dm^3) will be used in place of *l* or litre.

In practical work, candidates will be expected to use SI units or, where appropriate, units approved by the BIPM for use with the SI (e.g. minute). A list of SI units and units approved for use with the SI may be found in the SI brochure at **www.bipm.org**. The use of imperial / customary units such as the inch and degree Fahrenheit are not acceptable and should be discouraged.

In all examinations, where data is supplied for use in questions, candidates will be expected to use units that are consistent with the units supplied and should not attempt conversion to other systems of units unless this is a requirement of the question.

Command words

Command words and their meanings help candidates know what is expected from them in the exams. The table below includes command words used in the assessment for this syllabus. The use of the command word will relate to the subject context.

Command word	What it means
Analyse	examine in detail to show meaning, identify elements and the relationship between them
Calculate	work out from given facts, figures or information
Comment	give an informed opinion
Compare	identify/comment on similarities and/or differences
Consider	review and respond to given information
Contrast	identify/comment on differences
Deduce	conclude from available information
Define	give precise meaning
Demonstrate	show how or give an example
Describe	state the points of a topic / give characteristics and main features
Determine	establish an answer using the information available
Discuss	write about issue(s) or topic(s) in depth in a structured way
Evaluate	judge or calculate the quality, importance, amount, or value of something
Examine	investigate closely, in detail
Explain	set out purposes or reasons / make the relationships between things clear / say why and/or how and support with relevant evidence
Give	produce an answer from a given source or recall/memory
Identify	name/select/recognise
Justify	support a case with evidence/argument
Outline	set out the main points
Predict	suggest what may happen based on available information
Show (that)	provide structured evidence that leads to a given result
Sketch	make a simple freehand drawing showing the key features, taking care over proportions
State	express in clear terms
Suggest	apply knowledge and understanding to situations where there are a range of valid responses in order to make proposals / put forward considerations

5 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 to require about 130 guided learning hours for each subject. This is for guidance only. The number of hours a learner needs to achieve the qualification may vary according to each school and the learners' 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. Find your administrative zone at **www.cambridgeinternational.org/adminzone**

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

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

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

Private candidates can enter for this syllabus. For more information, please refer to the *Cambridge Guide to Making Entries*.

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 Biology (0610)
- Cambridge IGCSE (9–1) Biology (0970)
- Cambridge IGCSE Chemistry (0620)
- Cambridge IGCSE (9–1) Chemistry (0971)
- Cambridge IGCSE Physics (0625)
- Cambridge IGCSE (9–1) Physics (0972)
- Cambridge IGCSE Co-ordinated Sciences (Double Award) (0654)
- Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973)
- Cambridge IGCSE Physical Science (0652)
- Cambridge O Level Physics (5054)
- Cambridge O Level Chemistry (5070)
- Cambridge O Level Biology (5090)
- 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 encourages schools to offer a broad and balanced curriculum by recognising the achievements of learners who pass exams 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. 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 access to 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 an 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 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.

Learn more about retake entries, including definitions and information on entry deadlines, at **www.cambridgeinternational.org/retakes**

To confirm what entry options are available for this syllabus, refer to the *Cambridge Guide to Making Entries* for the relevant series. Regulations for carrying forward component marks can be found in the *Cambridge Handbook* for the relevant year of assessment at **www.cambridgeinternational.org/eoguide**

Language

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

Accessibility and equality

Syllabus and assessment design

At Cambridge we recognise that our candidates have highly diverse socio-economic, cultural and linguistic backgrounds, and may also have a variety of protected characteristics. Protected characteristics include special educational needs and disability (SEND), religion and belief, and characteristics related to gender and identity.

We follow accessible design principles to make our syllabuses and assessment materials as accessible and inclusive as possible. We review language accessibility, visual resources, question layout and the contexts used in questions. Using this approach means that we give all candidates the fairest possible opportunity to demonstrate their knowledge, skills and understanding.

Access arrangements

Our design principles aim to make sure our assessment materials are accessible for all candidates. To further minimise barriers faced by candidates with SEND, illness or injury, we offer a range of access arrangements and modified papers. This is the principal way in which we comply with our duty to make 'reasonable adjustments', as guided by the UK Equality Act 2010.

Important:

Requested access arrangements should be based on evidence of the candidate's barrier to taking an assessment and should also reflect their normal way of working. For Cambridge to approve an access arrangement, we need to agree that it constitutes a reasonable adjustment and does not affect the security or integrity of the assessment. This is explained in section 1.3 of the *Cambridge Handbook* **www.cambridgeinternational.org/eoguide**

Applying for access arrangements

- Details of our standard access arrangements and modified question papers are available in section 1.3 of the *Cambridge Handbook* **www.cambridgeinternational.org/eoguide**
- Centres are expected to check the availability of access arrangements and modified question papers at the start of the course. Check the *Cambridge Handbook*, the assessment objectives listed in the syllabus document and, where applicable, any access arrangement restrictions listed in the syllabus document.
- Contact us at the start of the course to find out if we can approve an access arrangement that is not listed in the *Cambridge Handbook*.
- All applications should be made by the deadlines published in the *Cambridge Handbook*.

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).

These letters do not appear on the certificate.

On the statement of results, Cambridge IGCSE is shown as INTERNATIONAL GENERAL CERTIFICATE OF SECONDARY EDUCATION (IGCSE).

On certificates, Cambridge IGCSE is shown as International General Certificate of Secondary Education.

How students and teachers can use the grades

Assessment at Cambridge IGCSE has two purposes:

1 to measure learning and achievement

The assessment confirms achievement and performance in relation to the knowledge, understanding and skills specified in the syllabus.

2 to show likely future success

The outcomes help predict which students are well prepared for or likely to be successful in a particular course or career.

The outcomes help students choose the most suitable course or career.

Changes to this syllabus for 2028 and 2029

The syllabus has been updated. This is version 1, published September 2025.

You must read the whole syllabus before planning your teaching programme. We review our syllabuses regularly to make sure they continue to meet the needs of our schools. In updating this syllabus, we have made it easier for teachers and students to understand, keeping the familiar features that teachers and schools value.

There are no significant changes which affect teaching.

Any textbooks endorsed to support the syllabus for examination from 2025 are still suitable for use with this syllabus.

Syllabuses and specimen materials represent the final authority on the content and structure of all of our assessments.

With a Customer Services team available 24 hours a day, 6 days a week, and dedicated regional teams supporting schools in 160 countries, we understand your local context and are here to guide you so you can provide your learners with everything they need to prepare for Cambridge IGCSE.

Quality management

We are committed to providing exceptional quality. In line with this commitment, our quality management system for the provision of international education programmes and qualifications for students aged 5 to 19 is independently certified as meeting the internationally recognised standard, ISO 9001:2015.
Learn more at **www.cambridgeinternational.org/about-us/our-standards/**

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

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

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