CAMBRIDGE
International Examinations

Cambridge
IGCSE

SYLLABUS

Cambridge IGCSE®
Co-ordinated Sciences (Double Award)

0654

For examination in June and November 2016

Cambridge Secondary 2

Version 2

Changes to syllabus for 2016

This is version 2 of the syllabus, released February 2015.

- Text relating to teacher accreditation from January 2016 has been removed from page 15.

More information is available in the February 2015 update for this syllabus.

|| The changes in version 2 of this syllabus, released February 2015, are indicated by double black vertical lines on either side of the text. ||

Changes in version 1 of the syllabus, released February 2014:

- Please note that the format of the Period Table has changed in this version of the syllabus (2016) to reflect current practice. The examination papers sat in 2016 will contain this version of the Periodic Table.

| The changes in version 1 of this syllabus, released February 2014 are indicated by single vertical lines on either side of the text. |

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

Contents

1. Introduction

1.1 Why choose Cambridge?

Recognition

Cambridge International Examinations is the world's largest provider of international education programmes and qualifications for learners aged 5 to 19. We are part of Cambridge Assessment, a department of the University of Cambridge, trusted for excellence in education. Our qualifications are recognised by the world's universities and employers.

Cambridge IGCSE® (International General Certificate of Secondary Education) is internationally recognised by schools, universities and employers as equivalent in demand to UK GCSEs. Learn more at **www.cie.org.uk/recognition**

Excellence in education

Our mission is to deliver world-class international education through the provision of high-quality curricula, assessment and services.

More than 9000 schools are part of our Cambridge learning community. We support teachers in over 160 countries who offer their learners an international education based on our curricula and leading to our qualifications. Every year, thousands of learners use Cambridge qualifications to gain places at universities around the world.

Our syllabuses are reviewed and updated regularly so that they reflect the latest thinking of international experts and practitioners and take account of the different national contexts in which they are taught.

Cambridge programmes and qualifications are designed to support learners in becoming:

- **confident** in working with information and ideas – their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **reflective** as learners, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference

Support for teachers

A wide range of materials and resources is available to support teachers and learners in Cambridge schools. Resources suit a variety of teaching methods in different international contexts. Through subject discussion forums and training, teachers can access the expert advice they need for teaching our qualifications. More details can be found in Section 2 of this syllabus and at **www.cie.org.uk/teachers**

Support for exams officers

Exams officers can trust in reliable, efficient administration of exams entries and excellent personal support from our customer services. Learn more at **www.cie.org.uk/examsofficers**

Not-for-profit, part of the University of Cambridge

We are a not-for-profit organisation where the needs of the teachers and learners are at the core of what we do. We continually invest in educational research and respond to feedback from our customers in order to improve our qualifications, products and services.

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

1.2 Why choose Cambridge IGCSE?

Cambridge IGCSEs are international in outlook, but retain a local relevance. The syllabuses provide opportunities for contextualised learning and the content has been created to suit a wide variety of schools, avoid cultural bias and develop essential lifelong skills, including creative thinking and problem-solving.

Our aim is to balance knowledge, understanding and skills in our programmes and qualifications to enable candidates to become effective learners and to provide a solid foundation for their continuing educational journey.

Through our professional development courses and our support materials for Cambridge IGCSEs, we provide the tools to enable teachers to prepare learners to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge IGCSEs are considered to be an excellent preparation for Cambridge International AS and A Levels, the Cambridge AICE (Advanced International Certificate of Education) Group Award, Cambridge Pre-U, and other education programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge IGCSEs at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge IGCSE syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of the course. As this is a double award the guided learning hours are about 260 hours, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

1.3 Why choose Cambridge IGCSE Co-ordinated Sciences (Double Award)?

A double award, Cambridge IGCSE Co-ordinated Sciences gives candidates the opportunity to study biology, chemistry and physics within a scientifically coherent syllabus. Candidates learn about the basic principles of each subject through a mix of theoretical and practical studies, while also developing an understanding of the scientific skills essential for further study.

Candidates learn how science is studied and practised, and become aware that the results of scientific research can have both good and bad effects on individuals, communities and the environment. As well as focusing on the individual sciences, the syllabus enables candidates to better understand the technological world they live in, and take an informed interest in science and scientific developments.

The syllabus is aimed at candidates across a very wide range of attainments, and will allow them to show success over the full range of grades from A*A* to GG.

The syllabus is part of a suite of Cambridge IGCSE Sciences. One particular feature of the Co-ordinated Sciences (Double Award) is that it is a subset of the separate sciences (Triple Award) and that Combined Science (Single Award) is a subset of the Co-ordinated Sciences. This enables co-teaching of Cambridge's Science courses which allows Centres greater flexibility in timetabling, teaching and also entering candidates for the most appropriate examination.

Prior learning

We recommend that candidates who are beginning this course should have previously studied a science curriculum such as that of the Cambridge Lower Secondary Programme or equivalent national educational frameworks. Candidates should also have adequate mathematical skills for the content contained in this syllabus.

Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades CC to A*A* in Cambridge IGCSE Co-ordinated Sciences are well prepared to follow courses leading to Cambridge International AS and A Level sciences, or the equivalent.

1.4 Cambridge ICE (International Certificate of Education)

Cambridge ICE is a group award for Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognising the achievements of learners who pass examinations in at least seven subjects. To qualify for the Cambridge ICE award learners are required to have studied subjects from five groups: two languages from Group 1, and one subject from each of the remaining four groups. The seventh subject can be taken from any of the five subject groups.

Co-ordinated Sciences (Double Award) is in Group 3, Science.

Learn more about Cambridge ICE at **www.cie.org.uk/cambridgesecondary2**

The Cambridge ICE is awarded from examinations administered in the June and November series each year.

1.5 How can I find out more?

If you are already a Cambridge school

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at **info@cie.org.uk**

If you are not yet a Cambridge school

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**. Email us at **info@cie.org.uk** to find out how your organisation can register to become a Cambridge school.

2. Teacher support

2.1 Support materials

Cambridge syllabuses, past question papers and examiner reports to cover the last examination series are on the *Syllabus and Support Materials* DVD, which we send to all Cambridge schools.

You can also go to our public website at **www.cie.org.uk/igcse** to download current and future syllabuses together with specimen papers or past question papers and examiner reports from one series.

For teachers at registered Cambridge schools a range of additional support materials for specific syllabuses is available from Teacher Support, our secure online support for Cambridge teachers. Go to **http://teachers.cie.org.uk** (username and password required).

2.2 Resource lists

We work with publishers providing a range of resources for our syllabuses including textbooks, websites, CDs, etc. Any endorsed, recommended and suggested resources are listed on both our public website and on Teacher Support.

The resource lists can be filtered to show all resources or just those which are endorsed or recommended by Cambridge. Resources endorsed by Cambridge go through a detailed quality assurance process and are written to align closely with the Cambridge syllabus they support.

2.3 Training

We offer a range of support activities for teachers to ensure they have the relevant knowledge and skills to deliver our qualifications. See **www.cie.org.uk/events** for further information.

3. Syllabus content at a glance

B1. Characteristics of living organisms

B2. Cells

2.1 Cell structure
2.2 Movement in and out of cells

B3. Enzymes

B4. Nutrition

4.1 Nutrients
4.2 Plant nutrition
4.3 Animal nutrition

B5. Transportation

5.1 Transport in plants
5.2 Transport in humans

B6. Respiration

6.1 Aerobic and anaerobic respiration
6.2 Gas exchange

B7. Co-ordination and response

7.1 Nervous control in humans
7.2 Hormones
7.3 Tropic responses
7.4 Homeostasis

B8. Reproduction

8.1 Asexual and sexual reproduction
8.2 Sexual reproduction in plants
8.3 Sexual reproduction in humans

B9. Inheritance

9.1 Chromosomes and genes
9.2 Cell division
9.3 Monohybrid inheritance
9.4 Variation and selection

B10. Energy flow in ecosystems

B11. Human influences on the ecosystem

C1. The particulate nature of matter

C2. Experimental techniques

2.1 Methods of separation and purification

C3. Atoms, elements and compounds

- 3.1 Physical and chemical changes
- 3.2 Elements, compounds and mixtures
- 3.3 Atomic structure and the Periodic Table
- 3.4 Ions and ionic bonds
- 3.5 Molecules and covalent bonds
- 3.6 Giant structures

C4. Stoichiometry

- 4.1 The mole concept

C5. Electricity and chemistry

C6. Energy changes in chemical reactions

- 6.1 Energetics of a reaction

C7. Chemical reactions

- 7.1 Speed of reaction
- 7.2 Redox

C8. Acids, bases and salts

- 8.1 The characteristic properties of acids and bases
- 8.2 Types of oxides
- 8.3 Preparation of salts
- 8.4 Identification of ions and gases

C9. The Periodic Table

- 9.1 Periodic trends
- 9.2 Group properties
- 9.3 Transition elements
- 9.4 Noble gases

C10. Metals

- 10.1 Properties of metals
- 10.2 Reactivity series
- 10.3 Extraction of metals
- 10.4 Uses of metals

C11. Air and water

C12. Sulfur

C13. Carbonates

C14. Organic chemistry

- 14.1 Fuels
- 14.2 Introduction to organic compounds
- 14.3 Hydrocarbons
- 14.4 Alcohols
- 14.5 Macromolecules
- 14.6 Synthetic polymers
- 14.7 Natural macromolecules

P1. Motion

P2. Matter and forces

2.1 Mass and weight
2.2 Density
2.3 Effects of forces
2.4 Pressure

P3. Energy, work and power

3.1 Energy
3.2 Energy resources
3.3 Work
3.4 Power

P4. Simple kinetic molecular model of matter

4.1 States of matter
4.2 Molecular model
4.3 Evaporation
4.4 Pressure changes

P5. Matter and thermal properties

5.1 Thermal expansion of solids, liquids and gases
5.2 Thermal capacity
5.3 Melting and boiling

P6. Transfer of thermal energy

6.1 Conduction
6.2 Convection
6.3 Radiation
6.4 Consequences of energy transfer

P7. Waves

7.1 General wave properties

P8. Light

8.1 Reflection of light
8.2 Refraction of light
8.3 Thin converging lens
8.4 Dispersion of light

P9. Electromagnetic spectrum

P10. Sound

P11. Magnetism

P12. Electricity

12.1 Electrical quantities
12.2 Electric charge
12.3 Current, electromotive force and potential difference
12.4 Resistance
12.5 Electrical energy
12.6 Dangers of electricity

P13. Electric circuits

13.1 Circuit diagrams
13.2 Series and parallel circuits
13.3 Action and use of circuit components

P14. Electromagnetic effects

14.1 Electromagnetic induction
14.2 a.c. generator
14.3 Transformer
14.4 The magnetic effect of a current
14.5 Force on a current-carrying conductor
14.6 d.c. motor

P15. Radioactivity

15.1 Detection of radioactivity
15.2 Characteristics of the three kinds of emission
15.3 Radioactive decay
15.4 Half-life
15.5 Safety precautions
15.6 The nuclear atom
15.7 Isotopes

4. Assessment at a glance

Candidates are awarded grades A*A* to GG.

Candidates expected to achieve grades DD, EE, FF or GG study the core syllabus content only and are eligible for grades CC to GG.

Candidates expected to achieve grades CC or higher should study the core and supplementary syllabus content.

All candidates must enter for **three** papers.

<table>
<tr><th colspan="2">Candidates take:</th></tr>
<tr><td colspan="2">Paper 1 (30% of total marks)
(45 minutes)
A multiple choice paper consisting of 40 items of the four-choice type.</td></tr>
<tr><th>and either:</th><th>or:</th></tr>
<tr><td>Paper 2 (50% of total marks)
(2 hours)
Core curriculum – Grades C to G available
Core theory paper consisting of short-answer and structured questions, based on the core curriculum.</td><td>Paper 3 (50% of total marks)
(2 hours)
Extended curriculum – Grades A* to G available
Extended theory paper consisting of short-answer and structured questions. The questions will be based on all of the material, both from the core and supplement, and will allow candidates across the full ability range to demonstrate their knowledge and understanding.</td></tr>
<tr><th colspan="2">and:</th></tr>
<tr><td colspan="2">Practical assessment (20% of total marks)
either: Paper 4 Coursework
or: Paper 5 Practical Test (2 hours)
or: Paper 6 Alternative to Practical (1 hour)</td></tr>
</table>

Availability

This syllabus is examined in the June and November examination series.

This syllabus is available to private candidates.

Detailed timetables are available from **www.cie.org.uk/examsofficers**

Centres in the UK that receive government funding are advised to consult the Cambridge website **www.cie.org.uk** for the latest information before beginning to teach this syllabus.

Combining this with other syllabuses

Candidates can combine this syllabus in an examination series with any other Cambridge syllabus, except:

- syllabuses with the same title at the same level
- 0610 Cambridge IGCSE Biology
- 0620 Cambridge IGCSE Chemistry
- 0625 Cambridge IGCSE Physics
- 0652 Cambridge IGCSE Physical Science
- 0653 Cambridge IGCSE Combined Science
- 5054 Cambridge O Level Physics
- 5070 Cambridge O Level Chemistry
- 5090 Cambridge O Level Biology
- 5129 Cambridge O Level Combined Science

Please note that Cambridge IGCSE, Cambridge International Level 1/Level 2 Certificate and Cambridge O Level syllabuses are at the same level.

5. Syllabus aims and assessment objectives

5.1 Aims

The aims of the syllabus below are not listed in order of priority.

The aims are:

1. to provide a worthwhile educational experience for all candidates, through well-designed studies of experimental and practical science, whether or not they go on to study science beyond this level. In particular, candidates' studies should enable them to acquire understanding and knowledge of the concepts, principles and applications of biology, chemistry and physics and, where appropriate, other related sciences so that they may
   - become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific importance
   - recognise the usefulness, and limitations, of scientific method and appreciate its applicability in other disciplines and in everyday life
   - be suitably prepared for studies beyond Cambridge IGCSE in pure science, in applied sciences or in science-dependent vocational courses
2. to develop abilities and skills that
   - are relevant to the study and practice of science
   - are useful in everyday life
   - encourage safe practice
   - encourage effective communication
3. to stimulate
   - curiosity, interest and enjoyment in science and its methods of enquiry
   - interest in, and care for, the environment
4. to promote an awareness that
   - the study and practice of science are co-operative and cumulative activities subject to social, economic, technological, ethical and cultural influences and limitations
   - the applications of science may be both beneficial and detrimental to the individual, the community and the environment
   - the concepts of science are of a developing and sometimes transient nature
   - science transcends national boundaries and that the language of science is universal

In addition to these general aims, Cambridge IGCSE Co-ordinated Sciences seeks:

5. to emphasise that some principles and concepts are common to all science, while others are more particular to the separate sciences of biology, chemistry and physics
6. to promote interdisciplinary enquiry through practical investigations and through the co-ordination of the subject matter of the three separate sciences

5.2 Assessment objectives

The three assessment objectives in Co-ordinated Sciences are:

A Knowledge with understanding
B Handling information and problem solving
C Experimental skills and investigations

A description of each assessment objective follows.

A Knowledge with understanding

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

- 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 quantities and their determination
- scientific and technological applications with their social, economic and environmental implications

The curriculum content defines the factual material that candidates may be required to recall and explain. Questions testing this will often begin with one of the following words: *define, state, describe, explain* or *outline*.

B Handling information and problem solving

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

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

These skills cannot be precisely specified in the curriculum content, because questions testing such skills are often based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts in the syllabus and apply them in a logical, deductive manner to a new situation. Questions testing these skills will often begin with one of the following words: *discuss, predict, suggest, calculate* or *determine*.

C Experimental skills and investigations

Students should be able to:

- use techniques, apparatus and materials (including the following of a sequence of instructions where appropriate)
- make and record observations, measurements and estimates
- interpret and evaluate experimental observations and data
- plan investigations and/or evaluate methods, and suggest possible improvements (including the selection of techniques, apparatus and materials)

5.3 Scheme of assessment

All candidates must enter for three papers: Paper 1; *either* Paper 2 *or* Paper 3; *one from* Papers 4, 5 or 6.

Candidates who have only studied the core syllabus content or who are expected to achieve grade DD or below should normally be entered for Paper 2.

Candidates who have studied the extended syllabus content, and who are expected to achieve grade CC or above, should be entered for Paper 3.

Candidates take:

Paper 1 **(30% of total marks)**

(45 minutes)

A multiple choice paper consisting of 40 items of the four-choice type.

The questions will be based on the core syllabus content, will be of a difficulty appropriate to grades C to G, and will test skills mainly in Assessment Objectives A and B.

and either:

Paper 2 **(50% of total marks)**

(2 hours)

Core curriculum – Grades C to G available

Core theory paper consisting of short-answer and structured questions, based on the core curriculum.

The questions will be of a difficulty appropriate to grades C to G and will test skills mainly in Assessment Objectives A and B.

120 marks

or:

Paper 3 **(50% of total marks)**

(2 hours)

Extended curriculum – Grades A to G available*

Extended theory paper consisting of short-answer and structured questions. The questions will be based on all of the material, from both the core and supplement, and will allow candidates to demonstrate their knowledge and understanding.

The questions will be of a difficulty appropriate to the higher grades and will test skills mainly in Assessment Objectives A and B.

120 marks

and:

Practical assessment * **(20% of total marks)**

either:	Paper 4	Coursework – a school-based assessment of practical skills **
or:	Paper 5	Practical Test (2 hours) – with questions covering experimental and observational skills
or:	Paper 6	Alternative to Practical (1 hour) – a written paper designed to test familiarity with laboratory based procedures

* Scientific subjects are, by their nature, experimental. So, it is important that an assessment of a candidate's knowledge and understanding of science should contain a component relating to practical work and experimental skills (see Assessment Objective C). Because schools and colleges have different circumstances – such as the availability of resources – three different means of assessment are provided: school-based assessment, a formal practical test and an 'alternative to practical' paper.

** Teachers may not undertake school-based assessment without the written approval of Cambridge. This will only be given to teachers who satisfy Cambridge requirements concerning moderation.

NB The Periodic Table will be included in Papers 1, 2 and 3.

5.4 Weightings

The approximate weightings allocated to each of the assessment objectives in the assessment model are summarised in the table below.

Assessment objective	Weighting
A Knowledge with understanding	50% (not more than 25% recall)
B Handling information and problem solving	30%
C Experimental skills and investigations	20%

The relationship between the assessment objectives and the scheme of assessment is set out in the table below. All the figures given below are for guidance only and have a tolerance of ±2%.

Assessment objective	Paper 1 (%)	Paper 2 or 3 (%)	Paper 4, 5 or 6 (%)	Whole assessment (%)
A Knowledge with understanding	20	30	–	50
B Handling information and problem solving	10	20	–	30
C Experimental skills and investigations	–	–	20	20

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

Syllabuses and question papers will conform with generally accepted international practice.

In particular, attention is drawn to the following documents, published in the UK, which will be used as guidelines.

(a) Reports produced by the Association for Science Education (ASE):
- *SI Units, Signs, Symbols and Abbreviations* (1981)
- *Chemical Nomenclature, Symbols and Terminology for use in school science* (1985)
- *Signs, Symbols and Systematics: The ASE Companion to 16–19 Science* (2000)

(b) Reports produced by the Society of Biology (in association with the ASE):
- *Biological Nomenclature, Standard terms and expressions used in the teaching of biology* Fourth Edition (2009)

Litre/dm^3

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

Decimal markers

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

Numbers

Numbers from 1000 to 9999 will be printed without commas or spaces. Numbers greater than or equal to 10000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4256789.

Experimental work

Experimental work is an essential component of all science. Experimental work within science education

- gives candidates first-hand experience of phenomena
- enables candidates to acquire practical skills
- provides candidates with the opportunity to plan and carry out investigations into practical problems

This can be achieved by individual or group experimental work, or by demonstrations which actively involve the candidates.

6. Syllabus content

The syllabus content that follows is divided into three sections: Biology (B1–B11), Chemistry (C1–C14) and Physics (P1–P15). **Candidates must study all three sections.**

Candidates can follow either the core curriculum only, or they can follow the extended syllabus which includes both the core and the supplement. Candidates aiming for grades A*A* to CC should follow the extended syllabus.

Note:

1. The syllabus content is designed to provide guidance to teachers as to what will be assessed in the overall evaluation of the candidate. It is not meant to limit, in any way, the teaching programme of any particular school or college.
2. The content is set out in topic areas within biology, chemistry and physics. Each topic area is divided into a number of sections. The left-hand column provides amplification of the core content, which all candidates must study. The right-hand column outlines the supplementary content, which should be studied by candidates following the extended syllabus content.

The syllabus content below is a guide to the areas on which candidates are assessed.

It is important that, throughout this course, teachers should make candidates aware of the relevance of the concepts studied to everyday life, and to the natural and man-made worlds.

In particular, attention should be drawn to:

- the finite nature of the world's resources, the impact of human activities on the environment, and the need for recycling and conservation
- economic considerations for agriculture and industry, such as the availability and cost of raw materials and energy
- the importance of natural and man-made materials, including chemicals, in both industry and everyday life

Specific content has been limited in order to encourage this approach, and to allow flexibility in the design of teaching programmes. Cambridge provides science schemes of work which teachers may find helpful; these can be found on the Cambridge Teacher Support website.

6.1 Biology

Core	Supplement
B1. Characteristics of living organisms	
1 List and describe the characteristics of living organisms.	2 Define the terms: • *nutrition* as taking in of nutrients which are organic substances and mineral ions, containing raw materials or energy for growth and tissue repair, absorbing and assimilating them, • *excretion* as removal from organisms of toxic materials, the waste products of metabolism (chemical reactions in cells including respiration) and substances in excess of requirements, • *respiration* as the chemical reactions that break down nutrient molecules in living cells to release energy, • *sensitivity* as the ability to detect or sense changes in the environment (stimuli) and to make responses, • *reproduction* as the processes that make more of the same kind of organism, • *growth* as a permanent increase in size and dry mass by an increase in cell number or cell size or both, • *movement* as an action by an organism or part of an organism causing a change of position or place.

Core	Supplement
B2. Cells	
2.1 Cell structure	
1 State that living organisms are made of cells. 2 Identify and describe the structure of a plant cell (palisade cell) and an animal cell (liver cell), as seen under a light microscope. 3 Describe the differences in structure between typical animal and plant cells. 6 Calculate magnification and size of biological specimens using millimetres as units.	4 Relate the structures seen under the light microscope in the plant cell and in the animal cell to their functions. 5 Relate the structure of the following to their functions • red blood cells – transport, • root hair cells – absorption.
2.2 Movement in and out of cells	
1 Define *diffusion* as the net movement of molecules from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of their random movement. 2 Describe the importance of diffusion of gases and solutes and of water as a solvent.	3 Define *osmosis* as the diffusion of water molecules from a region of their higher concentration (dilute solution) to a region of their lower concentration (concentrated solution), through a partially permeable membrane. 4 Describe the importance of osmosis in the uptake of water by plants, and its effects on plant and animal tissues. 5 Describe and explain the importance of a water potential gradient in the uptake of water by plants.

Core	Supplement
B3. Enzymes	
1 Define *enzymes* as proteins that function as biological catalysts. 2 Investigate and describe the effect of changes in temperature and pH on enzyme activity.	3 Explain the effect of changes in temperature and pH on enzyme activity.
B4. Nutrition	
4.1 Nutrients	
1 List the chemical elements that make up: • carbohydrates, • fats, • proteins. 3 Describe the structure of large molecules made from smaller basic units, i.e. • simple sugars to starch and glycogen, • amino acids to proteins, • fatty acids and glycerol to fats and oils. 4 Describe tests for: • starch (iodine solution), • reducing sugars (Benedict's solution), • protein (biuret test), • fats (ethanol).	2 Define *nutrition* as taking in of nutrients which are organic substances and mineral ions, containing raw materials or energy for growth and tissue repair, absorbing and assimilating them.
5 List the principal sources of, and describe the importance of: • carbohydrates, • fats, • proteins, • vitamins (C and D only), • mineral salts (calcium and iron only), • fibre (roughage), • water. 7 Describe the deficiency symptoms for: • vitamins (C and D only), • mineral salts (calcium and iron only).	6 Describe the use of microorganisms in the manufacture of yoghurt.

Core	Supplement
4.2 Plant nutrition	
1 Define *photosynthesis* as the fundamental process by which plants manufacture carbohydrates from raw materials using energy from light. 3 State the word equation for the production of simple sugars and oxygen. 5 Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls. 7 Describe the intake of carbon dioxide and water by plants. 8 Identify and label the cuticle, cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the light microscope and describe the significance of the features of a leaf in terms of functions, to include: • distribution of chloroplasts – photosynthesis, • stomata and mesophyll cells – gas exchange, • vascular bundles (xylem and phloem) – transport and support. 9 Describe the importance of: • nitrate ions for protein synthesis, • magnesium ions for chlorophyll synthesis.	2 Explain that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage. 4 State the balanced equation for photosynthesis in symbols $6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$ 6 Investigate and state the effect of varying light intensity on the rate of photosynthesis (e.g. in submerged aquatic plants). 10 Explain the effects of nitrate ion and magnesium ion deficiency on plant growth. 11 Describe the uses, and the dangers of overuse, of nitrogen-containing fertilisers.
4.3 Animal nutrition	
1 State what is meant by the term balanced diet and describe a balanced diet related to age, sex and activity of an individual. 3 Define *ingestion* as taking substances (e.g. food, drink) into the body through the mouth. 4 Define *egestion* as passing out of food that has not been digested, as faeces, through the anus.	2 Describe the effects of malnutrition in relation to starvation, coronary heart disease, constipation and obesity.

Core	Supplement
5 Identify the main regions of the alimentary canal and associated organs including mouth, salivary glands, oesophagus, stomach, small intestine: duodenum and ileum, pancreas, liver, gall bladder, large intestine: colon and rectum, anus.	
6 Describe the functions of the regions of the alimentary canal listed above, in relation to ingestion, digestion, absorption, assimilation and egestion of food.	
7 Define *digestion* as the break-down of large, insoluble food molecules into small, water-soluble molecules using mechanical and chemical processes.	
8 Identify the types of human teeth and describe their structure and functions.	
9 State the causes of dental decay and describe the proper care of teeth.	
10 State the significance of chemical digestion in the alimentary canal in producing small, soluble molecules that can be absorbed.	11 Outline the role of bile in emulsifying fats, to increase the surface area for the action of enzymes.
12 State where, in the alimentary canal, amylase, protease and lipase enzymes are secreted.	
13 State the functions of a typical amylase, a protease and a lipase, listing the substrate and end-products.	
14 Define *absorption* as movement of digested food molecules through the wall of the intestine into the blood.	15 Describe the significance of villi in increasing the internal surface area of the small intestine.
16 Identify the small intestine as the region for the absorption of digested food.	17 Describe the structure of a villus, including the role of capillaries and lacteals.
18 Describe the role of the liver in the metabolism of glucose (glucose → glycogen).	
19 Describe the role of fat as an energy storage substance.	

Core	Supplement
B5. Transportation	
5.1 Transport in plants	
1 State the functions of xylem and phloem. 2 Identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves. 3 Identify root hair cells, as seen under the light microscope, and state their functions. 5 State the pathway taken by water through root, stem and leaf (root hair, root cortex cells, xylem, mesophyll cells). 6 Investigate, using a suitable stain, the pathway of water through the above-ground parts of a plant. 7 Define *transpiration* as evaporation of water at the surfaces of the mesophyll cells followed by loss of water vapour from plant leaves, through the stomata. 9 Describe the effects of variation of temperature, humidity and light intensity on transpiration rate.	4 Relate the structure and functions of root hairs to their surface area and to water and ion uptake. 8 Describe how water vapour loss is related to cell surfaces, air spaces and stomata. 10 Explain the mechanism of water uptake and movement in terms of transpiration producing a tension ('pull') from above, creating a water potential gradient in the xylem, drawing cohesive water molecules up the plant. 11 Define *translocation* in terms of the movement of sucrose and amino acids in phloem; from regions of production to regions of storage OR to regions of utilisation in respiration or growth.

Core	Supplement
5.2 Transport in humans	
1 Describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood.	2 Describe double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits.
3 Describe the structure of the heart including the muscular wall and septum, atria, ventricles, valves and associated blood vessels.	4 Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible causes (diet, stress and smoking) and preventive measures.
5 Describe the function of the heart in terms of muscular contraction and the working of the valves.	
6 Investigate the effect of physical activity on pulse rate.	7 Investigate, state and explain the effect of physical activity on pulse rate.
8 Name the main blood vessels to and from the heart, lungs, liver and kidney.	
9 Describe the structure and functions of arteries, veins and capillaries.	10 Explain how structure and function are related in arteries, veins and capillaries.
11 Identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs.	
12 List the components of blood as red blood cells, white blood cells, platelets and plasma.	
13 State the functions of blood: • red blood cells – haemoglobin and oxygen transport, • white blood cells – phagocytosis and antibody formation, • platelets – causing clotting (no details), • plasma – transport of blood cells, ions, soluble nutrients, hormones and carbon dioxide.	14 Describe the immune system in terms of antibody production, tissue rejection and phagocytosis.

Core	Supplement
B6. Respiration	
6.1 Aerobic and anaerobic respiration	
1 Define *respiration* as the chemical reactions that break down nutrient molecules in living cells to release energy. 2 State the uses of energy in the body of humans: muscle contraction, protein synthesis, cell division, growth, the passage of nerve impulses and the maintenance of a constant body temperature. 3 State the word equation for aerobic respiration.	4 Define *aerobic respiration* as the release of a relatively large amount of energy in cells by the breakdown of food substances in the presence of oxygen. 5 State the equation for aerobic respiration using symbols ($C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$). 6 Define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen. 7 State the word equation for anaerobic respiration in muscles during hard exercise (glucose → lactic acid) and the microorganism yeast (glucose → alcohol + carbon dioxide). 8 Describe the effect of lactic acid in muscles during exercise (include oxygen debt in outline only). 9 Describe the role of anaerobic respiration in yeast during brewing and bread-making. 10 Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released.

Core	Supplement
6.2 Gas exchange	
1 Identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries.	2 List the features of gas exchange surfaces in animals. 3 Explain the role of mucus and cilia in protecting the gas exchange system from pathogens and particles. 4 Describe the effects of tobacco smoke and its major toxic components (tar, nicotine, carbon monoxide, smoke particles) on the gas exchange system.
5 State the differences in composition between inspired and expired air. 6 Use limewater as a test for carbon dioxide to investigate the differences in composition between inspired and expired air.	
7 Investigate and describe the effects of physical activity on rate and depth of breathing.	8 Explain the effects of physical activity on rate and depth of breathing.
B7. Co-ordination and response	
7.1 Nervous control in humans	
1 Describe the human nervous system in terms of the central nervous system (brain and spinal cord as areas of co-ordination) and the peripheral nervous system which together serve to co-ordinate and regulate body functions. 3 Identify motor (effector), relay (connector) and sensory neurones from diagrams. 4 Describe a simple reflex arc in terms of sensory, relay and motor neurones, and a reflex action as a means of automatically and rapidly integrating and co-ordinating stimuli with responses.	2 Describe the structure and function of the eye, including accommodation and pupil reflex.

Core	Supplement
7.2 Hormones	
1 Define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver. 2 State the role of the hormone adrenaline in the chemical control of metabolic activity, including increasing the blood glucose concentration and pulse rate. 3 Give examples of situations in which adrenaline secretion increases.	4 Compare nervous and hormonal control systems.
7.3 Tropic responses	
1 Define and investigate *geotropism* (as a response in which a plant grows towards or away from gravity) and *phototropism* (as a response in which a plant grows towards or away from the direction from which light is coming).	2 Explain the chemical control of plant growth by auxins including geotropism and phototropism in terms of auxins regulating differential growth.
7.4 Homeostasis	
1 Define *homeostasis* as the maintenance of a constant internal environment. 2 Identify, on a diagram of the skin: hairs, sweat glands, temperature receptors, blood vessels and fatty tissue. 3 Describe the maintenance of a constant body temperature in humans in terms of insulation and the role of temperature receptors in the skin, sweating, shivering, vasodilation and vasoconstriction of arterioles supplying skin-surface capillaries and the co-ordinating role of the brain.	4 Explain the concept of control by negative feedback. 5 Describe the control of the glucose content of the blood by the liver, and by insulin and glucagon from the pancreas.

Core	Supplement
B8. Reproduction	
8.1 Asexual and sexual reproduction	
1 Define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent. 3 Define *sexual reproduction* as the process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring.	2 Discuss the advantages and disadvantages to a species of asexual reproduction. 4 Discuss the advantages and disadvantages to a species of sexual reproduction.
8.2 Sexual reproduction in plants	
1 Identify and draw, using a hand lens if necessary, the sepals, petals, stamens, anthers, carpels, ovaries and stigmas of one, locally available, named, insect-pollinated, dicotyledonous flower, and examine the pollen grains under a light microscope or in photomicrographs. 3 State the functions of the sepals, petals, anthers, stigmas and ovaries. 4 Candidates should expect to apply their understanding of the flowers they have studied to unfamiliar flowers. 5 Define *pollination* as the transfer of pollen grains from the male part of the plant (anther of stamen) to the female part of the plant (stigma). 6 Name the agents of pollination. 8 Investigate and state the environmental conditions that affect germination of seeds: requirement for water and oxygen, suitable temperature.	2 Use a hand lens to identify and describe the anthers and stigmas of one, locally available, named, wind-pollinated flower. 7 Compare the different structural adaptations of insect-pollinated and wind-pollinated flowers. 9 Investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and testa, protected by the fruit. 10 State that seed and fruit dispersal by wind and by animals provides a means of colonising new areas. 11 Describe, using named examples, seed and fruit dispersal by wind and by animals.

Core	Supplement
8.3 Sexual reproduction in humans	
1 Identify on diagrams of the male reproductive system, the testes, scrotum, sperm ducts, prostate gland, urethra and penis, and state the functions of these parts.	2 Compare male and female gametes in terms of size, numbers and mobility.
3 Identify on diagrams of the female reproductive system, the ovaries, oviducts, uterus, cervix and vagina, and state the functions of these parts.	
4 Describe the menstrual cycle in terms of changes in the uterus and ovaries.	
5 Describe fertilisation in terms of the joining of the nuclei of male gamete (sperm) and the female gamete (egg).	
6 Outline early development of the zygote simply in terms of the formation of a ball of cells that becomes implanted in the wall of the uterus.	7 Indicate the functions of the amniotic sac and amniotic fluid. 8 Describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (no structural details are required). 9 Describe the advantages and disadvantages of breast-feeding compared with bottle-feeding using formula milk.
10 Describe the methods of transmission of human immunodeficiency virus (HIV), and the ways in which HIV/AIDS can be prevented from spreading.	11 Outline how HIV affects the immune system in a person with HIV/AIDS.

Core	Supplement
B9. Inheritance	
9.1 Chromosomes and genes	
1 Define *inheritance* as the transmission of genetic information from generation to generation. 2 Define the terms: • *chromosome* as a thread of DNA, made up of a string of genes, • *gene* as a length of DNA that is the unit of heredity and codes for a specific protein. A gene may be copied and passed on to the next generation, • *allele* as any of two or more alternative forms of a gene. 4 Describe the inheritance of sex in humans (XX and XY chromosomes).	3 Define the terms: • *haploid nucleus* as a nucleus containing a single set of unpaired chromosomes (e.g. sperm and egg), • *diploid nucleus* as a nucleus containing two sets of chromosomes (e.g. in body cells).
9.2 Cell division	
	1 Define *mitosis* as nuclear division giving rise to genetically identical cells in which the chromosome number is maintained by the exact duplication of chromosomes (details of stages are **not** required). 2 State the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction. 3 Define *meiosis* as reduction division in which the chromosome number is halved from diploid to haploid (details of stages are **not** required). 4 State that gametes are the result of meiosis. 5 State that meiosis results in genetic variation so the cells produced are not all genetically identical.

Core	Supplement
9.3 Monohybrid inheritance	
1 Define the terms: • *genotype* as the genetic makeup of an organism in terms of the alleles present (e.g. Tt or GG), • *phenotype* as the physical or other features of an organism due to both its genotype and its environment (e.g. tall plant or green seed), • *homozygous* as having two identical alleles of a particular gene (e.g. TT or gg). Two identical homozygous individuals that breed together will be pure-breeding, • *heterozygous* as having two different alleles of a particular gene (e.g. Tt or Gg), not pure-breeding, • *dominant* as an allele that is expressed if it is present (e.g. T or G), • *recessive* as an allele that is only expressed when there is no dominant allele of the gene present (e.g. t or g). 2 Calculate and predict the results of monohybrid crosses involving 1 : 1 and 3 : 1 ratios.	

Core	Supplement
9.4 Variation and selection	
	1 State that continuous variation is influenced by genes and environment, resulting in a range of phenotypes between two extremes, e.g. height in humans. 2 State that discontinuous variation is caused by genes alone and results in a limited number of distinct phenotypes with no intermediates, e.g. A, B, AB and O blood groups in humans. 3 Define *mutation* as a change in a gene or chromosome. 4 Outline the effects of ionising radiation on the rate of mutation.
5 Describe the role of artificial selection in the production of varieties of animals and plants with increased economic importance. 7 Define *natural selection* as the greater chance of passing on of genes by the best adapted organisms.	6 Describe variation and state that competition leads to differential survival of, and reproduction by, those organisms best fitted to the environment. 8 Explain the importance of natural selection as a possible mechanism for evolution. 9 Describe the development of strains of antibiotic resistant bacteria as an example of natural selection.

Core	Supplement
B10. Energy flow in ecosystems	
1 State that the Sun is the principal source of energy input to biological systems. 2 Define the terms: • *food chain* as a chart showing the flow of energy (food) from one organism to the next beginning with a producer (e.g. mahogany tree → caterpillar → song bird → hawk), • *food web* as a network of interconnected food chains showing the energy flow through part of an ecosystem, • *producer* as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis, • *consumer* as an organism that gets its energy by feeding on other organisms, • *herbivore* as an animal that gets its energy by eating plants, • *carnivore* as an animal that gets its energy by eating other animals.	3 Describe energy losses between trophic levels. 4 Define the terms: • *decomposer* as an organism that gets its energy from dead or waste organic matter, • *ecosystem* as a unit containing all of the organisms and their environment, interacting together, in a given area, e.g. decomposing log or a lake, • *trophic level* as the position of an organism in a food chain or food web. 5 Explain why food chains usually have fewer than five trophic levels.
6 Describe the carbon cycle.	7 Discuss the effects of the combustion of fossil fuels and the cutting down of forests on the oxygen and carbon dioxide concentrations in the atmosphere.

Core	Supplement
B11. Human influences on the ecosystem	
1 List the undesirable effects of deforestation (to include extinction, loss of soil, flooding, carbon dioxide build up). 3 Describe the undesirable effects of pollution to include: • water pollution by sewage and chemical waste, • air pollution by greenhouse gases (carbon dioxide and methane) contributing to global warming. 6 Describe the need for conservation of: • species and their habitats, • natural resources (limited to water and non-renewable materials including fossil fuels).	2 Describe the undesirable effects of overuse of fertilisers (to include eutrophication of lakes and rivers). 4 Discuss the causes and effects on the environment of acid rain, and the measures that might be taken to reduce its incidence. 5 Explain how increases in greenhouse gases (carbon dioxide and methane) are thought to cause global warming.

6.2 Chemistry

Core	Supplement
C1. The particulate nature of matter	
See P4.1 and P4.2 for details of essential common content. 1 Demonstrate understanding of the terms *atom* and *molecule.*	
C2. Experimental techniques	
2.1 Methods of separation and purification	
1 Describe paper chromatography. 2 Interpret simple chromatograms. 3 Describe methods of separation and purification: filtration, crystallisation, distillation, fractional distillation. 4 Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs. 6 Suggest suitable purification techniques, given information about the substances involved.	5 Identify substances and assess their purity from melting point and boiling point information.
C3. Atoms, elements and compounds	
3.1 Physical and chemical changes	
1 Identify physical and chemical changes, and understand the differences between them.	
3.2 Elements, compounds and mixtures	
1 Describe the differences between elements, compounds and mixtures.	2 Demonstrate understanding of the concepts of element, compound and mixture.

Core	Supplement
3.3 Atomic structure and the Periodic Table	
1 Describe the structure of an atom in terms of electrons and a nucleus containing protons and neutrons. 3 State the relative charges and approximate relative masses of protons, neutrons and electrons. 4 Define *proton number* and *nucleon number.* 5 Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see C9), with special reference to the elements with proton numbers 1 to 20. 6 Define *isotopes.*	2 Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of valency electrons (the ideas of the distribution of electrons in s and p orbitals and in d block elements are **not** required).
3.4 Ions and ionic bonds	
1 Describe the formation of ions by electron loss or gain. 2 Describe the formation of ionic bonds between metals and non-metals as exemplified by elements from Groups I and VII.	3 Explain the formation of ionic bonds between metallic and non-metallic elements. 4 Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions, exemplified by the sodium chloride structure.
3.5 Molecules and covalent bonds	
1 State that non-metallic elements form non-ionic compounds using a different type of bonding called covalent bonding. 3 Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds.	2 Draw dot-and-cross diagrams to represent the sharing of electron pairs to form single covalent bonds in simple molecules, exemplified by (but not restricted to) H_2, Cl_2, H_2O, CH_4 and HCl. 4 Draw dot-and-cross diagrams to represent the multiple bonding in N_2, C_2H_4 and CO_2.

Core	Supplement
3.6 Giant structures	
	1 Describe the giant covalent structures of graphite and diamond. 2 Relate their structures to the use of graphite as a lubricant and of diamond in cutting. 3 Describe the structure of silicon(IV) oxide (silicon dioxide).
C4. Stoichiometry	
1 Use the symbols of the elements to write the formulae of simple compounds. 2 Deduce the formula of a simple compound from the relative numbers of atoms present. 3 Deduce the formula of a simple compound from a model or a diagrammatic representation. 4 Construct and use word equations.	5 Determine the formula of an ionic compound from the charges on the ions present. 6 Construct and use symbolic equations with state symbols, including ionic equations. 7 Deduce the balanced equation for a chemical reaction, given relevant information. 8 Define *relative atomic mass*, A_r. 9 Define *relative molecular mass*, M_r, as the sum of the relative atomic masses (*relative formula mass* or M_r will be used for ionic compounds).

Core	Supplement
4.1 The mole concept	
	1 Define the *mole* in terms of a specific number of particles called Avogadro's constant. (Questions requiring recall of Avogadro's constant will not be set.) 2 Use the molar gas volume, taken as 24 dm^3 at room temperature and pressure. 3 Calculate stoichiometric reacting masses and reacting volumes of solutions; solution concentrations will be expressed in mol / dm^3. (Calculations involving the idea of limiting reactants may be set.)
C5. Electricity and chemistry	
1 State that electrolysis is the chemical effect of electricity on ionic compounds, causing them to break up into simpler substances, usually elements. 2 Use the terms *electrode*, *electrolyte*, *anode* and *cathode.* 4 Describe the electrode products, using inert electrodes, in the electrolysis of: • molten lead(II) bromide, • aqueous copper chloride, • dilute sulfuric acid.	3 Describe electrolysis in terms of the ions present and the reactions at the electrodes. 5 State and use the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode). 6 Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper).
7 Describe the electroplating of metals, using laboratory apparatus.	8 Predict the products of the electrolysis of a specified binary compound in the molten state, or in aqueous solution. 9 Describe, in outline, the chemistry of the manufacture of: • aluminium from pure aluminium oxide in molten cryolite, • chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride.
C6. Energy changes in chemical reactions	

Core	Supplement
6.1 Energetics of a reaction	
1 Relate the terms *exothermic* and *endothermic* to the temperature changes observed during chemical reactions.	2 Demonstrate understanding that exothermic and endothermic changes relate to the transformation of chemical energy to heat (thermal energy), and vice versa.
C7. Chemical reactions	
7.1 Speed of reaction	
1 Describe the effect of concentration, particle size, catalysis and temperature on the speeds of reactions. 2 Describe a practical method for investigating the speed of a reaction involving gas evolution. 3 Devise a suitable method for investigating the effect of a given variable on the speed of a reaction. 5 Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. mines). 7 Define catalyst as an agent which increases rate but which remains unchanged.	4 Interpret data obtained from experiments concerned with speed of reaction. 6 Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles (concept of activation energy will not be examined).
7.2 Redox	
1 Define *oxidation* and *reduction* in terms of oxygen loss/gain, and identify such reactions from given information.	2 Define *redox* in terms of electron transfer, and identify such reactions from given information.

Core	Supplement
C8. Acids, bases and salts	
8.1 The characteristic properties of acids and bases	
1 Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using full-range indicator and litmus. 2 Describe the characteristic reactions between acids and metals, bases (including alkalis) and carbonates. 3 Describe and explain the importance of controlling acidity in the environment (air, water and soil).	
8.2 Types of oxides	
1 Classify oxides as either acidic or basic, related to the metallic and non-metallic character of the other element in the oxide.	2 Further classify some other oxides as neutral, given relevant information.
8.3 Preparation of salts	
1 Describe the preparation, separation and purification of salts using techniques selected from section C2.1 and the reactions specified in section C8.1.	2 Suggest a method of making a given salt from suitable starting materials, given appropriate information.

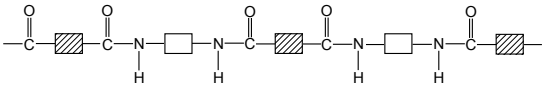
Core	Supplement
8.4 Identification of ions and gases	
1 Use the following tests to identify: **aqueous cations:** • *ammonium*, *copper(II)*, *iron(II)*, *iron(III)* and *zinc* by means of aqueous sodium hydroxide and aqueous ammonia as appropriate. (Formulae of complex ions are **not** required.) **anions:** • *carbonate* by means of dilute acid and then limewater, • *chloride* by means of aqueous silver nitrate under acidic conditions, • *nitrate* by reduction with aluminium, • *sulfate* by means of aqueous barium ions under acidic conditions, **gases:** • *ammonia* by means of damp red litmus paper, • *carbon dioxide* by means of limewater, • *chlorine* by means of damp litmus paper, • *hydrogen* by means of a lighted splint, • *oxygen* by means of a glowing splint.	
C9. The Periodic Table	
1 Describe the way the Periodic Table classifies elements in order of proton number.	2 Use the Periodic Table to predict properties of elements by means of groups and periods.
9.1 Periodic trends	
1 Describe the change from metallic to non-metallic character across a period.	2 Describe the relationship between Group number, number of outer-shell (valency) electrons and metallic/non-metallic character.

Core	Supplement
9.2 Group properties	
1 Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point and reaction with water. 3 Describe the trends in properties of chlorine, bromine and iodine in Group VII including colour, physical state and reactions with other halide ions.	2 Predict the properties of other elements in Group I, given data where appropriate. 4 Predict the properties of other elements in Group VII, given data where appropriate.
9.3 Transition elements	
1 Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts.	
9.4 Noble gases	
1 Describe the noble gases as being unreactive. 2 Describe the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons.	
C10. Metals	
10.1 Properties of metals	
1 Distinguish between metals and non-metals by their general physical and chemical properties. 3 Explain why metals are often used in the form of alloys.	2 Identify and interpret diagrams that represent the structure of an alloy.
10.2 Reactivity series	
1 Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, hydrogen and copper, by reference to the reactions, if any, of the elements with • water or steam, • dilute hydrochloric acid (except for alkali metals).	2 Compare the reactivity series to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with: • the aqueous ions of other listed metals, • the oxides of the other listed metals. 3 Deduce an order of reactivity from a given set of experimental results.

Core	Supplement
10.3 Extraction of metals	
1 Describe the use of carbon in the extraction of some metals from their ores.	2 Describe the essential reactions in the extraction of iron in the blast furnace. 3 Relate the method of extraction of a metal from its ore to its position in the reactivity series.
10.4 Uses of metals	
1 Explain the use of aluminium in aircraft manufacture in terms of the properties of the metal and alloys made from it. 3 Explain the use of aluminium in food containers because of its resistance to corrosion.	2 Explain the use of zinc for galvanising steel, and for sacrificial protection.

Core	Supplement
C11. Air and water	
1 Describe a chemical test for water. 2 Describe and explain, in outline, the purification of the water supply by filtration and chlorination. 3 State some of the uses of water in industry and in the home. 5 Describe the composition of clean air as being a mixture of 78% nitrogen, 21% oxygen and small quantities of noble gases, water vapour and carbon dioxide. 6 State the common air pollutants as carbon monoxide, sulfur dioxide and oxides of nitrogen, and describe their sources. 9 State the adverse effect of common air pollutants on buildings and on health. 10 Describe the formation of carbon dioxide: • as a product of complete combustion of carbon-containing substances, • as a product of respiration, • as a product of the reaction between an acid and a carbonate, • as a product of thermal decomposition. 12 Describe the rusting of iron in terms of a reaction involving air and water, and simple methods of rust prevention, including paint and other coatings to exclude oxygen. 13 Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers. 14 Describe the displacement of ammonia from its salts by warming with an alkali.	4 Describe the separation of oxygen and nitrogen from liquid air by fractional distillation. 7 Explain the presence of oxides of nitrogen in car exhausts and their catalytic removal. 8 Explain why the proportion of carbon dioxide in the atmosphere is increasing, and why this is important. 11 Describe the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air.
C12. Sulfur	
	1 Describe the manufacture of sulfuric acid by the Contact process, including essential conditions. 2 Describe the properties of dilute sulfuric acid as a typical acid.

Core	Supplement
C13. Carbonates	
1 Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reactions involved, and its uses in treating acidic soil and neutralising industrial waste products.	
C14. Organic chemistry	
14.1 Fuels	
1 Recall coal, natural gas and petroleum as fossil fuels that produce carbon dioxide on combustion. 3 Name methane as the main constituent of natural gas. 4 Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation. 5 State the use of: • refinery gas for bottled gas for heating and cooking, • gasoline fraction for fuel (petrol) in cars, • diesel oil / gas oil for fuel in diesel engines.	2 Understand the essential principle of fractional distillation in terms of differing boiling points (ranges) of fractions related to molecular size and intermolecular attractive forces.
14.2 Introduction to organic compounds	
1 Identify and draw the structures of methane, ethane, ethene and ethanol. 3 State the type of compound present, given a chemical name ending in *-ane*, *-ene* and *-ol*, or a molecular structure.	2 Describe the concept of homologous series of alkanes and alkenes as families of compounds with similar properties. 4 Name, identify and draw the structures of the unbranched alkanes and alkenes (not *cis-trans*), containing up to four carbon atoms per molecule.

Core	Supplement
14.3 Hydrocarbons	
1 Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning. 2 State that the products of complete combustion of hydrocarbons, exemplified by methane, are carbon dioxide and water. 3 Name *cracking* as a reaction which produces alkenes. 5 Recognise saturated and unsaturated hydrocarbons • from molecular structures, • by their reaction with aqueous bromine.	4 Describe the manufacture of alkenes by cracking. 6 Describe the addition reactions of alkenes, exemplified by ethene, with bromine, hydrogen and steam.
14.4 Alcohols	
1 State that ethanol may be formed by reaction between ethene and steam. 3 Describe the complete combustion reaction of ethanol. 4 State the uses of ethanol as a solvent and as a fuel.	2 Describe the formation of ethanol by the catalytic addition of steam to ethene.
14.5 Macromolecules	
	1 Describe macromolecules in terms of large molecules built up from small units (monomers), different macromolecules having different units.
14.6 Synthetic polymers	
1 Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units.	2 Draw the structure of poly(ethene). 3 Describe the formation of a simple condensation polymer exemplified by nylon, the structure of nylon being represented as: 

Core	Supplement
14.7 Natural macromolecules	
	1 Describe proteins as possessing the same (amide) linkages as nylon but formed from the linking of amino acids. 2 State that proteins can be hydrolysed to amino acids under acid or alkaline conditions. (Structures and names are **not** required.)

6.3 Physics

Core	Supplement
P1. Motion	
1 Define speed and calculate average speed from $\frac{\text{total distance}}{\text{total time}}$. 3 Plot and interpret a speed/time graph and a distance/time graph. 4 Recognise from the shape of a speed/time graph when a body is: • at rest, • moving with constant speed, • moving with changing speed. 8 Demonstrate a qualitative understanding that acceleration is related to changing speed.	2 Distinguish between speed and velocity. 5 Recognise linear motion for which the acceleration is constant and calculate the acceleration. 6 Recognise motion for which the acceleration is not constant. 7 Calculate the area under a speed/time graph to work out the distance travelled for motion with constant acceleration.
P2. Matter and forces	
2.1 Mass and weight	
1 Be able to distinguish between the mass and weight of an object. 3 Know that the Earth is the source of a gravitational field.	2 Demonstrate understanding that mass is a property that 'resists' change in motion. 4 Describe, and use the concept of, weight as the effect of a gravitational field on a mass.
2.2 Density	
1 Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation using the equation density = mass/volume or $d = m/v$. 2 Describe the determination of the density of an irregularly shaped solid by the method of displacement, and make the necessary calculation.	

Core	Supplement
2.3 Effects of forces	
1 Know that a force is measured in newtons (N). 2 Describe how forces may change the size, shape and motion of a body. 3 Plot extension / load graphs and describe the associated experimental procedure. 8 Find the resultant of two or more forces acting along the same line. 9 Explain how a system is in equilibrium when there is no resultant force.	4 Interpret extension / load graphs. 5 State and use Hooke's Law and recall and use the expression force = constant × extension ($F = kx$) 6 Recognise the significance of the term 'limit of proportionality' for an extension / load graph. 7 Recall and use the relation between force, mass and acceleration (including the direction), $F = ma$
2.4 Pressure	
1 Relate (without calculation) pressure to force and area.	2 Recall and use the equation $P = F/A$
P3. Energy, work and power	
3.1 Energy	
1 Know that energy and work are measured in joules (J), and power in watts (W). 2 Demonstrate understanding that an object may have energy due to its motion (kinetic) or its position (potential), and that energy may be transferred and stored. 4 Give and identify examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, thermal (heat), electrical, light and sound. 5 Give and identify examples of the conversion of energy from one form to another, and of its transfer from one place to another.	3 Recall and use the expressions K.E. = ½ mv^2 and P.E. = mgh 6 Apply the principle of energy conservation to simple examples.

Core	Supplement
3.2 Energy resources	
1 Distinguish between renewable and non-renewable sources of energy. 3 Know that the Sun is the source of energy for all our energy resources except geothermal and nuclear. 4 Describe how electricity or other useful forms of energy may be obtained from: • chemical energy stored in fuel, • water, including the energy stored in waves, in tides, and in water behind hydroelectric dams, • geothermal resources, • nuclear fission, • heat and light from the Sun (solar cells and panels), • wind. 5 Give advantages and disadvantages of each method in terms of reliability, scale and environmental impact. 7 Demonstrate a qualitative understanding of efficiency.	2 Demonstrate understanding that energy is released by nuclear fusion in the Sun. 6 Recall and use the equation: $\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$
3.3 Work	
1 Relate (without calculation) work done to the magnitude of a force and the distance moved.	2 Describe energy changes in terms of work done. 3 Recall and use $W = F \times d$
3.4 Power	
1 Relate (without calculation) power to work done and time taken, using appropriate examples.	2 Recall and use the equation $P = E / t$ in simple systems.
P4. Simple kinetic molecular model of matter	
4.1 States of matter	
1 State the distinguishing properties of solids, liquids and gases.	

Core	Supplement
4.2 Molecular model	
1 Describe qualitatively the molecular structure of solids, liquids and gases. 3 Interpret the temperature of a gas in terms of the motion of its molecules. 4 Describe qualitatively the pressure of a gas in terms of the motion of its molecules. 5 Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume.	2 Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules.
4.3 Evaporation	
1 Describe evaporation in terms of the escape of more energetic molecules from the surface of a liquid. 3 Relate evaporation to the consequent cooling.	2 Demonstrate understanding of how temperature, surface area and air flow over a surface influence evaporation.
4.4 Pressure changes	
	1 Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature and use the equation pV = constant at constant temperature.
P5. Matter and thermal properties	
5.1 Thermal expansion of solids, liquids and gases	
1 Describe qualitatively the thermal expansion of solids, liquids and gases. 3 Identify and explain some of the everyday applications and consequences of thermal expansion. 4 Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure.	2 Explain in terms of motion and arrangement of molecules the relative order of magnitude of the expansion of solids, liquids and gases.

Core	Supplement
5.2 Thermal capacity	
	1 Demonstrate understanding of the term thermal capacity. 2 Describe an experiment to measure the specific heat capacity of a substance. 3 Recall and use the equation: energy = mass × specific heat capacity × change in temperature
5.3 Melting and boiling	
1 Describe melting and boiling in terms of energy input without a change in temperature. 3 Describe condensation and solidification. 5 State the meaning of *melting point* and *boiling point*.	2 Distinguish between boiling and evaporation. 4 Use the terms *latent heat of vaporisation* and *latent heat of fusion* and give a molecular interpretation of latent heat.
P6. Transfer of thermal energy	
6.1 Conduction	
1 Describe experiments to demonstrate the properties of good and bad conductors of heat.	2 Explain heat transfer in solids in terms of molecular motion.
6.2 Convection	
1 Recognise convection as the main method of heat transfer in liquids and gases. 3 Describe experiments to illustrate convection in liquids and gases.	2 Relate convection in fluids to density changes.
6.3 Radiation	
1 Recognise radiation as the method of heat transfer that does not require a medium to travel through. 3 Identify infra-red radiation as the part of the electromagnetic spectrum often involved in heat transfer by radiation.	2 Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation.
6.4 Consequences of energy transfer	
1 Identify and explain some of the everyday applications and consequences of conduction, convection and radiation.	

Core	Supplement
P7. Waves	
7.1 General wave properties	
1 Demonstrate understanding that wave motion transfers energy without transferring matter in the direction of wave travel. 2 Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves. 3 State the meaning of and use the terms *speed*, *frequency*, *wavelength* and *amplitude*. 5 Distinguish between transverse and longitudinal waves and give suitable examples. 6 Identify how a wave can be reflected off a plane barrier and can change direction as its speed changes.	4 Recall and use the equation $v = f\lambda$ 7 Interpret reflection and refraction using wave theory.
P8. Light	
8.1 Reflection of light	
1 Describe the formation and characteristics of an optical image seen in a plane mirror. 3 Use the law angle of incidence = angle of reflection.	2 Perform simple constructions, measurements and calculations based on reflections in plane mirrors.
8.2 Refraction of light	
1 Describe an experimental demonstration of the refraction of light. 2 Describe, using ray diagrams, the passage of light through parallel-sided transparent material, indicating the angle of incidence *i* and angle of refraction *r*. 4 State the meaning of *critical angle*. 5 Identify and describe internal and total internal reflection using ray diagrams.	3 Describe the action of optical fibres and their use in medicine and communications technology.

Core	Supplement
8.3 Thin converging lens	
1 Describe the action of a thin converging lens on a beam of light using ray diagrams. 2 Use the terms *principal focus* and *focal length.* 4 Draw ray diagrams to illustrate the formation of a real image by a single lens.	3 Draw and interpret simple ray diagrams that illustrate the formation of real and virtual images by a single converging lens.
8.4 Dispersion of light	
1 Describe the dispersion of light by a glass prism.	
P9. Electromagnetic spectrum	
1 Describe the main features of the electromagnetic spectrum. 3 Describe the role of electromagnetic waves in: • radio and television communications (radio waves), • satellite television and telephones (microwaves), • electrical appliances, remote controllers for televisions and intruder alarms (infra-red), • medicine and security (X-rays). 4 Demonstrate understanding of safety issues regarding the use of microwaves and X-rays.	2 State the approximate value of the speed of all electromagnetic waves *in vacuo.*
P10. Sound	
1 Describe the production of sound by vibrating sources. 3 State the approximate human range of audible frequencies. 4 Demonstrate understanding that a medium is needed to transmit sound waves. 5 Describe and interpret an experiment to determine the speed of sound in air. 7 Relate the loudness and pitch of sound waves to amplitude and frequency. 8 Describe how the reflection of sound may produce an echo.	2 Describe transmission of sound in air in terms of compressions and rarefactions. 6 State the order of magnitude of the speed of sound in air, liquids and solids.

Core	Supplement
P11. Magnetism	
1 Describe the properties of magnets. 3 Identify the pattern of field lines round a bar magnet. 4 Distinguish between the magnetic properties of iron and steel. 5 Distinguish between the design and use of permanent magnets and electromagnets.	2 Give an account of induced magnetism.
P12. Electricity	
12.1 Electrical quantities	
1 Demonstrate understanding of *current*, *potential difference*, *e.m.f.* and *resistance*, and use with their appropriate units. 3 Use and describe the use of an ammeter and a voltmeter.	2 State that charge is measured in coulombs (C).
12.2 Electric charge	
1 Describe and interpret simple experiments to show the production and detection of electrostatic charges. 2 State that there are positive and negative charges. 4 State that unlike charges attract and that like charges repel. 5 Distinguish between electrical conductors and insulators and give typical examples.	3 Describe an electric field as a region in which an electric charge experiences a force.
12.3 Current, electromotive force and potential difference	
1 State that current is related to the flow of charge. 2 State that the current in metals is due to a flow of electrons. 4 Use the term potential difference (p.d.) to describe what drives the current between two points in a circuit.	3 Demonstrate understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$ 5 Distinguish between the direction of flow of electrons and conventional current. 6 Demonstrate understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit.

Core	Supplement
12.4 Resistance	
1 State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current. 2 Recall and use the equation $R = V/I$ 3 Describe an experiment to determine resistance using a voltmeter and an ammeter. 5 Relate (without calculation) the resistance of a wire to its length and to its diameter.	4 Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire.
12.5 Electrical energy	
	1 Recall and use the equations $P = IV$ and $E = IVt$
12.6 Dangers of electricity	
1 Identify electrical hazards including • damaged insulation, • overheating of cables, • damp conditions. 3 Demonstrate understanding of the use of fuses.	2 Demonstrate understanding of the use of circuit-breakers.
P13. Electric circuits	
13.1 Circuit diagrams	
1 Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters voltmeters, and fuses.	2 Draw and interpret circuit diagrams containing magnetising coils, transformers, bells and relays.

Core	Supplement
13.2 Series and parallel circuits	
1 Demonstrate understanding that the current at every point in a series circuit is the same. 3 Calculate the combined resistance of two or more resistors in series. 4 State that, for a parallel circuit, the current from the source is larger than the current in each branch. 6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself. 8 State the advantages of connecting lamps in parallel in a lighting circuit.	2 Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply. 5 Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit. 7 Calculate the effective resistance of two resistors in parallel.
13.3 Action and use of circuit components	
	1 Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers. 2 Describe the action of a relay and show understanding of its use in switching circuits. 3 Recognise and demonstrate understanding of circuits operating as light sensitive switches and temperature-operated alarms using a relay.
P14. Electromagnetic effects	
14.1 Electromagnetic induction	
	1 Describe an experiment that shows that a changing magnetic field can induce an e.m.f. in a circuit. 2 State the factors affecting the magnitude of an induced e.m.f.
14.2 a.c. generator	
	1 Describe a rotating-coil generator and the use of slip rings. 2 Sketch a graph of voltage output against time for a simple a.c. generator.

Core	Supplement
14.3 Transformer	
	1 Describe the construction of a basic iron-cored transformer as used for voltage transformations. 2 Recall and use the equation $(V_p / V_s) = (N_p / N_s)$ 3 Describe the use of the transformer in high-voltage transmission of electricity. 4 Recall and use the equation $V_p I_p = V_s I_s$ (for 100% efficiency). 5 Explain why energy losses in cables are lower when the voltage is high.
14.4 The magnetic effect of a current	
1 Describe the pattern of the magnetic field due to currents in straight wires and in solenoids. 3 Describe applications of the magnetic effect of current, including the action of a relay.	2 Describe the effect on the magnetic field of changing the magnitude and direction of the current.
14.5 Force on a current-carrying conductor	
1 Describe and interpret an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing: • the current, • the direction of the field.	2 State and use the relative directions of force, field and current.
14.6 d.c. motor	
	1 Describe the turning effect on a current-carrying coil in a magnetic field. 2 Relate this turning effect to the action of an electric motor. 3 Describe the effect of increasing (a) the number of turns in the coil (b) the current.

Core	Supplement
P15. Radioactivity	
15.1 Detection of radioactivity	
1 Demonstrate understanding of background radiation. 2 Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included; β-particles will be taken to refer to β^-).	
15.2 Characteristics of the three kinds of emission	
1 State that radioactive emissions occur randomly over space and time. 2 Recall for radioactive emissions, and use to identify them: • their nature, • their relative ionising effects, • their relative penetrating abilities.	3 Describe the deflection of α-particles, β-particles and γ-rays in electric fields and magnetic fields. 4 Interpret their relative ionising effects.
15.3 Radioactive decay	
1 State the meaning of radioactive decay.	2 Use equations (involving words or symbols) to represent changes in the composition of the nucleus when particles are emitted.
15.4 Half-life	
	1 Use the term *half-life* in simple calculations, including the use of information in tables or decay curves.
15.5 Safety precautions	
1 Describe the hazards of ionising radiation to living things. 2 Describe how radioactive materials are handled, used and stored in a safe way to minimise the effects of these hazards.	
15.6 The nuclear atom	
1 Describe the composition of the nucleus in terms of protons and neutrons 2 Use the term *proton number Z* 3 Use the term *nucleon number A*	

Core	Supplement
15.7 Isotopes	
1 Use the term *isotope*. 2 Give and explain examples of practical applications of isotopes. 3 Use the term *nuclide* and use the nuclide notation ${}^{A}_{Z}X$	

7. Practical assessment

Scientific subjects are, by their nature, experimental. It is therefore important that an assessment of a student's knowledge and understanding of science should contain a component relating to practical work and experimental skills (as identified by assessment objective C). To accommodate, within Cambridge IGCSE, differing circumstances – such as the availability of resources – Cambridge provides three different means of assessing assessment objective C: School-based assessment, a formal Practical Test and an Alternative to Practical Paper.

7.1 Paper 4: Coursework (School-based assessment of practical skills)

The experimental skills and abilities to be assessed are:

C1 Using and organising techniques, apparatus and materials

C2 Observing, measuring and recording

C3 Handling experimental observations and data

C4 Planning, carrying out and evaluating investigations

The four skills carry equal weighting.

All assessments must be based upon experimental work carried out by the candidates.

The teaching and assessment of experimental skills and abilities should take place throughout the course.

Teachers must ensure that they can make available to Cambridge evidence of **two** assessments for each skill for each candidate. For skills C1 to C4 inclusive, information about the tasks set and how the marks were awarded will be required. For skills C2, C3 and C4, the candidate's written work will also be required.

The final assessment scores for each skill must represent the candidate's best performances.

For candidates who miss the assessment of a given skill through no fault of their own, for example because of illness, and who cannot be assessed on another occasion, Cambridge's procedure for special consideration should be followed. However, candidates who for no good reason absent themselves from an assessment of a given skill should be given a mark of zero for that assessment.

Criteria for assessment of experimental skills and abilities

Each skill must be assessed on a six-point scale, level 6 being the highest level of achievement. Each of the skills is defined in terms of three levels of achievement at scores of 2, 4, and 6.

A score of 0 is available if there is no evidence of positive achievement for a skill.

For candidates who do not meet the criteria for a score of 2, a score of 1 is available if there is some evidence of positive achievement.

A score of 3 is available for candidates who go beyond the level defined for 2, but who do not meet fully the criteria for 4.

Similarly, a score of 5 is available for those who go beyond the level defined for 4, but do not meet fully the criteria for 6.

Score	Skill C1: Using and organising techniques, apparatus and materials
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Follows written, diagrammatic or oral instructions to perform a single practical operation. Uses familiar apparatus and materials adequately, needing reminders on points of safety.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Follows written, diagrammatic or oral instructions to perform an experiment involving a series of step-by-step practical operations. Uses familiar apparatus, materials and techniques adequately and safely.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Follows written, diagrammatic or oral instructions to perform an experiment involving a series of practical operations where there may be a need to modify or adjust one step in the light of the effect of a previous step. Uses familiar apparatus, materials and techniques safely, correctly and methodically.

Score	Skill C2: Observing, measuring and recording
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Makes observations or readings given detailed instructions. Records results in an appropriate manner given a detailed format.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Makes relevant observations, measurements or estimates given an outline format or brief guidelines. Records results in an appropriate manner given an outline format.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Makes relevant observations, measurements or estimates to a degree of accuracy appropriate to the instruments or techniques used. Records results in an appropriate manner given no format.

Score	Skill C3: Handling experimental observations and data
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Processes results in an appropriate manner given a detailed format. Draws an obvious qualitative conclusion from the results of an experiment.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Processes results in an appropriate manner given an outline format. Recognises and comments on anomalous results. Draws qualitative conclusions which are consistent with obtained results and deduces patterns in data.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Processes results in an appropriate manner given no format. Deals appropriately with anomalous or inconsistent results. Recognises and comments on possible sources of experimental error. Expresses conclusions as generalisations or patterns where appropriate.

Score	Skill C4: Planning, carrying out and evaluating investigations
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Suggests a simple experimental strategy to investigate a given practical problem. Attempts 'trial and error' modification in the light of the experimental work carried out.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Specifies a sequence of activities to investigate a given practical problem. In a situation where there are two variables, recognises the need to keep one of them constant while the other is being changed. Comments critically on the original plan, and implements appropriate changes in the light of the experimental work carried out.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Analyses a practical problem systematically and produces a logical plan for an investigation. In a given situation, recognises that there are a number of variables and attempts to control them. Evaluates chosen procedures, suggests/implements modifications where appropriate and shows a systematic approach in dealing with unexpected results.

Notes for guidance

The following notes are intended to help teachers to make valid and reliable assessments of the skills and abilities of their candidates.

The assessments should be based on the principle of positive achievement: candidates should be given opportunities to demonstrate what they understand and can do.

It is expected that candidates will have had opportunities to acquire a given skill before assessment takes place.

It is not expected that all of the practical work undertaken by a candidate will be assessed.

Assessments can be carried out at any time during the course. However, at whatever stage assessments are done, the standards applied must be those expected at the end of the course as exemplified in the criteria for the skills.

Assessments should normally be made by the person responsible for teaching the candidates.

It is recognised that a given practical task is unlikely to provide opportunities for all aspects of the criteria at a given level for a particular skill to be satisfied, for example, there may not be any anomalous results (skill C3). However, by using a range of practical work, teachers should ensure that opportunities are provided for all aspects of the criteria to be satisfied during the course.

The educational value of extended experimental investigations is widely recognised. Where such investigations are used for assessment purposes, teachers should make sure that candidates have ample opportunity for displaying the skills and abilities required by the scheme of assessment.

It is not necessary for all candidates in a Centre, or in a teaching group within a Centre, to be assessed on exactly the same practical work, although teachers may well wish to make use of work that is undertaken by all of their candidates.

When an assessment is carried out on group work the teacher must ensure that the individual contribution of each candidate can be assessed.

Skill C1 may not generate a written product from the candidates. It will often be assessed by watching the candidates carrying out practical work.

Skills C2, C3 and C4 will usually generate a written product from the candidates. This product will provide evidence for moderation.

Recording candidates' marks

Candidates' marks for Paper 4: Coursework must be recorded on the Individual Candidate Record Card produced by Cambridge. These forms, and the instructions for completing them, may be downloaded from **www.cie.org.uk/samples**. The database will ask you for the syllabus code (i.e. 0654) and your Centre number, after which it will take you to the correct forms. Follow the instructions when completing each form.

Raw scores for individual practical assessments may be given to candidates as part of the normal feedback from the teacher. The final, internally-moderated, total score, which is submitted to Cambridge should not be given to the candidate.

Moderation

(a) Internal moderation

When several teachers in a Centre are involved in internal assessments, arrangements must be made within the Centre for all candidates to be assessed to a common standard.

It is essential that within each Centre the marks for each skill assigned within different teaching groups (e.g. different classes) are moderated internally for the whole Centre entry. The Centre assessments will then be subject to external moderation.

The internally moderated marks for all candidates must be recorded on the Coursework Assessment Summary Form and Co-ordinated Sciences Experiment Form. These forms, and the instructions for completing them, may be downloaded from **www.cie.org.uk/samples**. The database will ask you for the syllabus code (i.e. 0654) and your Centre number, after which it will take you to the correct form. Follow the instructions when completing the form.

(b) External moderation

External moderation of internal assessment is carried out by Cambridge. Centres must submit candidates' internally assessed marks to Cambridge. The deadlines and methods for submitting internally assessed marks are in the *Cambridge Administrative Guide* available on our website.

Once Cambridge has received the marks, Cambridge will select a sample of candidates whose work should be submitted for external moderation. Cambridge will communicate the list of candidates to the Centre, and the Centre should despatch the coursework of these candidates to Cambridge immediately. For each candidate on the list, every piece of work which has contributed to the final mark should be sent to Cambridge. Individual Candidate Record Cards and Coursework Assessment Summary Forms must be enclosed with the coursework.

Further information about external moderation may be found in the *Cambridge Handbook* and the *Cambridge Administrative Guide*.

A further sample may be required. All records and supporting written work should be retained until after publication of results. Centres may find it convenient to use loose-leaf A4 file paper for assessed written work. This is because samples will be sent through the post for moderation and postage bills are likely to be large if whole exercise books are sent. Authenticated photocopies of the sample required would be acceptable.

The individual pieces of work should **not** be stapled together. Each piece of work should be labelled with the skill being assessed, the Centre number and candidate name and number, title of the experiment, a copy of the mark scheme used, and the mark awarded. This information should be attached securely, mindful that adhesive labels tend to peel off some plastic surfaces.

7.2 Paper 5: Practical Test

Biology

Candidates may be asked to carry out exercises involving:

- following instructions and handling apparatus and material safely and correctly
- observing and measuring biological material, carrying out a biological experiment using appropriate equipment/characters/units
- carefully drawing, using a sharp pencil, and labelling specimens of plant or animal material
- recording observations and measurements in a suitable form such as a table or bar chart
- representing results graphically, using appropriate scales, intervals and axes, drawing suitable lines. Understanding that points on a graph maybe experimental and joining the points serves no purpose
- interpreting and evaluating observational and experimental data from specimens or from experiments
- commenting on an experimental method used and suggesting possible improvements
- devising an experiment to enable a task to be performed

The list below details the apparatus expected to be generally available for examination purposes. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a science laboratory (such as Bunsen burners, tripods, hot water baths, etc.) are not included. It is expected that the following items would be available for each candidate:

- rulers capable of measuring to 1 mm
- mounted needles or seekers or long pins with large heads
- means of cutting biological materials such as scalpels, solid-edged razor blades or knives
- scissors
- forceps
- means of writing on glassware
- beakers, 100 cm^3, 250 cm^3
- test-tubes, 125 mm × 15 mm and 150 mm × 25 mm including some hard glass test-tubes
- means of measuring small and larger volumes of liquids such as syringes and measuring cylinders
- dropping pipette
- white tile
- hand lens
- a thermometer, –10 °C to +110 °C at 1 °C graduations
- clock (or wall clock) to measure to an accuracy of about 1 s

Chemistry

Candidates may be asked to carry out exercises involving:

- simple quantitative experiments involving the measurement of volumes
- speeds of reaction
- measurement of temperature based on a thermometer with 1 °C graduations
- problems of an investigatory nature, possibly including suitable organic compounds
- filtration
- identification of ions and gases as specified in the Core curriculum. The question paper will include *Notes for Use in Qualitative Analysis*
- making suitable observations without necessarily identifying compounds.

Candidates may be required to do the following:

- record readings from apparatus
- estimate small volumes without the use of measuring devices
- describe, explain or comment on experimental arrangements and techniques
- complete tables of data
- draw conclusions from observations and/or from information given
- interpret and evaluate observations and experimental data
- plot graphs and/or interpret graphical information
- identify sources of error and suggest possible improvements in procedures
- plan an investigation, including suggesting suitable techniques and apparatus.

Note on taking readings

When approximate volumes are used, e.g. about 2 cm^3, it is expected that candidates will estimate this and not use measuring devices. Thermometers may be marked with intervals of 1 °C. It is, however, appropriate to record a reading which coincides exactly with a mark, e.g. 22.0 °C rather than 22 °C. Interpolation between scale divisions should also be used such that a figure of 22.5 °C may be more appropriate.

Apparatus List

The list below details the apparatus expected to be generally available for examination purposes. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a chemical laboratory (such as Bunsen burners, tripods, hot water baths, etc.) are not included. It is expected that the following items would be available for each candidate.

- two conical flasks within the range 150 cm^3 to 250 cm^3
- measuring cylinders, 100 cm^3, 25 cm^3 and 10 cm^3
- a filter funnel
- two beakers, 250 cm^3 and 100 cm^3
- a thermometer, –10 °C to +110 °C at 1 °C graduations
- a dropping pipette
- clocks (or wall clock) to measure to an accuracy of about 1 s. Candidate's own wristwatch may be used
- a plastic trough of approximate size W150 mm × L220 mm × D80 mm
- test-tubes. Sizes approximately 125 × 15 mm and 150 × 25 mm should be available and should include some hard glass test-tubes.

Physics

Candidates should be able to:

- assemble common pieces of equipment such as simple electrical circuits and where necessary follow written instructions to do so
- use a balance to determine the mass of an object
- carry out the specified manipulation of the apparatus
- take reading from a measuring device, including:
  - reading a scale with appropriate precision / accuracy, (see note below)
  - consistent use of significant figures,
  - taking repeated measurements to obtain an average
- record their observations systematically, e.g. construct a table of data with appropriate units
- process their data, as required. Calculators may be used
- present data graphically, using suitable axes and scales and understanding the importance of the origin
- use their graph to take readings including interpolation and extrapolation and calculating a gradient
- describe sources of error and how to improve accuracy
- devise an experiment to test a hypothesis or an alternative to the experiment carried out

Note: a measuring instrument should be used to its full precision. Thermometers may be marked in 1 °C intervals but it is often appropriate to interpolate between scale divisions and record a temperature as 21.5 °C. Measurements using a rule requires suitable accuracy of recording such as 15.0 cm rather than 15 cm and use of millimetres used more regularly. Similarly, when measuring current, it is often more useful to use milliamperes rather than amperes.

Apparatus List

The list below details the apparatus expected to be generally available for examination purposes. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a physics laboratory are not included. It is expected that the following items would be available for each candidate.

- an ammeter FSD 1 A or 1.5 A
- voltmeter FSD 1 V, 5 V
- cells and holders to enable several cells to be joined
- connecting leads and crocodile clips
- d.c. power supply – variable to 12 V
- metre rule
- converging lens with f = 15 cm
- low voltage filament bulbs in holders
- good supply of masses and holder
- Newton meter
- plastic or polystyrene cup
- Plasticine or modelling clay
- various resistors
- switch
- thermometer, –10 °C to +110 °C at 1 °C graduations
- wooden board

- glass or perspex block, rectangular and semi-circular
- measuring cylinder, 100 cm^3, 250 cm^3
- springs
- stopwatch
- ray box

7.3 Paper 6: Alternative to Practical

This paper is designed to test candidates' familiarity with laboratory practical procedures.

Questions may be set requesting candidates to:

- describe in simple terms how they would carry out practical procedures
- explain and/or comment critically on described procedures or points of practical detail
- follow instructions for drawing diagrams
- draw, complete and/or label diagrams of apparatus
- take readings from their own diagrams, drawn as instructed, and/or from printed diagrams including:
  - reading a scale with appropriate precision/accuracy with consistent use of significant figures and with appropriate units,
  - interpolating between scale divisions,
  - taking repeat measurements to obtain an average value
- process data as required, complete tables of data
- present data graphically, using suitable axes and scales (appropriately labelled) and plotting the points accurately
- take readings from a graph by interpolation and extrapolation
- determine a gradient, intercept or intersection on a graph
- draw and report a conclusion or result clearly
- identify and/or select, with reasons, items of apparatus to be used for carrying out practical procedures
- explain, suggest and/or comment critically on precautions taken and/or possible improvements to techniques and procedures
- describe, from memory, tests for gases and ions, and/or draw conclusions from such tests (*Notes for Use in Qualitative Analysis*, will **not** be provided in the question paper.)

8. Appendix

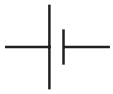
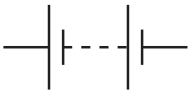
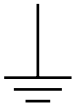
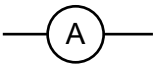
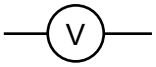
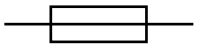
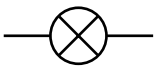
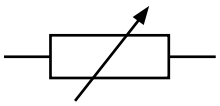
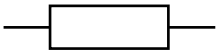
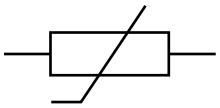
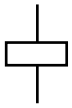
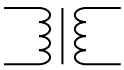
8.1 Symbols, units and definitions of physical quantities

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. Candidates should be able to define those items indicated by an asterisk (*). The list for the extended curriculum includes both the core and the supplement.

Core			Supplement		
Quantity	***Symbol***	***Unit***	***Quantity***	***Symbol***	***Unit***
length	*l, h ...*	km, m, cm, mm			
area	*A*	m^2, cm^2			
volume	*V*	m^3, dm^3, cm^3			
weight	*W*	N			N*
mass	*m, M*	kg, g			mg
time	*t*	h, min, s			ms
density*	*d, ρ*	kg/m^3, g/cm^3			
speed*	*u, v*	km/h, m/s, cm/s	velocity*		km/h, m/s, cm/s
acceleration	*a*		acceleration*		m/s^2
acceleration of free fall	*g*				
force	*F, P ...*	N	force*		N*
			moment of a force*		N m
work done*	*W, E*	J	work done by a force*		J*
energy	*E*	J			J*, kW h*
power	*P*	W	power*		W*
pressure	*P*	Pa			
temperature	*θ, T*	°C		*T*	K
specific heat capacity	*c*	J/(kg °C)	specific heat capacity*		
frequency*	*f*	Hz			Hz*
wavelength*	*λ*	m, cm			
focal length	*f*	cm, mm			
angle of incidence	*i*	degree (°)			
angle of reflection, refraction	*r*	degree (°)			
critical angle	*c*	degree (°)			
potential difference/ voltage	*V*	V, mV	potential difference*		V*
current	*I*	A*, mA	current*		
charge		C, A s			
e.m.f.	*E*	V	e.m.f.*		
resistance	*R*	Ω			

8.2 Electrical symbols

Candidates are expected to be able to recall and use the standard electrical symbols listed below.

Core			
cell		switch	
battery of cells	 or 	earth or ground	
power supply		ammeter	
a.c. power supply		voltmeter	
junction of conductors		fuse	
lamp		variable resistor	
fixed resistor		thermistor	
Supplement			
relay coil		electric bell	
transformer		buzzer	

8.3 Notes for use in qualitative analysis

Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
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	–
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	'pops' with a lighted splint
oxygen (O_2)	relights a glowing splint

8.4 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 –		114 Fl flerovium –		116 Lv livermorium –		

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.)

8.5 Grade descriptions

The scheme of assessment is intended to encourage positive achievement by all candidates. Mastery of the core syllabus content is required for further academic study.

A **Grade A** candidate must show mastery of the core curriculum and the extended syllabus content.

A **Grade C** candidate must show mastery of the core curriculum plus some ability to answer questions which are pitched at a higher level.

A **Grade F** candidate must show competence in the core syllabus content.

A **Grade A** candidate will be able to:

- relate facts to principles and theories and vice versa
- state why particular techniques are preferred for a procedure or operation
- select and collate information from a number of sources and present it in a clear logical form
- solve problems in situations which may involve a wide range of variables
- process data from a number of sources to identify any patterns or trends
- generate a hypothesis to explain facts, or find facts to support an hypothesis

A **Grade C** candidate will be able to:

- link facts to situations not specified in the syllabus
- describe the correct procedure(s) for a multi-stage operation
- select a range of information from a given source and present it in a clear logical form
- identify patterns or trends in given information
- solve problems involving more than one step, but with a limited range of variables
- generate a hypothesis to explain a given set of facts or data

A **Grade F** candidate will be able to:

- recall facts contained in the syllabus
- indicate the correct procedure for a single operation
- select and present a single piece of information from a given source
- solve a problem involving one step, or more than one step if structured help is given
- identify a pattern or trend where only a minor manipulation of data is needed
- recognise which of two given hypotheses explains a set of facts or data

8.6 Mathematical requirements

Calculators may be used in all parts of the assessment.

Candidates should be able to:

- add, subtract, multiply and divide
- understand and use *averages, decimals, fractions, percentages, ratios* and *reciprocals*
- recognise and use standard notation
- use direct and inverse proportion
- use positive, whole number indices
- draw charts and graphs from given data
- interpret charts and graphs
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recognise and use the relationship between length, surface area and volume and their units on metric scales
- use usual mathematical instruments (ruler, compasses, protractor, set square)
- understand the meaning of *angle, curve, circle, radius, diameter, square, parallelogram, rectangle* and *diagonal*
- solve equations of the form $x = yz$ for any one term when the other two are known
- recognise and use points of the compass (N, S, E, W)

8.7 Glossary of terms used in science papers

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

1. *Define* (the term(s) ...) is intended literally, only a formal statement or equivalent paraphrase being required.
2. *What do you understand by/What is meant by* (the term(s) ...) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *State* implies a concise answer with little or no supporting argument, (e.g. a numerical answer that can readily be obtained 'by inspection').
4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified this should not be exceeded.
5. *Explain* may imply reasoning or some reference to theory, depending on the context.
6. *Describe* requires the candidate to state in words, (using diagrams where appropriate), the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena.

   In other contexts, *describe* should be interpreted more generally, (i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer). *Describe and explain* may be coupled, as may *state and explain*.

7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.
8. *Outline* implies brevity, (i.e. restricting the answer to giving essentials).
9. *Predict* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

   Predict also implies a concise answer with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required, (e.g. reference to a law, principle, or the necessary reasoning is to be included in the answer).
11. *Suggest* is used in two main contexts, (i.e. either to imply that there is no unique answer, (e.g. in Chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus').
12. *Find* is a general term that may variously be interpreted as *calculate, measure, determine*, etc.
13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, (e.g. length, using a rule, or mass, using a balance).
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, (e.g. resistance, the formula of an ionic compound).
16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, **but** candidates should be aware that, depending on the context, some quantitative aspects may be looked for, (e.g. passing through the origin, having an intercept).

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

9. Other information

Equality and inclusion

Cambridge International Examinations has taken great care in the preparation of this syllabus and assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), Cambridge has designed this qualification with the aim of avoiding direct and indirect discrimination.

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

Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is found in the *Cambridge Handbook* which can be downloaded from the website **www.cie.org.uk/examsofficer**

Language

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

Grading and reporting

Cambridge IGCSE results are shown by one of the grades A*, A, B, C, D, E, F or G indicating the standard achieved, A* being the highest and G the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade G. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no results) and Y (to be issued) may also appear on the statement of results but not on the certificate.

As Co-ordinated Sciences is a Double Award, results are shown as a repeated letter, e.g. A*A*, CC, EE.

Entry codes

To maintain the security of our examinations, we produce question papers for different areas of the world, known as 'administrative zones'. Where the component entry code has two digits, the first digit is the component number given in the syllabus. The second digit is the location code, specific to an administrative zone. Information about entry codes can be found in the *Cambridge Guide to Making Entries*.

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