

# SYLLABUS

**Cambridge IGCSE<sup>®</sup>**

**Co-ordinated Sciences (Double Award)**

**0654**

For examination in June and November 2017 and 2018

## Changes to syllabus for 2017 and 2018

**The syllabus has been revised. You are advised to read the whole of the syllabus before planning your teaching programme. The most significant changes are outlined below.**

**| Significant changes to the syllabus are indicated by black vertical lines at the side of the text. |**

### **Changes to the structure of the assessment**

The practical option, Paper 4: Coursework has been withdrawn.

A new Multiple Choice paper for Extended candidates has been introduced. This paper is now Paper 2.

Core candidates will now take Paper 1: Multiple Choice (Core), Paper 3: Theory (Core) and either Paper 5: Practical Test or Paper 6: Alternative to Practical.

Extended candidates will now take Paper 2: Multiple Choice (Extended), Paper 4: Theory (Extended), and either Paper 5: Practical Test or Paper 6: Alternative to Practical.

### **Changes to other sections of the syllabus**

#### 1. Introduction

In the introductory section, some small changes have been made to wording to align this syllabus with the equivalent section in the IGCSEs for Biology, Physics and Chemistry.

#### 2. Syllabus content at a glance

This section has been revised.

#### 5. Syllabus aims and assessment objectives

This section has been updated to align this syllabus with the other science IGCSEs and are to ensure coherence across the IGCSE science suite.

The syllabus aims have been amended to more fully reflect the skills and knowledge promoted by study of the course.

The assessment objectives have been revised slightly for clarity. The meaning of the assessment objectives remains unchanged.

#### 7. Practical assessment

The wording of this section has been revised to align this syllabus with the equivalent sections in the other science IGCSEs.

#### 8. Appendix

Notes on safety in the laboratory and on presentation of data have been added to align this syllabus with the equivalent sections in the other IGCSE science syllabuses.

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# 1. Introduction

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## 1.1 Why choose Cambridge?

Cambridge International Examinations is part of the University of Cambridge. We prepare school students for life, helping them develop an informed curiosity and a lasting passion for learning. Our international qualifications are recognised by the world's best universities and employers, giving students a wide range of options in their education and career. As a not-for-profit organisation, we devote our resources to delivering high-quality educational programmes that can unlock learners' potential.

Our programmes set the global standard for international education. They are created by subject experts, are rooted in academic rigour, and provide a strong platform for progression. Over 10 000 schools in 160 countries work with us to prepare nearly a million learners for their future with an international education from Cambridge.

### Cambridge learners

Cambridge programmes and qualifications develop not only subject knowledge but also skills. We encourage Cambridge learners to be:

- **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.

### Recognition

Cambridge IGCSE is recognised by leading universities and employers worldwide, and is an international passport to progression and success. It provides a solid foundation for moving on to higher level studies. Learn more at [www.cie.org.uk/recognition](http://www.cie.org.uk/recognition)

### 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](http://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](http://www.cie.org.uk/examsOfficers)

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](http://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 students 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](http://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)?

Cambridge IGCSE Co-ordinated Sciences gives learners the opportunity to study biology, chemistry and physics within a scientifically coherent syllabus and is accepted by universities and employers as proof of essential knowledge and ability. As well as a subject focus, the co-ordinated sciences syllabus enables learners to:

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

## Prior learning

We recommend that learners 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. Learners should also have adequate mathematical skills for the content contained in this syllabus.

## Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates either to progress 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 Level 3 AS and A Levels in sciences, Cambridge Pre-U sciences, IB certificates in sciences or the 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 a number of different subjects.

Learn more about Cambridge ICE at [www.cie.org.uk/cambridgesecondary2](http://www.cie.org.uk/cambridgesecondary2)

## 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](mailto: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](http://www.cie.org.uk/startcambridge). Email us at [info@cie.org.uk](mailto:info@cie.org.uk) to find out how your organisation can register to become a Cambridge school.

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## 2. Teacher support

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### 2.1 Support materials

We send Cambridge syllabuses, past question papers and examiner reports to cover the last examination series to all Cambridge schools.

You can also go to our public website at [www.cie.org.uk/igcse](http://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 Endorsed resources

We work with publishers providing a range of resources for our syllabuses including print and digital materials. Resources endorsed by Cambridge go through a detailed quality assurance process to ensure they provide a high level of support for teachers and learners.

We have resource lists which can be filtered to show all resources, or just those which are endorsed by Cambridge. The resource lists include further suggestions for resources to support teaching.

### 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](http://www.cie.org.uk/events) for further information.

### 3. Syllabus content at a glance

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 either follow the Core syllabus 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.

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.

#### **Biology**

- B1. Characteristics of living organisms
- B2. Cells
- B3. Enzymes
- B4. Nutrition
- B5. Transportation
- B6. Respiration
- B7. Co-ordination and response
- B8. Reproduction
- B9. Inheritance
- B10. Energy flow in ecosystems
- B11. Human influences on the ecosystem

#### **Chemistry**

- C1. The particulate nature of matter
- C2. Experimental techniques
- C3. Atoms, elements and compounds
- C4. Stoichiometry
- C5. Electricity and chemistry
- C6. Energy changes in chemical reactions
- C7. Chemical reactions
- C8. Acids, bases and salts
- C9. The Periodic Table
- C10. Metals
- C11. Air and water
- C12. Sulfur
- C13. Carbonates
- C14. Organic chemistry



**Physics**

- P1. Motion
- P2. Matter and forces
- P3. Energy, work and power
- P4. Simple kinetic molecular model of matter
- P5. Matter and thermal properties
- P6. Transfer of thermal energy
- P7. Waves
- P8. Light
- P9. Electromagnetic spectrum
- P10. Sound
- P11. Magnetism
- P12. Electricity
- P13. Electric circuits
- P14. Electromagnetic effects
- P15. Radioactivity

## 4. Assessment at a glance

All candidates must enter for three papers.

Core candidates take:		Extended candidates take:	
<p><b>Paper 1</b> 45 minutes</p> <p>A multiple-choice paper consisting of 40 items of the four-choice type.</p> <p>This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.</p> <p>This paper will be weighted at 30% of the final total mark.</p>		<p><b>Paper 2</b> 45 minutes</p> <p>A multiple-choice paper consisting of 40 items of the four-choice type.</p> <p>This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).</p> <p>This paper will be weighted at 30% of the final total mark.</p>	
<b>and:</b>		<b>and:</b>	
<p><b>Paper 3</b> 2 hours</p> <p>A written paper consisting of short-answer and structured questions.</p> <p>This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.</p> <p>120 marks</p> <p>This paper will be weighted at 50% of the final total mark.</p>		<p><b>Paper 4</b> 2 hours</p> <p>A written paper consisting of short-answer and structured questions.</p> <p>This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).</p> <p>120 marks</p> <p>This paper will be weighted at 50% of the final total mark.</p>	

All candidates take:			
either:		or:	
<p><b>Paper 5</b> 2 hours</p> <p>Practical Test</p> <p>This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 7.</p> <p>The paper is structured to assess grade ranges A*A*–GG.</p> <p>45 marks</p> <p>This paper will be weighted at 20% of the final total mark.</p>		<p><b>Paper 6</b> 1 hour</p> <p>Alternative to Practical</p> <p>This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 7.</p> <p>The paper is structured to assess grade ranges A*A*–GG.</p> <p>60 marks</p> <p>This paper will be weighted at 20% of the final total mark.</p>	

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

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

## 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](http://www.cie.org.uk/examsOfficers)

## 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 Syllabus aims

The syllabus aims listed below describe the educational purposes of a course based on this syllabus. These aims are not intended as assessment criteria but outline the educational context in which the syllabus content should be viewed. These aims are the same for all learners and are not listed in order of priority. Some of these aims may be delivered by the use of suitable local, international or historical examples and applications, or through collaborative experimental work.

The aims are:

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

## 5.2 Assessment objectives

### AO1: Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

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

Syllabus content defines the factual material that candidates may be required to recall and explain.

Candidates will also be asked questions which require them to apply this material to unfamiliar contexts and to apply knowledge from one area of the syllabus to another.

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

### AO2: Handling information and problem solving

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

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

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

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

### AO3: Experimental skills and investigations

Candidates should be able to:

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

### 5.3 Relationship between assessment objectives and components

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

Assessment objective	Papers 1 and 2	Papers 3 and 4	Papers 5 and 6	Weighting of AO in overall qualification
AO1: Knowledge with understanding	63%	63%	–	50%
AO2: Handling information and problem solving	37%	37%	–	30%
AO3: Experimental skills and investigations	–	–	100%	20%
Weighting of paper in overall qualification	30%	50%	20%	

### 5.4 Grade descriptions

The scheme of assessment is intended to encourage positive achievement by all candidates.

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

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

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

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

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

- recall and communicate limited knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply a limited range of scientific facts and concepts to give basic explanations of familiar phenomena, to solve straightforward problems and to make simple predictions
- communicate and present simple scientific ideas, observations and data using a limited range of scientific terminology and conventions
- select a single piece of information from a given source, and use it to support a given conclusion, and to make links between scientific information and its scientific, technological, social, economic or environmental implications
- solve problems involving more than one step if structured help is given
- analyse data to identify a pattern or trend
- select, describe and evaluate techniques for a limited range of scientific operations and laboratory procedures.

## 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<sup>3</sup>

To avoid any confusion concerning the symbol for litre, **dm<sup>3</sup>** 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. 4 256 789.



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## 6. Syllabus content

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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 syllabus 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 Supplement content, which should be studied by candidates following the Extended syllabus.

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 are available from Teacher Support. Go to <http://teachers.cie.org.uk>

## 6.1 Biology

Core	Supplement
<b>B1. Characteristics of living organisms</b>	
<p>1 List and describe the characteristics of living organisms.</p>	<p>2 Define the terms:</p> <ul style="list-style-type: none"> <li>• <i>nutrition</i> 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</li> <li>• <i>excretion</i> as removal from organisms of toxic materials, the waste products of metabolism (chemical reactions in cells including respiration) and substances in excess of requirements</li> <li>• <i>respiration</i> as the chemical reactions that break down nutrient molecules in living cells to release energy</li> <li>• <i>sensitivity</i> as the ability to detect or sense changes in the environment (stimuli) and to make responses</li> <li>• <i>reproduction</i> as the processes that make more of the same kind of organism</li> <li>• <i>growth</i> as a permanent increase in size and dry mass by an increase in cell number or cell size or both</li> <li>• <i>movement</i> as an action by an organism or part of an organism causing a change of position or place.</li> </ul>

Core	Supplement
<b>B2. Cells</b>	
<b>2.1 Cell structure</b>	
<ol style="list-style-type: none"> <li>1 State that living organisms are made of cells.</li> <li>2 Identify and describe the structure of a plant cell (palisade cell) and an animal cell (liver cell), as seen under a light microscope.</li> <li>3 Describe the differences in structure between typical animal and plant cells.</li> <li>6 Calculate magnification and size of biological specimens using millimetres as units.</li> </ol>	<ol style="list-style-type: none"> <li>4 Relate the structures seen under the light microscope in the plant cell and in the animal cell to their functions.</li> <li>5 Relate the structure of the following to their functions: <ul style="list-style-type: none"> <li>• red blood cells – transport</li> <li>• root hair cells – absorption.</li> </ul> </li> </ol>
<b>2.2 Movement in and out of cells</b>	
<ol style="list-style-type: none"> <li>1 Define <i>diffusion</i> 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.</li> <li>2 Describe the importance of diffusion of gases and solutes and of water as a solvent.</li> </ol>	<ol style="list-style-type: none"> <li>3 Define <i>osmosis</i> 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.</li> <li>4 Describe the importance of osmosis in the uptake of water by plants, and its effects on plant and animal cells.</li> <li>5 Describe and explain the importance of a water potential gradient in the uptake of water by plants.</li> </ol>
<b>B3. Enzymes</b>	
<ol style="list-style-type: none"> <li>1 Define <i>enzymes</i> as proteins that function as biological catalysts.</li> <li>2 Investigate and describe the effect of changes in temperature and pH on enzyme activity.</li> </ol>	<ol style="list-style-type: none"> <li>3 Explain the effect of changes in temperature and pH on enzyme activity.</li> </ol>

Core	Supplement
<b>B4. Nutrition</b>	
<b>4.1 Nutrients</b>	
<p>1 List the chemical elements that make up:</p> <ul style="list-style-type: none"> <li>• carbohydrates</li> <li>• fats</li> <li>• proteins.</li> </ul> <p>3 Describe the structure of large molecules made from smaller basic units, i.e.</p> <ul style="list-style-type: none"> <li>• simple sugars to starch and glycogen</li> <li>• amino acids to proteins</li> <li>• fatty acids and glycerol to fats and oils.</li> </ul> <p>4 Describe tests for:</p> <ul style="list-style-type: none"> <li>• starch (iodine solution)</li> <li>• reducing sugars (Benedict's solution)</li> <li>• protein (biuret test)</li> <li>• fats (ethanol).</li> </ul> <p>5 List the principal sources of, and describe the importance of:</p> <ul style="list-style-type: none"> <li>• carbohydrates</li> <li>• fats</li> <li>• proteins</li> <li>• vitamins (C and D only)</li> <li>• mineral salts (calcium and iron only)</li> <li>• fibre (roughage)</li> <li>• water.</li> </ul> <p>6 Describe the deficiency symptoms for:</p> <ul style="list-style-type: none"> <li>• vitamins (C and D only)</li> <li>• mineral salts (calcium and iron only).</li> </ul>	<p>2 Define <i>nutrition</i> 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.</p> <p>7 Describe the use of microorganisms in the manufacture of yoghurt.</p>

Core	Supplement
<b>4.2 Plant nutrition</b>	
<p>1 Define <i>photosynthesis</i> as the fundamental process by which plants manufacture carbohydrates from raw materials using energy from light.</p> <p>3 State the word equation for the production of simple sugars and oxygen.</p> <p>5 Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls.</p> <p>7 Describe the intake of carbon dioxide and water by plants.</p> <p>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:</p> <ul style="list-style-type: none"> <li>• distribution of chloroplasts – photosynthesis</li> <li>• stomata, palisade and mesophyll cells – gas exchange</li> <li>• vascular bundles (xylem and phloem) – transport and support.</li> </ul> <p>9 Describe the importance of:</p> <ul style="list-style-type: none"> <li>• nitrate ions for protein synthesis</li> <li>• magnesium ions for chlorophyll synthesis.</li> </ul>	<p>2 Explain that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage.</p> <p>4 State the balanced equation for photosynthesis in symbols</p> $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ <p>6 Investigate and state the effect of varying light intensity on the rate of photosynthesis (e.g. in submerged aquatic plants).</p> <p>10 Explain the effects of nitrate ion and magnesium ion deficiency on plant growth.</p> <p>11 Describe the uses, and the dangers of overuse, of nitrogen-containing fertilisers.</p>
<b>4.3 Animal nutrition</b>	
<p>1 State what is meant by the term <i>balanced diet</i> and describe a balanced diet related to the age, sex and activity of an individual.</p> <p>3 Define <i>ingestion</i> as taking substances (e.g. food, drink) into the body through the mouth.</p> <p>4 Define <i>egestion</i> as passing out of food that has not been digested, as faeces, through the anus.</p>	<p>2 Describe the effects of malnutrition in relation to starvation, coronary heart disease, constipation and obesity.</p>

Core	Supplement
<p>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.</p> <p>6 Describe the functions of the regions of the alimentary canal listed above, in relation to ingestion, digestion, absorption, assimilation and egestion of food.</p> <p>7 Define <i>digestion</i> as the breakdown of large, insoluble food molecules into small, water-soluble molecules using mechanical and chemical processes.</p> <p>8 Identify the types of human teeth and describe their structure and functions.</p> <p>9 State the causes of dental decay and describe the proper care of teeth.</p> <p>10 State the significance of chemical digestion in the alimentary canal in producing small, soluble molecules that can be absorbed.</p> <p>12 State where, in the alimentary canal, amylase, protease and lipase enzymes are secreted.</p> <p>13 State the functions of a typical amylase, a protease and a lipase, listing the substrate and end-products.</p> <p>14 Define <i>absorption</i> as movement of digested food molecules through the wall of the intestine into the blood.</p> <p>16 Identify the small intestine as the region for the absorption of digested food.</p> <p>18 Describe the role of the liver in the metabolism of glucose (glucose <math>\rightleftharpoons</math> glycogen).</p> <p>19 Describe the role of fat as an energy storage substance.</p>	<p>11 Outline the role of bile in emulsifying fats, to increase the surface area for the action of enzymes.</p> <p>15 Describe the significance of villi in increasing the internal surface area of the small intestine.</p> <p>17 Describe the structure of a villus, including the role of capillaries and lacteals.</p>

Core	Supplement
<b>B5. Transportation</b>	
<b>5.1 Transport in plants</b>	
<ol style="list-style-type: none"> <li>1 State the functions of xylem and phloem.</li> <li>2 Identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves.</li> <li>3 Identify root hair cells, as seen under the light microscope, and state their functions.</li> <li>5 State the pathway taken by water through root, stem and leaf (root hair, root cortex cells, xylem, mesophyll cells).</li> <li>6 Investigate, using a suitable stain, the pathway of water through the above-ground parts of a plant.</li> <li>7 Define <i>transpiration</i> as evaporation of water at the surfaces of the mesophyll cells followed by loss of water vapour from plant leaves, through the stomata.</li> <li>9 Describe the effects of variation of temperature, humidity and light intensity on transpiration rate.</li> </ol>	<ol style="list-style-type: none"> <li>4 Relate the structure and functions of root hairs to their surface area and to water and ion uptake.</li> <li>8 Describe how water vapour loss is related to cell surfaces, air spaces and stomata.</li> <li>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.</li> <li>11 Define <i>translocation</i> 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.</li> </ol>

Core	Supplement
<b>5.2 Transport in humans</b>	
<ol style="list-style-type: none"> <li>1 Describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood.</li>   <li>3 Describe the structure of the heart, including the muscular wall and septum, atria, ventricles, valves and associated blood vessels.</li>   <li>5 Describe the function of the heart in terms of muscular contraction and the working of the valves.</li>   <li>6 Investigate the effect of physical activity on pulse rate.</li>   <li>8 Name the main blood vessels to and from the heart, lungs, liver and kidney.</li>   <li>9 Describe the structure and functions of arteries, veins and capillaries.</li>   <li>11 Identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs.</li>   <li>12 List the components of blood as red blood cells, white blood cells, platelets and plasma.</li>   <li>13 State the functions of blood: <ul style="list-style-type: none"> <li>• red blood cells – haemoglobin and oxygen transport</li> <li>• white blood cells – phagocytosis and antibody formation</li> <li>• platelets – causing clotting (no details)</li> <li>• plasma – transport of blood cells, ions, soluble nutrients, hormones and carbon dioxide.</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>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.</li>   <li>4 Describe coronary heart disease in terms of the blockage of coronary arteries, and state the possible causes (diet, stress, smoking and genetic factors) and preventive measures.</li>     <li>7 Investigate, state and explain the effect of physical activity on pulse rate.</li>     <li>10 Explain how structure and function are related in arteries, veins and capillaries.</li>     <li>14 Describe the immune system in terms of antibody production, tissue rejection and phagocytosis.</li> </ol>



Core	Supplement
<b>B6. Respiration</b>	
<b>6.1 Aerobic and anaerobic respiration</b>	
<ol style="list-style-type: none"> <li>1 Define <i>respiration</i> as the chemical reactions that break down nutrient molecules in living cells to release energy.</li> <li>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.</li> <li>3 State the word equation for aerobic respiration.</li> </ol>	<ol style="list-style-type: none"> <li>4 Define <i>aerobic respiration</i> as the release of a relatively large amount of energy in cells by the breakdown of food substances in the presence of oxygen.</li> <li>5 State the equation for aerobic respiration, using symbols: (<math>C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O</math>).</li> <li>6 Define <i>anaerobic respiration</i> as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen.</li> <li>7 State the word equation for anaerobic respiration in muscles during hard exercise (glucose <math>\rightarrow</math> lactic acid) and the microorganism yeast (glucose <math>\rightarrow</math> alcohol + carbon dioxide).</li> <li>8 Describe the effect of lactic acid in muscles during exercise (include oxygen debt in outline only).</li> <li>9 Describe the role of anaerobic respiration in yeast during brewing and bread-making.</li> <li>10 Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released.</li> </ol>

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

Core	Supplement
<b>7.2 Hormones</b>	
<ol style="list-style-type: none"> <li>1 Define a <i>hormone</i> 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.</li> <li>2 State the role of the hormone adrenaline in the chemical control of metabolic activity, including increasing the blood glucose concentration and pulse rate.</li> <li>3 Give examples of situations in which adrenaline secretion increases.</li> </ol>	<ol style="list-style-type: none"> <li>4 Compare nervous and hormonal control systems.</li> </ol>
<b>7.3 Tropic responses</b>	
<ol style="list-style-type: none"> <li>1 Define and investigate <i>geotropism</i> (as a response in which a plant grows towards or away from gravity) and <i>phototropism</i> (as a response in which a plant grows towards or away from the direction from which light is coming).</li> </ol>	<ol style="list-style-type: none"> <li>2 Explain the chemical control of plant growth by auxins including geotropism and phototropism in terms of auxins regulating differential growth.</li> </ol>
<b>7.4 Homeostasis</b>	
<ol style="list-style-type: none"> <li>1 Define <i>homeostasis</i> as the maintenance of a constant internal environment.</li> <li>2 Identify, on a diagram of the skin: hairs, sweat glands, temperature receptors, blood vessels and fatty tissue.</li> <li>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 coordinating role of the brain.</li> </ol>	<ol style="list-style-type: none"> <li>4 Explain the concept of control by negative feedback.</li> <li>5 Describe the control of the glucose content of the blood by the liver, and by insulin and glucagon from the pancreas.</li> </ol>

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

Core	Supplement
<b>8.3 Sexual reproduction in humans</b>	
<ol style="list-style-type: none"> <li>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.</li> <li>3 Identify on diagrams of the female reproductive system: the ovaries, oviducts, uterus, cervix and vagina, and state the functions of these parts.</li> <li>4 Describe the menstrual cycle in terms of changes in the uterus and ovaries.</li> <li>5 Describe fertilisation in terms of the joining of the nuclei of male gamete (sperm) and the female gamete (egg).</li> <li>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.</li>   <li>10 Describe the methods of transmission of human immunodeficiency virus (HIV), and the ways in which HIV/AIDS can be prevented from spreading.</li> </ol>	<ol style="list-style-type: none"> <li>2 Compare male and female gametes in terms of size, numbers and mobility.</li>   <li>7 Indicate the functions of the amniotic sac and amniotic fluid.</li> <li>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).</li> <li>9 Describe the advantages and disadvantages of breast-feeding compared with bottle-feeding using formula milk.</li> <li>11 Outline how HIV affects the immune system in a person with HIV/AIDS.</li> </ol>

Core	Supplement
<b>B9. Inheritance</b>	
<b>9.1 Chromosomes and genes</b>	
<ol style="list-style-type: none"> <li>1 Define <i>inheritance</i> as the transmission of genetic information from generation to generation.</li> <li>2 Define the terms: <ul style="list-style-type: none"> <li>• <i>chromosome</i> as a thread of DNA, made up of a string of genes</li> <li>• <i>gene</i> 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</li> <li>• <i>allele</i> as any of two or more alternative forms of a gene.</li> </ul> </li> <li>4 Describe the inheritance of sex in humans (XX and XY chromosomes).</li> </ol>	<ol style="list-style-type: none"> <li>3 Define the terms: <ul style="list-style-type: none"> <li>• <i>haploid nucleus</i> as a nucleus containing a single set of unpaired chromosomes (e.g. sperm and egg)</li> <li>• <i>diploid nucleus</i> as a nucleus containing two sets of chromosomes (e.g. in body cells).</li> </ul> </li> </ol>
<b>9.2 Cell division</b>	
	<ol style="list-style-type: none"> <li>1 Define <i>mitosis</i> 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 <b>not</b> required).</li> <li>2 State the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction.</li> <li>3 Define <i>meiosis</i> as reduction division in which the chromosome number is halved from diploid to haploid (details of stages are <b>not</b> required).</li> <li>4 State that gametes are the result of meiosis.</li> <li>5 State that meiosis results in genetic variation so the cells produced are not all genetically identical.</li> </ol>

Core	Supplement
<b>9.3 Monohybrid inheritance</b>	
<p>1 Define the terms:</p> <ul style="list-style-type: none"> <li>• <i>genotype</i> as the genetic makeup of an organism in terms of the alleles present (e.g. Tt or GG)</li> <li>• <i>phenotype</i> as the physical or other features of an organism due to both its genotype and its environment (e.g. tall plant or green seed)</li> <li>• <i>homozygous</i> 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</li> <li>• <i>heterozygous</i> as having two different alleles of a particular gene (e.g. Tt or Gg), not pure-breeding</li> <li>• <i>dominant</i> as an allele that is expressed if it is present (e.g. T or G)</li> <li>• <i>recessive</i> as an allele that is only expressed when there is no dominant allele of the gene present (e.g. t or g).</li> </ul> <p>2 Calculate and predict the results of monohybrid crosses involving 1 : 1 and 3 : 1 ratios.</p>	

Core	Supplement
<b>9.4 Variation and selection</b>	
<p>5 Describe the role of artificial selection in the production of varieties of animals and plants with increased economic importance.</p> <p>7 Define <i>natural selection</i> as the greater chance of passing on of genes by the best-adapted organisms.</p>	<p>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.</p> <p>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.</p> <p>3 Define <i>mutation</i> as a change in a gene or chromosome.</p> <p>4 Outline the effects of ionising radiation on the rate of mutation.</p> <p>6 Describe variation, and state that competition leads to differential survival of, and reproduction by, those organisms best fitted to the environment.</p> <p>8 Explain the importance of natural selection as a possible mechanism for evolution.</p> <p>9 Describe the development of strains of antibiotic resistant bacteria as an example of natural selection.</p>



Core	Supplement
<b>B10. Energy flow in ecosystems</b>	
<ol style="list-style-type: none"> <li>1 State that the Sun is the principal source of energy input to biological systems.</li> <li>2 Define the terms: <ul style="list-style-type: none"> <li>• <i>food chain</i> as the flow of energy (food) from one organism to the next beginning with a producer (e.g. mahogany tree → caterpillar → song bird → hawk)</li> <li>• <i>food web</i> as a network of interconnected food chains showing the energy flow through part of an ecosystem</li> <li>• <i>producer</i> as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis</li> <li>• <i>consumer</i> as an organism that gets its energy by feeding on other organisms</li> <li>• <i>herbivore</i> as an animal that gets its energy by eating plants</li> <li>• <i>carnivore</i> as an animal that gets its energy by eating other animals.</li> </ul> </li> <li>6 Describe the carbon cycle.</li> </ol>	<ol style="list-style-type: none"> <li>3 Describe energy losses between trophic levels.</li> <li>4 Define the terms: <ul style="list-style-type: none"> <li>• <i>decomposer</i> as an organism that gets its energy from dead or waste organic matter</li> <li>• <i>ecosystem</i> as a unit containing all of the organisms and their environment, interacting together, in a given area, e.g. decomposing log or a lake</li> <li>• <i>trophic level</i> as the position of an organism in a food chain or food web.</li> </ul> </li> <li>5 Explain why food chains usually have fewer than five trophic levels.</li> <li>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.</li> </ol>
<b>B11. Human influences on the ecosystem</b>	
<ol style="list-style-type: none"> <li>1 List the undesirable effects of deforestation (to include extinction, loss of soil, flooding, carbon dioxide build-up).</li> <li>3 Describe the undesirable effects of pollution, to include: <ul style="list-style-type: none"> <li>• water pollution by sewage and chemical waste</li> <li>• air pollution by greenhouse gases (carbon dioxide and methane) contributing to global warming.</li> </ul> </li> <li>6 Describe the need for conservation of: <ul style="list-style-type: none"> <li>• species and their habitats</li> <li>• natural resources (limited to water and non-renewable materials including fossil fuels).</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>2 Describe the undesirable effects of overuse of fertilisers (to include eutrophication of lakes and rivers).</li> <li>4 Discuss the causes and effects on the environment of acid rain, and the measures that might be taken to reduce its incidence.</li> <li>5 Explain how increases in greenhouse gases (carbon dioxide and methane) are thought to cause global warming.</li> </ol>

## 6.2 Chemistry

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

Core	Supplement
<b>3.3 Atomic structure and the Periodic Table</b>	
<p>1 Describe the structure of an atom in terms of electrons and a nucleus containing protons and neutrons.</p> <p>3 State the relative charges and approximate relative masses of protons, neutrons and electrons.</p> <p>4 Define <i>atomic (proton) number</i> and <i>mass (nucleon) number</i>.</p> <p>5 Use atomic (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 atomic (proton) numbers 1 to 20. (A copy of the Periodic Table will be provided in Papers 1 and 3.)</p> <p>6 Define <i>isotope</i>.</p>	<p>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 <b>not</b> required).</p> <p>(A copy of the Periodic Table will be provided in Papers 2 and 4.)</p>
<b>3.4 Ions and ionic bonds</b>	
<p>1 Describe the formation of ions by electron loss or gain.</p> <p>2 Describe the formation of ionic bonds between metals and non-metals as exemplified by elements from Groups I and VII.</p>	<p>3 Explain the formation of ionic bonds between metallic and non-metallic elements.</p> <p>4 Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions, exemplified by the sodium chloride structure.</p>
<b>3.5 Molecules and covalent bonds</b>	
<p>1 State that non-metallic elements form non-ionic compounds using a different type of bonding called covalent bonding.</p> <p>3 Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds.</p>	<p>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) <math>H_2</math>, <math>Cl_2</math>, <math>H_2O</math>, <math>CH_4</math> and <math>HCl</math>.</p> <p>4 Draw dot-and-cross diagrams to represent the multiple bonding in <math>N_2</math>, <math>C_2H_4</math> and <math>CO_2</math>.</p>

Core	Supplement
<b>3.6 Giant structures</b>	
	<ol style="list-style-type: none"> <li>1 Describe the giant covalent structures of graphite and diamond.</li> <li>2 Relate their structures to the use of graphite as a lubricant and of diamond in cutting.</li> <li>3 Describe the structure of silicon(IV) oxide (silicon dioxide).</li> </ol>
<b>C4. Stoichiometry</b>	
<ol style="list-style-type: none"> <li>1 Use the symbols of the elements to write the formulae of simple compounds.</li> <li>2 Deduce the formula of a simple compound from the relative numbers of atoms present.</li> <li>3 Deduce the formula of a simple compound from a model or a diagrammatic representation.</li> <li>5 Construct and use word equations.</li> </ol>	<ol style="list-style-type: none"> <li>4 Determine the formula of an ionic compound from the charges on the ions present.</li> <li>6 Construct and use symbolic equations with state symbols, including ionic equations.</li> <li>7 Deduce the balanced equation for a chemical reaction, given relevant information.</li> <li>8 Define <i>relative atomic mass</i>, <math>A_r</math>.</li> <li>9 Define <i>relative molecular mass</i>, <math>M_r</math>, as the sum of the relative atomic masses (<i>relative formula mass</i> or <math>M_r</math> will be used for ionic compounds).</li> </ol>
<b>4.1 The mole concept</b>	
	<ol style="list-style-type: none"> <li>1 Define the <i>mole</i> in terms of a specific number of particles called Avogadro's constant. (Questions requiring recall of Avogadro's constant will <b>not</b> be set.)</li> <li>2 Use the molar gas volume, taken as <math>24\text{ dm}^3</math> at room temperature and pressure.</li> <li>3 Calculate stoichiometric reacting masses and reacting volumes of solutions; solution concentrations will be expressed in <math>\text{mol}/\text{dm}^3</math>. (Calculations involving the idea of limiting reactants may be set.)</li> </ol>

Core	Supplement
<b>C5. Electricity and chemistry</b>	
<p>1 State that electrolysis is the chemical effect of electricity on ionic compounds, causing them to break up into simpler substances, usually elements.</p> <p>2 Use the terms <i>electrode</i>, <i>electrolyte</i>, <i>anode</i> and <i>cathode</i>.</p> <p>4 Describe the electrode products, using inert electrodes, in the electrolysis of:</p> <ul style="list-style-type: none"> <li>• molten lead(II) bromide</li> <li>• aqueous copper chloride</li> <li>• dilute sulfuric acid.</li> </ul> <p>7 Describe the electroplating of metals, using laboratory apparatus.</p>	<p>3 Describe electrolysis in terms of the ions present and the reactions at the electrodes.</p> <p>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).</p> <p>6 Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core content, together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper).</p> <p>8 Predict the products of the electrolysis of a specified binary compound in the molten state, or in aqueous solution.</p> <p>9 Describe, in outline, the chemistry of the manufacture of:</p> <ul style="list-style-type: none"> <li>• aluminium from pure aluminium oxide in molten cryolite</li> <li>• chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride.</li> </ul>
<b>C6. Energy changes in chemical reactions</b>	
<p>1 Relate the terms <i>exothermic</i> and <i>endothermic</i> to the temperature changes observed during chemical reactions.</p>	<p>2 Demonstrate understanding that exothermic and endothermic changes relate to the transformation of chemical energy to heat (thermal energy), and vice versa.</p>

Core	Supplement
<b>C7. Chemical reactions</b>	
<b>7.1 Rate of reaction</b>	
1 Describe the effect of concentration, particle size, catalysis and temperature on the rates of reactions. 2 Describe a practical method for investigating the rate of a reaction involving gas evolution. 3 Devise a suitable method for investigating the effect of a given variable on the rate 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 <i>catalyst</i> as an agent which increases rate but which remains unchanged.	4 Interpret data obtained from experiments concerned with rate of reaction. 6 Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles (the concept of activation energy will <b>not</b> be examined).
<b>7.2 Redox</b>	
1 Define <i>oxidation</i> and <i>reduction</i> in terms of oxygen loss/gain, and identify such reactions from given information.	2 Define <i>redox</i> in terms of electron transfer, and identify such reactions from given information.
<b>C8. Acids, bases and salts</b>	
<b>8.1 The characteristic properties of acids and bases</b>	
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 of acids with metals, bases (including alkalis) and carbonates. 3 Describe and explain the importance of controlling acidity in the environment (air, water and soil).	
<b>8.2 Types of oxides</b>	
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.

Core	Supplement
<b>8.3 Preparation of salts</b>	
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.
<b>8.4 Identification of ions and gases</b>	
1 Use the following tests to identify: <b>aqueous cations:</b> <ul style="list-style-type: none"> <li><i>ammonium</i>, <i>copper(II)</i>, <i>iron(II)</i>, <i>iron(III)</i> and <i>zinc</i> by means of aqueous sodium hydroxide and aqueous ammonia as appropriate (formulae of complex ions are <b>not</b> required)</li> </ul> <b>anions:</b> <ul style="list-style-type: none"> <li><i>carbonate</i> by means of dilute acid and then limewater</li> <li><i>chloride</i> by means of aqueous silver nitrate under acidic conditions</li> <li><i>nitrate</i> by reduction with aluminium</li> <li><i>sulfate</i> by means of aqueous barium ions under acidic conditions</li> </ul> <b>gases:</b> <ul style="list-style-type: none"> <li><i>ammonia</i> by means of damp red litmus paper</li> <li><i>carbon dioxide</i> by means of limewater</li> <li><i>chlorine</i> by means of damp litmus paper</li> <li><i>hydrogen</i> by means of a lighted splint</li> <li><i>oxygen</i> by means of a glowing splint.</li> </ul>	
<b>C9. The Periodic Table</b>	
1 Describe the way the Periodic Table classifies elements in order of atomic (proton) number.	2 Use the Periodic Table to predict properties of elements by means of groups and periods.
<b>9.1 Periodic trends</b>	
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
<b>9.2 Group properties</b>	
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.
<b>9.3 Transition elements</b>	
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.	
<b>9.4 Noble gases</b>	
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.	
<b>C10. Metals</b>	
<b>10.1 Properties of metals</b>	
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.
<b>10.2 Reactivity series</b>	
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: <ul style="list-style-type: none"> <li>• water or steam</li> <li>• dilute hydrochloric acid (except for alkali metals).</li> </ul>	2 Compare the reactivity series to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with: <ul style="list-style-type: none"> <li>• the aqueous ions of other listed metals</li> <li>• the oxides of the other listed metals.</li> </ul> 3 Deduce an order of reactivity from a given set of experimental results.



Core	Supplement
<b>10.3 Extraction of metals</b>	
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.
<b>10.4 Uses of metals</b>	
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
<b>C11. Air and water</b>	
<ol style="list-style-type: none"> <li>1 Describe a chemical test for water.</li> <li>2 Describe and explain, in outline, the purification of the water supply by filtration and chlorination.</li> <li>3 State some of the uses of water in industry and in the home.</li> <li>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.</li> <li>6 State the common air pollutants as carbon monoxide, sulfur dioxide and oxides of nitrogen, and describe their sources.</li> <li>9 State the adverse effect of common air pollutants on buildings and on health.</li> <li>10 Describe the formation of carbon dioxide: <ul style="list-style-type: none"> <li>• as a product of complete combustion of carbon-containing substances</li> <li>• as a product of respiration</li> <li>• as a product of the reaction between an acid and a carbonate</li> <li>• as a product of thermal decomposition.</li> </ul> </li> <li>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.</li> <li>13 Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers.</li> <li>14 Describe the displacement of ammonia from its salts by warming with an alkali.</li> </ol>	<ol style="list-style-type: none"> <li>4 Describe the separation of oxygen and nitrogen from liquid air by fractional distillation.</li> <li>7 Explain the presence of oxides of nitrogen in car exhausts and their catalytic removal.</li> <li>8 Explain why the proportion of carbon dioxide in the atmosphere is increasing, and why this is important.</li> <li>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.</li> </ol>
<b>C12. Sulfur</b>	
	<ol style="list-style-type: none"> <li>1 Describe the manufacture of sulfuric acid by the Contact process, including essential conditions.</li> <li>2 Describe the properties of dilute sulfuric acid as a typical acid.</li> </ol>

Core	Supplement
<b>C13. Carbonates</b>	
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.	
<b>C14. Organic chemistry</b>	
<b>14.1 Fuels</b>	
1 Recall coal, natural gas and petroleum as fossil fuels that produce carbon dioxide on combustion. 2 Name methane as the main constituent of natural gas. 3 Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation. 5 State the use of: <ul style="list-style-type: none"> <li>• refinery gas for bottled gas for heating and cooking</li> <li>• gasoline fraction for fuel (petrol) in cars</li> <li>• diesel oil/gas oil for fuel in diesel engines.</li> </ul>	4 Understand the essential principle of fractional distillation in terms of differing boiling points (ranges) of fractions related to molecular size and intermolecular attractive forces.
<b>14.2 Introduction to organic compounds</b>	
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 <i>-ane</i> , <i>-ene</i> and <i>-ol</i> , 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 ( <b>not</b> <i>cis-trans</i> ), containing up to four carbon atoms per molecule.

Core	Supplement
<b>14.3 Hydrocarbons</b>	
<ol style="list-style-type: none"> <li>Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning.</li> <li>State that the products of complete combustion of hydrocarbons, exemplified by methane, are carbon dioxide and water.</li> <li>Name <i>cracking</i> as a reaction which produces alkenes.</li> <li>Recognise saturated and unsaturated hydrocarbons: <ul style="list-style-type: none"> <li>from molecular structures</li> <li>by their reaction with aqueous bromine.</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>Describe the manufacture of alkenes by cracking.</li> <li>Describe the addition reactions of alkenes, exemplified by ethene, with bromine, hydrogen and steam.</li> </ol>
<b>14.4 Alcohols</b>	
<ol style="list-style-type: none"> <li>State that ethanol may be formed by reaction between ethene and steam.</li> <li>Describe the complete combustion reaction of ethanol.</li> <li>State the uses of ethanol as a solvent and as a fuel.</li> </ol>	<ol style="list-style-type: none"> <li>Describe the formation of ethanol by the catalytic addition of steam to ethene.</li> </ol>
<b>14.5 Macromolecules</b>	
	<ol style="list-style-type: none"> <li>Describe macromolecules in terms of large molecules built up from small units (monomers), different macromolecules having different units.</li> </ol>
<b>14.6 Synthetic polymers</b>	
<ol style="list-style-type: none"> <li>Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units.</li> </ol>	<ol style="list-style-type: none"> <li>Draw the structure of poly(ethene).</li> <li>Describe the formation of a simple condensation polymer exemplified by nylon, the structure of nylon being represented as: <div style="text-align: center;"> </div> </li> </ol>

Core	Supplement
<b>14.7 Natural macromolecules</b>	
	<ol style="list-style-type: none"><li data-bbox="831 376 1390 472">1 Describe proteins as possessing the same (amide) linkages as nylon but formed from the linking of amino acids.</li><li data-bbox="831 488 1390 618">2 State that proteins can be hydrolysed to amino acids under acid or alkaline conditions (the structures and names are <b>not</b> required).</li></ol>

## 6.3 Physics

Core	Supplement
<b>P1. Motion</b>	
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: <ul style="list-style-type: none"> <li>• at rest</li> <li>• moving with constant speed</li> <li>• moving with changing speed.</li> </ul> 8 Demonstrate a qualitative understanding that acceleration is related to changing speed.	2 Distinguish between <i>speed</i> and <i>velocity</i> .  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.
<b>P2. Matter and forces</b>	
<b>2.1 Mass and weight</b>	
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.
<b>2.2 Density</b>	
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
<b>2.3 Effects of forces</b>	
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 $\times$ 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): $F = ma$
<b>2.4 Pressure</b>	
1 Relate (without calculation) pressure to force and area.	2 Recall and use the equation $P = F/A$
<b>P3. Energy, work and power</b>	
<b>3.1 Energy</b>	
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 energy, K.E.) or its position (potential energy, P.E.), 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. = $\frac{1}{2}mv^2$ and P.E. = $mgh$  6 Apply the principle of energy conservation to simple examples.

Core	Supplement
<b>3.2 Energy resources</b>	
<p>1 Distinguish between renewable and non-renewable sources of energy.</p> <p>2 Know that the Sun is the source of energy for all our energy resources except geothermal and nuclear.</p> <p>4 Describe how electricity or other useful forms of energy may be obtained from:</p> <ul style="list-style-type: none"> <li>• chemical energy stored in fuel</li> <li>• water, including the energy stored in waves, in tides, and in water behind hydroelectric dams</li> <li>• geothermal resources</li> <li>• nuclear fission</li> <li>• heat and light from the Sun (solar cells and panels)</li> <li>• wind.</li> </ul> <p>5 Give advantages and disadvantages of each method in terms of reliability, scale and environmental impact.</p> <p>6 Demonstrate a qualitative understanding of efficiency.</p>	<p>3 Demonstrate understanding that energy is released by nuclear fusion in the Sun.</p> <p>7 Recall and use the equation:  <math display="block">\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%</math></p>
<b>3.3 Work</b>	
<p>1 Relate (without calculation) work done to the magnitude of a force and the distance moved.</p>	<p>2 Describe energy changes in terms of work done.</p> <p>3 Recall and use <math>W = F \times d</math></p>
<b>3.4 Power</b>	
<p>1 Relate (without calculation) power to work done and time taken, using appropriate examples.</p>	<p>2 Recall and use the equation <math>P = E/t</math> in simple systems.</p>
<b>P4. Simple kinetic molecular model of matter</b>	
<b>4.1 States of matter</b>	
<p>1 State the distinguishing properties of solids, liquids and gases.</p>	



Core	Supplement
<b>4.2 Molecular model</b>	
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.
<b>4.3 Evaporation</b>	
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.
<b>4.4 Pressure changes</b>	
	1 Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature and use the equation $PV = \text{constant}$ at constant temperature.
<b>P5. Matter and thermal properties</b>	
<b>5.1 Thermal expansion of solids, liquids and gases</b>	
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
<b>5.2 Thermal capacity</b>	
	<ol style="list-style-type: none"> <li>1 Demonstrate understanding of the term <i>thermal capacity</i>.</li> <li>2 Describe an experiment to measure the specific heat capacity of a substance.</li> <li>3 Recall and use the equation: energy = mass × specific heat capacity × change in temperature</li> </ol>
<b>5.3 Melting and boiling</b>	
<ol style="list-style-type: none"> <li>1 Describe melting and boiling in terms of energy input without a change in temperature.</li> <li>3 Describe condensation and solidification.</li> <li>5 State the meaning of <i>melting point</i> and <i>boiling point</i>.</li> </ol>	<ol style="list-style-type: none"> <li>2 Distinguish between boiling and evaporation.</li> <li>4 Use the terms <i>latent heat of vaporisation</i> and <i>latent heat of fusion</i>, and give a molecular interpretation of latent heat.</li> </ol>
<b>P6. Transfer of thermal energy</b>	
<b>6.1 Conduction</b>	
<ol style="list-style-type: none"> <li>1 Describe experiments to demonstrate the properties of good and bad conductors of heat.</li> </ol>	<ol style="list-style-type: none"> <li>2 Explain heat transfer in solids in terms of molecular motion.</li> </ol>
<b>6.2 Convection</b>	
<ol style="list-style-type: none"> <li>1 Recognise convection as the main method of heat transfer in liquids and gases.</li> <li>3 Describe experiments to illustrate convection in liquids and gases.</li> </ol>	<ol style="list-style-type: none"> <li>2 Relate convection in fluids to density changes.</li> </ol>
<b>6.3 Radiation</b>	
<ol style="list-style-type: none"> <li>1 Recognise radiation as the method of heat transfer that does not require a medium to travel through.</li> <li>2 Identify infra-red radiation as the part of the electromagnetic spectrum often involved in heat transfer by radiation.</li> </ol>	<ol style="list-style-type: none"> <li>3 Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation.</li> </ol>
<b>6.4 Consequences of energy transfer</b>	
<ol style="list-style-type: none"> <li>1 Identify and explain some of the everyday applications and consequences of conduction, convection and radiation.</li> </ol>	

Core	Supplement
<b>P7. Waves</b>	
<b>7.1 General wave properties</b>	
1 Demonstrate understanding that wave motion transfers energy without transferring matter in the direction of wave travel. 2 Describe what is meant by <i>wave motion</i> as illustrated by vibration in ropes and springs and by experiments using water waves. 3 State the meaning of and use the terms <i>speed, frequency, wavelength</i> and <i>amplitude</i> . 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.
<b>P8. Light</b>	
<b>8.1 Reflection of light</b>	
1 Describe the formation and characteristics of an optical image seen in a plane mirror. 3 Use the law: angle of incidence, $i$ = angle of reflection, $r$	2 Perform simple constructions, measurements and calculations based on reflections in plane mirrors.
<b>8.2 Refraction of light</b>	
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 $r$ . 3 State the meaning of <i>critical angle</i> . 4 Identify and describe internal and total internal reflection using ray diagrams.	5 Describe the action of optical fibres and their use in medicine and communications technology.

Core	Supplement
<b>8.3 Thin converging lens</b>	
1 Describe the action of a thin converging lens on a beam of light using ray diagrams. 2 Use the terms <i>principal focus</i> and <i>focal length</i> . 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.
<b>8.4 Dispersion of light</b>	
1 Describe the dispersion of light by a glass prism.	
<b>P9. Electromagnetic spectrum</b>	
1 Describe the main features of the electromagnetic spectrum. 3 Describe the role of electromagnetic waves in: <ul style="list-style-type: none"> <li>• radio and television communications (radio waves)</li> <li>• satellite television and telephones (microwaves)</li> <li>• electrical appliances, remote controllers for televisions and intruder alarms (infra-red)</li> <li>• medicine and security (X-rays).</li> </ul> 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 <i>in vacuo</i> .
<b>P10. Sound</b>	
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 typical values of the speed of sound in air, liquids and solids.

Core	Supplement
<b>P11. Magnetism</b>	
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.
<b>P12. Electricity</b>	
<b>12.1 Electrical quantities</b>	
1 Demonstrate understanding of <i>current</i> , <i>potential difference</i> , <i>e.m.f.</i> and <i>resistance</i> , 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).
<b>12.2 Electric charge</b>	
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.
<b>12.3 Current, electromotive force and potential difference</b>	
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
<b>12.4 Resistance</b>	
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.
<b>12.5 Electrical energy</b>	
	1 Recall and use the equations $P = IV$ and $E = IVt$
<b>12.6 Dangers of electricity</b>	
1 Identify electrical hazards, including: <ul style="list-style-type: none"> <li>• damaged insulation</li> <li>• overheating of cables</li> <li>• damp conditions.</li> </ul> 3 Demonstrate understanding of the use of fuses.	2 Demonstrate understanding of the use of circuit-breakers.
<b>P13. Electric circuits</b>	
<b>13.1 Circuit diagrams</b>	
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
<b>13.2 Series and parallel circuits</b>	
<ol style="list-style-type: none"> <li>1 Demonstrate understanding that the current at every point in a series circuit is the same.</li> <li>3 Calculate the combined resistance of two or more resistors in series.</li> <li>4 State that, for a parallel circuit, the current from the source is larger than the current in each branch.</li> <li>6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself.</li> <li>8 State the advantages of connecting lamps in parallel in a lighting circuit.</li> </ol>	<ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>7 Calculate the effective resistance of two resistors in parallel.</li> </ol>
<b>13.3 Action and use of circuit components</b>	
	<ol style="list-style-type: none"> <li>1 Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers.</li> <li>2 Describe the action of a relay and show understanding of its use in switching circuits.</li> <li>3 Recognise and demonstrate understanding of circuits operating as light-sensitive switches and temperature-operated alarms using a relay.</li> </ol>
<b>P14. Electromagnetic effects</b>	
<b>14.1 Electromagnetic induction</b>	
	<ol style="list-style-type: none"> <li>1 Describe an experiment that shows that a changing magnetic field can induce an e.m.f. in a circuit.</li> <li>2 State the factors affecting the magnitude of an induced e.m.f.</li> </ol>
<b>14.2 a.c. generator</b>	
	<ol style="list-style-type: none"> <li>1 Describe a rotating-coil generator and the use of slip rings.</li> <li>2 Sketch a graph of voltage output against time for a simple a.c. generator.</li> </ol>

Core	Supplement
<b>14.3 Transformer</b>	
	<ol style="list-style-type: none"> <li>Describe the construction of a basic iron-cored transformer as used for voltage transformations.</li> <li>Recall and use the equation <math>(V_p / V_s) = (N_p / N_s)</math></li> <li>Describe the use of the transformer in high-voltage transmission of electricity.</li> <li>Recall and use the equation <math>V_p I_p = V_s I_s</math> (for 100% efficiency).</li> <li>Explain why energy losses in cables are lower when the voltage is high.</li> </ol>
<b>14.4 The magnetic effect of a current</b>	
<ol style="list-style-type: none"> <li>Describe the pattern of the magnetic field due to currents in straight wires and in solenoids.</li> <li>Describe applications of the magnetic effect of current, including the action of a relay.</li> </ol>	<ol style="list-style-type: none"> <li>Describe the effect on the magnetic field of changing the magnitude and direction of the current.</li> </ol>
<b>14.5 Force on a current-carrying conductor</b>	
<ol style="list-style-type: none"> <li>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: <ul style="list-style-type: none"> <li>the current</li> <li>the direction of the field.</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>State and use the relative directions of force, field and current.</li> </ol>
<b>14.6 d.c. motor</b>	
	<ol style="list-style-type: none"> <li>Describe the turning effect on a current-carrying coil in a magnetic field.</li> <li>Relate this turning effect to the action of an electric motor.</li> <li>Describe the effect of increasing: <ul style="list-style-type: none"> <li>the number of turns in the coil</li> <li>the current.</li> </ul> </li> </ol>



Core	Supplement
<b>P15. Radioactivity</b>	
<b>15.1 Detection of radioactivity</b>	
1 Demonstrate understanding of background radiation. 2 Describe the detection of $\alpha$ -particles, $\beta$ -particles and $\gamma$ -rays ( $\beta^+$ are not included; $\beta$ -particles will be taken to refer to $\beta^-$ ).	
<b>15.2 Characteristics of the three kinds of emission</b>	
1 State that radioactive emissions occur randomly over space and time. 2 Recall for radioactive emissions, and use to identify them: <ul style="list-style-type: none"> <li>• their nature</li> <li>• their relative ionising effects</li> <li>• their relative penetrating abilities.</li> </ul>	3 Describe the deflection of $\alpha$ -particles, $\beta$ -particles and $\gamma$ -rays in electric fields and magnetic fields. 4 Interpret their relative ionising effects.
<b>15.3 Radioactive decay</b>	
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.
<b>15.4 Half-life</b>	
	1 Use the term <i>half-life</i> in simple calculations, including the use of information in tables or decay curves.
<b>15.5 Safety precautions</b>	
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.	
<b>15.6 The nuclear atom</b>	
1 Describe the composition of the nucleus in terms of protons and neutrons. 2 Use the term <i>atomic (proton) number Z</i> . 3 Use the term <i>mass (nucleon) number A</i> .	

Core	Supplement
<b>15.7 Isotopes</b>	
<ol style="list-style-type: none"><li>1 Use the term <i>isotope</i>.</li><li>2 Give and explain examples of practical applications of isotopes.</li><li>3 Use the term <i>nuclide</i> and use the nuclide notation <math>{}^A_ZX</math></li></ol>	

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## 7. Practical assessment

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Scientific subjects are, by their nature, experimental. It is therefore important that an assessment of a candidate's knowledge and understanding of science should contain a practical component (see assessment objective AO3).

Schools' circumstances (e.g. the availability of resources) differ greatly, so two alternative ways of examining the practical component are provided. The alternatives are:

- Paper 5: Practical Test
- Paper 6: Alternative to Practical (written paper).

Whichever practical assessment route is chosen, the following points should be noted:

- the same assessment objectives apply
- the same practical skills are to be learned and developed
- the same sequence of practical activities is appropriate.

Candidates may **not** use textbooks in the practical component, nor any of their own records of laboratory work carried out during their course.

Calculators may be used in all parts of the assessment.

### 7.1 Teaching experimental skills

The best preparation for these papers is for learners to pursue a course in which practical work is fully integrated so that it is a normal and natural part of the teaching.

Teachers are expected to identify suitable opportunities to embed practical techniques and investigative work throughout the course, rather than as an isolated aspect of preparation for examination. This approach will not only provide opportunities for developing experimental skills but will increase the appeal of the course, and the enjoyment of the subject. Practical work helps learners to acquire a secure understanding of the syllabus topics and to appreciate how scientific theories are developed and tested. It also promotes important scientific attitudes such as objectivity, integrity, co-operation, enquiry and inventiveness.

### Experimental work

Experimental work is an essential component of all science and should form a key part of teachers' delivery plans for this syllabus.

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.

## Note on taking readings

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

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

## Apparatus list

The list below details the apparatus expected to be generally available for both the teaching and the examination of Paper 5. The list is not exhaustive: in particular, some items that are commonly regarded as standard equipment in a science laboratory are not included.

The *Confidential Instructions*, provided to Centres prior to the examination of Paper 5, will give the detailed requirements for each examination.

- rulers capable of measuring to 1 mm
- metre rule
- 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,  $100\text{ cm}^3$ ,  $250\text{ cm}^3$
- a polystyrene or other plastic beaker of approximate capacity  $150\text{ cm}^3$
- test-tubes (Pyrex or hard glass), approximately  $125\text{ mm} \times 16\text{ mm}$
- test-tubes, approximately  $125\text{ mm} \times 16\text{ mm}$
- boiling tubes, approximately  $150\text{ mm} \times 25\text{ mm}$
- delivery tubes
- conical flasks, within the range  $150\text{ cm}^3$  to  $250\text{ cm}^3$
- means of measuring small volumes of liquids, such as syringes (with needles removed)
- measuring cylinders,  $100\text{ cm}^3$ ,  $50\text{ cm}^3$ ,  $25\text{ cm}^3$ ,  $10\text{ cm}^3$
- dropping pipettes
- white tiles
- spotting tiles
- water-bath
- large containers (e.g. plastic bowl) to hold cold water
- hand lens  $\times 6$  magnification
- thermometers,  $-10^\circ\text{C}$  to  $+110^\circ\text{C}$  with  $1^\circ\text{C}$  graduations
- stopclocks (or wall clock or wrist-watch), to measure to an accuracy of 1 s
- Petri dishes
- glass rods
- spatulas

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

## 7.2 Description of Components, Paper 5: Practical Test and Paper 6: Alternative to Practical

These papers are based on testing experimental skills. The questions do not assess specific syllabus content from Section 6: Syllabus content. Any information required to answer these questions is contained within the question paper or from the experimental context and skills listed below.

Questions are structured to assess across the grade range A\*A\*–GG.

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

Questions may be set requiring candidates to:

- carefully follow a sequence of instructions
- describe, explain or comment on experimental arrangements and techniques
- select the most appropriate apparatus or method for a task and justify the choice made
- draw, complete or label diagrams of apparatus
- perform simple arithmetical calculations
- take readings from an appropriate measuring device or from an image of the device (e.g. thermometer, rule, protractor, measuring cylinder, ammeter, stopwatch), including:
  - reading analogue and digital scales with accuracy and appropriate precision
  - interpolating between scale divisions when appropriate
  - correcting for zero errors when appropriate
- plan to take a sufficient number and range of measurements, repeating where appropriate to obtain an average value
- describe or explain precautions taken in carrying out a procedure to ensure safety or the accuracy of observations and data, including the control of variables and repetition of measurements
- identify key variables and describe how, or explain why, certain variables should be controlled
- record observations systematically, for example in a table, using appropriate units and to a consistent and appropriate degree of precision
- process data, using a calculator where necessary
- present and analyse data graphically, including the use of best-fit lines where appropriate, interpolation and extrapolation, and the determination of a gradient, intercept or intersection
- interpret and evaluate observations and experimental data
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- comment critically on a procedure or point of practical detail, and suggest an appropriate improvement
- evaluate the quality of data, identifying and dealing appropriately with any anomalous results
- identify possible causes of uncertainty, in data or in a conclusion
- make estimates or describe outcomes which demonstrate their familiarity with an experiment, procedure or technique
- plan an experiment or investigation, including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

## Biology

Candidates may be asked questions on the following experimental contexts:

- the use of familiar, and unfamiliar, techniques to record observations and data, process them and make deductions from them
- recall of simple chemical tests, e.g. for food substances and the use of limewater, hydrogencarbonate indicator, litmus and Universal Indicator paper
- recognise, observe, record and measure images of familiar, and unfamiliar, biological specimens
- make a clear line drawing from an image of a specimen, calculating the magnification and adding labels as required.

## Chemistry

Candidates may be asked questions on the following experimental contexts:

- simple quantitative experiments involving the measurement of volumes and/or masses
- rates (speeds) of reaction
- measurement of temperature based on a thermometer with 1 °C graduations and energetics
- problems of an investigatory nature, possibly including suitable organic compounds
- filtration
- electrolysis
- identification of ions and gases
- metals and the reactivity series
- acids, bases, oxides and the preparation of salts
- redox reactions and rusting.

## Physics

Candidates may be asked questions on the following experimental contexts:

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

## 8. Appendix

### 8.1 Symbols, units and definitions of physical quantities


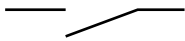

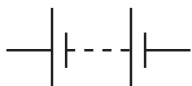






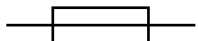

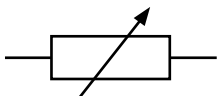
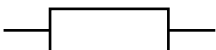


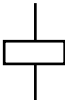

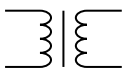

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. Candidates should be able to define those items indicated by an asterisk (\*). The list for the Extended curriculum includes both the Core and the Supplement.

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
density*	$d, \rho$	$kg/m^3, g/cm^3$			
time	$t$	h, min, s			ms
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*
work done	$W, E$	J	work done by a force*		J*
energy	$E$	J			J*, kWh
power	$P$	W	power*		W*
			pressure	$P$	Pa
temperature	$\theta, T$	$^{\circ}C$		$T$	K
specific heat capacity	$c$	J/(kg $^{\circ}C$ )	specific heat capacity*		
frequency	$f$	Hz	frequency*	$f$	Hz*
wavelength	$\lambda$	m, cm	wavelength*	$\lambda$	m, cm
focal length	$f$	cm, mm			
angle of incidence	$i$	degree ( $^{\circ}$ )			
angle of reflection, refraction	$r$	degree ( $^{\circ}$ )			
critical angle*	$c$	degree ( $^{\circ}$ )			
potential difference/voltage*	$V$	V, mV	potential difference*		V*
current	$I$	A*, mA	current*		
charge	$Q$	C			C
e.m.f.	$E$	V	e.m.f.*		
resistance*	$R$	$\Omega$			
			mole*	$n$	mol
			concentration	$c$	mol/dm <sup>3</sup>



## 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	
light dependent resistor			
Supplement			
relay coil		electric bell	
transformer		buzzer	

## 8.3 Safety in the laboratory

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

### Associations

CLEAPSS is an advisory service providing support in practical science and technology, primarily for UK schools. International schools and post-16 colleges can apply for associate membership, which includes access to the CLEAPSS publications listed below.

**<http://www.cleapss.org.uk>**

### Websites

**<http://www.ncbe.reading.ac.uk/NCBE/SAFETY/menu.html>**

**<http://www.microbiologyonline.org.uk/teachers/safety-information>**

### Publications

*Safeguards in the School Laboratory*, ASE, 11th edition, 2006

*Topics in Safety*, ASE, 3rd edition, 2001

*CLEAPSS Laboratory Handbook*, updated 2009 (available to CLEAPSS members only)

*CLEAPSS Hazcards*, 2007 update of 1995 edition (available to CLEAPSS members only)

*Safety in Science Education*, DfES, HMSO, 1996

*Hazardous Chemicals Manual*, SSERC, 1997

*Hazardous Chemicals. An interactive manual for science education*, SSERC, 2002 (CD)

### UK Regulations

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

**<http://www.legislation.gov.uk/uksi/2002/2677/contents/made>**

**<http://www.legislation.gov.uk/uksi/2004/3386/contents/made>**

A brief guide may be found at

**<http://www.hse.gov.uk/pubns/indg136.pdf>**

## 8.4 Notes for use in qualitative analysis

### Tests for anions

anion	test	test result
carbonate ( $\text{CO}_3^{2-}$ )	add dilute acid	effervescence, carbon dioxide produced
chloride ( $\text{Cl}^-$ ) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
nitrate ( $\text{NO}_3^-$ ) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate ( $\text{SO}_4^{2-}$ ) [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 ( $\text{NH}_4^+$ )	ammonia produced on warming	–
copper(II) ( $\text{Cu}^{2+}$ )	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) ( $\text{Fe}^{2+}$ )	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) ( $\text{Fe}^{3+}$ )	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc ( $\text{Zn}^{2+}$ )	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 ( $\text{NH}_3$ )	turns damp red litmus paper blue
carbon dioxide ( $\text{CO}_2$ )	turns limewater milky
chlorine ( $\text{Cl}_2$ )	bleaches damp litmus paper
hydrogen ( $\text{H}_2$ )	'pops' with a lighted splint
oxygen ( $\text{O}_2$ )	relights a glowing splint

## 8.5 The Periodic Table of Elements

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

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

The volume of one mole of any gas is 24dm<sup>3</sup> at room temperature and pressure (r.t.p.)

## 8.6 Mathematical requirements

Calculators may be used in all parts of the assessment.

Candidates should be able to:

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

## 8.7 Presentation of data

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

(a) Tables

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

(b) Graphs

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

- The gradient of a straight line should be taken using a triangle whose hypotenuse extends over at least half of the length of the best-fit line, and this triangle should be marked on the graph.
- (c) Numerical results
- Data should be recorded so as to reflect the precision of the measuring instrument.
  - The number of significant figures given for calculated quantities should be appropriate to the least number of significant figures in the raw data used.
- (d) Pie charts
- These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie charts should preferably contain no more than six sectors.
- (e) Bar charts
- These should be drawn when one of the variables is not numerical. They should be made up of narrow blocks of equal width that do **not** touch.
- (f) Histograms
- These are drawn when plotting frequency graphs with continuous data. The blocks should be drawn in order of increasing or decreasing magnitude and they **should** touch.

## 8.8 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 (i.e. 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: 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.

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## 9. Other information

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### 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/examsOfficers](http://www.cie.org.uk/examsOfficers)**

### 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\*, AA, BB, CC, DD, EE, FF or GG indicating the standard achieved, A\*A\* being the highest and GG the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade GG. '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.

### 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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