CAMBRIDGE
International Examinations

Cambridge
IGCSE

SYLLABUS

Cambridge IGCSE™
Physical Science

0652

For examination in November 2019, 2020 and 2021.

Cambridge Secondary 2

Version 3

What has changed in Cambridge IGCSE Physical Science 0652 for 2019, 2020 and 2021?

The syllabus has been revised for first examination in 2019. Some changes are significant.

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

Changes in version 3 of the syllabus, published December 2018

We have clarified the information about the grades available for Core and Extended tier assessment.

- The information has been clarified in section 3 Syllabus overview and section 6 Practical assessment.

Changes in version 2 of the syllabus, published September 2017

Combining this with other syllabuses

Candidates cannot take Cambridge IGCSE (9–1) Chemistry (0971), Cambridge IGCSE (9–1) Physics (0972) or Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973) with this syllabus.

Changes in version 1 of the syllabus, published September 2016

Section 5. Syllabus content

The syllabus content has been completely revised, updated and reorganised to align with the single Science syllabuses (Cambridge IGCSE Chemistry 0620 and Cambridge IGCSE Physics 0625).

Section 7. Appendix

The appendix has been revised, updated and reorganised to align with the single Science syllabuses (Cambridge IGCSE Chemistry 0620 and Cambridge IGCSE Physics 0625).

| Significant changes to the appendix are indicated by black vertical lines either side of the text. |

Changes to assessment

Paper 5, Practical Test, 1 hour 15 minutes, 40 marks

– The number of marks for Paper 5 Practical Test is now 40 marks.

– The duration of Paper 5 Practical Test is now 1 hour 15 minutes.

Paper 5: Practical Test will now typically consist of 4 exercises, only 3 of which will require the use of apparatus.

One question on Paper 5 will assess the skill of planning. This question will be based on any one of the sciences, which could be Chemistry or Physics and may vary between each examination series.

Paper 6, Alternative to Practical, 1 hour, 40 marks

– The number of marks for Paper 6 Alternative to Practical is now 40 marks.

– The duration of Paper 6 Alternative to Practical is unchanged.

One question on Paper 6 will assess the skill of planning. This question will be based on any one of the sciences, which could be Chemistry or Physics and may vary between each examination series.

| Significant changes to the assessment are indicated by black vertical lines either side of the text. |

In addition to reading the syllabus, teachers should refer to the updated specimen papers.

Contents

1. Introduction

1.1 Why choose Cambridge?

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

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 and qualifications set the global standard for international education. They are created by subject experts, rooted in academic rigour and reflect the latest educational research. They provide a strong platform for learners to progress from one stage to the next, and are well supported by teaching and learning resources.

Every year, nearly a million Cambridge learners from 10 000 schools in 160 countries prepare for their future with an international education from Cambridge.

Cambridge learners

Our mission is to provide educational benefit through provision of international programmes and qualifications for school education and to be the world leader in this field. Together with schools, we develop Cambridge learners who are:

- **confident** 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**

Support for teachers

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

Support for exams officers

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

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

1.2 Why choose Cambridge IGCSE?

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

Our aim is to balance knowledge, understanding and skills in our programmes and qualifications to enable 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 & A Levels, the Cambridge AICE (Advanced International Certificate of Education) Diploma, Cambridge Pre-U, and other education programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge IGCSEs at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge IGCSE syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of the course, 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 Physical Science?

Cambridge IGCSE Physical Science gives learners the opportunity to study 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 Cambridge IGCSE Physical Science syllabus encourages learners to develop:

- a better understanding of the technological world, with an informed interest in scientific matters
- a recognition of the usefulness (and limitations) of scientific method, and how to apply this to other disciplines and in everyday life
- relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness
- an interest in, and care for, the environment
- a better understanding of the influence and limitations placed on scientific study by society, economy, technology, ethics, the community and the environment
- 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 previously have studied a science syllabus 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 (see the *Mathematical requirements* in Section 7.7).

Progression

Cambridge IGCSEs are general qualifications that enable learners to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades A* to C in Cambridge IGCSE Physical Science are well prepared to follow courses leading to Cambridge International AS & A Level Science subjects, 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**

1.5 How can I find out more?

If you are already a Cambridge school

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

If you are not yet a Cambridge school

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

2. Teacher support

2.1 Support materials

You can go to our public website at **www.cie.org.uk/igcse** to download current and future syllabuses together with specimen papers or past question papers and examiner reports and grade threshold tables 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 **https://teachers.cie.org.uk** (username and password required). If you do not have access, speak to the Teacher Support coordinator at your school.

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 make sure 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. See **www.cie.org.uk/i-want-to/resource-centre** for further information.

2.3 Training

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

3. Syllabus overview

3.1 Content

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

Chemistry

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

Physics

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

3.2 Assessment

All candidates must enter for three papers.

Core candidates take:		Extended candidates take:
Paper 1 **45 minutes** A multiple-choice paper consisting of 40 items of the four-choice type. (This paper will test assessment objectives AO1 and AO2.) Questions will be based on the Core syllabus content. 40 marks This paper will be weighted at 30% of the final total mark. Externally assessed.		**Paper 2** **45 minutes** A multiple-choice paper consisting of 40 items of the four-choice type. (This paper will test assessment objectives AO1 and AO2.) Questions will be based on the Extended syllabus content (Core and Supplement). 40 marks This paper will be weighted at 30% of the final total mark. Externally assessed.
and:		**and:**
Paper 3 **1 hour 15 minutes** A written paper consisting of short-answer and structured questions. (This paper will test assessment objectives AO1 and AO2.) Questions will be based on the Core syllabus content. 80 marks This paper will be weighted at 50% of the final total mark. Externally assessed.		**Paper 4** **1 hour 15 minutes** A written paper consisting of short-answer and structured questions. (This paper will test assessment objectives AO1 and AO2.) Questions will be based on the Extended syllabus content (Core and Supplement). 80 marks This paper will be weighted at 50% of the final total mark. Externally assessed.

All candidates take:	
either:	**or:**
Paper 5 **1 hour 15 minutes** Practical Test This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 6. 40 marks This paper will be weighted at 20% of the final total mark. Externally assessed.	**Paper 6** **1 hour** Alternative to Practical This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 6. 40 marks This paper will be weighted at 20% of the final total mark. Externally assessed.

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

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

Availability

This syllabus is examined in the November examination series.

This syllabus is available to private candidates.

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

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

From 2020 this syllabus is not available in all administrative zones. To find out about the availability visit the syllabus page at **www.cie.org.uk/igcse**

Combining this with other syllabuses

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

- 0620 Cambridge IGCSE Chemistry
- 0971 Cambridge IGCSE (9–1) Chemistry
- 0625 Cambridge IGCSE Physics
- 0972 Cambridge IGCSE (9–1) Physics
- 0653 Cambridge IGCSE Combined Science
- 0654 Cambridge IGCSE Co-ordinated Sciences (Double Award)
- 0973 Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award)
- 5054 Cambridge O Level Physics
- 5070 Cambridge O Level Chemistry
- 5129 Cambridge O Level Combined Science
- syllabuses with the same title at the same level.

Please note that Cambridge IGCSE, Cambridge IGCSE (9–1) (Level 1/Level 2 Certificate) and Cambridge O Level syllabuses are at the same level.

4. Syllabus aims and assessment objectives

4.1 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 to:

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

4.2 Assessment objectives

AO1: **Knowledge with understanding**

Candidates should be able to demonstrate knowledge and understanding of:

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

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* in Section 7.6).

AO2: **Handling information and problem solving**

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

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

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

Questions testing these skills will often begin with one of the following words: *predict*, *suggest*, *calculate* or *determine* (see the *Glossary of terms used in science papers* in Section 7.6).

AO3: **Experimental skills and investigations**

Candidates should be able to:

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

4.3 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%	

4.4 Grade descriptions

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

A **Grade A** 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 C** 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 F** 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.

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

Syllabuses and question papers conform with generally accepted international practice. In particular, the following document, produced by the Association for Science Education (ASE), should be used as guidelines.

- *Signs, Symbols and Systematics: The ASE Companion to 16–19 Science* (2000)

Litre/dm^3

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

Decimal markers

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

Numbers

Numbers from 1000 to 9999 will be printed without commas or spaces. Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

5. Syllabus content

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

All candidates should be taught the Core syllabus content. Candidates who are only taught the Core syllabus content can achieve a maximum of grade C. Candidates aiming for grades A* to C should be taught the Extended syllabus content. The Extended syllabus content includes both the Core and the Supplement. Candidates should be made familiar with the information found in Sections 7.1, 7.2, 7.3 and 7.4.

In delivering the course, teachers should aim to show the relevance of concepts to the learners' everyday lives and to the world around them. The syllabus content has been designed so as to allow teachers to develop flexible programmes which meet all of the general aims of the syllabus while drawing on appropriate local and international contexts.

Scientific subjects are, by their nature, experimental. Wherever possible, learners should pursue a fully integrated course which allows them to develop their practical skills by carrying out practical work and investigations within all of the topics listed.

0652 Chemistry	
C1 The particulate nature of matter	
Core	**Supplement**
1 State the distinguishing properties of solids, liquids and gases	
2 Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion	
	3 Explain changes of state in terms of the kinetic particle theory and the energy changes involved
4 Describe and explain diffusion in terms of the movement of particles (atoms, molecules or ions)	
	5 Describe and explain dependence of rate of diffusion on molecular mass
C2 Experimental techniques	
C2.1 Measurement **Core** 1 Name and suggest appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders	

0652 Chemistry	
C2.2 Criteria of purity **Core** 1 Interpret simple chromatograms 3 Recognise that mixtures melt and boil over a range of temperatures	**Supplement** 2 Interpret simple chromatograms, including the use of R_f values 4 Outline how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (Knowledge of *specific* locating agents is **not** required) 5 Identify substances and assess their purity from melting point and boiling point information
C2.3 Methods of purification **Core** 1 Describe and explain methods of separation and purification by the use of a suitable solvent, filtration, crystallisation, distillation, fractional distillation and paper chromatography 2 Suggest suitable separation and purification techniques, given information about the substances involved	
C3 Atoms, elements and compounds	
C3.1 Physical and chemical changes **Core** 1 Identify physical and chemical changes, and understand the differences between them	
C3.2 Elements, compounds and mixtures **Core** 1 Describe the differences between elements, mixtures and compounds, and between metals and non-metals 2 Define the terms *solvent*, *solute*, *solution* and *concentration*	

<table>
<tr><th colspan="2">0652 Chemistry</th></tr>
<tr><td>C3.3 Atomic structure and the Periodic Table

Core

1 Describe the structure of an atom in terms of a central nucleus, containing protons and neutrons, and ‘shells’ of electrons
2 Describe the build-up of electrons in ‘shells’ and understand the significance of the noble gas electronic structures and of the outer shell electrons
(The ideas of the distribution of electrons in s and p orbitals and in d block elements are not required)
3 State the relative charge and approximate relative mass of a proton, a neutron and an electron
4 Define and use proton number (atomic number) as the number of protons in the nucleus of an atom
5 Define and use nucleon number (mass number) as the total number of protons and neutrons in the nucleus of an atom
6 Use proton number and the simple structure of atoms to explain the basis of the Periodic Table, with special reference to the elements of proton numbers 1 to 20
7 Define isotopes as atoms of the same element which have the same proton number but a different nucleon number

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

8 Understand that isotopes have the same properties because they have the same number of electrons in their outer shell</td></tr>
<tr><td>C3.4 Ions and ionic bonds

Core

1 Describe the formation of ions by electron loss or gain
2 Use dot-and-cross diagrams to describe the formation of ionic bonds between Group I and Group VII</td><td>Supplement

3 Describe the formation of ionic bonds between metallic and non-metallic elements to include the strong attraction between ions because of their opposite electrical charges
4 Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions, exemplified by the sodium chloride structure</td></tr>
</table>

0652 Chemistry	
C3.5 Molecules and covalent bonds	
Core	**Supplement**
1 State that non-metallic elements form simple molecules with covalent bonds between atoms	
2 Describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4, NH_3 and HCl as the sharing of pairs of electrons leading to the noble gas configuration including the use of dot-and-cross diagrams	3 Use and draw dot-and-cross diagrams to represent the bonding in the more complex covalent molecules such as N_2, C_2H_4, CH_3OH, and CO_2
4 Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds	5 Explain the differences in melting point and boiling point of ionic and covalent compounds in terms of attractive forces
C3.6 Macromolecules	
Core	**Supplement**
1 State that there are several different forms of carbon, including diamond and graphite	
2 Describe the giant covalent structures of diamond and graphite	3 Relate the structures of diamond and graphite to their uses, e.g. graphite as a lubricant and a conductor and diamond in cutting tools
C4 Stoichiometry	
Core	**Supplement**
1 Use the symbols of the elements and write the formulae of simple compounds	2 Determine the formula of an ionic compound from the charges on the ions present
3 Deduce the formula of a simple compound from the relative numbers of atoms present	
4 Deduce the formula of a simple compound from a model or a diagrammatic representation	
5 Construct and use word equations	
6 Interpret and balance simple symbol equations	7 Construct and use symbol equations, with state symbols, including ionic equations
	8 Deduce the balanced equation of a chemical reaction, given relevant information
	9 Define *relative atomic mass*, A_r as the average mass of naturally occurring atoms of an element on a scale where the ^{12}C atom has a mass of exactly 12 units
	10 Define *relative molecular mass*, M_r and calculate it as the sum of the relative atomic masses (the term *relative formula mass* or M_r will be used for ionic compounds)
	11 Calculate stoichiometric reacting masses, volumes of gases and solutions and solution concentrations expressed in g/dm^3 and mol/dm^3 (Calculations based on limiting reactants may be set. Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.)

0652 Chemistry

C5 Electricity and chemistry

Core	Supplement
1 Define *electrolysis* as the breakdown of an ionic compound when molten or in aqueous solution by the passage of electricity	
2 Use the terms *inert electrode*, *electrolyte*, *anode* and *cathode*	3 Describe electrolysis in terms of the ions present and the reactions at the electrodes, in terms of gain of electrons by cations and loss of electrons by anions to form atoms
4 Describe the electrode products and the observations made, using inert electrodes (platinum or carbon), in the electrolysis of: – molten lead(II) bromide – concentrated aqueous sodium chloride – dilute sulfuric acid	5 Predict the products of the electrolysis of a specified molten binary compound

C6 Energy changes in chemical reactions

C6.1 Energetics of a reaction

Core	Supplement
1 Describe the meaning of *exothermic* and *endothermic* reactions	2 Describe bond breaking as an endothermic process and bond forming as an exothermic process 3 Draw and label energy level diagrams for exothermic and endothermic reactions using data provided 4 Interpret energy level diagrams showing exothermic and endothermic reactions and the activation energy of a reaction

C6.2 Energy transfer

Core	
1 Describe the release of thermal energy by burning fuels 2 State the use of hydrogen as a fuel	

0652 Chemistry	
C6.3 Rate (speed) of reaction **Core** 1 Describe practical methods for investigating the rate of a reaction which produces a gas 2 Interpret data obtained from experiments concerned with rate of reaction 3 Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the rate of reactions 6 Describe how concentration, temperature and surface area create a danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. methane in mines) Note: Candidates should be encouraged to use the term *rate* rather than *speed*.	**Supplement** 4 Describe and explain the effect of concentration in terms of frequency of collisions between reacting particles 5 Describe and explain the effect of changing temperature in terms of the frequency of collisions between reacting particles and more colliding particles possessing the minimum energy (activation energy) to react
C6.4 Redox **Core** 1 Describe oxidation and reduction in chemical reactions in terms of oxygen loss/gain (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II).)	**Supplement** 2 Define and identify an *oxidising agent* as a substance which oxidises another substance during a redox reaction and a *reducing agent* as a substance which reduces another substance during a redox reaction
C7 Acids, bases and salts	
C7.1 The characteristic properties of acids and bases **Core** 1 Describe the characteristic properties of acids (exemplified by dilute hydrochloric acid and dilute sulfuric acid) including their effect on litmus paper and their reactions with metals, bases and carbonates 2 Describe the characteristic properties of bases including their effect on litmus paper and their reactions with acids and ammonium salts 4 Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator 5 Describe and explain the importance of controlling acidity in soil	**Supplement** 3 Define *acids* and *bases* in terms of proton transfer, limited to aqueous solutions

0652 Chemistry	
C7.2 Types of oxides **Core** 1 Classify oxides as either acidic or basic, related to the metallic and non-metallic character	**Supplement** 2 Further classify other oxides as neutral or amphoteric
C7.3 Preparation of salts **Core** 1 Describe the preparation, separation and purification of salts using techniques specified in Section C2 and the reactions specified in Section C7.1	**Supplement** 2 Suggest a method of making a given salt from suitable starting material, given appropriate information, including precipitation
C7.4 Identification of ions and gases **Core** 1 Describe and use the following tests to identify: *aqueous cations:* ammonium, calcium, copper(II), iron(II), iron(III) and zinc, using aqueous sodium hydroxide and aqueous ammonia as appropriate (formulae of complex ions are **not** required) *cations*: flame tests to identify lithium, sodium, potassium and copper(II) *anions*: carbonate (by reaction with dilute acid and then limewater), chloride and bromide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium) and sulfate (by reaction under acidic conditions with aqueous barium ions) *gases*: ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using a lighted splint), oxygen (using a glowing splint)	
C8 The Periodic Table	
C8.1 The Periodic Table **Core** 1 Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements	

0652 Chemistry	
C8.2 Periodic trends **Core** 1 Describe the change from metallic to non-metallic character across a period	**Supplement** 2 Describe and explain the relationship between Group number, number of outer shell electrons and metallic/non-metallic character
C8.3 Group properties **Core** 1 Describe lithium, sodium and potassium in Group I (the alkali metals) as a collection of relatively soft metals showing a trend in melting point, density and reaction with water 3 Describe the halogens, chlorine, bromine and iodine in Group VII, as a collection of diatomic non-metals showing a trend in colour and physical state	**Supplement** 2 Predict the properties of other elements in Group I given data, where appropriate 4 State the reaction of chlorine, bromine and iodine with other halide ions 5 Predict the properties of other elements in Group VII, given data where appropriate 6 Identify trends in other groups, given data about the elements concerned
C8.4 Transition elements **Core** 1 Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts	
C8.5 Noble gases **Core** 1 Describe the noble gases, in Group VIII or 0, as being unreactive, monoatomic gases and explain this in terms of electronic structure 2 State the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons	
C9 Metals	
C9.1 Properties of metals **Core** 1 Describe the general physical properties of metals as solids with high melting and boiling points, malleable and good conductors of heat and electricity 3 Describe alloys, such as brass, as mixtures of a metal with other elements 4 Explain in terms of their properties why alloys are used instead of pure metals	**Supplement** 2 Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to explain the electrical conductivity and malleability of metals 5 Describe how the properties of iron are changed by the controlled use of additives to form steel alloys, such as mild steel and stainless steel

0652 Chemistry	
C9.2 Reactivity series **Core** 1 Place in order of reactivity: potassium, sodium, calcium, magnesium, aluminium, (carbon), zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the elements with: – water or steam – dilute hydrochloric acid – reduction of their oxides with carbon 3 Deduce an order of reactivity from a given set of experimental results	**Supplement** 2 Describe the reactivity series in terms of the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with the aqueous ions of other listed metals
C9.3 Extraction of metals **Core** 1 Describe the use of carbon in the extraction of some metals from their ores 2 Know that aluminium is extracted from the ore bauxite by electrolysis	**Supplement** 3 Describe and explain the essential reactions in the extraction of iron from hematite in the blast furnace $C + O_2 \rightarrow CO_2$ $C + CO_2 \rightarrow 2CO$ $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
C9.4 Uses of metals **Core** 1 Describe the uses of aluminium: – in aircraft parts because of its strength and low density – in food containers because of its resistance to corrosion 3 State the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)	**Supplement** 2 Describe and explain the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal 4 Explain the uses of zinc for galvanising steel and for making brass
C10 Air and water	
C10.1 Water **Core** 1 Describe a chemical test for water using copper(II) sulfate and cobalt(II) chloride 3 Describe, in outline, and explain the purification treatment of the water supply in terms of filtration and chlorination	**Supplement** 2 Describe how hydration can be reversed (e.g. by heating hydrated copper(II) sulfate or hydrated cobalt(II) chloride)

0652 Chemistry	
C10.2 Air	
Core	**Supplement**
1 State the composition of clean air as being a mixture of 78% nitrogen, 21% oxygen and small quantities of noble gases, water vapour and carbon dioxide	
2 Name the common pollutants in air as being carbon monoxide, sulfur dioxide and oxides of nitrogen	
3 State the source of each of these pollutants: – carbon monoxide from the incomplete combustion of carbon-containing substances – sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to acid rain) – oxides of nitrogen from car engines	4 Describe some approaches to reducing emissions of sulfur dioxide, including the use of low sulfur petrol and flue gas desulfurisation by calcium oxide 5 Describe, in outline, how a catalytic converter removes nitrogen monoxide and carbon monoxide from exhaust emissions by reaction over a hot catalyst $2CO + O_2 \rightarrow 2CO_2$ $2NO + 2CO \rightarrow N_2 + 2CO_2$ $2NO \rightarrow N_2 + O_2$
6 State the adverse effect of these common air pollutants on buildings and on health	
7 State the conditions required for the rusting of iron (presence of oxygen and water)	
8 Describe and explain barrier methods of rust prevention, including paint and other coatings	9 Describe and explain sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention
C10.3 Carbon dioxide and methane	
Core	
1 State the formation of carbon dioxide: – as a product of complete combustion of carbon-containing substances – as a product of respiration – as a product of the reaction between an acid and a carbonate – as a product of thermal decomposition of calcium carbonate	
2 State that carbon dioxide and methane are greenhouse gases	
C11 Carbonates	
Core	
1 Describe the manufacture of lime (calcium oxide) from limestone (calcium carbonate) in terms of the chemical reactions involved, and the use of limestone in treating acidic soil and neutralising acidic industrial waste products	
2 Describe the thermal decomposition of calcium carbonate (limestone)	

0652 Chemistry	
C12 Organic chemistry	
C12.1 Names of compounds **Core** 1 Name and draw the structures of methane, ethane, ethene and ethanol 2 State the type of compound present, given a chemical name ending in -*ane*, -*ene* and -*ol*, or a molecular structure	
C12.2 Fuels **Core** 1 State that coal, natural gas and petroleum are fossil fuels that produce carbon dioxide on combustion 2 Name methane as the main constituent of natural gas 3 Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation 5 Name the uses of the fractions as: – refinery gas for bottled gas for heating and cooking – gasoline fraction for fuel (petrol) in cars – naphtha fraction as a feedstock for making chemicals – diesel oil/gas oil for fuel in diesel engines – bitumen for road surfaces	**Supplement** 4 Describe the properties of molecules within a fraction
C12.3 Homologous series	**Supplement** 1 Describe the homologous series of alkanes and alkenes as families of compounds with the same general formula and similar chemical properties
C12.4 Alkanes **Core** 1 Describe alkanes as saturated hydrocarbons whose molecules contain only single covalent bonds 2 Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning 3 Describe the complete combustion of hydrocarbons to give carbon dioxide and water	

0652 Chemistry	
C12.5 Alkenes **Core** 1 Describe alkenes as unsaturated hydrocarbons whose molecules contain one double covalent bond 2 State that cracking is a reaction that produces alkenes 4 Recognise saturated and unsaturated hydrocarbons: – from molecular structures – by their reaction with aqueous bromine 6 Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units	**Supplement** 3 Describe the formation of smaller alkanes, alkenes and hydrogen by the cracking of larger alkane molecules and state the conditions required for cracking 5 Describe the properties of alkenes in terms of addition reactions, with bromine, hydrogen and steam, exemplified by ethene
C12.6 Alcohols **Core** 1 State that ethanol may be formed by fermentation and by reaction between ethene and steam 3 Describe the complete combustion of ethanol to give carbon dioxide and water 4 State the uses of ethanol as a solvent and as a fuel	**Supplement** 2 Describe the formation of ethanol by fermentation and the catalytic addition of steam to ethene

0652 Physics	
P1 General Physics	
P1.1 Length and time **Core** 1 Use and describe the use of rules and measuring cylinders to find a length or a volume 3 Use and describe the use of clocks and devices, both analogue and digital, for measuring an interval of time 4 Obtain an average value for a small distance and for a short interval of time by measuring multiples (including the period of a pendulum)	**Supplement** 2 Understand that a micrometer screw gauge is used to measure very small distances
P1.2 Motion **Core** 1 Define speed and calculate average speed from $\frac{\text{total distance}}{\text{total time}}$	**Supplement** 2 Distinguish between *speed* and *velocity* 3 Define and calculate acceleration using $\frac{\text{change in velocity}}{\text{time taken}}$
4 Plot and interpret a speed-time graph and a distance-time graph 6 Recognise from the shape of a speed-time graph when a body is: – at rest – moving with constant speed – moving with changing speed 8 Calculate the area under a speed-time graph to work out the distance travelled for motion with constant acceleration 9 Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed-time graph	5 Calculate acceleration from the gradient of a speed-time graph 7 Recognise linear motion for which the acceleration is not constant
10 State that the acceleration of free fall g for a body near to the Earth is constant	11 Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance including reference to terminal velocity

0652 Physics	
P1.3 Mass and weight **Core** 1 Show familiarity with the idea of the mass of a body 3 State that weight is a gravitational force 4 Distinguish between *mass* and *weight* 5 Demonstrate understanding that weights (and hence masses) may be compared using a balance 7 Recognise that g is the gravitational force on unit mass and is measured in N/kg 8 Recall and use the equation $W = mg$	**Supplement** 2 Demonstrate an understanding that mass is a property which 'resists' change in motion 6 Describe, and use the concept of, weight as the effect of a gravitational field on a mass
P1.4 Density **Core** 1 Recall and use the equation $\rho = \frac{m}{V}$ 2 Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation	**Supplement** 3 Describe the determination of the density of an irregularly shaped solid by the method of displacement and make the necessary calculation
P1.5 Forces P1.5.1 Effects of forces **Core** 1 Recognise that a force may produce a change in the size, shape and motion of a body 6 Understand friction as the force between two surfaces which impedes motion and results in heating 7 Recognise air resistance as a form of friction 8 Find the resultant of two or more forces acting along the same line 9 Recognise that if there is no resultant force on a body it either remains at rest or continues at constant speed in a straight line	**Supplement** 2 Plot and interpret extension-load graphs and describe the associated experimental procedure 3 State Hooke's Law and recall and use the $F = kx$ where k is the spring constant 4 Recognise the significance of the term 'limit of proportionality' for an extension-load graph 5 Recall and use the relationship between resultant force, mass and acceleration, $F = ma$

0652 Physics	
P1.5.2 Turning effect **Core** 1 Describe the moment of a force as a measure of its turning effect, and give everyday examples 2 Calculate moment using the product force × perpendicular distance from the pivot 4 Recognise that, when there is no resultant force and no resultant turning effect, a system is in equilibrium	**Supplement** 3 Apply the principle of moments to the balancing of a weightless beam about a pivot
P1.5.3 Centre of mass **Core** 1 Perform and describe an experiment to determine the position of the centre of mass of a plane lamina 2 Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects	
P1.5.4 Pressure **Core** 1 Relate qualitatively pressure to force and area, using appropriate examples	**Supplement** 2 Recall and use the equation $p = F/A$
P1.6 Work, energy and power P1.6.1 Work **Core** 1 Relate (without calculation) work done to the magnitude of a force and distance moved in the direction of the force	**Supplement** 2 Recall and use $W = Fd = \Delta E$

0652 Physics	
P1.6.2 Energy **Core** 1 Demonstrate an understanding that work done = energy transferred 2 Demonstrate understanding that an object may have energy due to its motion (kinetic energy, K.E.) or its position (potential energy, P.E.) and that energy may be transferred and stored 3 Give and identify examples of changes in kinetic, gravitational potential, chemical potential, elastic (strain), nuclear and thermal energy that have occurred as a result of an event or process 5 Recognise that energy is transferred during events and processes, including examples of transfer by forces (mechanical working), by electric currents (electrical working), by heating and by waves 6 Apply the principle of conservation of energy to simple examples	**Supplement** 4 Recall and use the expressions K.E. = $\frac{1}{2}mv^2$ and gravitational potential energy (G.P.E) = mgh or change in G.P.E = $mg\Delta h$
P1.6.3 Power **Core** 1 Relate (without calculation) power to work done and time taken, using appropriate examples	**Supplement** 2 Recall and use the equation $P = \Delta E / t$ in simple systems

0652 Physics	
P1.6.4 Energy resources **Core**	 **Supplement**
1 Distinguish between renewable and non-renewable sources of energy 2 Describe how electricity or other useful forms of energy may be obtained from: – chemical energy stored in fuel – energy from water, including the energy stored in waves, in tides, and in water behind hydroelectric dams – geothermal resources – nuclear fission – heat and light from the Sun (solar cells and panels) – wind energy 3 Give advantages and disadvantages of each method in terms of renewability, cost, reliability, scale and environmental impact	
4 Show a qualitative understanding of efficiency	5 Understand that the Sun is the source of energy for all our energy resources except geothermal, nuclear and tidal 6 Understand that the source of tidal energy is mainly the moon 7 Show an understanding that energy is released by nuclear fusion in the Sun 8 Recall and use the equations: $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{energy input}} \times 100\%$ $\text{efficiency} = \dfrac{\text{userful power output}}{\text{power input}} \times 100\%$

0652 Physics	
P2 Thermal Physics	
P2.1 Thermal properties and temperature P2.1.1 Thermal expansion of solids, liquids and gases **Core** 1 State the distinguishing properties of solids, liquids and gases 2 Describe qualitatively the molecular structure of solids, liquids and gases in terms of the arrangement, separation, and motion of the molecules 3 Describe qualitatively the pressure of a gas and the temperature of a gas, liquid or solid in terms of the motion of its particles 4 Describe qualitatively the thermal expansion of solids, liquids and gases at constant pressure 5 Identify and explain some of the everyday applications and consequences of thermal expansion 6 Know the relative order of the magnitude of the expansion of solids, liquids and gases	
P2.1.2 Measurement of temperature **Core** 1 Describe how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties 3 Recognise the need for and identify fixed points 4 Describe and explain the structure and action of liquid-in-glass thermometers	**Supplement** 2 Demonstrate understanding of *sensitivity*, *range* and *linearity* 5 Use and describe the use of thermometers to measure temperature on the Celsius scale 6 Describe the structure of a thermocouple, and show understanding of its use as a thermometer for measuring high temperatures and those which vary rapidly
P2.1.3 Melting and boiling **Core** 1 Describe melting and boiling in terms of energy input without a change in temperature 2 State the meaning of *melting point* and *boiling point*, and recall the melting and boiling points for water	**Supplement** 3 Distinguish between *boiling* and *evaporation*

0652 Physics	
P2.2 Thermal processes P2.2.1 Conduction **Core** 1 Recognise and name typical good and bad thermal conductors 2 Describe experiments to demonstrate the properties of good and bad thermal conductors	**Supplement** 3 Explain conduction in solids in terms of molecular vibrations and transfer by electrons
P2.2.2 Convection **Core** 1 Recognise convection as the main method of energy transfer in fluids 3 Interpret and describe experiments designed to illustrate convection in liquids and gases (fluids)	**Supplement** 2 Relate convection in fluids to density changes
P2.2.3 Radiation **Core** 1 Recognise radiation as the method of energy transfer that does not require a medium to travel through 2 Identify infra-red radiation as the part of the electromagnetic spectrum often involved in energy transfer by radiation	**Supplement** 3 Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation 4 Interpret and describe experiments to investigate the properties of good and bad emitters and good and bad absorbers of infra-red radiation
P2.2.4 Consequences of energy transfer **Core** 1 Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	

0652 Physics

P3 Properties of waves, including light and sound

P3.1 General wave properties

Core	Supplement
1 Demonstrate understanding that waves transfer energy without transferring matter 2 Describe what is meant by *wave motion* as illustrated by vibration in ropes, springs and by experiments using water waves 3 Use the term *wavefront*	
4 State the meaning of *speed*, *frequency*, *wavelength* and *amplitude*	5 Distinguish between *transverse* and *longitudinal* waves and give suitable examples
6 Describe how waves can undergo: – reflection at a plane surface – refraction due to a change of speed	
7 Describe the use of water waves to demonstrate reflection and refraction	8 Recall and use the equation $v = f\lambda$ 9 Understand that refraction is caused by a change in speed as a wave moves from one medium to another 10 Describe how waves can undergo diffraction through a narrow gap 11 Describe the use of water waves to demonstrate diffraction

P3.2 Light

P3.2.1 Reflection of light

Core	Supplement
1 Describe the formation of an optical image by a plane mirror and give its characteristics 2 Recall and use the law angle of incidence i = angle of reflection r recognising these angles are measured to the normal 3 Give the meaning of *critical angle*	
4 Describe internal and total internal reflection 5 Perform simple constructions, measurements and calculations for reflection by plane mirrors	6 Recall that the image in a plane mirror is virtual 7 Describe and explain the action of optical fibres particularly in medicine and communications technology

P3.2.2 Refraction of light

Core	Supplement
1 Interpret and describe an experimental demonstration of the refraction of light	2 Recall and use the definition of refractive index n in terms of speed
3 Use the terminology for the angle of incidence i and angle of refraction r and describe the passage of light through parallel-sided transparent material	4 Recall and use the equation for refractive index $n = \frac{\sin i}{\sin r}$

<table>
<tr><th colspan="2">0652 Physics</th></tr>
<tr><td>P3.2.3 Thin converging lens
Core
1 Describe the action of a thin converging lens on a beam of light
2 Use the terms principal focus and focal length
3 Draw ray diagrams for the formation of a real image by a single lens
6 Describe the nature of an image using the terms enlarged/same size/diminished and upright/inverted</td><td>Supplement
4 Show understanding of the terms real image and virtual image
5 Draw and use ray diagrams for the formation of a virtual image by a single converging lens
7 Use and describe the use of a single lens as a magnifying glass</td></tr>
<tr><td>P3.2.4 Electromagnetic spectrum
Core
1 Describe the main features of the electromagnetic spectrum in order of frequency, from radio waves to gamma radiation (γ)
2 State that all electromagnetic waves travel with the same high speed in a vacuum
4 Describe typical properties and uses of radiations in all the different regions of the electromagnetic spectrum including:
– radio and television communications (radio waves)
– satellite television and telephones (microwaves)
– electrical appliances, remote controllers for televisions and intruder alarms (infra-red)
– medicine and security (X-rays)</td><td>Supplement
3 State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air</td></tr>
<tr><td>P3.3 Sound
Core
1 Describe how vibrating objects produce sound waves, and how sound waves can cause objects to vibrate, including the eardrum
4 State that the approximate range of audible frequencies for a healthy human ear is 20 Hz to 20 000 Hz
5 Show an understanding that a medium is needed to transmit sound waves</td><td>Supplement
2 Describe the longitudinal nature of sound waves
3 Describe the transmission of sound waves in air in terms of compressions and rarefactions</td></tr>
</table>

0652 Physics	
P4 Electricity and magnetism	
P4.1 Simple phenomena of magnetism **Core** 1 Describe the forces between magnets, and between magnets and magnetic materials 3 Distinguish between magnetic and non-magnetic materials 4 Draw and describe the pattern and direction of magnetic field lines around a bar magnet 5 Distinguish between the magnetic properties of soft iron and steel 6 Recognise that an electric current has an associated magnetic field 7 Distinguish between the design and use of permanent magnets and electromagnets 8 Describe methods of magnetisation to include stroking with a magnet, use of d.c. in a coil and hammering in a magnetic field	**Supplement** 2 Give an account of induced magnetism 9 Describe methods of demagnetisation, to include hammering, heating and use of alternating current (a.c.) in a coil
P4.2 Electrical quantities P4.2.1 Electric charge **Core** 1 State that there are positive and negative charges 2 State that unlike charges attract and that like charges repel 3 Describe and interpret simple experiments to show the production and detection of electrostatic charges by friction 4 State that charging a body involves the addition or removal of electrons 6 Distinguish between electrical conductors and insulators and give typical examples	**Supplement** 5 Describe an electric field as a region in which an electric charge experiences a force
P4.2.2 Current **Core** 1 State that current is related to the flow of charge 4 Use and describe the use of an ammeter, both analogue and digital 5 State that current in metals is due to a flow of electrons	**Supplement** 2 Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$ 3 Distinguish between the direction of flow of electrons and conventional current

0652 Physics	
P4.2.3 Electromotive force (e.m.f.) and potential difference (p.d.) **Core** 1 State that the potential difference (p.d.) across a circuit component is measured in volts 3 Use and describe the use of a voltmeter, both analogue and digital 4 State that the electromotive force (e.m.f.) of an electrical source of energy is measured in volts	**Supplement** 2 Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge around a complete circuit 5 Recall that 1 V is equivalent to 1 J/C
P4.2.4 Resistance **Core** 1 State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current 2 Recall and use the equation $R = V/I$ 3 Describe an experiment to determine resistance using a voltmeter and an ammeter 4 Relate (without calculation) the resistance of a wire to its length and to its diameter 5 Demonstrate understanding of *current*, *potential difference*, *e.m.f.* and *resistance*	**Supplement** 6 Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire
P4.3 Electric circuits P4.3.1 Circuit diagrams **Core** 1 Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters and fuses (Symbols for other common circuit components will be provided in questions)	

0652 Physics	
P4.3.2 Series and parallel circuits **Core**	 **Supplement**
1 Understand that the current at every point in a series circuit is the same	
2 Calculate the combined resistance of two or more resistors in series	3 Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply
4 State that, for a parallel circuit, the current from the source is larger than the current in each branch	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
6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself	7 Calculate the combined resistance of two resistors in parallel
8 State the advantages of connecting components in parallel in a circuit	9 Draw and interpret circuit diagrams containing NTC thermistors and light-dependent resistors (LDRs) 10 Describe the action of NTC thermistors and LDRs and show understanding of their use as input transducers
P4.4 Electrical energy	**Supplement** 1 Recall and use the equations $P = IV$ and $E = IVt$
P4.5 Dangers of electricity **Core** 1 State the hazards of: – damaged insulation – overheating of cables – damp conditions 2 State that a fuse protects a circuit 3 Explain the use of fuses and circuit breakers and choose appropriate fuse ratings and circuit-breaker ratings 4 Explain the benefits of earthing metal cases	

0652 Physics	
P4.6 Electromagnetic effects P4.6.1 Electromagnetic induction	**Supplement** 1 Show understanding that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an electromotive force (e.m.f.) in the conductor 2 Describe an experiment to demonstrate electromagnetic induction 3 State the factors affecting the magnitude of an induced e.m.f. 4 Show understanding that the direction of an induced e.m.f. opposes the change causing it
P4.6.2 a.c. generator	**Supplement** 1 Distinguish between direct current (d.c) and alternating current (a.c) 2 Describe and explain the operation of a rotating-coil generator and the use of slip rings 3 Sketch a graph of voltage output against time for a simple a.c. generator
P4.6.3 Transformers	**Supplement** 1 Describe the construction of a basic transformer with a soft-iron core, as used for voltage transformations 2 Describe the principle of operation of a transformer 3 Use the terms step-up and step-down 4 Recall and use the equation $(V_p / V_s) = (N_p / N_s)$ (for 100% efficiency) 5 Recall and use the equation $I_p V_p = I_s V_s$ (for 100% efficiency) 6 Describe the use of the transformer in high-voltage transmission of electricity 7 Explain why power losses in cables are lower when the voltage is high

<table>
<tr><th colspan="2">0652 Physics</th></tr>
<tr><td>P4.6.4 Force on a current-carrying conductor
Core
1 Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing:
– the current
– the direction of the field</td><td></td></tr>
<tr><td>P4.6.5 d.c. motor
Core
1 State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by:
– increasing the number of turns on the coil
– increasing the current
– increasing the strength of the magnetic field</td><td>Supplement
1 Relate this turning effect to the action of an electric motor including the action of a split-ring commutator</td></tr>
<tr><td colspan="2">P5 Atomic physics</td></tr>
<tr><td>P5.1 The nuclear atom
Core
1 Describe the composition of the nucleus in terms of protons and neutrons
2 Use the terms proton number Z and nucleon number A
3 Use and interpret the term nuclide and use the nuclide notation $^{A}_{Z}X$
4 Use and explain the term isotope</td><td></td></tr>
<tr><td>P5.2 Radioactivity
P5.2.1 Detection of radioactivity
Core
1 Demonstrate understanding of background radiation
2 Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included, β-particles will be taken to refer to β^-)</td><td></td></tr>
</table>

0652 Physics	
P5.2.2 Characteristics of the three kinds of emission **Core** 1 Describe the random nature of radioactive emission 2 Identify alpha, beta and gamma (α, β and γ-emissions) by recalling: – their nature – their relative ionising effects – their relative penetrating abilities	**Supplement** 3 Describe deflection of α, β and γ-emissions in electric fields and in magnetic fields 4 Give and explain examples of practical applications of α, β and γ-emissions
P5.2.3 Radioactive decay **Core** 1 State the meaning of *radioactive decay* 2 Use word equations to represent changes in the composition of the nucleus when particles are emitted	**Supplement** 3 Use nuclide notation in equations to show the effect on the nucleus of α and β decay
P5.2.4 Half-life **Core** 1 Show an understanding of the term *half-life* and use the term in context 2 Use the term *half-life* in simple calculations which may involve information in tables or decay curves	**Supplement** 3 Calculate half-life from data or decay curves, including curves from which background radiation has not been subtracted
P5.2.5 Safety precautions **Core** 1 Recall the effects of ionising radiations on living things 2 Describe how radioactive materials are handled, used and stored in a safe way	

6. Practical assessment

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.

6.1 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 cm^3, it is expected that candidates will estimate this and not use measuring devices.

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

Apparatus list

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 Instruction*s, 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
- means of writing on glassware
- beakers, 100 cm^3, 250 cm^3
- a polystyrene or other plastic beaker of approximate capacity 150 cm^3
- test-tubes (Pyrex or hard glass), approximately 125 mm × 16 mm
- boiling tubes, approximately 150 mm × 25 mm
- delivery tubes
- conical flasks, within the range 150 cm^3 to 250 cm^3
- measuring cylinders, 100 cm^3, 50 cm^3, 25 cm^3, 10 cm^3
- dropping pipettes
- white tiles
- large containers (e.g. plastic bowl) to hold cold water
- thermometers, –10 °C to +110 °C with 1 °C graduations
- stopclocks (or wall clock or wrist-watch), to measure to an accuracy of 1 s
- glass rods
- spatulas
- wooden splints
- indicators (e.g. litmus paper, Universal Indicator paper, full range Universal Indicator)
- common reagents for tests (e.g. limewater test)
- burettes, 50 cm^3
- pipettes, 25 cm^3
- pipette fillers
- filter funnels and filter paper
- wash bottle
- an ammeter FSD 1 A, 1.5A
- 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 $f = 15\,\text{cm}$
- glass or Perspex block, rectangular and semi-circular
- glass or Perspex prism, triangular
- optics pins
- plane mirrors
- ray box

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

These papers are based on testing experimental skills. One question on each paper assesses the skill of planning. This question will be based on any one of the sciences, which could be Chemistry or Physics and may vary between each examination series. The questions do not assess specific syllabus content from Section 5: 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 full grade range.

Paper 5: Practical Test will typically consist of four questions, three of which require the use of apparatus.

Paper 6: Alternative to Practical will test the same experimental skills as Paper 5, and will contain many of the same question parts.

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.

Chemistry

Candidates may be asked questions on the following experimental contexts:

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

Physics

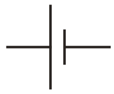
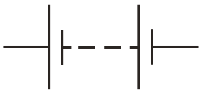
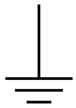
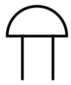
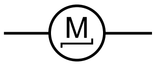
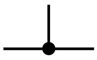
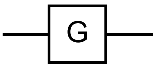
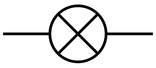
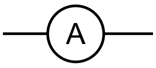
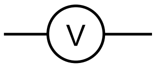
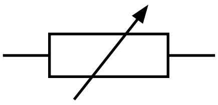
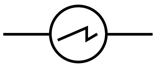
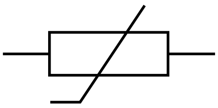
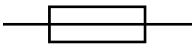
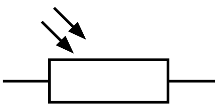
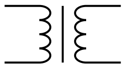
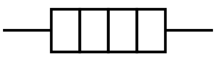
Candidates may be asked questions on the following experimental contexts:

- measurement of physical quantities such as length or volume or force or density
- cooling and heating
- springs and balances
- timing motion or oscillations
- electrical circuits, circuit diagrams and electrical symbols
- optics equipment such as mirrors, prisms and lenses
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate

- use or describe the use of common techniques, apparatus and materials, e.g. ray-tracing equipment or the connection of electric circuits
- explain the manipulation of the apparatus to obtain observations or measurements, e.g.:
  – when determining a derived quantity, such as the extension per unit load for a spring
  – when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length
  – when comparing physical quantities, such as two masses, using a balancing method.

7. Appendix

7.1 Electrical symbols

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

7.2 Symbols and units for physical quantities

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

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

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

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

7.3 Notes for use in qualitative analysis

Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt. or very slight white ppt.
copper (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

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

Flame tests for metal ions

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

7.4 The Periodic Table

Key

atomic number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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

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

7.5 Safety in the laboratory

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

Associations

CLEAPSS is an advisory service providing support in practical science and technology.
http://www.cleapss.org.uk

Publications

CLEAPSS Laboratory Handbook, updated 2009 (available to CLEAPSS members only)
CLEAPSS Hazcards, 2007 update of 1995 edition (available to CLEAPSS members only)

UK Regulations

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

7.6 Glossary of terms used in science papers

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

1 *Define* (the term(s) …) is intended literally, only a formal statement or equivalent paraphrase being required.

2 *What do you understand by/What is meant by* (the term(s) …) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

3 *State* implies a concise answer with little or no supporting argument (e.g. a numerical answer that can readily be obtained 'by inspection').

4 *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified this should not be exceeded.

5 (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons. The candidate needs to leave the examiner in no doubt why something happens.

(b) *Give a reason/Give reasons* is another way of asking candidates to explain why something happens.

6 *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points. *Describe* and *explain* may be coupled, as may *state* and *explain*.

7 *Discuss* requires the candidate to give a critical account of the points involved.

8 *Outline* implies brevity (i.e. restricting the answer to giving essentials).

9 *Predict* implies that the candidate is expected to make a prediction not by recall but by making a logical connection between other pieces of information.

10 *Deduce* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information.

11 *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in physics there are several examples of energy resources from which electricity, or other useful forms of energy, may be obtained), or to imply that candidates are expected to apply their general knowledge of the subject to a 'novel' situation, one that may be formally 'not in the syllabus' – many data response and problem solving questions are of this type.

12 *Find* is a general term that may variously be interpreted as calculate, measure, determine, etc.

13 *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

14 *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length using a rule, or mass using a balance).

15 *Determine* often implies that the quantity concerned cannot be measured directly but is obtained from a graph or by calculation.

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

17 *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept).

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

7.7 Mathematical requirements

Calculators may be used in all parts of the examination.

Candidates should be able to:

- add, subtract, multiply and divide
- use averages, decimals, fractions, percentages, ratios and reciprocals
- use standard notation, including both positive and negative indices
- understand significant figures and use them appropriately
- recognise and use direct and inverse proportion
- use positive, whole number indices in algebraic expressions
- draw charts and graphs from given data
- interpret charts and graphs
- determine the gradient and intercept of a graph
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recall and use equations for the areas of a rectangle, triangle and circle and the volumes of a rectangular block and a cylinder
- use mathematical instruments (ruler, compasses, protractor and set square)
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and diagonal
- solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known
- recognise and use clockwise and anticlockwise directions
- recognise and use points of the compass (N, S, E, W)
- use sines and inverse sines (Extended candidates only).

7.8 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.

7.9 ICT opportunities

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This syllabus provides candidates with a wide range of opportunities to use ICT in their study of chemistry and physics.

Opportunities for ICT include:

- gathering information from the internet, DVDs and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using software to present ideas and information on paper and on screen.

8. Other information

Equality and inclusion

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

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

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

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

Language

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

Grading and reporting

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

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 option 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 option codes can be found in the *Cambridge Guide to Making Entries*.

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