Syllabus

Cambridge IGCSE Chemistry
Syllabus code 0620
For examination in June and November 2012

UNIVERSITY *of* CAMBRIDGE
International Examinations

Contents

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1. Introduction

1.1 Why choose Cambridge?

University of Cambridge International Examinations (CIE) is the world's largest provider of international qualifications. Around 1.5 million students from 150 countries enter Cambridge examinations every year. What makes educators around the world choose Cambridge?

Recognition

Cambridge IGCSE is internationally recognised by schools, universities and employers as equivalent to UK GCSE. Cambridge IGCSE is excellent preparation for A/AS Level, the Advanced International Certificate of Education (AICE), US Advanced Placement Programme and the International Baccalaureate (IB) Diploma. Learn more at **www.cie.org.uk/recognition**.

Support

CIE provides a world-class support service for teachers and exams officers. We offer a wide range of teacher materials to Centres, plus teacher training (online and face-to-face) and student support materials. Exams officers can trust in reliable, efficient administration of exams entry and excellent, personal support from CIE Customer Services. Learn more at **www.cie.org.uk/teachers**.

Excellence in education

Cambridge qualifications develop successful students. They not only build understanding and knowledge required for progression, but also learning and thinking skills that help students become independent learners and equip them for life.

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

CIE is part of Cambridge Assessment, a not-for-profit organisation and part of the University of Cambridge. The needs of teachers and learners are at the core of what we do. CIE invests constantly in improving its qualifications and services. We draw upon education research in developing our qualifications.

1. Introduction

1.2 Why choose Cambridge IGCSE Chemistry?

Cambridge IGCSE Chemistry is accepted by universities and employers as proof of essential chemistry knowledge and ability. As well as a subject focus, the Chemistry syllabus enables students to:

- better understand the technological world in which they live, and take an informed interest in science and scientific developments
- learn about the basic principles of Chemistry through a mix of theoretical and practical studies
- develop an understanding of the scientific skills essential for further study at A Level, skills which are useful in everyday life
- learn how science is studied and practised, and become aware that the results of scientific research can have both good and bad effects on individuals, communities and the environment.

1.3 Cambridge International Certificate of Education (ICE)

Cambridge ICE is the group award of the International General Certificate of Secondary Education (IGCSE). It requires the study of subjects drawn from the five different IGCSE subject groups. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognising the achievements of students who pass examinations in at least seven subjects, including two languages, and one subject from each of the other subject groups.

The Cambridge portfolio of IGCSE qualifications provides a solid foundation for higher level courses such as GCE A and AS Levels and the International Baccalaureate Diploma as well as excellent preparation for employment.

A wide range of IGCSE subjects is available and these are grouped into five curriculum areas. Chemistry falls into Group III, Science.

Learn more about ICE at **www.cie.org.uk/qualifications/academic/middlesec/ice**.

1.4 How can I find out more?

If you are already a Cambridge Centre

You can make entries for this qualification through your usual channels, e.g. CIE Direct. If you have any queries, please contact us at **international@cie.org.uk**.

If you are not a Cambridge Centre

You can find out how your organisation can become a Cambridge Centre. Email us at **international@cie.org.uk**. Learn more about the benefits of becoming a Cambridge Centre at **www.cie.org.uk**.

2. Assessment at a glance

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Cambridge IGCSE Chemistry candidates are awarded grades ranging from A* to G.

Candidates expected to achieve grades D, E, F or G, study the Core Curriculum only and are eligible for grades C to G.

Candidates expected to achieve grade C or higher should study the Extended Curriculum, which comprises the Core and Supplement Curriculums; these candidates are eligible for all grades from A* to G.

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

<table>
<tr><th colspan="3">All candidates take:</th></tr>
<tr><td colspan="3">Paper 1 45 minutes
Multiple choice question paper
weighted at 30% of total available marks</td></tr>
<tr><th colspan="2">and either:</th><th>or:</th></tr>
<tr><td colspan="2">Paper 2 1 hour 15 minutes
Core theory paper
weighted at 50% of total available marks</td><td>Paper 3 1 hour 15 minutes
Extended theory paper
weighted at 50% of total available marks</td></tr>
<tr><th>and either:</th><th>or:</th><th>or:</th></tr>
<tr><td>Paper 4
Coursework
weighted at 20% of total available marks</td><td>Paper 5 1 hour 15 minutes
Practical test
weighted at 20% of total available marks</td><td>Paper 6 1 hour
Alternative to Practical paper
weighted at 20% of total available marks</td></tr>
</table>

Alterations in the syllabus assessment, content and practical assessment sections for 2012 are indicated by black vertical lines on either side of the text.

2. Assessment at a glance

Availability

This syllabus is examined in the May/June examination session and the October/November examination session.

This syllabus is available to private candidates.

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

Combining this with other syllabuses

Candidates can combine this syllabus in an examination session with any other CIE syllabus, except:

- syllabuses with the same title at the same level
- 0652 IGCSE Physical Science
- 0653 IGCSE Combined Science
- 0654 IGCSE Co-ordinated Sciences (Double Award)
- 5124 O Level Science (Physics, Chemistry)
- 5126 O Level Science (Chemistry, Biology)
- 5129 O Level Combined Science
- 5130 O Level Additional Combined Science

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

3. Syllabus aims and objectives

3.1 Aims

The aims of the syllabus listed below describe the educational purposes of this examination. The aims of the syllabus are the same for all students and are not listed in order of priority.

The aims are:

1. to provide a worthwhile educational experience for all candidates, through well-designed studies of experimental and practical science, whether or not they go on to study science beyond this level
2. to enable candidates to acquire sufficient understanding and knowledge to
   - become confident citizens in a technological world, able to take an informed interest in scientific matters
   - recognise both the usefulness and the limitations of scientific method, and appreciate its applicability in other disciplines and in everyday life
   - be suitably prepared for studies beyond IGCSE in pure sciences, in applied sciences or in science-dependent vocational courses
3. to develop abilities and skills that
   - are relevant to the study and practice of Chemistry
   - are useful in everyday life
   - encourage efficient and safe practice
   - encourage effective communication
4. to develop attitudes relevant to Chemistry such as
   - concern for accuracy and precision
   - objectivity
   - integrity
   - enquiry
   - initiative
   - inventiveness
5. to stimulate interest in the environment and caring for it
6. to promote an awareness that
   - scientific theories and methods have developed, and continue to do so, as a result of co-operative activities of groups and individuals
   - the study and practice of science are 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
   - science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal.

3. Syllabus aims and objectives

3.2 Assessment objectives

The three assessment objectives in Cambridge IGCSE Chemistry are:

A Knowledge with understanding

B Handling information and problem solving

C Experimental skills and investigations

A description of each assessment objective follows.

A: Knowledge with understanding

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

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

Curriculum 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 knowledge of a different syllabus area.

Questions testing these objectives will often begin with one of the following words: *define, state, describe, explain* or *outline* (see Glossary of Terms).

B: Handling information and problem solving

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

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

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

Questions testing these skills will often begin with one of the following words: *predict, suggest, calculate* or *determine*. (See the Glossary of Terms.)

C: Experimental skills and investigations

Students should be able to:

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

3.3 Scheme of assessment

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

Candidates who have only studied the Core curriculum, or who are expected to achieve a grade D or below, should normally be entered for Paper 2.

Candidates who have studied the Extended curriculum, and who are expected to achieve a grade C or above, should be entered for Paper 3.

All candidates must take a practical paper, chosen from: Paper 4 (Coursework), Paper 5 (Practical Test), or Paper 6 (Alternative to Practical).

3. Syllabus aims and objectives

All candidates take:

Paper 1 45 minutes

A multiple-choice paper consisting of 40 items of the four-choice type.
This paper will test skills mainly in Assessment objectives A and B.
Questions will be based on the Core curriculum and will be of a difficulty appropriate to grades C to G.
This paper will be weighted at 30% of the final total available marks.

and either:	**or:**
Paper 2 1 hour 15 minutes Written paper consisting of short-answer and structured questions. Questions will be based on the Core curriculum and will be of a difficulty appropriate to grades C to G. Questions will test skills mainly in Assessment objectives A and B. 80 marks This paper will be weighted at 50% of the final total available marks.	**Paper 3** 1 hour 15 minutes Written paper consisting of short-answer and structured questions. Questions will be based on the Extended curriculum and will be of a difficulty appropriate to the higher grades. Questions will test skills mainly in Assessment objectives A and B. A quarter of the marks available will be based on Core material and the remainder on the Supplement. 80 marks This paper will be weighted at 50% of the final total available marks.

and either:	**or:**	**or:**
Paper 4*	**Paper 5*** 1 hour 15 minutes	**Paper 6*** 1 hour
Coursework	Practical Test	Alternative to Practical
School-based assessment of practical skills.**	Questions covering experimental and observational skills.	Written paper designed to test familiarity with laboratory based procedures.
weighted at 20% of the final total available marks	weighted at 20% of the final total available marks	weighted at 20% of the final total available marks

* This component tests appropriate skills in assessment Objective C. Candidates will not be required to use knowledge outside the Core curriculum.

** Teachers may not undertake school-based assessment without the written approval of CIE. This is only given to teachers who satisfy CIE requirements concerning moderation and who have undergone special training in assessment. CIE offers schools in-service training in the form of occasional face-to-face courses held in countries where there is a need, and also through the Coursework Training Handbook, available from CIE Publications.

3.4 Weightings

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

Teachers should take note that there is an equal weighting of 50% for skills (including handling information, problem solving, practical, experimental and investigative skills) and for knowledge and understanding. Teachers' schemes of work and the sequence of learning activities should reflect this balance, so that the aims of the syllabus may be met, and the candidates fully prepared for the assessment.

Assessment objective	Paper 1 (marks)	Papers 2 or 3 (marks)	Papers 4, 5 or 6 (marks)	Whole assessment (%)
A: Knowledge with understanding	25–30	48–52	0	47–54
B: Handling information and problem solving	10–15	28–32	0	26–33
C: Experimental skills and investigations	0	0	40	20

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

Syllabuses and question papers conform with generally accepted international practice. In particular, the following documents, published in the UK, should be used as guidelines:

Reports produced by the Association for Science Education (ASE):

SI Units, Signs, Symbols and Abbreviations (1981)

Chemical Nomenclature, Symbols and Terminology for use in School Science (1985)

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

Litre/dm^3

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

4. Curriculum content

The Curriculum content below is a guide to the areas on which candidates are assessed.
It is important that, throughout this course, teachers should make candidates aware of the relevance of the concepts studied to everyday life, and to the natural and man-made worlds.
In particular, attention should be drawn to:

- the finite life of the world's resources and the need for recycling and conservation
- economic considerations in the chemical industry, such as the availability and cost of raw materials and energy
- the importance of chemicals in both industry and everyday life.

Specific content has been limited in order to encourage this approach, and to allow flexibility in the design of teaching programmes. CIE provides schemes of work, which can be found on the CIE Teacher Support website.

Candidates may follow the Core curriculum only **or** they may follow the Extended curriculum, which includes both the Core and the Supplement.

1. The particulate nature of matter	
Core • Describe the states of matter and explain their interconversion in terms of the kinetic particle theory • Describe and explain diffusion • Describe evidence for the movement of particles in gases and liquids (a treatment of Brownian motion is **not** required)	**Supplement** • Describe dependence of rate of diffusion on molecular mass (treated qualitatively)
2. Experimental techniques	
2.1 Measurement **Core** • Name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders	
2.2 (a) Criteria of purity **Core** • Describe paper chromatography • Interpret simple chromatograms • Identify substances and assess their purity from melting point and boiling point information • Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs	**Supplement** • Interpret simple chromatograms, including the use of R_f values • 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)

2.2 (b) Methods of purification **Core** • Describe methods of purification by the use of a suitable solvent, filtration, crystallisation, distillation (including use of fractionating column). (Refer to the fractional distillation of crude oil in section 14.2 and products of fermentation in section 14.6.) • Suggest suitable purification techniques, given information about the substances involved	
3. Atoms, elements and compounds	
3.1 Atomic structure and the Periodic Table **Core** • State the relative charges and approximate relative masses of protons, neutrons and electrons • Define *proton number* and *nucleon number* • Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see section 9), with special reference to the elements of proton number 1 to 20 • Define *isotopes* • State the two types of isotopes as being radioactive and non-radioactive • State one medical and one industrial use of radioactive isotopes • Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of valency electrons (the ideas of the distribution of electrons in s and p orbitals and in d block elements are **not** required.) (Note: a copy of the Periodic Table, as shown in the Appendix, will be available in Papers 1, 2 and 3)	

3.2 Bonding: the structure of matter **Core** • Describe the differences between elements, mixtures and compounds, and between metals and non-metals • Describe an alloy, such as brass, as a mixture of a metal with other elements	
3.2 (a) Ions and ionic bonds **Core** • Describe the formation of ions by electron loss or gain • Describe the formation of ionic bonds between elements from Groups I and VII	**Supplement** • Describe the formation of ionic bonds between metallic and non-metallic elements • Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions
3.2 (b) Molecules and covalent bonds **Core** • Describe the formation of single covalent bonds in H_2, Cl_2 , H_2O, CH_4 and HCl as the sharing of pairs of electrons leading to the noble gas configuration • Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds	**Supplement** • Describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH and CO_2
3.2 (c) Macromolecules **Core** • Describe the giant covalent structures of graphite and diamond • Relate their structures to the use of graphite as a lubricant and of diamond in cutting	**Supplement** • Describe the macromolecular structure of silicon(IV) oxide (silicon dioxide) • Describe the similarity in properties between diamond and silicon(IV) oxide, related to their structures
3.2 (d) Metallic bonding	**Supplement** • Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to describe the electrical conductivity and malleability of metals

4. Stoichiometry	
Core • Use the symbols of the elements and write the formulae of simple compounds • Deduce the formula of a simple compound from the relative numbers of atoms present • Deduce the formula of a simple compound from a model or a diagrammatic representation • Construct word equations and simple balanced chemical equations • Define *relative atomic mass*, A_r • Define *relative molecular mass*, M_r, as the sum of the relative atomic masses (*relative formula mass* or M_r will be used for ionic compounds) (Calculations involving reacting masses in simple proportions may be set. Calculations will **not** involve the mole concept.)	**Supplement** • Determine the formula of an ionic compound from the charges on the ions present • Construct equations with state symbols, including ionic equations • Deduce the balanced equation for a chemical reaction, given relevant information
4.1 The mole concept	**Supplement** • Define the *mole* and the *Avogadro constant* • Use the molar gas volume, taken as 24 dm^3 at room temperature and pressure • Calculate stoichiometric reacting masses and volumes of gases and solutions, solution concentrations expressed in g/dm^3 and mol/dm^3. (Calculations involving the idea of 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.) • Calculate empirical formulae and molecular formulae • Calculate % yield and % purity

5. Electricity and chemistry	
Core • Describe the electrode products in the electrolysis of: – molten lead(II) bromide – concentrated hydrochloric acid – concentrated aqueous sodium chloride between inert electrodes (platinum or carbon) • State the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode) • Predict the products of the electrolysis of a specified binary compound in the molten state • Describe the electroplating of metals • Name the uses of electroplating • Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators	**Supplement** • Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper) • Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given • Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution • Describe, in outline, the manufacture of – aluminium from pure aluminium oxide in molten cryolite – chlorine and sodium hydroxide from concentrated aqueous sodium chloride (Starting materials and essential conditions should be given but not technical details or diagrams.)
6. Chemical energetics	
6.1 Energetics of a reaction **Core** • Describe the meaning of *exothermic* and *endothermic* reactions	**Supplement** • Describe bond breaking as endothermic and bond forming as exothermic

6.2 Production of energy **Core** • Describe the production of heat energy by burning fuels • Describe hydrogen as a fuel • Describe radioactive isotopes, such as ^{235}U, as a source of energy	**Supplement** • Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte. (This should be linked with the reactivity series in section 10.2 and redox in section 7.3.) • Describe the use of hydrogen as a potential fuel reacting with oxygen to generate electricity in a fuel cell (details of the construction and operation of a fuel cell are **not** required)
7. Chemical reactions	
7.1 Speed of reaction **Core** • Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the speeds of reactions • Describe a practical method for investigating the speed of a reaction involving gas evolution • Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. mines)	**Supplement** • Devise a suitable method for investigating the effect of a given variable on the speed of a reaction • Interpret data obtained from experiments concerned with speed of reaction • Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles • Describe the role of light in photochemical reactions and the effect of light on the speed of these reactions • Describe the use of silver salts in photography as a process of reduction of silver ions to silver; and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose and oxygen

7.2 Reversible reactions **Core** • Describe the idea that some chemical reactions can be reversed by changing the reaction conditions (Limited to the effects of heat on hydrated salts. Concept of equilibrium is **not** required.)	**Supplement** • Predict the effect of changing the conditions (concentration, temperature and pressure) on other reversible reactions • Concept of equilibrium
7.3 Redox **Core** • Define *oxidation* and *reduction* in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII), dichromate(VI).)	**Supplement** • Define *redox* in terms of electron transfer • Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving $KMnO_4$ is **not** required.)
8. Acids, bases and salts	
8.1 The characteristic properties of acids and bases **Core** • Describe the characteristic properties of acids as reactions with metals, bases, carbonates and effect on litmus • Describe the characteristic properties of bases as reactions with acids and with ammonium salts and effect on litmus • Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator paper • Describe and explain the importance of controlling acidity in soil	**Supplement** • Define *acids* and *bases* in terms of proton transfer, limited to aqueous solutions • Describe the meaning of weak and strong acids and bases
8.2 Types of oxides **Core** • Classify oxides as either acidic or basic, related to metallic and non-metallic character	**Supplement** • Further classify other oxides as neutral or amphoteric

8.3 Preparation of salts **Core** • Describe the preparation, separation and purification of salts as examples of some of the techniques specified in section 2.2(b) and the reactions specified in section 8.1	**Supplement** • Describe the preparation of insoluble salts by precipitation • Suggest a method of making a given salt from suitable starting material, given appropriate information
8.4 Identification of ions and gases **Core** • Describe the following tests to identify: *aqueous cations:* aluminium, 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.) *anions:* carbonate (by reaction with dilute acid and then limewater), chloride (by reaction under acidic conditions with aqueous silver nitrate), iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium), 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 lighted splint), oxygen (using a glowing splint).	

9. The Periodic Table	
Core • Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements	
9.1 Periodic trends **Core** • Describe the change from metallic to non-metallic character across a period	**Supplement** • Describe the relationship between Group number, number of valency electrons and metallic/non-metallic character
9.2 Group properties **Core** • Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and reaction with water • Predict the properties of other elements in Group I, given data, where appropriate • Describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour, and state their reaction with other halide ions • Predict the properties of other elements in Group VII, given data where appropriate	**Supplement** • Identify trends in other Groups, given information about the elements concerned
9.3 Transition elements **Core** • Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts	
9.4 Noble gases **Core** • Describe the noble gases as being unreactive • Describe the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons	

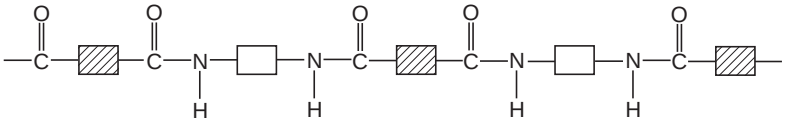
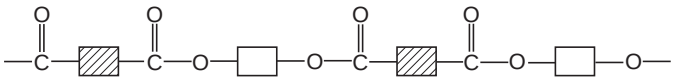
10. Metals	
10.1 Properties of metals **Core** • Describe the general physical and chemical properties of metals • Explain why metals are often used in the form of alloys • Identify representations of alloys from diagrams of structure	
10.2 Reactivity series **Core** • Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with – water or steam – dilute hydrochloric acid and the reduction of their oxides with carbon • Deduce an order of reactivity from a given set of experimental results	**Supplement** • Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with – the aqueous ions – the oxides of the other listed metals • Describe the action of heat on the hydroxides and nitrates of the listed metals • Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal
10.3 (a) Extraction of metals **Core** • Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series • Describe the essential reactions in the extraction of iron from hematite • Describe the conversion of iron into steel using basic oxides and oxygen	**Supplement** • Describe in outline, the extraction of zinc from zinc blende • Name the main ore of aluminium as bauxite (see section 5)

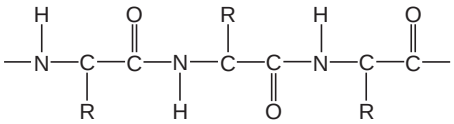
10.3 (b) Uses of metals **Core** • Name the uses of aluminium: – in the manufacture of aircraft because of its strength and low density – in food containers because of its resistance to corrosion • Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys • Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)	**Supplement** • Name the uses of zinc for galvanising and for making brass • Name the uses of copper related to its properties (electrical wiring and in cooking utensils)
11. Air and water	
Core • Describe a chemical test for water • Describe, in outline, the treatment of the water supply in terms of filtration and chlorination • Name some of the uses of water in industry and in the home • Describe the composition of clean air as being approximately 79% nitrogen, 20% oxygen and the remainder as being a mixture of noble gases, water vapour and carbon dioxide • Name the common pollutants in the air as being carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds • 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' – see section 13) – oxides of nitrogen from car exhausts • State the adverse effect of common pollutants on buildings and on health	**Supplement** • Describe the separation of oxygen and nitrogen from liquid air by fractional distillation • Describe and explain the presence of oxides of nitrogen in car exhausts and their catalytic removal

• Describe methods of rust prevention, specifically paint and other coatings to exclude oxygen • Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers • Describe the displacement of ammonia from its salts • State that carbon dioxide and methane are greenhouse gases and may contribute to climate change • Describe the formation of carbon dioxide: – as a product of complete combustion of carbon-containing substances – as a product of respiration – as a product of the reaction between an acid and a carbonate • State the sources of methane, including decomposition of vegetation and waste gases from digestion in animals	• Describe sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention • Describe the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air • Describe the carbon cycle, in simple terms, to include the processes of combustion, respiration and photosynthesis
12. Sulfur	
	Supplement • Name some sources of sulfur • Name the use of sulfur in the manufacture of sulfuric acid • Name the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria) • Describe the manufacture of sulfuric acid by the Contact process, including essential conditions • Describe the properties of dilute sulfuric acid as a typical acid

13. Carbonates	
Core • Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reactions involved • Name some uses of lime and slaked lime as in treating acidic soil and neutralising acidic industrial waste products, e.g. flue gas desulfurisation • Name the uses of calcium carbonate in the manufacture of iron and of cement	
14. Organic chemistry	
14.1 Names of compounds **Core** • Name and draw the structures of methane, ethane, ethene, ethanol, ethanoic acid and the products of the reactions stated in sections 14.4–14.6 • State the type of compound present, given a chemical name ending in *-ane, -ene, -ol,* or *-oic acid*, or a molecular structure	**Supplement** • Name and draw the structures of the unbranched alkanes, alkenes (not *cis-trans*), alcohols and acids containing up to four carbon atoms per molecule
14.2 Fuels **Core** • Name the fuels coal, natural gas and petroleum • Name methane as the main constituent of natural gas • Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation • 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 for making chemicals – kerosene/paraffin fraction for jet fuel – diesel oil/gas oil for fuel in diesel engines – fuel oil fraction for fuel for ships and home heating systems – lubricating fraction for lubricants, waxes and polishes – bitumen for making roads	

14.3 Homologous series **Core** • Describe the concept of homologous series as a 'family' of similar compounds with similar properties due to the presence of the same functional group	**Supplement** • Describe the general characteristics of an homologous series • Describe and identify structural isomerism
14.4 Alkanes **Core** • Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning • Describe the bonding in alkanes	**Supplement** • Describe substitution reactions of alkanes with chlorine
14.5 Alkenes **Core** • Describe the manufacture of alkenes and of hydrogen by cracking • Distinguish between saturated and unsaturated hydrocarbons – from molecular structures – by reaction with aqueous bromine • Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units	**Supplement** • Describe the properties of alkenes in terms of addition reactions with bromine, hydrogen and steam
14.6 Alcohols **Core** • Describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethene • Describe the properties of ethanol in terms of burning • Name the uses of ethanol as a solvent and as a fuel	

14.7 Acids	**Supplement** • Describe the formation of ethanoic acid by the oxidation of ethanol by fermentation and with acidified potassium manganate(VII) • Describe ethanoic acid as a typical weak acid • Describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate)
14.8 Macromolecules	**Supplement** • Describe macromolecules in terms of large molecules built up from small units (monomers), different macromolecules having different units and/or different linkages
14.8 (a) Synthetic polymers	**Supplement** • Name some typical uses of plastics and of man-made fibres • Describe the pollution problems caused by non-biodegradable plastics • Deduce the structure of the polymer product from a given alkene and vice versa • Describe the formation of nylon (a polyamide) and *Terylene* (a polyester) by condensation polymerisation, the structure of nylon being represented as:  and the structure of *Terylene* as:  (Details of manufacture and mechanisms of these polymerisations are **not** required.)

14.8 (b) Natural macromolecules	**Supplement** • Name proteins, fats and carbohydrates as the main constituents of food • Describe proteins as possessing the same (amide) linkages as nylon but with different units Describe the structure of proteins as:  • Describe the hydrolysis of proteins to amino acids (Structures and names are **not** required.) • Describe fats as esters possessing the same linkage as *Terylene* but with different units • Describe soap as a product of hydrolysis of fats • Describe complex carbohydrates in terms of a large number of sugar units, considered as HO—□—OH, joined together by condensation polymerisation, e.g. —O—□—O—□—O—□—O— • Describe the acid hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars • Describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) (Candidates will **not** be expected to give the molecular formulae of sugars.) • Describe, in outline, the usefulness of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

5. Practical assessment

Scientific subjects are, by their nature, experimental. So it is important that an assessment of a candidate's knowledge and understanding of Chemistry should contain a practical component (see Assessment objective C).

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

- Paper 4 – Coursework (school-based assessment)
- 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 benefits to theoretical understanding come from all practical work
- the same motivational effect, enthusiasm and enjoyment should be experienced
- the same sequence of practical activities is appropriate.

5.1 Paper 4: Coursework

Teachers may not undertake school-based assessment without the written approval of CIE. This will only be given to teachers who satisfy CIE requirements concerning moderation and they will have to undergo special training in assessment before entering candidates.

CIE offers schools in-service training in the form of courses held at intervals in Cambridge and elsewhere, and also via distance training manuals.

The experimental skills and abilities to be assessed are:

C1 Using and organising techniques, apparatus and materials

C2 Observing, measuring and recording

C3 Handling experimental observations and data

C4 Planning and evaluating investigations

The four skills carry equal weighting.

All assessments must be based on experimental work carried out by the candidates.
It is expected that the teaching and assessment of experimental skills and abilities will take place throughout the course.

5. Practical assessment

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

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

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

Criteria for assessment of experimental skills and abilities

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

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

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

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

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

5. Practical assessment

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

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

5. Practical assessment

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

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

5. Practical assessment

Guidance on candidate assessment

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

- The assessments should be based on the principle of positive achievement: candidates should be given opportunities to demonstrate what they understand and can do.
- It is expected that candidates will have had opportunities to acquire a given skill before assessment takes place.
- It is not expected that all of the practical work undertaken by a candidate will be assessed.
- Assessments can be carried out at any time during the course. However, at whatever stage assessments are done, the standards applied must be those expected at the end of the course, as exemplified in the criteria for the skills.
- Assessments should normally be made by the person responsible for teaching the candidates.
- A given practical task is unlikely to provide opportunities for all aspects of the criteria at a given level for a particular skill to be satisfied; for example, there may not be any anomalous results (Skill C3). However, by using a range of practical work, teachers should ensure that opportunities are provided for all aspects of the criteria to be satisfied during the course.
- Extended experimental investigations are of great educational value. If such investigations are used for assessment purposes, teachers should make sure that the candidates have ample opportunity for displaying the skills and abilities required by the scheme of assessment.
- It is not necessary for all candidates within a teaching group, or within a Centre, to be assessed on exactly the same practical work, although teachers can use work that is undertaken by all of their candidates.
- When assessing group work, teachers must ensure that each candidate's individual contribution is assessed.
- Skill C1 might not generate a written product from the candidates; it will often be assessed by watching the candidates carrying out practical work.
- Skills C2, C3 and C4 will usually generate a written product from the candidates; this will provide evidence for moderation.
- Raw scores for individual practical assessments should be recorded on the Individual Candidate Record Card. The final, internally moderated total score should be recorded on the Coursework Assessment Summary Form (examples of both forms, plus the Sciences Experiment Form, are at the back of this syllabus).
- Raw scores for individual practical assessments may be given to candidates as part of the normal feedback from the teacher. The final, internally moderated, total score should **not** be given to the candidate.

5. Practical assessment

Moderation

Internal moderation

When several teachers in a Centre are involved in internal assessment, arrangements must be made within the Centre for all candidates to be assessed to the same standard. It is essential that the marks for each skill assigned within different teaching groups (or classes) are moderated internally for the whole Centre entry. The Centre assessments will then be moderated externally by CIE.

External moderation

CIE must receive internally moderated marks for all candidates by 30 April for the May/June examination and by 31 October for the November examination. See the Handbook for Centres and the Administrative Guide for Centres for more information on external moderation and on how to submit marks.

Once it has received the marks, CIE will draw up a list of sample candidates whose work will be moderated (a further sample may also be requested), and will ask the Centre to send immediately every piece of work that has contributed towards these candidates' final marks. Individual Candidate Record Cards and Coursework Assessment Summary Forms must also be sent with the coursework. All remaining coursework and records should be kept by the Centre until results are published.

Ideally, Centres should use loose-leaf A4 file paper for practical written work, as this is cheaper to send by post. Original work is preferred for moderation, but authenticated photocopies can be sent if absolutely necessary.

Pieces of work for each skill should **not** be stapled together. Each piece of work should be clearly and securely labelled with:

- the skill being assessed
- the Centre number
- the candidate's name and number
- the title of the experiment
- a copy of the mark scheme used
- the mark awarded.

5.2 Paper 5: Practical test

Candidates may be asked to carry out exercises involving:

- simple quantitative experiments involving the measurement of volumes
- speeds of reaction
- measurement of temperature based on a thermometer with 1 °C graduations
- problems of an investigatory nature, possibly including suitable organic compounds
- simple paper chromatography
- filtration
- identification of ions and gases as specified in the Core curriculum (the question papers will include notes on qualitative analysis for the use of candidates in the examination).

Candidates may be required to do the following:

- record readings from apparatus
- describe, explain or comment on experimental arrangements and techniques
- complete tables of data
- draw conclusions from observations and/or from information given
- interpret and evaluate observations and experimental data
- plot graphs and/or interpret graphical information
- identify sources of error and suggest possible improvements in procedures
- plan an investigation, including suggesting suitable techniques and apparatus.

Candidates will not be required to carry out weighing for the practical test.

Apparatus List

This list below details the apparatus expected to be generally available for examination purposes. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a chemical laboratory (such as Bunsen burners or tripods) are not included. The number of items stated is for each candidate:

- one burette, 50 cm^3
- one pipette, 25 cm^3
- a pipette filler
- two conical flasks within the range 150 cm^3 to 250 cm^3
- a measuring cylinder, 50 cm^3 or 25 cm^3
- a filter funnel
- a beaker, squat form with lip, 250 cm^3

- a thermometer, –10 °C to +110 °C at 1 °C graduations
- a polystyrene or other plastic beaker of approximate capacity 150 cm^3
- clocks (or wall-clock) to measure to an accuracy of about 1s (where clocks are specified, candidates may use their own wristwatch if they prefer)
- wash bottle
- test-tubes (some of which should be Pyrex or hard glass), approximately 125 mm × 16 mm
- boiling tubes, approximately 150 mm × 25 mm
- stirring rod.

5.3 Paper 6: Alternative to Practical

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

Questions may be set from the following experimental contexts:

- simple quantitative experiments involving the measurement of volumes
- speeds of reaction
- measurement of temperature based on a thermometer with 1 °C graduations
- problems of an investigatory nature, possibly including suitable organic compounds
- simple paper chromatography
- filtration
- identification of ions and gases as specified in the Core curriculum.

Questions may be set requiring candidates to do the following:

- record readings from diagrams of apparatus
- describe, explain or comment on experimental arrangements and techniques
- complete tables of data
- draw conclusions from information given
- interpret and evaluate observations and experimental data
- describe tests for gases and ions, and/or draw conclusions from such tests
- plot graphs and/or interpret graphical information
- identify sources of error and suggest possible improvements in procedures
- plan an investigation, including suggesting suitable techniques and apparatus.

6. Appendix

6.1 Grade descriptions

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

Grade A	**Candidate must show mastery of the Core curriculum and the Extended curriculum**
A **Grade A** candidate will be able to:	• relate facts to principles and theories and vice versa • state why particular techniques are preferred for a procedure or operation • select and collate information from a number of sources and present it in a clear, logical form • solve problems in situations which may involve a wide range of variables • process data from a number of sources to identify any patterns or trends • generate a hypothesis to explain facts, or find facts to support a hypothesis
Grade C	**Candidate must show mastery of the Core curriculum plus some ability to answer questions which are pitched at a higher level**
A **Grade C** candidate will be able to:	• link facts to situations not specified in the syllabus • describe the correct procedure(s) for a multi-stage operation • select a range of information from a given source and present it in a clear, logical form • identify patterns or trends in given information • solve a problem involving more than one step, but with a limited range of variables • generate a hypothesis to explain a given set of facts or data
Grade F	**Candidate must show competence in answering questions based on the Core curriculum**
A **Grade F** candidate will be able to:	• recall facts contained in the syllabus • indicate the correct procedure for a single operation • select and present a single piece of information from a given source • solve a problem involving one step, or more than one step if structured help is given • identify a pattern or trend where only minor manipulation of data is needed • recognise which of two given hypotheses explains a set of facts or data

The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 **H** Hydrogen 1									4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4										11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12										27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

C

*58–71 Lanthanoid series
†90–103 Actinoid series

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

Key

a
X
b

a = relativea tomic mass
X = atomic symbol
b = proton (atomic) number

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

6.3 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.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow 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
aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
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

6. Appendix

6.4 Safety in the laboratory

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

Associations

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

Websites

http://www.chemsoc.org/networks/learnnet/Safety.htm
http://www.ncbe.reading.ac.uk/NCBE/SAFETY/menu.html
http://www.microbiologyonline.org.uk/safety.html

Publications

Safeguards in the School Laboratory, ASE, 11th Edition, 2006
Topics in Safety, ASE, 3rd Edition, 2001
CLEAPSS Laboratory Handbook, updated 2005 (available to CLEAPSS members only)
CLEAPSS Hazcards, 2005 update of 1995 edition (available to CLEAPSS members only)
Safety in Science Education, DfES, HMSO, 1996
Hazardous Chemicals Manual, SSERC, 1997
Hazardous Chemicals. An interactive manual for science education, SSERC, 2002 (CD)

UK Regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002
http://www.opsi.gov.uk/SI/si2002/20022677.htm, a brief guide may be found at
http://www.hse.gov.uk/pubns/indg136.pdf

6. Appendix

6.5 Glossary of terms used in science papers

The 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. *Explain* may imply reasoning or some reference to theory, depending on the context.
6. *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena.

   In other contexts, *describe* should be interpreted more generally (i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer). *Describe and explain* may be coupled, as may *state and explain*.
7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.
8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).
9. *Predict* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

   Predict also implies a concise answer with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required, e.g. reference to a law or principle, or the necessary reasoning is to be included in the answer.
11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in Chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge 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.

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13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length, using a rule, or mass, using a balance).
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula e.g. relative molecular mass.
16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, **but** candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept).

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

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6.6 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
- recognise and use standard notation
- use direct and inverse proportion
- use positive, whole number indices
- draw charts and graphs from given data
- interpret charts and graphs
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recognise and use the relationship between length, surface area and volume and their units on metric scales
- use usual mathematical instruments (ruler, compasses, protractor, set square)
- understand the meaning of angle, curve, circle, radius, diameter, square, parallelogram, rectangle and diagonal
- solve equations of the form $x = yz$ for any one term when the other two are known.

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6.7 Resource list

Books endorsed by CIE for use with this syllabus

These books have been through an independent quality assurance process and match the syllabus content closely.

Author	Title	Date	Publisher	ISBN
R. Norris & R. Stanbridge	*Chemistry for IGCSE*	2009	Nelson Thornes	9781408500187
R. Berry	*IGCSE Study Guide for Chemistry*	2005	Hodder Murray	0719579023
R. Harwood	*Chemistry (Edition 2)**	2003	Cambridge University Press	0521530938

*This book is also available from Cambridge University Press in a Low Priced Edition (ISBN 0 5216 6662 7) from their local distributors in Africa, The Caribbean, Bangladesh, India, Nepal, Pakistan and Sri Lanka.

Reference books

Teachers may also find reference to the following books helpful. They are all suitable for use with this syllabus. Content of the books does not necessarily match the CIE syllabus closely and examples may be British in focus.

Author	Title	Date	Publisher	ISBN
A. Clegg	*Chemistry for IGCSE*		Heinemann	0435966758
B. Earl & L.D. Wilford	*IGCSE Chemistry*	2005	Hodder Murray	0719586178
G. Hill	*Chemistry Counts*		Hodder and Stoughton	0340639342
Lewis & Waller	*Thinking Chemistry (GCSE Edition)*		Oxford University Press	0199142572

These titles represent some of the texts available at the time of printing this booklet. Teachers are encouraged to choose texts for class use which they feel will be of interest to their students and will support their own teaching style.

6. Appendix

Other resources

Copies of syllabuses, the most recent question papers and Principal Examiners' reports are available on the Syllabus and Support Materials CD-ROM, which is sent to all CIE Centres.

Resources are also listed on CIE's public website at **www.cie.org.uk**. Please visit this site on a regular basis as the Resource lists are updated through the year.

Access to teachers' email discussion groups, suggested schemes of work and regularly updated resource lists may be found on the CIE Teacher Support website at **http://teachers.cie.org.uk**. This website is available to teachers at registered CIE Centres.

6. Appendix

6.8 Forms

This section contains copies of the following forms, together with instructions on how to complete them.

Sciences Experiment Form
Individual Candidate Record Card
Coursework Assessment Summary Form

SCIENCES
Experiment Form
IGCSE 2012

Please read the instructions printed overleaf.

Centre number						Centre name	
Syllabus code	**0**	**6**	**2**	**0**		Syllabus title	**Chemistry**
Component number	**0**		**4**			Component title	**Coursework**
June/November	**2**	**0**	**1**	**2**			

Experiment number	Experiment	Skill(s) assessed

Instructions for completing Sciences Experiment Form

1. Complete the information at the head of the form.
2. Use a separate form for each Syllabus.
3. Give a brief description of each of the experiments your students performed for assessment in the IGCSE Syllabus indicated. Use additional sheets as necessary.
4. Copies of the experiment forms and the corresponding worksheets/instructions and marking schemes will be required for each assessed task sampled, for each of Skills C1 to C4 inclusive.

SCIENCES
Individual Candidate Record Card
IGCSE 2012

Please read the instructions printed on the previous page and the General Coursework Regulations before completing this form.															
Centre number						Centre name					June/November	**2**	**0**	**1**	**2**
Candidate number						Candidate name					Teaching group/set				
Syllabus code	**0**	**6**	**2**	**0**		Syllabus title	**CHEMISTRY**	Component number	**0**	**4**	Component title	**COURSEWORK**			

Date of assessment	Experiment number from Sciences Experiment Form	Assess at least twice: ring highest two marks for each skill (Max 6 each assessment)				Relevant comments (for example, if help was given)
		C1	C2	C3	C4	
Marks to be transferred to Coursework Assessment Summary Form		(max 12)	(max 12)	(max 12)	(max 12)	TOTAL (max 48)

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Instructions for completing Individual Candidate Record Cards

1. Complete the information at the head of the form.
2. Mark each item of Coursework for each candidate according to instructions given in the Syllabus and Training Manual.
3. Enter marks and total marks in the appropriate spaces. Complete any other sections of the form required.
4. Ensure that the addition of marks is independently checked.
5. **It is essential that the marks of candidates from different teaching groups within each Centre are moderated internally**. This means that the marks awarded to all candidates within a Centre must be brought to a common standard by the teacher responsible for co-ordinating the internal assessment (i.e. the internal moderator), and a single valid and reliable set of marks should be produced which reflects the relative attainment of all the candidates in the Coursework component at the Centre.
6. Transfer the marks to the Coursework Assessment Summary Form in accordance with the instructions given on that document.
7. Retain all Individual Candidate Record Cards and Coursework **which will be required for external moderation**. Further detailed instructions about external moderation will be sent in late March of the year of the June examination and early October of the year of the November examination. See also the instructions on the Coursework Assessment Summary Form.

   Note: These Record Cards are to be used by teachers only for students who have undertaken Coursework as part of their IGCSE.

SCIENCES
Coursework Assessment Summary Form
IGCSE 2011

Please read the instructions printed overleaf and the General Coursework Regulations before completing this form.

Centre number						Centre name		June/November	2	0	1	2
Syllabus code	0	6	2	0	Syllabus title	CHEMISTRY	Component number	0	4	Component title	COURSEWORK	

Candidate number	Candidate name	Teaching group/set	C1 (max 12)	C2 (max 12)	C3 (max 12)	C4 (max 12)	Total mark (max 48)	Internally moderated mark (max 48)

Name of teacher completing this form		Signature		Date					
Name of internal moderator		Signature		Date					

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IGCSE/CHEMISTRY/CW/S/

A. Instructions for completing Coursework Assessment Summary Forms

1. Complete the information at the head of the form.
2. List the candidates in an order which will allow ease of transfer of information to a computer-printed Coursework mark sheet MS1 at a later stage (i.e. in candidate index number order, where this is known; see item B.1 below). Show the teaching group or set for each candidate. The initials of the teacher may be used to indicate group or set.
3. Transfer each candidate's marks from his or her Individual Candidate Record Card to this form as follows:
   (a) Where there are columns for individual skills or assignments, enter the marks initially awarded (i.e. before internal moderation took place).
   (b) In the column headed 'Total Mark', enter the total mark awarded before internal moderation took place.
   (c) In the column headed 'Internally Moderated Mark', enter the total mark awarded *after* internal moderation took place.
4. Both the teacher completing the form and the internal moderator (or moderators) should check the form and complete and sign the bottom portion.

B. Procedures for external moderation

1. University of Cambridge International Examinations (CIE) sends a computer-printed Coursework mark sheet MS1 to each Centre (in late March for the June examination and in early October for the November examination) showing the names and index numbers of each candidate. Transfer the total internally moderated mark for each candidate from the Coursework Assessment Summary Form to the computer-printed Coursework mark sheet MS1.
2. The top copy of the computer-printed Coursework mark sheet MS1 must be despatched in the specially provided envelope to arrive as soon as possible at CIE but no later than 30 April for the June examination and 31 October for the November examination.
3. CIE will select a list of candidates whose work is required for external moderation. As soon as this list is received, send candidates' work, with the corresponding Individual Candidate Record Cards, this summary form and the second copy of MS1, to CIE.
4. Experiment Forms, Work Sheets and Marking Schemes must be included for each task **that has contributed to the final mark of these candidates**.
5. Photocopies of the samples may be sent **but** candidates' original work, with marks and comments from the teacher, is preferred.
6. (a) The pieces of work for each skill should **not** be stapled together, nor should individual sheets be enclosed in plastic wallets.
   (b) Each piece of work should be clearly labelled with the skill being assessed, Centre name, candidate name and index number and the mark awarded. For each task, supply the information requested in B.4 above.
7. CIE reserves the right to ask for further samples of Coursework.

7. Additional information

7.1 Guided learning hours

IGCSE syllabuses are designed on the assumption that candidates have about 130 guided learning hours per subject over the duration of the course. ('Guided learning hours' include direct teaching and any other supervised or directed study time. They do not include private study by the candidate.)

However, this figure is for guidance only, and the number of hours required may vary according to local curricular practice and the candidates' prior experience of the subject.

7.2 Recommended prior learning

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

7.3 Progression

IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.
Candidates who are awarded grades C to A* in IGCSE Chemistry are well prepared to follow courses leading to AS and A Level Chemistry, or the equivalent.

7.4 Component codes

Because of local variations, in some cases component codes will be different in instructions about making entries for examinations and timetables from those printed in this syllabus, but the component names will be unchanged to make identification straightforward.

7.5 Grading and reporting

IGCSE results are shown by one of the grades A*, A, B, C, D, E, F or G indicating the standard achieved, Grade A* being the highest and Grade 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. For some language syllabuses CIE also reports separate oral endorsement grades on a scale of 1 to 5 (1 being the highest).

7. Additional information

Percentage uniform marks are also provided on each candidate's Statement of Results to supplement their grade for a syllabus. They are determined in this way:

- A candidate who obtains…
  … the minimum mark necessary for a Grade A* obtains a percentage uniform mark of 90%.
  … the minimum mark necessary for a Grade A obtains a percentage uniform mark of 80%.
  … the minimum mark necessary for a Grade B obtains a percentage uniform mark of 70%.
  … the minimum mark necessary for a Grade C obtains a percentage uniform mark of 60%.
  … the minimum mark necessary for a Grade D obtains a percentage uniform mark of 50%.
  … the minimum mark necessary for a Grade E obtains a percentage uniform mark of 40%.
  … the minimum mark necessary for a Grade F obtains a percentage uniform mark of 30%.
  … the minimum mark necessary for a Grade G obtains a percentage uniform mark of 20%.
  … no marks receives a percentage uniform mark of 0%.

Candidates whose mark is none of the above receive a percentage mark in between those stated according to the position of their mark in relation to the grade 'thresholds' (i.e. the minimum mark for obtaining a grade). For example, a candidate whose mark is halfway between the minimum for a Grade C and the minimum for a Grade D (and whose grade is therefore D) receives a percentage uniform mark of 55%.

The uniform percentage mark is stated at syllabus level only. It is not the same as the 'raw' mark obtained by the candidate, since it depends on the position of the grade thresholds (which may vary from one session to another and from one subject to another) and it has been turned into a percentage.

7.6 Resources

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University of Cambridge International Examinations
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
Tel: +44 (0)1223 553554 Fax: +44 (0)1223 553558
Email: international@cie.org.uk Website: www.cie.org.uk