

SYLLABUS

Cambridge IGCSE[®]

Chemistry (US)

0439

For examination in June and November 2015

**This syllabus is available only to Centers taking part in the
Board Examination Systems (BES) Pilot.**

**If you have any questions about this syllabus, please contact Cambridge at
info@cie.org.uk quoting syllabus code 2015.**

Changes to syllabus for 2015

This syllabus has been updated. Significant changes to the syllabus are indicated by black vertical lines either side of the text.

Note

The subject content of this syllabus is the same as the international version. The alternative to practical paper is not included to ensure that coursework or the practical paper is a mandatory part of the syllabus.

Please read the *Cambridge Glossary* alongside this syllabus. This is available from our website. Administration materials appear in UK English and are standard for all our international customers.

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1. Introduction

1.1 Why Choose Cambridge?

Recognition

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

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

Excellence in Education

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

More than 9,000 schools are part of our Cambridge learning community. We support teachers in over 160 countries who offer their students an international education based on our curricula and leading to our qualifications. Every year, thousands of students use Cambridge qualifications to gain admission to universities around the world.

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

Cambridge programs and qualifications are designed to support students in becoming:

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

Support for Teachers

A wide range of materials and resources is available to support teachers and students 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 exam entries and excellent personal support from our customer services. Learn more at www.cie.org.uk/examsOfficers

Non profit, Part of the University of Cambridge

We are a non profit organization where the needs of the teachers and students are at the core of what we do. We continually invest in educational research and respond to feedback from our customers in order to improve our qualifications, products, and services.

Our systems for managing the provision of international qualifications and education programs for students aged 5 to 19 are certified as meeting the internationally recognized 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 syllabi provide opportunities for contextualized 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 goal is to balance knowledge, understanding, and skills in our programs and qualifications to enable candidates to become effective students 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 students to the best of their ability and work with us in the pursuit of excellence in education.

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

Guided Learning Hours

Cambridge IGCSE syllabi are designed with the assumption that candidates 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 candidates' prior experience of the subject.

1.3 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 Cambridge International A Level, skills which are useful in everyday life
- learn how science is studied and practiced, and become aware that the results of scientific research can have both good and bad effects on individuals, communities, and the environment.

Prerequisites

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

Progression

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

Candidates who are awarded grades C to A* in Cambridge IGCSE Chemistry are well prepared to follow courses leading to Cambridge International AS and A Level Chemistry, 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 recognizing the achievements of candidates who pass examinations in at least seven subjects. To qualify for the Cambridge ICE award candidates are required to have studied subjects from five groups: two languages from Group I and one subject from each of the remaining four groups. The seventh subject can be taken from any of the five subject groups.

Chemistry falls into Group III, Science.

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

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

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

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 organization can register to become a Cambridge school.

2. Teacher Support

2.1 Support Materials

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

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

For teachers at registered Cambridge schools a range of additional support materials for specific syllabi is available online. For Teacher Support go to <http://teachers.cie.org.uk> (username and password required).

2.2 Resource Lists

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

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

2.3 Training

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

3. Syllabus Content at a Glance

1. The particulate nature of matter**2. Experimental techniques**

2.1 Measurement

2.2 (a) Criteria of purity

2.2 (b) Methods of purification

3. Atoms, elements and compounds

3.1 Atomic structure and the Periodic Table

3.2 Bonding the structure of matter

3.2 (a) Ions and ionic bonds

3.2 (b) Molecules and covalent bonds

3.2 (c) Macromolecules

3.2 (d) Metallic bonding

4. Stoichiometry

4.1 The mole concept

5. Electricity and chemistry**6. Chemical energetics**

6.1 Energetics of a reaction

6.2 Production of energy

7. Chemical reactions

7.1 Rate (speed) of reaction

7.2 Reversible reactions

7.3 Redox

8. Acids, bases and salts

8.1 The characteristic properties of acids and bases

8.2 Types of oxides

8.3 Preparation of salts

8.4 Identification of ions and gases

9. The Periodic Table

9.1 Periodic trends

9.2 Group properties

9.3 Transition elements

9.4 Noble gases

10. Metals

10.1 Properties of metals

10.2 Reactivity series

10.3 (a) Extraction of metals

10.3 (b) Uses of metals

11. Air and water**12. Sulfur****13. Carbonates****14. Organic chemistry**

14.1 Names of compounds

14.2 Fuels#

14.3 Homologous series

14.4 Alkanes

14.5 Alkenes

14.6 Alcohols

14.7 Acids

14.8 Macromolecules

14.8 (a) Synthetic polymers

14.9 (b) Natural macromolecules

4. Assessment at a Glance

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 consists of the Core and Supplement Curricula; these candidates are eligible for all grades from A* to G.

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

All candidates take:			
Paper 1		45 minutes	
Multiple-choice question paper			
Weighted at 30% of total available marks			
and either:		or:	
Paper 2	1 hour, 15 minutes	Paper 3	1 hour, 15 minutes
Core theory paper		Extended theory paper	
Weighted at 50% of total available marks		Weighted at 50% of total available marks	
and either:		or:	
Paper 4		Paper 5	1 hour, 15 minutes
Coursework		Practical test	
Weighted at 20% of total available marks		Weighted at 20% of total available marks	

Availability

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

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

Combining This with Other Syllabi

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

- syllabi with the same title at the same level
- 0652 Cambridge IGCSE Physical Science
- 0653 Cambridge IGCSE Combined Science
- 0654 Cambridge IGCSE Coordinated Sciences (Double Award)

5. Syllabus Goals and Assessment Objectives

5.1 Goals

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

The goals 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
 - recognize 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 Cambridge 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
 - inquiry
 - 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 cooperative 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.

5.2 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

Candidates 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 that 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 Used in Science Papers).

B: Handling Information and Problem Solving

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

1. locate, select, organize, 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 Glossary of Terms Used in Science Papers.)

C: Experimental Skills and Investigations

Candidates 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).

5.3 Scheme of Assessment

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

Candidates who have studied only 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 either Paper 4 (Coursework) or Paper 5 (Practical Test).

All candidates take:	
Paper 1	45 minutes
<p>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.</p>	
and either:	or:
<p>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.</p>	<p>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.</p>
and either:	or:
<p>Paper 4* 1 hour, 15 minutes Coursework Internal assessment of practical skills.** This paper will be weighted at 20% of the final total available marks.</p>	<p>Paper 5* 1 hour, 15 minutes Practical test Questions covering experimental skills. This paper will be weighted at 20% of the final total available marks.</p>

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

** At least one teacher in each Center offering a subject including coursework must be accredited by Cambridge. Accreditation is only given to teachers who satisfy Cambridge requirements concerning moderation and who have undergone special training in assessment.

5.4 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 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 (unit lesson plans) and the sequence of learning activities should reflect this balance so that the goals 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 or 5 (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

5.5 Conventions (e.g., Signs, Symbols, Terminology, and Nomenclature)

This syllabus 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).

Liter/dm³

To avoid any confusion concerning the symbol for liter, **dm³** will be used in place of *l* or liter.

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.

6. Syllabus 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.

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 programs. Cambridge provides schemes of work (unit lesson plans), which can be found on the Cambridge 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	
<p>Core</p> <ul style="list-style-type: none"> • 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) 	<p>Supplement</p> <ul style="list-style-type: none"> • Describe dependence of rate of diffusion on molecular mass (treated qualitatively)
2. Experimental Techniques	
<p>2.1 Measurement</p> <p>Core</p> <ul style="list-style-type: none"> • Name appropriate apparatus for the measurement of time, temperature, mass, and volume, including burets, droppers, and graduated cylinders 	
<p>2.2 (a) Criteria of Purity</p> <p>Core</p> <ul style="list-style-type: none"> • 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 	<p>Supplement</p> <ul style="list-style-type: none"> • Interpret simple chromatograms, including the use of R_f values • Outline how chromatography techniques can be applied to colorless substances by exposing chromatograms to substances called locating agents (knowledge of <i>specific</i> locating agents is not required)

<p>2.2 (b) Methods of Purification</p> <p>Core</p> <ul style="list-style-type: none"> Describe methods of purification by the use of a suitable solvent, filtration, crystallization, 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	
<p>3.1 Atomic Structure and the Periodic Table</p> <p>Core</p> <ul style="list-style-type: none"> State the relative charges and approximate relative masses of protons, neutrons, and electrons Define <i>proton number</i> and <i>nucleon number</i> (mass 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 <i>isotopes</i> State the two types of isotopes as being radioactive and nonradioactive 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) 	
<p>3.2 Bonding: The Structure of Matter</p> <p>Core</p> <ul style="list-style-type: none"> Describe the differences between elements, mixtures, and compounds, and between metals and nonmetals Describe an alloy, such as brass, as a mixture of a metal with other elements 	

<p>3.2 (a) Ions and Ionic Bonds</p> <p>Core</p> <ul style="list-style-type: none"> Describe the formation of ions by electron loss or gain Describe the formation of ionic bonds between elements from Groups I and VII 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the formation of ionic bonds between metallic and nonmetallic elements Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions
<p>3.2 (b) Molecules and Covalent Bonds</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH, and CO_2
<p>3.2 (c) Macromolecules</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> 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
<p>3.2 (d) Metallic Bonding</p>	<p>Supplement</p> <ul style="list-style-type: none"> 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	
<p>Core</p> <ul style="list-style-type: none"> • 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 <i>relative atomic mass</i>, A_r • Define <i>relative molecular mass</i>, M_r, as the sum of the relative atomic masses (<i>relative formula mass</i> or M_r will be used for ionic compounds) <p>(Calculations involving reacting masses in simple proportions may be set. Calculations will not involve the mole concept.)</p>	<p>Supplement</p> <ul style="list-style-type: none"> • 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
<p>4.1 The Mole Concept</p>	<p>Supplement</p> <ul style="list-style-type: none"> • Define the <i>mole</i> and the <i>Avogadro constant</i> • 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	
<p>Core</p> <ul style="list-style-type: none"> Describe the electrode products in the electrolysis of: <ul style="list-style-type: none"> 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 nonmetals (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) aluminum in cables, and why plastics and ceramics are used as insulators 	<p>Supplement</p> <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> aluminum from pure aluminum 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	
<p>6.1 Energetics of a Reaction</p> <p>Core</p> <ul style="list-style-type: none"> Describe the meaning of <i>exothermic</i> and <i>endothermic</i> reactions 	<p>Supplement</p> <ul style="list-style-type: none"> Describe bond breaking as endothermic and bond forming as exothermic
<p>6.2 Production of Energy</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> 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	
<p>7.1 Rate (speed) of Reaction</p> <p>Core</p> <ul style="list-style-type: none"> Describe the effect of concentration, particle size, catalysts (including enzymes), and temperature on the rate (speed) of reactions Describe a practical method for investigating the rate (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) <p>Note: Candidates should be encouraged to use the term <i>rate</i> rather than <i>speed</i>.</p>	<p>Supplement</p> <ul style="list-style-type: none"> Devise a suitable method for investigating the effect of a given variable on the rate (speed) of a reaction Interpret data obtained from experiments concerned with rate (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 rate (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
<p>7.2 Reversible Reactions</p> <p>Core</p> <ul style="list-style-type: none"> Describe the idea that some chemical reactions can be reversed by changing the reaction conditions <p>Limited to the effects of heat on hydrated salts including hydrated copper(II) sulfate and hydrated cobalt(II) chloride. (Concept of equilibrium is not required.)</p>	<p>Supplement</p> <ul style="list-style-type: none"> Predict the effect of changing the conditions (concentration, temperature, and pressure) on other reversible reactions Concept of equilibrium
<p>7.3 Redox</p> <p>Core</p> <ul style="list-style-type: none"> Define <i>oxidation</i> and <i>reduction</i> 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).) 	<p>Supplement</p> <ul style="list-style-type: none"> Define <i>redox</i> in terms of electron transfer Identify redox reactions by changes in oxidation state and by the color 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	
<p>8.1 The Characteristic Properties of Acids and Bases</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> Define <i>acids</i> and <i>bases</i> in terms of proton transfer, limited to aqueous solutions Describe the meaning of weak and strong acids and bases
<p>8.2 Types of Oxides</p> <p>Core</p> <ul style="list-style-type: none"> Classify oxides as either acidic or basic, related to metallic and nonmetallic character 	<p>Supplement</p> <ul style="list-style-type: none"> Further classify other oxides as neutral or amphoteric
<p>8.3 Preparation of Salts</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the preparation of insoluble salts by precipitation Suggest a method of making a given salt from suitable starting material, given appropriate information

<p>8.4 Identification of Ions and Gases</p> <p>Core</p> <ul style="list-style-type: none"> Describe the following tests to identify: <p><i>aqueous cations:</i></p> aluminum, 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.) <p><i>anions:</i></p> 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 aluminum), sulfate (by reaction under acidic conditions with aqueous barium ions) <p><i>gases:</i></p> ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using lighted splint), oxygen (using a glowing splint). 	
<p>9. The Periodic Table</p>	
<p>Core</p> <ul style="list-style-type: none"> Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements 	
<p>9.1 Periodic Trends</p> <p>Core</p> <ul style="list-style-type: none"> Describe the change from metallic to nonmetallic character across a period 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the relationship between Group number, number of valency electrons, and metallic/nonmetallic character
<p>9.2 Group Properties</p> <p>Core</p> <ul style="list-style-type: none"> 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 nonmetals showing a trend in color, and state their reaction with other halide ions Predict the properties of other elements in Group VII, given data where appropriate 	<p>Supplement</p> <ul style="list-style-type: none"> Identify trends in other Groups, given information about the elements concerned

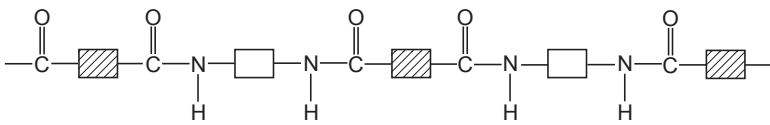
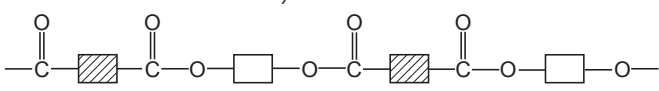
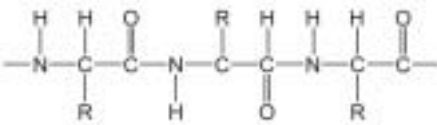
<p>9.3 Transition Elements</p> <p>Core</p> <ul style="list-style-type: none"> Describe the transition elements as a collection of metals having high densities, high melting points, and forming colored compounds, and which, as elements and compounds, often act as catalysts 	
<p>9.4 Noble Gases</p> <p>Core</p> <ul style="list-style-type: none"> 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 	
<p>10. Metals</p>	
<p>10.1 Properties of Metals</p> <p>Core</p> <ul style="list-style-type: none"> 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 	
<p>10.2 Reactivity Series</p> <p>Core</p> <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> water or steam dilute hydrochloric acid and the reduction of their oxides with carbon <ul style="list-style-type: none"> Deduce an order of reactivity from a given set of experimental results 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with <ul style="list-style-type: none"> 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 aluminum in terms of the oxide layer which adheres to the metal

<p>10.3 (a) Extraction of Metals</p> <p>Core</p> <ul style="list-style-type: none"> 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 	<p>Supplement</p> <ul style="list-style-type: none"> Describe in outline, the extraction of zinc from zinc blende Name the main ore of aluminum as bauxite (see section 5)
<p>10.3 (b) Uses of Metals</p> <p>Core</p> <ul style="list-style-type: none"> Name the uses of aluminum: <ul style="list-style-type: none"> in the manufacture of airplanes 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) 	<p>Supplement</p> <ul style="list-style-type: none"> Name the uses of zinc for galvanizing and for making brass Name the uses of copper related to its properties (electrical wiring and in cooking utensils)
<p>11. Air and Water</p>	
<p>Core</p> <ul style="list-style-type: none"> Describe chemical tests for water using cobalt(II) chloride and copper(II) sulfate 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 vapor, 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: <ul style="list-style-type: none"> carbon monoxide from the incomplete combustion of carbon-containing substances sulfur dioxide from the combustion of fossil fuels that 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 	<p>Supplement</p> <ul style="list-style-type: none"> 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

<ul style="list-style-type: none"> Describe methods of rust prevention, specifically paint and other coatings to exclude oxygen Describe the need for nitrogen-, phosphorus-, and potassium-containing fertilizers 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: <ul style="list-style-type: none"> 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 from the thermal decomposition of a carbonate State the sources of methane, including decomposition of vegetation and waste gases from digestion in animals 	<ul style="list-style-type: none"> Describe sacrificial protection in terms of the reactivity series of metals and galvanizing 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	
	<p>Supplement</p> <ul style="list-style-type: none"> 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	
<p>Core</p> <ul style="list-style-type: none"> Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of thermal decomposition Name some uses of lime and slaked lime as in treating acidic soil and neutralizing acidic industrial waste products, e.g., flue gas desulfurization Name the uses of calcium carbonate in the manufacture of iron and of cement 	

14. Organic Chemistry	
<p>14.1 Names of Compounds</p> <p>Core</p> <ul style="list-style-type: none"> 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 <i>-ane</i>, <i>-ene</i>, <i>-ol</i>, or <i>-oic acid</i>, or a molecular structure 	<p>Supplement</p> <ul style="list-style-type: none"> Name and draw the structures of the unbranched alkanes, alkenes (not <i>cis-trans</i>), alcohols, and acids containing up to four carbon atoms per molecule
<p>14.2 Fuels</p> <p>Core</p> <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> refinery gas for bottled gas for heating and cooking gasoline fraction for fuel (gas) 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 	
<p>14.3 Homologous Series</p> <p>Core</p> <ul style="list-style-type: none"> Describe the concept of homologous series as a “family” of similar compounds with similar properties due to the presence of the same functional group 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the general characteristics of a homologous series Describe and identify structural isomerism
<p>14.4 Alkanes</p> <p>Core</p> <ul style="list-style-type: none"> Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning Describe the bonding in alkanes 	<p>Supplement</p> <ul style="list-style-type: none"> Describe substitution reactions of alkanes with chlorine

<p>14.5 Alkenes</p> <p>Core</p> <ul style="list-style-type: none"> Describe the manufacture of alkenes and of hydrogen by cracking Distinguish between saturated and unsaturated hydrocarbons <ul style="list-style-type: none"> from molecular structures by reaction with aqueous bromine Describe the formation of poly(ethene) as an example of addition polymerization of monomer units 	<p>Supplement</p> <ul style="list-style-type: none"> Describe the properties of alkenes in terms of addition reactions with bromine, hydrogen, and steam
<p>14.6 Alcohols</p> <p>Core</p> <ul style="list-style-type: none"> 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 	
<p>14.7 Acids</p> <p>Core</p> <ul style="list-style-type: none"> Describe the physical properties of aqueous ethanoic acid 	<p>Supplement</p> <ul style="list-style-type: none"> 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)
<p>14.8 Macromolecules</p>	<p>Supplement</p> <ul style="list-style-type: none"> 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	<p>Supplement</p> <ul style="list-style-type: none"> Name some typical uses of plastics and of manufactured fibers Describe the pollution problems caused by nonbiodegradable 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 polymerization, the structure of nylon being represented as:  <p>and the structure of <i>Terylene</i> as:</p>  <p>(Details of manufacture and mechanisms of these polymerizations are not required.)</p>
14.8 (b) Natural Macromolecules	<p>Supplement</p> <ul style="list-style-type: none"> 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:  <ul style="list-style-type: none"> Describe the hydrolysis of proteins to amino acids (Structures and names are not required.) Describe fats as esters possessing the same linkage as <i>Terylene</i> 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-[white box]-OH, joined together by condensation polymerization, e.g., -O-[white box]-O-[white box]-O-[white box]-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

7. 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).

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

- Paper 4—Coursework (internal assessment)
- Paper 5—Practical Test

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.

7.1 Paper 4: Coursework

At least one teacher in each Center offering a subject including coursework must be accredited by Cambridge. Accreditation will only be given to teachers who satisfy Cambridge requirements concerning moderation and they will have to undergo special training in assessment before entering candidates.

The experimental skills and abilities to be assessed are:

C1 Using and organizing 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.

Teachers must ensure that they can make available to Cambridge 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, Cambridge procedure for special consideration should be followed. However, candidates who for no good reason absent themselves from an assessment of a given skill should be given a mark of zero for that assessment.

Criteria for Assessment of Experimental Skills and Abilities

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

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

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

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

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

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

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

Score	Skill C3: Handling Experimental Observations and Data
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Processes results in an appropriate manner given a detailed format. Draws an obvious qualitative conclusion from the results of an experiment.
3	Is beyond the level defined for 2 but does not meet fully the criteria for 4.
4	Processes results in an appropriate manner given an outline format. Recognizes and comments on anomalous results. Draws qualitative conclusions that 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. Recognizes and comments on possible sources of experimental error. Expresses conclusions as generalizations 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, recognizes 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	Analyzes a practical problem systematically and produces a logical plan for an investigation. In a given situation, recognizes 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.

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 Center, 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.

Moderation

Internal Moderation

When several teachers in a Center are involved in internal assessment, arrangements must be made within the Center 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 Center entry. The Center assessments will then be moderated externally by Cambridge.

External Moderation

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

Once it has received the marks, Cambridge will draw up a list of sample candidates whose work will be moderated (a further sample may also be requested), and will ask the Center to send immediately every piece of work that has contributed toward 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 Center until results are published.

Ideally, Centers should use loose-leaf letter-size filler paper for practical written work, as this is cheaper to send by mail. 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 labeled with:

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

7.2 Paper 5: Practical Test

Candidates may be asked to carry out exercises involving:

- simple quantitative experiments involving the measurement of volumes
- rates (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 candidates to use 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 ring stands) are not included. The number of items stated is for each candidate:

- one buret, 50 cm³
- one volumetric pipet, 25 cm³
- a pipet filler
- two Erlenmeyer flasks within the range 150 cm³ to 250 cm³
- a graduated cylinder, 50 cm³ or 25 cm³
- a filter funnel
- a beaker, squat form with lip, 250 cm³
- a thermometer, -10°C to +110°C at 1°C graduations
- a styrofoam or other plastic beaker of approximate capacity 150 cm³
- 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
- large test-tubes, approximately 150 mm × 25 mm
- stirring rod.

8. Appendix A

8.1 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:	<ul style="list-style-type: none"> • 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 that 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 that are pitched at a higher level
A Grade C candidate will be able to:	<ul style="list-style-type: none"> • link facts to situations not specified in the syllabus • describe the correct procedure(s) for a multistage 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:	<ul style="list-style-type: none"> • 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 • recognize 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 Aluminum 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	96 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	209 Po Polonium 84	209 At Astatine 85	209 Rn Radon 86		
87 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †																	

*58–71 Lanthanoid series

†90–103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 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	234 Pa Protactinium 91	238 U Uranium 92	238 Np Neptunium 93	244 Pu Plutonium 94	247 Am Americium 95	251 Cm Curium 96	257 Bk Berkelium 97	261 Cf Californium 98	265 Es Einsteinium 99	267 Fm Fermium 100	268 Md Mendelevium 101	269 No Nobelium 102	269 Lr Lawrencium 103

Key	a	a = relative atomic mass	
	X		X = atomic symbol
	b		

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

8.3 Notes for Use in Qualitative Analysis

Tests for Anions

Anion	Test	Test Result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
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 aluminum 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
aluminum (Al^{3+})	white ppt., soluble in excess giving a colorless 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 colorless solution	white ppt., soluble in excess, giving a colorless solution

Tests for Gases

Gas	Test and Test Result
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	“pops” with a lighted splint
oxygen (O_2)	relights a glowing splint

8.4 Safety in the Laboratory

Responsibility for safety matters rests with Centers. Further information can be found in the following UK association and websites.

Association

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

<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>

8.5 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 organization 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.
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.

8.6 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
- recognize and use scientific 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
- recognize 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.

8.7 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 2015

Please read the instructions printed overleaf.

Centre number					Centre name	
Syllabus code	0	4	3	9	Syllabus title	Chemistry
Component number	0		4		Component title	Coursework
June/November	2	0	1	5		

Experiment number	Experiment	Skill(s) assessed

WMS627

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International Examinations

IGCSE/CHEMISTRY/CW/EX/

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 Cambridge 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.

WMS627



IGCSE/CHEMISTRY/CW/EX/

SCIENCES
Individual Candidate Record Card
IGCSE 2015

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	5
Candidate number						Candidate name					Teaching group/set				
Syllabus code	0	4	3	9	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						TOTAL									
Coursework Assessment Summary Form		(max 12)	(max 12)	(max 12)	(max 12)	(max 48)									

WMS626



IGCSE/CHEMISTRY/CW/S/

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.** The deadlines and methods for submitting internally assessed marks are in the *Cambridge Administrative Guide* available on our website.

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

SCIENCES

Coursework Assessment Summary Form

IGCSE 2015

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

Centre number					Centre name		June/November	2	0	1	5
Syllabus code	0	4	3	9	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					

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 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. The deadlines and methods for submitting internally assessed marks are in the *Cambridge Administrative Guide* available on our website.
3. Cambridge 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 Cambridge.
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. Cambridge reserves the right to ask for further samples of Coursework.

9. Other Information

Equality and Inclusion

Cambridge 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 International Examinations 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 to if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who are unable to access a component of the assessment 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**

Language

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

Grading and Reporting

Cambridge IGCSE Certificate 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 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 examination timetables, administrative instructions, and entry codes for your administrative zone can be found in the *Cambridge Guide to Making Entries*.

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