Scheme of Work

Cambridge O Level

Cambridge O Level Chemistry

5070

For examination from 2016

Cambridge Secondary 2

CAMBRIDGE International Examinations

Contents

Introduction

Recommended prior knowledge

This scheme of work provides ideas about how to construct and deliver a course. The Cambridge O Level Chemistry syllabus has been broken down into teaching units with suggested teaching activities and learning resources to use in the classroom. This scheme of work provides additional support for teachers and should be used alongside the syllabus not in place of the syllabus. We recommend that learners who are beginning this course should have previously studied a science curriculum such as that of the Cambridge Secondary 1 curriculum framework or equivalent national educational frameworks. Learners should also have adequate mathematical skills for the content contained in the syllabus.

Outline

The units within this scheme of work are:

Unit	Topic	Content (syllabus reference)	Teaching time (%)
1	Kinetic theory and atomic structure	2.1 Kinetic particle theory 2.3 Structure and properties of materials 1.2 Methods of purification and analysis 2.2 Atomic structure	8%
2	The Periodic Table (including Ionic Bonding)	8.1 Periodic trends 8.2 Group properties 8.3 Transition elements 2.4 Ionic bonding	15%
3	Organic Chemistry 1 (includes covalent bonding and energy from chemicals)	11 Organic Chemistry 5 Energy from chemicals (part 1) 2.5 Covalent bonding 11.1 Alkanes 5 Energy from chemicals (part 2) 11.2 Alkenes 11.5 Macromolecules 2.3 Structure and properties of materials	15%
4	Atmosphere and environment	10.1 Air 10.2 Water 1.3 Identification of ions and gases	8%
5	Amount of substance	3 Formulae, stoichiometry and the mole concept	8%

Unit	Topic	Content (syllabus reference)	Teaching time (%)
6	Metals and metal reactivity	2.6 Metallic bonding 9.1 Properties of metals 9.2 Reactivity Series 6.2 Redox 9.3 Extraction of metals 9.4 Iron	10%
7	Rate of reaction	1.1 Experimental design 6.1 Rate of reaction	7%
8	Acids, bases and salts (including qualitative analysis)	1.1 Experimental design 1.2 Methods of purification 1.3 Identification of ions and gases 7.1 Characteristic properties of acids and bases 7.2 Preparation of salts 7.3 Properties and uses of ammonia 6.3 Reversible reactions 7.3 Properties and uses of ammonia 7.4 Sulfuric acid	15%
9	Electrolysis	4 Electrolysis 9.5 Manufacture of aluminium	8%
10	Organic Chemistry 2	11.3 Alcohols 11.4 Carboxylic acids 11.5 Macromolecules	6%

Teaching order

The units may be taught in order, 1 to 10. This is not essential, but the following recommendations apply.

(a) It is recommended that Unit 1 is taught as the first unit of the course.
(b) Other units that are suitable for teaching early in the course include Units 2, 3 and 4. Some of the ideas met in Units 2 and 3 (e.g. ionic and covalent bonding) are revisited in Unit 4.
(c) Some units contain slightly more difficult concepts and so are suitable for teaching in the middle of the course. These include Units 5, 6 and 7. It is recommended that Unit 5 is taught before Units 6, 7 and 8 so that amount of substance calculations can be carried out by learners in these units.
(d) Units that study the more difficult concepts, or rely on prior learning from earlier in the course, include Units 8, 9 and 10. Unit 10 must be taught after Unit 3.
(e) It is recommended that the teaching of some skills and concepts are ongoing across all units. These include the use of symbols, formulae, equations, calculations, ideas about redox, energy changes and chemical bonding and structure.

(f) It is recommended that the themes outlined in the syllabus content, Section 1, Experimental Chemistry, are ongoing across most units such that theory is backed up by experiment wherever possible and practical skills become second nature.

Resources

The up-to-date resource list for this syllabus, including textbooks endorsed by Cambridge, is listed at www.cie.org.uk
Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. As such, all textbooks endorsed by Cambridge for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective.

Teacher Support

Teacher Support https://teachers.cie.org.uk is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on Teacher Support at https://teachers.cie.org.uk If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge International Examinations is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

Unit 1: Kinetic theory and atomic structure

Recommended prior knowledge

Learners should have followed an introductory/foundation level course in chemistry. This unit would make a suitable 'starter unit' for the Cambridge O Level Chemistry course.

Context

This unit should be studied very early in the course. The concepts of kinetic theory and atomic structure are necessary prior learning for most of the other units.

Outline

Learners study the kinetic theory of solids, liquids, gases and solutions and are introduced to ideas about atomic structure. This unit contains core learning for all other units; therefore learners of all abilities need to study all of the concepts.

Syllabus ref	Learning objectives	Suggested teaching activities
2.1 (a)	**Kinetic particle theory** Describe the solid, liquid and gaseous states of matter and explain their interconversion in terms of the kinetic particle theory and of the energy changes involved	Learners should be familiar with diagrams or computer animations of 'particles in boxes' to represent solids, liquids and gases. Learners should be able to describe the arrangement and movement of particles in each state. Discuss by showing experiments or pictures of substances undergoing changes of state e.g. ice melting, water evaporating, steam condensing, flow chart of the water cycle. www.schoolscience.co.uk Click on 'Resources for ages 11–14' → 'Chemistry' → 'Materials'. www.rsc.org/learn-chemistry/resource Download and look at experiments 20, 23, 26, 36 and 37. **Suggested experiments** Observing state changes. Plotting a heating curve for water. www.presentingscience.com/vac/states/index.htm Use virtual lab to look at the m.pts. and b.pts. of different substance. A simulation: www.harcourtschool.com/acti vity/states_of_matter/

Syllabus ref	Learning objectives	Suggested teaching activities
		There is an opportunity to practise the use of thermometers and stop clocks, syllabus learning objective 1.1(a). Learners use a thermometer to measure the temperature change every 30 s as ice melts and the resultant water is heated to boiling. If available, a temperature probe can be used to show graphs on a computer.
(b)	Describe and explain evidence for the movement of particles in liquids and gases	Learners should practise describing diffusion using ideas about the arrangement and movement of particles at different temperatures. www.rsc.org/learn-chemistry/resource Download and look at experiment 27
(c)	Explain everyday effects of diffusion in terms of particles	**Suggested experiments** Use a dropping pipette to run coloured fruit juice under cold water in a beaker. Repeat using hot water. Spraying air freshener onto a watch glass and asking learners to raise their hands as they smell it travelling through the room. Introductory material: www.brainpop.com/science/matter/
(d)	State qualitatively the effect of molecular mass on the rate of diffusion and explain the dependence of rate of diffusion on temperature	**Suggested experiment** Set up a long horizontal tube with rubber bungs at each end. Insert cotton wool soaked in conc. ammonia at one end, and cotton wool soaked in conc. hydrochloric acid at the other. A white ring of ammonium chloride forms nearer the hydrochloric acid end, because HC*l* molecules have a greater mass so diffuse more slowly. This is an early opportunity to introduce the idea of relative molecular mass.
2.3 (a)	**Structure and properties of materials** Describe the differences between elements, compounds and mixtures	**Suggested experiment** Investigate the properties of iron and sulfur (appearance, magnetic properties, density compared with water, effect of dilute acid) and then a mixture of the two. The elements can then be heated to form a compound and the properties of the compound compared. **Downloadable element** flashcards, games and worksheets (care re non- systematic names): http://sphs.spusd.net/groves/

Syllabus ref	Learning objectives	Suggested teaching activities
		apchem.html www.rsc.org/learn-chemistry/resource Download and look at experiment 14 **Demonstration** React heated Na with Cl_2 gas; the explosion between H_2 and O_2. Learners need learn definitions for elements, compounds and mixtures and to be able to identify them from chemical formulae and 'particles in boxes' diagrams. Emphasis should be placed on the fact that compounds can differ greatly in properties from the elements they are made from. Alloys as examples of useful mixtures.
1.2 (e)	**Methods of purification and analysis** Deduce from the given melting point and boiling point the identities of substances and their purity	**Suggested activity** An experiment to plot a cooling curve for stearic acid or phenyl salicylate (salol) (pure substances), and for wax (a mixture). Data loggers can be used if available. Melt each in a boiling tube in a water bath of boiling water. Plot temperature against time as the solid cools and solidifies. Learners can practise using data books or an online database by looking up the melting points of elements and compounds (e.g. all elements in Group I or VII).
(f)	Explain the measurement of purity in substances used in everyday life e.g. foodstuffs and drugs	Learners should recognise that pure substances have sharp melting points but impure substances and mixtures melt over a range of temperature. Emphasise the energy changes involved in the cooling pattern. This activity forms a basis for work on Group trends in Unit 2.
(a)	Describe methods of purification by the use of a solvent, filtration and crystallisation, distillation and fractional distillation	**Suggested experiment** Separating mixtures e.g. salt from rock salt, pure water from sandy sea water. Demonstration: propanone from a propanone/water mixture using a heating mantle. This links to water purification (syllabus learning objectives 10.2 (c) and (d). Stress the usefulness of fractional distillation as it appears later for industrially separating fractions from crude oil or the gases from air.

Syllabus ref	Learning objectives	Suggested teaching activities
		For background information on salt extraction: www.british-salt.co.uk www.rsc.org/learn-chemistry/ Look at experiment 1 and 99
(c)	Describe paper chromatography and interpret chromatograms including comparison with 'known' samples and use of R_f values	**Suggested experiment** Chromatography of food colourings or ink from felt tip pens. Dyes from sugar coated sweets can be used by transferring the dye to filter paper using a damp paint brush. Learners can carry out chromatography of permanent inks using methanol as a solvent. This links to the identification of amino acids from hydrolysed proteins (11.5(k)), a technique used to diagnose some illnesses e.g. diabetes. The separation of food colourings can be carried out on paper and thin layer chromatography – the R_f values change using the different methods.
(d)	Explain the need to use locating agents in the chromatography of colourless compounds	Use Google to search for images of 'chromatography'; click on the image tab then enter 'chromatography – there are lots of colourful images available to show to learners as well as examples of other types of chromatographs including gas/liquid. www.rsc.org/learn-chemistry/resource Look at experiments 4, 40 and 71.
2.2 (a) (b)	**Atomic structure** State the relative charges and appropriate relative masses of a proton, a neutron and an electron Describe the structure of an atom	**Suggested activity** Learners use information from the Periodic Table to draw the atoms of the first twenty elements using crosses to represent electrons in circles to represent electron shells. These can be made colourful and used to make a class wall display.
(c)	Define proton and nucleon number	Learners need to learn the definitions of key terms, e.g. proton, neutron, electron, proton number, nucleon number. The terms atomic number and mass number are used throughout as well as proton and nucleon number.
(d)	Interpret and use symbols	www.absorblearning.com/chemistry/about.jsp Click on 'free sample units' and go to 'structure of the atom' and click on 'view unit'.

Syllabus ref	Learning objectives	Suggested teaching activities
(e) (f) (g)	Define the term *isotopes* Deduce the numbers of protons, neutrons and electrons in atoms and ions State that some isotopes are radioactive	Diagrams such as these can be particularly useful in emphasising the difference between isotopes. Isotopes with unstable nuclei are radioactive. The concept of relative atomic mass (A_r) can be introduced here in relation to the values quoted in the Periodic Table (syllabus learning objective 3(e)). www.schoolscience.co.uk Click on: 'Resources for ages 14–16' → 'Physics' → 'Atomic and Nuclear Physics' → 'A world of atoms'. www.s-cool.co.uk Click on 'GCSE revision' → 'Chemistry' → 'Atomic Structure'

Past paper and specimen papers
Nov 10 Paper 21 QA2 Nov 10 Paper 41 Q2 Nov 10 Paper 41 Q4 Jun 11 Paper 42 Q7 Nov 11 Paper 22 QA5 Nov 11 Paper 42 Q1 Nov 11 Paper 42 Q8 Past question papers available at http://teachers.cie.org.uk

Unit 2: The Periodic Table (including ionic bonding)

Recommended prior knowledge
Learners should have knowledge of the topics in Unit 1 of this Cambridge O Level Chemistry scheme of work.

Context
The learning in this unit follows directly from the ideas in Unit 1. Unit 2 needs to be studied early in the course because an understanding of the Periodic Table is necessary prior learning for most of the other units. The link between atomic structure and the Periodic Table can be emphasised early in the course.

Outline
Learners learn how the properties of elements depend on their position in the Periodic Table, with specific reference to Groups I, VII and the transition metals. This leads to a study of ionic bonding. The unit gives opportunity to introduce and practise the use of symbols, balanced chemical equations and state symbols. More able learners could begin an early introduction to ionic equations by writing equations for the formation of ions.

Syllabus ref	Learning objectives	Suggested teaching activities
8.1 (a) (b) (c) (d) (e)	**Periodic trends** Describe the Periodic Table as an arrangement of the elements in the order of increasing proton (atomic) number Describe how the position of an element in the Periodic Table is related to proton number and electronic structure Describe the relationship between Group number and the ionic charge of an element Use ideas about the position of an element in the Periodic Table to: explain similarities between elements in the same Group Describe the change from metallic to non-metallic character from left to right across a period of the	Learners should use the version of the Periodic Table from Appendix 6.2 of the syllabus. Larger coloured versions are available from scientific suppliers. Learners can annotate their own photocopied Periodic Table using shading and a key to show metals/non-metals. One approach is to ask groups of learners to research different elements. These should include: • the first 20 elements • all Group I and VII • some transition elements Learners produce a 'fact card' to show the symbol, proton number, relative mass, atomic structure, state and appearance, uses and other notes. The cards can then be compared and classified to show the similarities and trends of elements in groups/across periods etc. Learners can test each other by covering a card and asking each other to predict the properties by reference to the element's position. Data can be gathered from Periodic Table wall charts, data books, online Periodic Tables and textbooks. Learners should be familiar with some of these ideas from their work on atomic structure in Unit 1. They need to be able to draw the atomic structures of the first 20 elements by using information from the Periodic Table. A project building on IT skills, utilising the various web Periodic Tables can be a very useful cross-curricular exercise.

Syllabus ref	Learning objectives	Suggested teaching activities
  (f) (g)	Periodic Table Describe the relationship between Group number, number of valency electrons and metallic/ non-metallic character Predict the properties of elements in Group I, VII and the transition elements using the Periodic Table	This syllabus area provides opportunity to teach syllabus learning objectives 3(a) to 3(d), symbols, formulae of compounds and chemical equations. Periodic Table games: www.chemicalelements.com www.funbrain.com/periodic/in dex.html www.activescience- gsk.com/games/index.cfm?module=5 www.s-cool.co.uk Click on 'GCSE revision' → 'Chemistry' → 'The Periodic Table' Online Periodic Tables: www.webelements.com www.chemsoc.org/viselements
8.2 (a)	**Group properties** Describe lithium, sodium and potassium in Group I (trends in physical properties and reactions with water)	**Suggested demonstration** Demonstrate the reaction of lithium, sodium and potassium with air by observing the tarnishing of the cut surface (if available, this can be shown using a digital microscope and shown on a screen). Demonstrate the reactions with water, by adding small pieces to a trough containing water and Universal Indicator solution. Focus on the similarities between the reactions of each element, and the trend in reactivity. Ask learners to predict what will be observed when the more reactive elements are added to water. Show video clips of the more reactive metals in Group I. (See resources) This is a good opportunity for learners to practise making and predicting. This topic provides a good opportunity to practise writing and balancing chemical equations (syllabus learning objective 3(d)). This is an opportunity to teach the gas test for hydrogen (syllabus learning objectives 1.3(c)) and the use of Universal Indicator (7.1(a)) Learners need to learn the crucial difference between an observation (e.g. bubbles are seen) and an

Syllabus ref	Learning objectives	Suggested teaching activities
		inference (e.g. hydrogen gas is produced). Video clips of the reactions of Group I elements with water are available online at: www.chemsoc.org/viselements Balancing equations: www.creativechemistry.co.uk Go to 'Balancing Equations'
(b) (c) (d)	Describe chlorine, bromine and iodine in Group VII (trend in physical properties and displacement reactions) Describe elements in Group 0 (The lack of reactivity that can be related to their electronic structures and uses.) Describe the lack of reactivity of the noble gases in terms of their electronic structures	One approach is for learners to research the physical properties (e.g. appearance, melting and boiling points etc.) of the halogens and enter the data into a table or spreadsheet. Learners test each other by deleting/hiding information and trying to predict the missing properties by considering the position of the element in the Group. The displacement reactions can be carried out as a demonstration or experiment. A few drops of hexane can be used to distinguish between iodine (purple in hexane) from bromine (orange). Learners can check their understanding by using element (fluorine, chlorine etc.) and compound (aqueous potassium fluoride, aqueous potassium chloride etc.) cards. Learners take a card from each pile and say whether or not a reaction will happen. More able learners can be asked to predict observations and equations for each reaction. Learners can research the extremely low boiling points of the noble gases, the fact that they are monatomic gases and their uses using the interactive Periodic Tables. Ideas about ionic bonding (syllabus learning objective 2.4) can be taught alongside teaching about Groups I and VII. This is an opportunity to teach the gas test for chlorine (syllabus learning objective 1.3(c)). By the end of the course, learners should be able to discuss displacement reactions in terms of oxidation numbers, electron transfer and REDOX (syllabus learning objective 6.2(a) to (c)). If this unit is taught early in the course, it is recommended that these ideas are <u>not</u> introduced here, but are dealt with as revision later. www.rsc.org/learn-chemistry/resource Look at experiment 19

Syllabus ref	Learning objectives	Suggested teaching activities
8.3 (a)	**Transition elements** Describe the central block of elements (physical properties, variable oxidation states and coloured compounds)	Learners can carry out a data search of the physical properties of the transition elements and plot graphs to compare them with K and Ca. Learners can be shown examples of compounds to see that they are coloured and relate them to oxidation state e.g. Fe^{2+} and Fe^{3+}, Cr^{3+} and CrO_4^{2-}. Catalysis (syllabus learning objective 8.3(b)) and oxidation numbers will be met later in the course. The concept of oxidation state change can be covered later in Unit 6. www.rsc.org/learn-chemistry/resource Look at experiment 88
2.4 (a) (b)	**Ionic bonding** Describe the formation of ions by electron loss/gain in order to obtain the electronic configuration of an inert gas Describe the formation of ionic bonds between metals and non-metals (e.g. $NaCl$; $MgCl_2$)	Learners should practise drawing the ionic structures of ions that are formed from some of the first 20 elements (i.e. Groups I, II, III, VI and VII), showing the electron shells and overall ionic charge. Learners should practise predicting the formulae of common ionic compounds of the first 20 elements (i.e. Groups I, II, III, VI and VII). Learners can practise writing ionic equations (syllabus learning objective 3(d)) for the reactions that they have met in this unit e.g. formation of ions, displacement of halogens. www.s-cool.co.uk Click on ‘GCSE revision’ → ‘Chemistry’ → ‘Chemical Bonding’ www.gcsescience.com/r-reactivity-series-link Click on ‘Ionic Equations’
(c) (d)	State that ionic materials contain a giant lattice in which the ions are held by electrostatic attraction Deduce formulae of ionic compounds from diagrams of their lattice structures	This can be carried out as a data search with learners researching data such as appearance, melting point, state etc. of common compounds such as chlorides and oxides. **Suggested experiment** Learners examine common ionic compounds and identify similarities in their appearances. The white colour of Group I and II compounds can be compared to Transition element compounds to reinforce syllabus learning objective 8.3 (see above). Hand lenses, a microscope or digital microscope are useful to see the crystalline structures.

Syllabus ref	Learning objectives	Suggested teaching activities
		www.rsc.org/learn-chemistry/resource Look at experiment 32 www.btinternet.com/~c hemistry.diagrams/indexdiagrams.htm Choose appropriate diagrams from list – diagrams can be saved for future use
(e)	Relate the physical properties (including electrical property) of ionic compounds to their lattice structure	Learners can then test the properties of some ionically bonded compounds e.g. solubility in water, electrical conductivity of their crystals and solutions, whether crystals melt on heating. Learners can then be given two white solids (e.g. sodium chloride and powdered wax) and can be asked to identify which is ionically bonded.

Past paper and specimen papers
Jun 10 Paper 22 QA2 Jun 11 Paper 22 QA4 Nov 11 Paper 21 QA5 Past question papers available at http://teachers.cie.org.uk

Unit 3: Organic Chemistry 1 (includes covalent bonding and energy from chemicals)

Recommended prior knowledge
Learners should have knowledge of the topics in Unit 1 of this Cambridge O Level Chemistry scheme of work.

Context
This unit is suitable for studying towards the middle of the course. It is a necessary preparatory for Unit 10: Organic Chemistry 2. Ideas about energy from chemicals are used in rate of reaction (Unit 7).

Outline
This is a lengthy unit. The ideas all relate to the petrochemical industry. Learners study fractional distillation and cracking of crude oil, leading to a study of the properties and reactions of two homologous series: the alkanes and alkenes. It is suggested that the alkanes are used as examples of typical covalent compounds – thus an introduction to covalent bonding is taught alongside learning about the structures of alkanes. Following an introduction using simpler molecules (see syllabus), more able learners should be able to draw 'dot and cross' diagrams for more complex molecules, e.g. alkanes, and molecules which contain double or triple bonds. The unit ends with a study about energy changes in chemical reactions. All learners should be able to draw energy profile diagrams. Work on the petrochemical industry lends itself to 'topic' based work and the opportunity for learners to carry out their own research.

There are several possible routes through the unit. Syllabus learning objectives 2.5 (Covalent bonding) and 5 (Energy from chemicals) can be taught alongside 11.1 (Alkanes), using alkanes as examples to teach the key ideas. Another approach is to teach covalent bonding and energy discretely as preparation for teaching alkanes and alkenes together towards the end of the unit. More able learners should understand that the relative bond energies of products and reactants determine the nature of the energy change in reactions.

Syllabus ref	Learning objectives	Suggested teaching activities
11 (a) (b)	**Organic Chemistry** State that the naphtha fraction from crude oil is the main source of hydrocarbons used as the feedstock for the production of a wide range of organic compounds Describe the issues relating to the competing uses of oil as an energy source and as a chemical feedstock	Discuss the range of products made from oils e.g. fuels, detergents, plastics, paints, dyes, fibres etc. Learners could make an 'oil diary' for a day to show how they use oil products. Link crude oil to other fossil fuels, particularly natural gas and shale gas. Learners should realise that we depend on oil for chemicals to make many 'everyday' goods, and that oil reserves are being rapidly depleted by their use.

Syllabus ref	Learning objectives	Suggested teaching activities
5 (h)	**Energy from chemicals (part 1)** Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation	Learners need to be familiar with how the process of fractional distillation works by considering the different boiling points of the oil fractions. Most textbooks have suitable diagrams to use. See the list of websites for virtual visits to oil platforms and refineries. This cross-links to syllabus learning objective 1.2(a), purification by distillation. www.schoolscience.co.uk Click on: 'Resources for ages 14–16' → 'Chemistry' → 'Industrial Processes' → 'Discover Petroleum'
(i)	Name the main fractions and state their uses (see syllabus for list) – Note: The importance of the naptha fraction as the main organic feedstock.	Crude oil is a complex mixture of hydrocarbons – natural gas is largely methane. Use the properties of these to introduce the general physical properties of covalent compounds (in contrast to ionic compounds).
2.5 (a) (b) (c)	**Covalent bonding** Describe the formation of a covalent bond by the sharing of a pair of electrons in order to gain the electronic configuration of an inert gas Describe, using 'dot-and-cross' diagrams, the formation of covalent bonds between non-metallic elements Deduce the arrangement of electrons in other covalent molecules	Learners need to be able to draw dot and cross for all the molecules given in Syllabus section 2.5(b). They should start by drawing compounds that contain only single bonds and then progress to double (CO_2) and triple (N_2). Introduce bonding in alkanes (and alkenes). It is important to contrast the properties of covalent compounds to those of ionic (from Unit 2). Learners should be able to identify the type of bonding in a compound from tabulated data such as melting and boiling points, electrical conductivity etc.
11.1 (a)	**Alkanes** Describe a homologous series as a group of compounds with a general formula, similar chemical properties and showing a gradation in physical properties as a result of	Learners can produce a table of names, formulae (both condensed and structural), melting and boiling point, relative molecular mass for the alkanes. They can use databooks or online databases to find the information independently. Discuss the trends in the properties and produce a summary of the main points. Note: Use of the term 'saturated' and the general formula C_nH_{2n+2}

Syllabus ref	Learning objectives	Suggested teaching activities
	increase in the size and mass of the molecules	This syllabus area provides the opportunity for introducing relative atomic and molecular mass.
(b)	Describe the alkanes as a homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}	If resources are available, learners should build 3-D models of the alkanes. Molecular modelling kits can be used, but if these are not available they can use cocktail sticks or drinking straws for bonds and modelling clay or soft sweets for atoms. There is also opportunity to teach or practise using empirical and molecular formulae, syllabus learning objective 3(h). www.s-cool.co.uk Click on 'GCSE Revision' → 'Chemistry' → 'Products from crude oil'
(c)	Draw the structures of branched and unbranched alkanes, C1 to C4, and name the unbranched alkanes, methane to butane	Learners need to learn to name and give the formulae for the first four alkanes. One approach is to make flashcards for the learners to put in order, match names with formulae. The cards can then be used for learners to test each other.
(d)	Define isomerism and identify isomers	Learners need to learn the definition for isomers. Again, if possible they can build 3-D models of the isomers of butane and use them to draw structural formulae. This can be taught alongside covalent bonding 2.5 (above). www.nyu.edu/pages/mathmol/library Click on 'Hydrocarbons' http://antoine.frostburg.edu/
(e)	Describe the properties of alkanes as being generally unreactive except in terms of burning and substitution by chlorine	This is a further opportunity to practice balancing equations. Learners should be able to write equations for combustion and substitution reactions of the first four alkanes. The gases from a burning candle or Bunsen burner can be collected and tested for water and carbon dioxide. This provides an opportunity to teach Redox in terms of oxygen gain, syllabus learning objective 6.2(a). This is also an opportunity to teach the tests for carbon dioxide and water, syllabus learning objective

Syllabus ref	Learning objectives	Suggested teaching activities
		1.3(c).
5 (a) (b) (c) (d) (e)	**Energy from chemicals (part 2)** Describe the meaning of enthalpy change in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions Represent energy changes using energy profile diagrams. Describe bond breaking as an endothermic process and bond making as an exothermic process Explain overall enthalpy changes in terms of the energy changes associated with the breaking and making of covalent bonds Describe combustion of fuels as exothermic	Use the burning of methane as the initial example for constructing an energy profile. Test tube reactions suitable for experimenting with temperature and energy changes include: • magnesium and aqueous copper sulfate • hydrochloric acid and sodium hydroxide • any metal carbonate and hydrochloric acid • dissolving ammonium salts. Learners should draw energy profile diagrams for the reactions they carry out and label them with reactants, products, activation energy and enthalpy change. Use syllabus 5070 past examination papers to see the layout of energy profile diagrams used in examinations. Past question papers available at http://teachers.cie.org.uk Ideas about activation – energy should be introduced here, although a fuller treatment follows in Unit 7. Learners should appreciate that even very exothermic reactions (e.g. combustion of methane) require an initial energy input (a lighted match). Experiments using the various types of 'hand- warmer' available for outdoor expeditions can be useful here. www.rsc.org/learn-chemistry/resource Look at experiments 16, 22 and 84 Reeko's mad scientist lab: www.reekoscience.com
(f)	Describe hydrogen, derived from water or hydrocarbons, as a potential fuel for use in future, reacting with oxygen to generate electricity directly in a fuel cell (details of the construction and	Learners should compare using ethanol and hydrogen with using fossil fuels such as natural gas and oil fractions, and discuss issues such as: • hazards • storage/ liquid and gas states • method of manufacture

Syllabus ref	Learning objectives	Suggested teaching activities
(j)	operation of a fuel cell are **not** required) and discuss the advantages and disadvantages of this Describe photosynthesis and explain how this can provide a renewable energy source	• pollutant gases produced • long-term future/renewable v non-renewable. Use a search engine to search for 'Hydrogen car' to see the latest examples of hydrogen fuelled vehicles. Clean energy: www.bmweducation.co.uk/cleanEnergy/default.asp www.rsc.org/learn-chemistry/resource Look at experiment 54
11.2 (a)	**Alkenes** Describe the alkenes as a homologous series of unsaturated hydrocarbons with the general formula C_nH_{2n}	Note: Use of the term 'unsaturated' and the general formula C_nH_{2n}.
(b)	Draw the structures of branched and unbranched alkenes, C2 to C4, and name the unbranched alkenes, ethene to butene	Flash cards can be used in the same way as recommended for alkanes.
(c)	Describe the manufacture of alkenes and hydrogen by cracking hydrocarbons and recognise that cracking is essential to match the demand for fractions containing smaller molecules from the refinery process	This can be demonstrated by heating vaseline soaked on mineral wool in a horizontal test tube, passing the vapour over a broken pot catalyst (in the middle of the test tube) and collecting the product (ethene) over water. www.rsc.org/learn-chemistry/resource Look at experiment 96 See online links suggested under 'fractional distillation' above for oil refining.
(e)	Describe the properties of alkenes (combustion, polymerisation, addition reactions)	This is a further opportunity for equation writing practice. Learners should be able to draw the structures of alkenes showing the double bond reacting to form saturated products. **Suggested experiment** Distinguishing between hexene and hexane using aqueous bromine.

Syllabus ref	Learning objectives	Suggested teaching activities
(d) (f) (g)	Describe the difference between saturated and unsaturated hydrocarbons from their molecular structures and by using aqueous bromine State the meaning of *polyunsaturated* when applied to food products Describe the manufacture of margarine by the addition of hydrogen to unsaturated vegetable oils to form a solid produc	Learners can test different vegetable oils and melted animal fats for 'degree of unsaturation' by counting the number of drops of aqueous bromine that each will decolourise. This topic can be used to reinforce the use of transition metals as catalysts (syllabus learning objective 8.3, in Unit 2) by stressing the role of nickel in hydrogenation. This is also an opportunity to teach Redox in terms of hydrogen gain (syllabus learning objective 6.2(a)). www.rsc.org/learn-chemistry/resource Look at experiment 9
11.5 (a) (b) (d) (c)	**Macromolecules** Describe macromolecules as large molecules built up from small units, different macromolecules having different units and/or different linkages Describe the formation of poly(ethene) as an example of addition polymerisation of ethene as the monomer Deduce the structure of a polymer from a given monomer and vice versa Know some uses of poly(ethene)	Learners can practise drawing monomers and polymers of compounds related to ethene. They should be able to identify the repeating unit in a given polymer. Examples to try: polystyrene, PVC, Teflon, polypropylene. Learners can work out polymer lengths from relative mass data. An interesting **extension** is to look at the international symbols for recycling plastics (see website) and identifying which compounds are used for different packaging. This is an opportunity to teach ideas about empirical and molecular formulae (syllabus learning objective 3(h)). www.rsc.org/learn-chemistry/resource Look at experiments 77 and 95
2.3 (b)	**Structure and properties of materials** Compare the structure of simple	Learners need to be able to explain physical properties in terms of bonding and structure. They can research the properties of the substances in section 2.3 by using data books or online data-bases.

Syllabus ref	Learning objectives	Suggested teaching activities
(d)	molecular substances, e.g. methane, iodine, with those of giant molecular substances, e.g. sand, diamond, graphite in order to deduce their properties Deduce the physical and chemical properties of substances from their structures and bonding and vice versa	A suggested experiment is to ask learners to distinguish between silver sand (giant covalent), salt (ionic) and powdered wax (simple covalent) by experiment. This links to previous work on covalent and ionic bonding. Again, learners should practise identifying the type of bonding from tabulated data such as melting and boiling points, electrical conductivity www.s-cool.co.uk/ Click on 'GCSE revision' → 'Chemistry' → 'Chemical Bonding'
(c)	Compare the bonding, structure and properties of diamond and graphite in order to deduce properties such as electrical conductivity, lubricating or cutting action	Learners need to be familiar with the 3-D diagrams of the two forms of carbon. One activity is to give learner cards of different properties and their explanations and ask them to work out which property fits which explanation e.g. 'Property: diamond is denser than graphite' 'Reason: atoms in diamond are closer together than in graphite'.

Past papers and specimen papers

Jun 11 Paper 22 QA4
Nov 11 Paper 21 QA5
Jun 11 Paper 22 QB7
Jun 10 Paper 21 QB7
Jun 11 Paper 22 QA2
Jun 11 Paper 22 QA5
Nov 11 Paper 22 QA3
Nov 11 Paper 42 Q2
Jun 10 Paper 22 QA6

Past question papers available at http://teachers.cie.org.uk

Unit 4: Atmosphere and environment

Recommended prior knowledge
Learners should have knowledge of the topics in Unit 1 of this Cambridge O Level Chemistry scheme of work.

Context
The ideas covered in the unit are suitable to be studied early in the course.

Outline
This unit studies the gases in the atmosphere, both naturally occurring and pollutant, and the role of chemistry in supplying drinking water. The unit ‘stands alone’ but can be used to introduce or practise skills from other syllabus areas including the use of symbols and equations, covalent bonding, redox and acidic nature of non-metal oxides. The study of water purification can be used to practise separation techniques as preparation for the practical component of the examination. All learners should find the ideas in this unit accessible.

Syllabus ref	Learning objectives	Suggested teaching activities
10.1 (a) (b) (c)	**Air** Describe the volume composition of gases present in dry air as 78% nitrogen, 21% oxygen and the remainder being noble gases (with argon as the main constituent) and carbon dioxide Describe the separation of oxygen, nitrogen and the noble gases from liquid air by fractional distillation State the uses of oxygen (e.g. in making steel; oxygen tents in hospitals; in welding)	Learners can process the percentage composition data using bar graphs or pie charts or by using a spread sheet. This activity can be used to practise the mathematical requirements of the course (see Appendix 1 of the current syllabus). Learners should be taught how fractional distillation works. This is a good opportunity for learners to think about boiling points with negative values. Learners can use textbooks, CD-ROMs and the internet to find out what the gases are used for. Unit 3: Organic Chemistry 1 includes the teaching of covalent bonding. If learners have already studied Unit 3, they can draw ‘dot and cross’ diagrams to represent the bonding in the atmospheric gases that have a simple structure. This cross-links to syllabus learning objective 1.2(a), purification by distillation. The BOC website gives useful information on the separation and uses of gases from the air. Use a search engine such as ‘Google’ to search for uses of the gases in air. www.rsc.org/learn-chemistry/resource Look at experiment 11 BOC Industrial Gases UK: www.boconline.co.uk/en/index.html

Syllabus ref	Learning objectives	Suggested teaching activities
(d) (g)	Name some common atmospheric pollutants (e.g. carbon monoxide; methane; nitrogen oxides (NO and NO_2); ozone; sulfur dioxide; unburned hydrocarbons) Discuss the effects of pollutants on health and environment (carbon monoxide and acid rain)	**Suggested research activity** One approach is to ask different groups to research the different gases. Each group needs to be given specific tasks so that the key learning objectives are covered e.g. ask learners to find out: • the formula of the gas • how it is formed as a pollutant • what problems it causes • how we can solve the problems or reduce the pollution. Groups take turns to present their findings to the whole group e.g. using posters or by giving a talk supported by overhead transparencies (OHTs) or a presentation using 'PowerPoint'. Resources to use include textbooks, CD-ROMs and the internet. If this approach is followed, learners will need to be presented with a summary of all the information and carry out some comprehension-type questions to ensure that all learners consolidate information about all the gases. This is an opportunity to refer to the idea of exothermic reactions again in preparation for Unit 6. This is also an opportunity to teach the gas tests for carbon dioxide, sulfur dioxide and oxygen (syllabus learning objective 1.3(c)). Ideas about the acidity of non-metal oxides can be introduced here as preparation for syllabus learning objective 7.1(h) in Unit 8. Many governments monitor air quality. Use a search engine to search for 'Air quality data/information' to find local information about levels of pollutants. http://uk-air.defra.gov.uk/ www.carbonmonoxidekills.com www.epa.gov/ebtpages/air.html

Syllabus ref	Learning objectives	Suggested teaching activities
(f)	Describe the reactions in catalytic converters and flue-gas desulfurisation	Learners should use ideas about Redox reactions to explain the reactions in catalytic converters. At this early stage, the reactions can be discussed simply in terms of oxygen loss and gain. They also need to think about how the structure of the converters is linked to speeds of reaction. The reactions happen very fast due to the high temperature and high surface area (This links to syllabus learning objective 6.1). Flue-gas desulfurisation is an opportunity to consider some social and economic issues e.g. how industrial processes use large amounts of raw materials and can produce large amounts of waste for disposal. This unit provides an opportunity to teach ideas about REDOX reactions in terms of oxygen gain – particularly in reference to the reactions in a catalytic converter, (syllabus learning objective 6.2(a)). Energy profile diagrams (syllabus learning objective 5(b)) are taught in Unit 6. However, there is an opportunity to introduce these ideas here to represent the lowering of activation energy by the catalysts. Many governments set maximum levels of allowable exhaust emissions for pollutant gases. Local garages should be able to provide the school with a list of the maximum concentration of pollutant gases that are acceptable in exhaust emissions. www.howstuffworks.com Search for 'Catalytic converter'
(h)	Discuss the importance of the ozone layer and the problems involved with the depletion of ozone by reaction with chlorine-containing compounds, chlorofluorocarbons (CFCs)	Learners should know the nature of CFCs. They need to know an outline of the problems of ozone depletion e.g. UV light levels may rise; this may cause skin cancer to humans and kill smaller organisms. If Unit 3 has already been covered, learners can research names of CFCs and draw diagrams or make models of their structures. More able learners can draw dot and cross representations of the simpler molecules. This provides an opportunity to practise and consolidate syllabus learning objectives 2.5(a) to (d). http://svs.gsfc.nasa.gov/stories/index_2000.html Search for 'Ozone depletion' www.howstuffworks.com Search for 'Refrigerators'
(i) (j)	Describe the carbon cycle (combustion, respiration and photosynthesis) State that carbon dioxide and	Learners should use flow charts to show the processes occurring in the carbon cycle. They should know equations for the processes and appreciate that combustion of fossil fuels is causing a rise in atmospheric concentration of carbon dioxide. A suggested **extension** is to discuss the approaches that governments and scientists are using to

Syllabus ref	Learning objectives	Suggested teaching activities
	methane are greenhouse gases and may contribute to global warming, give the sources of these gases and discuss the possible consequences of an increase in global warming	reduce the amount of carbon dioxide that is being released. Refer to the sources of CO_2 and CH_4. Also mention other factors, e.g. deforestation. In order to obtain a balanced scientific view long-term cyclical climate change and the solar activity should be researched. As this is a highly politicised topic teachers are recommended to use a search engine to access sufficient sites to provide a balanced scientific view.. The Carbon Cycle: www.purchon.com/chemistry/flash/cycle.swf
10.2 (a)	**Water** State that water from natural sources contains a variety of dissolved substances both naturally occurring and pollutant	Learners can evaporate measured volumes of different types of water (e.g. sea, river, tap, bottled) and estimate the dissolved mass per litre. Labels from bottled water can be analysed. Learners can process the data using bar charts or tables and compare water composition from different sources. This is an opportunity to remind learners about the formulae, names and charges of common ions. www.rsc.org/learn-chemistry/resource Look at experiment 42
(b)	Discuss the environmental effects of dissolved substances (beneficial and pollutant)	Learners should know about the importance of the solubility of oxygen and mineral salts for aquatic life. Learners should know about the main stages in eutrophication (see Unit 8). This is a further opportunity to present a process using a flow chart. It is important to emphasise the chemical processes (solubility of salts and leaching) rather than the biological processes involved. This links to the high solubility of ionic compounds in Groups I and II, first discussed in Unit 2.
(c)	Outline the purification of the water supply in terms of *(i)* filtration to remove solids *(ii)* use of carbon to remove tastes and odours *(iii)* chlorination to disinfect the	**Suggested experiment** Learners can set up their own water filtration column using bands of successively smaller gravel and sand. They can test its effectiveness compared to conventional filter paper by filtering a mixture of soil and water and evaporating a measured sample of the filtrate.

Syllabus ref	Learning objectives	Suggested teaching activities
(d)	water State that seawater can be converted into drinkable water by desalination	It is not expected that learners should know any technical details of the processes of desalination. However, an interesting approach would be to look at a membrane and distillation process in outline. Use Google image search for 'desalination' to see images of both membrane and distillation processes.
1.3 (d)	**Identification of ions and gases** Describe a chemical test for water	Learners can carry out a water test on a test tube scale. www.rsc.org/learn-chemistry/resource Look at experiment 109
Past paper and Specimen papers		
Nov 11 Paper 41 Q6 Nov 11 Paper 42 Q6 Nov 11 Paper 22 QA4 Jun 11 Paper 21 QA5 Past question papers available at http://teachers.cie.org.uk		

Unit 5: Amount of substance

Recommended prior knowledge

Learners should have knowledge of the topics in Unit 1 of this Cambridge O Level Chemistry scheme of work. This unit is best taught towards the middle of the course when learners have become familiar with using formulae and equations.

Context

The skills taught in this unit are necessary for all other units. It is strongly suggested that ideas about symbols, equations and calculations are taught using an integrated approach through all other units. This unit should link together and revise ideas that have been introduced in earlier units. Unit 5 should be taught before Unit 6 and Unit 7.

Outline

The unit contains skills of using calculations to calculate amounts of substances, including volumes of gases, in chemical reactions. These calculations are useful in handling data throughout the course. Volumetric analysis is routinely assessed in the practical component of the examination.

A list of mathematical requirements for candidates is available under Appendix 1 of the syllabus.

Syllabus ref	Learning objectives	Suggested teaching activities
3 (a) (b) (c) (d)	**Formulae, stoichiometry and the mole concept** State the symbols of the elements and formulae of the compounds mentioned in the syllabus Deduce the formulae of simple compounds from the relative numbers of atoms present and *vice versa* Deduce the formulae of ionic compounds from the charges on the ions present and *vice versa* Interpret and construct chemical equations (including ionic equations and state symbols)	It is strongly suggested that these ideas are taught using an integrated approach across the syllabus. It is expected that examination candidates will be able to write, interpret and use formulae and equations fluently across all units. It is suggested that the use of symbols is introduced in Unit 1, with the teaching of atomic structure. The use of equations and formulae can be introduced in Unit 2 in the context of the Periodic Table and reactions of Groups I and VII. There are opportunities to teach and practise ionic equations in displacement reactions (Group VII (introductory work in Unit 2) and metals (Unit 6) and in electrolysis (Unit 9)). Learners can be given a copy of the Periodic Table (use Appendix 6.2 of the syllabus) and a list of guidance notes for writing symbols and formulae, and for writing and balancing equations. These notes can be stuck in the front cover of learners' books – or in a prominent section of their files - so that learners can refer to them during the course. www.s-cool.co.uk Click on 'GCSE' → 'Chemistry' → 'Writing formulae and balancing equations'

Syllabus ref	Learning objectives	Suggested teaching activities
(e) (f)	Define relative atomic mass, A_r Define relative molecular mass, M_r and calculate relative molecular mass (and relative formula mass) as the sum of relative atomic masses	It is suggested that this is covered in Units 1 and 3. Learners should be able to calculate relative molecular masses using formulae of compounds and by referring to the Periodic Table. www.rsc.org/learn-chemistry/resource Look at experiment 5
(g)	Calculate the percentage mass of an element in a compound when given appropriate information	A range of calculations using a variety of elements and compounds should be practised. Fertilisers are useful examples for this type of calculation.
(h)	Calculate empirical and molecular formulae from relevant data	**Suggested experiment** Heating magnesium to form magnesium oxide and determine its formula. Learners should understand, with reference to structures met in Units 2 and 4, such as poly(ethane), sodium chloride and silicon dioxide, that some formulae represent simple ratios. Suitable molecules for illustrating empirical formulae include hydrocarbons (alkanes and alkenes), phosphorus oxides and polymers See the current syllabus for advice about mathematical requirements. This experiment is useful in terms of processing a class set of results using a spreadsheet, such as Excel, and plotting the graph. www.rsc.org/learn-chemistry/resource Look at experiments 61, 67 and 90
(i)	Calculate stoichiometric reacting masses and volumes of gases (one mole of gas occupies 24 dm^3 at room temperature and pressure); calculations involving the idea of limiting reactants may be set	Learners should practise calculating reacting masses on both an experimental scale, using grams, and an industrial scale, using tonnes. Less able learners can calculate reacting masses from ratios of masses in the equation without learning about molar amounts.

Syllabus ref	Learning objectives	Suggested teaching activities
		Learners can be given a set of rules for guidance to carry out these calculations. These can be stuck in the back cover of their books for reference – or in a prominent section of their files – during later units. These skills should be practised in the context of the later units of the course. It is common for examination questions to test calculation skills in the context of other syllabus areas e.g. acids, bases and salts, extraction of metals and organic chemistry. www.rsc.org/learn-chemistry/resource Look at experiment 68
(j)	Apply the concept of solution concentration (in mol/dm^3 or g/dm^3) to process the results of volumetric experiments and to solve simple problems	**Suggested experiments** Acid-base titrations e.g. aqueous hydrochloric or sulfuric acid with aqueous sodium hydroxide. Redox titrations potassium manganate(VII) titrations. Learners should practise calculating concentrations of aqueous solutions from results using different molar ratios of reactants. Use past practical (or alternative to practical) examination papers for examples of common volumetric calculations. It is important that the techniques of rough and accurate titres are practised to prepare for the practical paper. www.rsc.org/learn-chemistry/resource Look at experiments 5, 8, 45 and 48
(k)	Calculate % yield and % purity	Learners need to be able to identify the limiting factor that determines the maximum yield. **Suggested experiments** Determination of percentage yield: preparation of copper sulfate from an excess of copper carbonate and a known volume of sulfuric acid. Purity: Determination of the copper carbonate content of a weighed sample of malachite by reaction with sulfuric acid. The calculation can either be based on the dried residue waste, or on a back-calculation from the mass of copper sulfate produced (this will need heating and drying to the anhydrous form).

Syllabus ref	Learning objectives	Suggested teaching activities
		Again, use past practical examination papers for examples of this type of calculation. Alternatively, this can be taught as an integral part of the preparation of salts in Unit 8 or the amount of metals in ores in Unit 6.

Past paper and specimen papers

Nov 11 Paper 31 Q1
Nov 11 Paper 41 Q9
Jun 11 Paper 31 Q1
Nov 10 Paper 21 QB7
Nov 10 Paper 31 Q1
Nov 10 Paper 41 Q6
Nov 10 Paper 41 Q8
Jun 10 Paper 31 Q1
Jun 10 Paper 41 Q8
Jun 11 Paper 42 Q4
Jun 11 Paper 42 Q8
Nov 11 Paper 42 Q10

Past question papers available at http://teachers.cie.org.uk

Unit 6: Metals and metal reactivity

Recommended prior knowledge

Unit 1 and Unit 2. It is suggested that this unit is taught in the middle of the course. If the unit is taught after Unit 7, the learners can use ideas about reaction rate to carry out quantitative experimental work to determine the different rates of reaction of metal reactions with acids.

Context

Learners should study this unit before Unit 9, as it covers the extraction of metals using carbon. Unit 9 includes the use of electrolysis to extract aluminium.

Outline

This unit covers physical and chemical properties of metals linked to the reactivity series. The unit should be taught using practical experiments wherever possible. It is suggested that Redox reactions are taught in the context of the unit so that more able learners learn to analyse metal reactions in terms of electron transfer and oxidation number change. Less able learners can focus on corrosion as an example of a simpler oxidation reaction. The reactivity series is linked to methods of extraction for metals. There are opportunities for topic based work on recycling.

Syllabus ref	Learning objectives	Suggested teaching activities
2.6 (a)	**Metallic bonding** Describe metals as a lattice of positive ions in a 'sea of electrons'	Learners should be familiar with the 'cations in delocalised mobile electrons' model of metal structure. They should be able to explain metallic properties using this model. Learners should be careful when drawing the diagram not to have the metal ions touching. A suggested activity is for learners to use a table or spreadsheet of data about metal physical properties (see 9.1 below) to explain why different metals are used for different purposes.
(b)	Relate properties of metals (malleability and electrical conductivity) to their structure	It is important that learner can compare metallic structure and properties with ionic and covalent structures e.g. electrical conductivity. Learners need to be able to identify the type of bonding from a table or list of data such as melting points and conductivity. Copper properties and uses: http://resources.schoolscience.co.uk/CDA/14-16/chemistry/copch0pg4.html
9.1 (a)	**Properties of metals** Describe the general physical properties of metals (as solids having high melting and boiling points; malleable; good conductors	The teaching of metal properties should be taught in the context of bonding (above). This links to early work on Kinetic theory of solids in Unit 1.

Syllabus ref	Learning objectives	Suggested teaching activities
	of heat and electricity) in terms of their structure	
(b) (c) (d)	Describe alloys as a mixture of a metal with another element, e.g. brass; stainless steel Identify representations of metals and alloys from diagrams of structures Explain why alloys have different physical properties to their constituent elements	Learners can research the properties of alloys compared with their constituent elements. Learners should use diagrams showing the effect of different sized atoms on metal structure and use the diagrams to explain why alloys are typically harder and less malleable than elements. Paper chromatography can be used to identify the metals present in an alloy such as brass or the coinage metals. www.rsc.org/learn-chemistry/resource Look at experiment 63 Information about gold alloys: www.9carat.co.uk
9.2 (a)	**Reactivity Series** Place in order of reactivity calcium, copper, (hydrogen), iron, lead, magnesium, potassium, silver, sodium and zinc by reference to *(i)* the reactions *(ii)* the reduction	Learners should carry out test-tube reactions of the named metals with water and acids. This is an opportunity for the learners to practise making observations and to draw conclusions about relative metal reactivity from their own data. They can compare reactivity by contrasting the rate of evolution of bubbles or by measuring temperature changes. Learners should practise making predictions about the reactions of a metal by reference to its position in the reactivity series. A mixture of lead oxide and carbon heated in a crucible will produce a puddle of molten lead. This is an opportunity to teach the gas test for hydrogen (syllabus learning objective 1.3(c)). Learners may note the exothermic nature of reactions involving acids by using a thermometer to monitor temperature changes during the reaction (syllabus learning objective 5(a)). These reactions are good examples for the use of datalogging methods using a temperature probe. Learners should realise that more reactive metals need more energy to reduce them from their

Syllabus ref	Learning objectives	Suggested teaching activities
		compounds. This idea is an important preparation for Unit 9. www.rsc.org/learn-chemistry/resource Look at experiment 31 and 62 www.s-cool.co.uk Click on 'GCSE revision' → 'Chemistry' → 'Metals – the Reactivity Series'. www.gcsescience.com Click on 'GCSE Chemistry 2013 → 'The Reactivity Series'
(b) (c)	Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction with *(i)* the aqueous ions of the other listed metals *(ii)* the oxides of the other listed metals Deduce the order of reactivity from a given set of experimental results	Learners can carry out test-tube reactions of copper, iron, lead, magnesium and zinc with aqueous solutions of their salts. They can produce tabulated observations and use their findings to deduce an order of reactivity. For reinforcing these ideas, learners can use two piles of cards; one of metal names, one of names of aqueous salts or metal oxides. They choose a card from each pile and say whether or not a reaction will happen. More able learners should predict observations and write equations for their predicted reactions. Learners should be able to represent displacement reactions using ionic equations (syllabus learning objective 3(d)). Metal reactions also need to be discussed in terms of electron transfer and oxidation state change (see syllabus learning objective 6.2 below). This is a further opportunity to reinforce ideas about exothermic reactions. The Thermit reaction is an interesting context to illustrate these ideas. www.rsc.org/learn-chemistry/resource Look at experiment 97 Use Google image search to search for 'Thermit process' or 'Thermite process' to see images of welding railway lines.
(d)	Describe the action of heat on the carbonates of the listed metals and relate thermal stability to the reactivity series	Learners can heat metal carbonates in test tubes attached to a delivery tube. The gas evolved can be bubbled through a second test tube containing lime water. Learners can time how long it takes for the lime water to go cloudy and so rank the carbonates in order of stability. As an **extension**, more able learners may consider the size and charge on the cation as a factor in

Syllabus ref	Learning objectives	Suggested teaching activities
		determining stability. This is an opportunity to teach the gas test for carbon dioxide (syllabus learning objective 1.3(c)). More able learners should be aware that these reactions require energy and are therefore endothermic. All learners should write equations for the reactions. www.rsc.org/learn-chemistry/resource Look at experiment 66
6.2 (a) (b) (c)	**Redox** Define oxidation and reduction (redox) in terms of oxygen/hydrogen gain/loss Define redox in terms of electron transfer Identify redox reactions in terms of oxygen/hydrogen, and/or electron, gain/loss	These ideas should be taught where they occur across the syllabus. Note: Use of the mnemonic 'OILRIG'. The learners can work to a set of rules for determining oxidation numbers. They can use metal displacement reactions as a context to learn to identify the oxidant and reductant from full and ionic equations. They need to be able to do this both in terms of electron transfer and oxidation number. This is an opportunity to teach the gas test for sulfur dioxide (syllabus learning objective 1.3(c)). This is also an opportunity to revise and compare displacement reactions of halogens from Unit 2 and analyse them using ideas about redox in terms of electron transfer.
(d)	Describe the use of aqueous potassium iodide in testing for oxidising agents and acidified potassium manganate(VII) in testing for reducing agents from the resulting colour changes	The common reactions and colour changes of oxidising and reducing agents can be demonstrated. These are covered again in other syllabus areas (e.g. amount of substance).
9.3 (a)	**Extraction of metals** Describe the ease of obtaining metals from their ores by relating the elements to their positions in the reactivity series	One approach is to ask different groups of learners to research the extraction of different metals e.g. • name of metal • occurrence in nature (element or compound) • how it is extracted from its ore? (heating with carbon or electricity) • cost per tonne (this can be found using an internet search engine for latest metal prices) • uses of the metal

Syllabus ref	Learning objectives	Suggested teaching activities
(b) (c)	Describe metal ores as a finite resource and hence the need to recycle metals Discuss the social, economic and environmental advantages and disadvantages of recycling metals, e.g. aluminium and copper	• whether or not the metal is usually recycled. This data can be displayed on fact cards or put into a table on board, spreadsheet or database. The metals can then be considered in order of reactivity to link trends in reactivity with the method and energy of extraction. It is important that learners recognise that the energy demand of extraction contributes towards the price of the metal, and that the use of large amounts of energy has implications for recycling and the need to save fuel resources. Percentage purity calculations (syllabus learning objective 3(k)) can be taught here. Learners can work out the percentage of metal compounds in various ores. www.rsc.org/learn-chemistry/resource Look at experiments 33, 74 and 94 www.s-cool.co.uk Click on 'GCSE' → 'Chemistry' → 'Extraction of Metals' Copper properties and uses: http://resources.schoolscience.co.uk/CDA/14-16/chemistry/copch0pg4.html www.schoolchem.com/ex.htm
9.4 (a)	**Iron** Describe and explain the essential reactions in the extraction of iron using haematite, limestone and coke in the blast furnace	Learners need to be familiar with an outline schematic diagram of the blast furnace. Learners need to know the raw materials, waste outputs (slag, carbon monoxide and dioxide) and equations for the oxidation of carbon, reduction of iron oxide and formation of slag. The equations for the reactions in the blast furnace should be discussed in terms of redox (oxidation state and oxygen transfer). www.rsc.org/learn-chemistry/resource Look at experiment 35
(b)	Describe steels as alloys which are a mixture of iron with carbon or other metals and how controlled	Learners can carry out a 'steel survey' using a magnet to identify where iron and steel are used in the materials around them. Examples include, food and drinks cans, vehicles, paper clips.

Syllabus ref	Learning objectives	Suggested teaching activities
	use of these additives changes the properties of the iron, e.g. high carbon steels are strong but brittle whereas low carbon steels are softer and more easily shaped	For each use learners should be able to outline which properties of steel are most important in its choice. This is an opportunity to reinforce ideas about alloys. Learners can research to find out which elements are added to make different types of steel e.g. mild steel, stainless steel, high tensile steel. Steel for many purposes: http://resources.schoolscience.co.uk/Corus/16plus/index.html
(d) (e)	Describe the essential conditions for the corrosion (rusting) of iron as the presence of oxygen and water; prevention of rusting can be achieved by placing a barrier around the metal Describe the sacrificial protection of iron by a more reactive metal in terms of the reactivity series where the more reactive metal corrodes preferentially	Test tube reactions using nails can be set up to show that air and water are needed for rusting to take place. Learners can investigate different methods of rust prevention e.g. coating the nails with oil, grease or paint, using copper or zinc foil, investigating the effect of acid and salt on rate of rusting. Another activity is to bring a bicycle into the classroom. Learners look to find out how the different parts of the bicycle are protected from rusting. They can consider why different methods of rust prevention are used for different areas. Contrast the rusting of iron to the formation of a protective oxide layer on aluminium (syllabus learning objective 9.5(b)). Learners should recognise rusting as an oxidation reaction. Contexts to use for discussion include the use of zinc and magnesium blocks to protect oil rigs, ships and boats in both salt and fresh water, the sealing of car box-sections with plastic sealants. www.rsc.org/learn-chemistry/resource Look at experiments 50, 55 and 69

Past paper and specimen papers
Past paper questions: Nov 10 Paper 41 Q5 Jun 11 Paper 22 QB9 Nov 11 Paper 21 QA5 Past question papers available at http://teachers.cie.org.uk

Unit 7: Rate of reaction

Recommended prior knowledge
This unit is best taught towards the middle of the course. Learners must have studied energy profile diagrams (syllabus learning objective 5(b)) from Unit 4.

The ideas themselves are not difficult, but the unit can be used to revise and consolidate learning from other units e.g. the writing of equations and calculations involving reacting masses and gas volumes (Unit 3), energy profile diagrams (Unit 4), metal reactivity (Unit 6) and reactions of metal carbonates with acids (Unit 8).

Context
This unit can be taught either as a preparatory unit for Units 6 and 8 or as a summative unit to consolidate ideas about reactions from these units.

Outline
The unit has a strong emphasis on practical chemistry. Learners should carry out extensive experimental work to generate data about speed of reaction under variable conditions. There is opportunity for ICT in the use of data loggers and spreadsheets. Suitable reactions for studying speeds of reaction include the reactions of metals with acids (Unit 6) and metal carbonates with acids (Unit 8).

A list of mathematical requirements for the examination is provided in the syllabus. The questions used to assess this syllabus area assume that candidates are familiar with using graphs.

Syllabus ref	Learning objectives	Suggested teaching activities
1.1 (a) (b)	**Experimental design** Name appropriate apparatus for the measurement of time, temperature, mass and volume, Suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurement of rates of	Learners should be familiar with the full range of apparatus through their experimental work in this unit. Learners should collect gases over water and using measuring cylinders. They should also measure rate by monitoring mass lost during a reaction in which a gas is evolved. If available, a data logger attached to a computer can collect mass changes from an electronic balance. If available, learners should have the opportunity of processing their data using a spreadsheet to produce tables and graphs.
6.1 (a)	**Rate of reaction** Describe the effect of concentration, pressure, particle size and temperature on the rates of reactions and explain these effects in terms of collisions between reacting particles	**Suggested experiment** The reaction between limestone/marble chips and dilute hydrochloric acid can be used to show the effects of all the variables listed with the exception of pressure. Learners collect the carbon dioxide evolved in a gas syringe or over water into a measuring cylinder. Trial runs should be used to determine the appropriate concentration and quantities to use. Learners should investigate the effects of changing the concentration of acid, particle size of limestone and

Syllabus ref	Learning objectives	Suggested teaching activities
(e) (f)	Suggest a suitable method for investigating the effect of a given variable on the rate of a reaction Interpret data obtained from experiments concerned with rate of reaction	temperature of acid. Learners need to use particle diagrams to explain these effects in terms of frequency of successful collisions. It is important when considering temperature effects to discuss ideas about the numbers of reactant particles with the minimum activation energy needed for successful collisions to occur. Learners should realise that not all collisions are successful. Learners should be given the opportunity to experiment with different ways of measuring rate of reaction (see 1.1 below). Alternative reactions: Iodine Clock. A reaction of sodium thiosulfate with hydrochloric acid. See the current syllabus for advice about graphs. Learners should present their data using graphs where possible. More able learners should realise that the gradient of the slope of the graph is related to the rate. Learners should be able to interpret the relative shape of graphs to identify what variables have changed e.g. how the shape changes when the rate is faster/slower. What happens to the shape when the temperature, surface area or concentration of acid changes. The effect of pressure should be discussed in theory. This concept is visited again in the industrial preparation of ammonia, Unit 8. The reaction of sodium thiosulfate with acid can be followed using the 'disappearing cross' method or using a light sensor linked to a computer/calculator. www.rsc.org/learn-chemistry/resource Look at experiments 29, 64 and 65 www.s-cool.co.uk Click on 'GCSE' → 'Chemistry' → 'Rates of Reaction' Rates of reaction: www.gcsescience.com/rc-reaction-rates-links.htm Iodine clock reaction: http://en.wikipedia.org/wiki/Iodine_clock_reaction

Syllabus ref	Learning objectives	Suggested teaching activities
(b) (c)	Define the term *catalyst* and describe the effect of catalysts (including enzymes) on the rates of reactions Explain how pathways with lower activation energies account for the increase in rates of reactions	An appropriate reaction to use is the decomposition of hydrogen peroxide using manganese(IV) oxide as a catalyst. The volume of oxygen evolved can be measured against time. This links to syllabus learning objective 5(b) from Unit 3. www.rsc.org/learn-chemistry/resource Look at experiment 58 Catalysts: www.gcsescience.com/rc11-catalyst-energy.htm
(d)	State that transition elements and their compounds act as catalysts in a range of industrial processes and that enzymes are biological catalysts	Learners can investigate different metal oxides as catalysts for the hydrogen peroxide experiment (See above). Examples: magnesium oxide, aluminium oxide, copper(II) oxide, manganese(IV) oxide, other transition metal oxides. Biological catalysts can also be used e.g. small amounts of liver or vegetables (celery and potatoes both work). This links to syllabus learning objective 8.3 from Unit 2. The use of transition element compounds as catalysts is reinforced in industrial processes in Units 8 and 10. Learners can be told that our liver metabolises hydrogen peroxide as it is a poison. Resources for schools: www.abpischools.org.uk/page/active_science.cfm

Past paper and specimen papers	
Jun 11 Paper 22 QB7 Nov 11 .Paper 21 QA3 Nov 11 Paper 41 Q7 Jun 11 Paper 41 Q7 Nov 10 Paper 41 Q10 Jun 10 Paper 21 QA2	Jun 11 Paper 42 Q6 Nov 11 Paper 42 Q9 Nov 11 Paper 42 Q12 Jun 10 Paper 22 QA3 Past question papers available at http://teachers.cie.org.uk

Unit 8: Acids, bases and salts (including qualitative analyses)

Recommended prior knowledge

It is suggested that this unit is taught later in the course. The unit assumes that learners can confidently handle complex practical procedures, write molecular and ionic equations and carry out calculations using ideas about amount of substance. It is essential that Units 1, 2 and 5 are studied prior to Unit 8. It is recommended that Unit 6 is taught before Unit 8 to give the learners practice with practical techniques.

Context

This unit contains a substantial quantity of learning objectives that are assessed as part of both theory and practical components. The unit contains the more complex inorganic chemistry in the course. The reaction of acids and carbonates is commonly used to teach rate of reaction (Unit 7). There are strong links between the two units.

Outline

Learners study the reactions of acids and the preparation and analysis of metal salts. This unit has an extensive practical component. Learner should carry out as many of the reactions as possible in the laboratory. More able learners should use this unit to consolidate their learning about equations, calculations, volumetric analysis and ionic bonding. Reactions of acids are accessible to all learners. Less able learners should use this unit in preparation for the practical component of the examination by focusing on techniques for salt preparation and analysis.

Two industrial processes are studied. These can be taught anywhere in the unit.

Syllabus ref	Learning objectives	Suggested teaching activities
1.1 (a)	**Experimental design** Name appropriate apparatus for the measurement of time, temperature, mass and volume	This should be taught alongside syllabus learning objectives 7.1 and 7.2 below. See past examination papers of Paper 4 for practice.
1.2 (a) (b)	**Methods of purification** Describe methods of purification by the use of a suitable solvent, filtration and crystallisation, distillation and fractional distillation, with particular references to the fractional distillation of crude oil, liquid air and fermented liquor *S*uggest suitable methods of purification, given information about	This should be taught alongside syllabus learner objectives 7.1 and 7.2 below. See past examination papers of Paper 4 for practice. Revise the measurement of purity in everyday substances (e.g. drugs, foodstuffs). This can be used to revise ideas about tests for purity. (syllabus learning objective 1.2(e) from Unit 1). www.rsc.org/learn-chemistry/resource Look at experiments 1 and 99

Syllabus ref	Learning objectives	Suggested teaching activities
	the substances involved	
1.3 (a) (b) (c)	**Identification of ions and gases** Describe the use of aqueous sodium hydroxide and aqueous ammonia to identify the following aqueous cations: aluminium, ammonium, calcium, copper(II), iron(II), iron(III) and zinc Describe tests to identify the following anions: carbonate (by the addition of dilute acid and subsequent use of limewater); chloride (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); iodide (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); nitrate (by reduction with aluminium and aqueous sodium hydroxide to ammonia and subsequent use of litmus paper) and sulfate (by reaction of an aqueous solution with nitric acid and aqueous barium nitrate) Describe tests to identify the following gases: ammonia (using damp red litmus paper); carbon dioxide (using limewater); chlorine (using damp litmus paper); hydrogen (using a burning splint); oxygen (using a glowing splint) and sulfur dioxide (using acidified potassium manganate(VII))	Learners need to be familiar with the methods of carrying out these tests. Learners should carry out the experiments and focus on learning to: • recall how to carry out each test • write an equation for each reaction • knowing how to test for any gas evolved (syllabus learning objective 1.3(c)) • recall the objectives of the cation tests • being able to record their observations and conclusions systematically • being able to identify a salt by combining the results of the cation and anion tests. See Practical / Alternative to Practical past papers for guidance on how to set out the recording and processing of results. www.rsc.org/learn-chemistry/resource Look at experiment 80

Syllabus ref	Learning objectives	Suggested teaching activities
7.1 (a) (b) (c)	**Characteristic properties of acids and bases** Describe the meanings of the terms acid and alkali in terms of the ions they contain or produce in aqueous solution and their effects on Universal Indicator paper Describe how to test hydrogen ion concentration and hence relative acidity using Universal Indicator paper and the pH scale Describe the characteristic properties of acids as in reactions with metals, bases and carbonates	Learners can test a range of laboratory acids and alkalis, including weak acids (e.g. ethanoic acid) and weak alkalis (e.g. aqueous sodium carbonate) using Universal Indicator paper and/or solution. An interesting **extension** is to test 'everyday' substances e.g. fruits, milk, toothpaste, skin etc. and find their pH. Learners should be able to discriminate between a strong and weak acid by using Universal Indicator or by considering the different rates of reaction with the substances named below. If available, learners can be shown other methods of measuring pH e.g. using pH meters, pH probes or a pH probe attached to a data logger. Issues to discuss include the increased accuracy and convenience of using electronic methods of measuring pH in the workplace and industry. This links to work in Unit 10 relating to the properties of ethanoic acid. www.rsc.org/learn-chemistry/resource Look at experiments 10 and 38 Acid-Base Indicators: http://antoine.frostburg.edu/chem/senese/101/acidbase/indicators.shtml
(g)	Describe the characteristic properties of bases in reactions with acids and with ammonium salts	• equations for the reactions (include state symbols) • trends in reactivity of the metals • gas tests for hydrogen and carbon dioxide • change in pH during the reactions • temperature changes in the reactions (an opportunity to revise exothermic reactions) • practise choosing reagants to make a named salt • practising techniques named in syllabus learning objectives 1.1, 1.2 (above) and 7.2 (below). Learners should carry out at least one of each type of reaction.
(e)	Describe neutralisation as a reaction between hydrogen ions and hydroxide ions to produce water, $H^+ + OH^- \rightarrow H_2O$	Learners may have carried out a titration during Unit 5. The emphasis this time should be on titration followed by partial evaporation and crystallisation as a method of preparing a soluble salt. Learners could make an ammonium salt such as ammonium nitrate or ammonium sulfate to show how artificial fertilisers are made. This links to syllabus learning objective 7.3 below. This provides an opportunity to teach volumetric analysis using an acid-base titration (syllabus learning

Syllabus ref	Learning objectives	Suggested teaching activities
		objective 3(j), Unit 5). Learners may note the exothermic nature of neutralisation by using a thermometer to monitor temperature changes during the reaction (syllabus learning objective 5(a)). www.rsc.org/learn-chemistry/resource Look at experiments 45, 48 and 60
(f)	Describe the importance of controlling the pH in soils and how excess acidity can be treated using calcium hydroxide	Learners can discuss reasons why calcium hydroxide is chosen to use on soil. Issues to discuss include the treatment of soil or lakes in areas where rain water is polluted and acidic. This can be taught in the context of the effect of calcium hydroxide on ammonium salts (syllabus learning objective 7.3 below). www.rsc.org/learn-chemistry/resource Look at experiment 91
(h)	Classify oxides as acidic, basic or amphoteric, based on metallic/non-metallic character	This should be linked to the Periodic Table. Learners can test the pH of some soluble oxides (e.g. calcium oxide, and bubbling carbon dioxide through Universal Indicator solution) and should practise predicting the character of an oxide from the position of an element in the Periodic Table. This is an opportunity to revise metallic and non-metallic elements related to their positions on the Periodic Table (syllabus learning objective 8.1(e)). Acidic oxides were met in Atmosphere and Environment, Unit 4. www.rsc.org/learn-chemistry/resource Look at experiment 21
7.2 (a)	**Preparation of salts** Describe the techniques used in the preparation, separation and purification of salts as examples of some of the techniques specified in Section 1.2(a) (methods for preparation should include precipitation and titration together with reactions of acids with metals, insoluble bases and	This section is commonly assessed via the Practical/Alternative to Practical paper (Paper 4). Learners should refer to past papers to practise the range of common tasks. One approach is to ask learners to research and devise their own method for making a named salt. Syllabus learning objective 7.1 (above) can be used to teach the techniques needed in preparation for the investigation. Learners will need to choose a method based on the solubility of the salt and sequence the techniques involved. This should be taught parallel to 1.2 below.

Syllabus ref	Learning objectives	Suggested teaching activities
 (b) (c)	insoluble carbonates) Describe the general rules of solubility for common salts to include nitrates, chlorides (including silver and lead), sulfates (including barium, calcium and lead), carbonates, hydroxides, Group I cations and ammonium salts *S*uggest a method of preparing a given salt from suitable starting materials, given appropriate information	**Extension** More able learners should calculate a theoretical yield and an experimental percentage yield (syllabus learning objective 3 (k), Unit 5). Each working group can enter their yield onto a spread sheet for a discussion relating to how to increase yields. This can be linked to the economic importance of high yields in industry. www.rsc.org/learn-chemistry/resource Look at experiments 47 and 48
7.3 (a) (c)	**Properties and uses of ammonia** Describe the use of nitrogen, from air, and hydrogen, from cracking oil, in the manufacture of ammonia Describe and explain the essential conditions for the manufacture of ammonia by the Haber process	This should be taught alongside syllabus learning objective 6.3 (below). Learners should be familiar with the yield against temperature/pressure graph and be able to discuss optimum conditions in terms of yield and rate. There is an opportunity to discuss the issue of the economic and environmental need for fuel and energy conservation in industry. Stress the importance of iron as a transition metal catalyst to reinforce syllabus learning objectives 8.3(b) and 6.1(b). An interesting **extension** is for learners to research the life of Fritz Haber. www.rsc.org/learn-chemistry/resource Look at experiment 49
6.3 (a)	**Reversible reactions** Describe the idea that some chemical reactions can be reversed by changing the reaction conditions Describe the idea that some	This should be taught in the context of the manufacture of ammonia, syllabus learning objective 7.3 (above). Learners should be familiar with the symbol for reversible reactions. These ideas can be revisited in the study of sulfuric acid manufacture (below).

Syllabus ref	Learning objectives	Suggested teaching activities
(b)	reversible reactions can reach dynamic equilibrium and predict the effect of changing the conditions	It is also important that learners practise predicting the effect on yield of changing conditions of temperature and pressure by looking at equations for unfamiliar reactions and considering the molar volumes of gases involved and the value of ΔH.
7.3 (d) (e)	**Properties and uses of ammonia** Describe the use of nitrogenous fertilisers in promoting plant growth and crop yield Compare nitrogen content of salts used for fertilisers by calculating percentage masses	Learners are not expected to know details of the role of nitrogen in the growth of plants. One approach is to look at labels of fertiliser bags. Learners can identify the compounds used and calculate the percentage nitrogen in each compound This links to calculations based on relative molecular masses first met in Unit 5. UK agriculture: www.ukagriculture.com/ukfarming/crops/fertilisingcrops.html
(f) (g)	Describe eutrophication and water pollution problems caused by nitrates leaching from farm land and explain why the high solubility of nitrates increases these problems Describe the displacement of ammonia from its salts and explain why adding calcium hydroxide to soil can cause the loss of nitrogen from added nitrogenous fertiliser	One approach is to summarise eutrophication using a flow chart. It is important to focus on the chemical process of solubility causing leaching and give only a brief outline of the subsequent biological processes that occur in the river. Learners can heat ammonium salts with solid calcium hydroxide in test tubes. Use damp Universal Indicator paper to test for ammonia evolved. This also works with proteins e.g. hair, nail clippings. Water pollution was introduced in Unit 4.
7.4 (a) (b)	**Sulfuric acid** Describe the manufacture of sulfuric acid from the raw materials sulfur, air and water in the Contact process State the use of sulfur dioxide as a bleach, in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria)	Use fertilisers – amomonium sulfate – as the link to this section Learners should study the manufacture of sulfuric acid with emphasis on: • a summary of the main reactions (e.g. using a flow chart) • equations, including state symbols for each reaction • considering the reversible nature of the reaction to form sulfur trioxide (see syllabus learning objective 6.3 above) • the large scale importance of sulfuric acid with reference to its uses. Stress the importance of vanadium(V) oxide as a transition metal compound catalyst to reinforce syllabus learning objectives

Syllabus ref	Learning objectives	Suggested teaching activities
		8.3(b) and 6.1(b). This is an opportunity to teach the gas test for sulfur dioxide (syllabus learning objective 1.3(c)).

Past paper and specimen papers
Nov 11 Paper 21 QB6 Nov 11 Paper 31 Q2 Nov 11 Paper 41 Q10 Jun 11 Paper 31 Q2 Jun 11 Paper 41 Q4 Jun 11 Paper 41 Q10 Nov 10 Paper 21 QA3 Nov 10 Paper 31 Q2 Nov 10 Paper 41 Q7 Nov 10 Paper 41 Q9 Jun 10 Paper 31 Q2 Jun 10 Paper 41 Q9 Jun 11 Paper 42 Q9 Nov 11 Paper 22 QB6 Nov 11 Paper 42 Q11 Past question papers available at http://teachers.cie.org.uk

Unit 9: Electrolysis

Recommended prior knowledge
This unit should be taught towards the end of the course. It is recommended that Units 1,2,4,5 and 6 are taught before this unit.

Context
This unit builds on learners' understanding of atomic structure, ionic bonding, ionic equations, energy changes, redox reactions and metal extraction. The unit can be used to consolidate and reinforce ideas from these syllabus areas.

Outline
The unit examines the electrolysis of molten and aqueous compounds. Learners should have the opportunity to observe or carry out these reactions as small scale experiments in the laboratory. More able learners should be practise writing ionic equations for the reactions and predicting the products of electrolysis. They should discuss the reactions using ideas of redox in terms of electron transfer. Less able learners should be able to learn the products of the reactions they study. The manufacture of aluminium is included in the unit. This gives an opportunity for studying the social and environmental importance of recycling of metals.

Syllabus ref	Learning objectives	Suggested teaching activities
4 (a) (b)	**Electrolysis** Describe electrolysis as the conduction of electricity by an ionic compound (an electrolyte), when molten or dissolved in water, leading to the decomposition of the electrolyte Describe electrolysis as evidence for the existence of ions which are held in a lattice when solid but which are free to move when molten or in solution	Learners can compare the conduction of electricity by metals and ionic compounds. Learners should be able to describe the term 'electrolyte' by referring to its decomposition by an electric current. Practical experiment with a $KMnO_4$ crystal on moist filter paper a useful demonstration. www.rsc.org/learn-chemistry/resource Look at experiment 34
(c)	Describe, in terms of the mobility of ions present and the electrode products, the electrolysis of molten lead bromide, using inert electrodes	This can be carried out as a demonstration by melting a small sample in a crucible and electrolysing it, while heating, using graphite electrodes. If possible, this should be carried out in a fume cupboard as the toxic bromine vaporises.

Syllabus ref	Learning objectives	Suggested teaching activities
(d)	Predict the likely products of the electrolysis of a molten compound	Learners should be able to predict the products of electrolysing other simple compounds e.g. other metal halides.
(e) (f)	Apply the idea of selective discharge (linked to the reactivity series for cations, see 9.2) to deduce the electrolysis of concentrated aqueous sodium chloride, aqueous copper(II) sulfate and dilute sulfuric acid using inert electrodes Predict the likely products of the electrolysis of an aqueous electrolyte, given relevant information Examples: concentrated aqueous sodium chloride, aqueous copper(II) sulfate, dilute sulfuric acid	Learners can carry out the electrolysis of the named solutions using graphite electrodes in small cells. Adding Universal Indicator to aqueous sodium chloride allows identification of the alkali (sodium hydroxide) and chlorine (the indicator is bleached). Learners should carry out at least one experiment where the gases are collected and tested. Learners should be given rules of selective discharge and should practise predicting the products of electrolysis of a range of other aqueous ionic salts. This is also an opportunity to teach the gas tests for hydrogen and oxygen (syllabus learning objective 1.3(c)). www.rsc.org/learn-chemistry/resource Look at experiments 82, 92 and 100
(g)	Construct equations for the reactions occurring at each electrode during electrolysis	Learners need to be able to write ionic equations, with state symbols, for common reactions at both the anode and cathode, including the discharge of oxygen gas from hydroxide ions from water. It is also important that reactions are discussed in terms of redox (electron transfer, oxidation number change).
(i)	Describe the electrolysis of aqueous copper(II) sulfate with copper electrodes as a means of purifying copper	This can be taught alongside the electrolysis of aqueous copper(II) sulfate with inert electrodes. Learners need to be able to compare the two processes e.g. the different observations and anode reactions. Interesting issues to discuss include the need for very pure copper for use in electrical cable. This can

Syllabus ref	Learning objectives	Suggested teaching activities
		be linked to the recycling of used copper first discussed in Unit 6. www.s-cool.co.uk Click on 'GCSE' → 'Chemistry' → 'Electrolysis'
(k)	Describe the production of electrical energy from simple cells (i.e. two electrodes in an electrolyte) linked to the reactivity series	Learners should use a voltmeter to measure voltages when different pairs of electrodes are dipped in an aqueous electrolyte e.g. dilute hydrochloric acid. They can also try making a fruit battery by using a citrus fruit or potato as the electrolyte. More able learners should discuss the size of the voltage to the difference in reactivity of the metals. This should be linked to the reactivity series (syllabus learning objective 9.2). Learners could research the Daniell Cell as an **extension** activity. www.rsc.org/learn-chemistry/resource Look at experiments 7 and 15 How batteries work: http://science.howstuffworks.com/battery.htm
9.5 (a)	**Manufacture of aluminium** Outline the manufacture of aluminium from pure aluminium oxide dissolved in cryolite (starting materials and essential conditions, including identity of electrodes should be given together with equations for the electrode reactions but no technical details or diagrams are required)	Learners should be familiar with a schematic diagram of an industrial cell for the electrolysis of molten aluminium oxide in molten cryolite. Teaching points include: • the role of the cryolite,electrode reaction, names of substances involved and ionic equations • reactions discussed in terms of redox (oxygen and electron transfer, oxidation number change) • the processes that erode the anodes. Further discussion can focus on the large energy demand for the process and the implications for depletion of non-renewable fuels. This should be linked to the importance of recycling of aluminium, first discussed in Unit 6.
(b) (c)	Explain the apparent lack of reactivity of aluminium State the uses of aluminium and relate the uses to the properties of	Suggested experiment is to compare the reaction with dilute acid of an 'old' aluminium strip to one that has had its surface oxide layer removed by rubbing with sandpaper (or been cleaned with vinegar). Contrast the role of the impervious oxide layer to the oxidation of iron causing iron to rust (syllabus learning objective 9(d)).

Syllabus ref	Learning objectives	Suggested teaching activities
	this metal and its alloys, e.g. the manufacture of aircraft; food containers; electrical cables	www.rsc.org/learn-chemistry/resource Look at experiment 55

Past paper and specimen papers
Nov 11 Paper 21 QB8 Nov 11 Paper 41 Q5 Jun 11 Paper 21 QB6 Jun 11 Paper 41 Q3 Nov 10 Paper 21 QA5 Jun 10 Paper 41 Q2 Jun 11 Paper 42 Q2 Jun 10 Paper 22 QA4 Past question papers available at http://teachers.cie.org.uk

Unit 10: Organic Chemistry 2

Recommended prior knowledge
This should be taught towards the end of the course. The unit assumes knowledge of Units 1, 4 and 8 and that the learners can write and balance equations.

Context
The unit builds on previous learning about homologous series, alkanes, alkenes and covalent bonding. Carboxylic acids are examples of weak acids and so link to learning about acids in Unit 8. The unit can be used to form a summary of the organic component of the course.

Outline
Learners study three main classes of organic compound; alcohols, carboxylic acids and condensation polymers. The level of the unit is accessible to most learners if it is studied late in the course.

Syllabus ref	Learning objectives	Suggested teaching activities
11.3 (a) (b)	**Alcohols** Describe the alcohols as a homologous series containing the –OH group Draw the structures of alcohols, C1 to C4, and name the unbranched alcohols, methanol to butanol	Learners can make flashcards of the names and formulae of the first four alcohols. These could be used in matching or ordering exercises or learners can work in pairs to test each other. **Extension** More able learners can derive a general formula for the alcohols and use it to predict the formula of larger molecules. Learners can use databooks or an online database to research the physical properties of the alcohols e.g. melting and boiling points. This information can be used to revise ideas about trends in homologous series first met in Unit 3. Learners may need to revise ideas about homologous series (syllabus learning objectives 11.1 and 11.2) first met in Unit 3. If modelling kits are available, learners should build models of the alcohols. Models can also be built using cocktail sticks or drinking straws for bonds and modelling clay or sweets for atoms.
(c)	Describe the properties of alcohols in terms of combustion and oxidation to carboxylic acids	This should be linked to exothermic changes (Unit 3, syllabus learning objective 5(a) onwards). Learners can compare the energy output of different alcohols by measuring temperature changes when water is heated using alcohol burners. Importance of ethanol (and methanol) as fuel for cars – reduction of CO pollution (renewable fuel – Brazil and New Zealand).

Syllabus ref	Learning objectives	Suggested teaching activities
		This is an opportunity to practise writing and balancing equations, and to revise the use of energy profile diagrams (syllabus learning objective 5(b)). www.rsc.org/learn-chemistry/resource Look at experiments 79 and 85
(d) (e)	Describe the formation of ethanol by the catalysed addition of steam to ethene and by fermentation of glucose State some uses of ethanol, e.g. as a solvent; as a renewable fuel; as a constituent of alcoholic beverages	The fermentation of ethanol can be carried out on a test-tube scale. The mixture can be fractionally distilled to give ethanol that is pure enough to ignite – this illustrates in outline the production of ethanol for fuel (e.g. in Brazil). Contrast the flammability, or not, of brandy and wine, or solutions of 10% and 40% alcohol. Learners should know the equation and conditions for the industrial preparation of ethanol from ethene. Learners can discuss the conditions by considering the choice of temperature, pressure and catalyst in terms of optimum yield and rate. The distillation of ethanol made by fermentation can be used as an example of fractional distillation to illustrate syllabus learning objective 1.2(a). This is an opportunity to discuss the use of ethanol as a renewable fuel made from glucose obtained by photosynthesis (syllabus learning objective 5(j)). How winemaking works: http://science.howstuffworks.com/winemaking.htm Ethanol fuel: http://journeytoforever.org/ethanol.html
11.4 (a) (b)	**Carboxylic acids** Describe the carboxylic acids as a homologous series containing the –CO_2H group Draw the structures of carboxylic acids, methanoic acid to butanoic acid, and name the unbranched acids, methanoic to butanoic acids	Similar activities to those used for the teaching of alcohols (above) can be used. Models of the molecules can be made, where materials are available (see alcohols, above).
(c)	Describe the carboxylic acids as	Learners can carry out the reactions on a test-tube scale. A worthwhile approach is to carry out

Syllabus ref	Learning objectives	Suggested teaching activities
	weak acids, reacting with carbonates, bases and some metals	experiments to compare the reactions to those of a typical strong mineral acid e.g. dilute hydrochloric acid. Learners should identify any gases formed and write equations for the reactions. This can be used to revise ideas about strong and weak acids met in Unit 8 (syllabus learning objective 7.1(d)). Learners can revise gas tests for carbon dioxide and hydrogen. www.rsc.org/learn-chemistry/resource Look at experiment 78
(d)	Describe the formation of ethanoic acid by the oxidation of ethanol by atmospheric oxygen or acidified potassium manganate(VII)	The formation of ethanoic acid works on a test-tube scale. A suggested experiment for aerial oxidation is to put the same volume of ethanol into vessels with different surface areas, and add a few drops of Universal Indicator solution to each. Learners can monitor the pH change over several days as ethanoic acid forms. Redox should be discussed in terms of oxygen transfer and oxidation number. If available, a pH probe and data logger should be used to monitor the pH changes. Oxidation of ethanol to ethanoic acid: www.creative-chemistry.org.uk/alevel/module3/documents/N-ch3-15.pdf
		Aerial oxidation of wine to vinegar. This reaction can be discussed in terms of the conditions needed for long term storage of ethanol.
(e) (f)	Describe the reaction of carboxylic acids from C1 to C4 with alcohols from C1 to C4 to form esters Draw the structures of and name the esters formed from carboxylic acids and alcohols	The reaction can be carried out either by the learners or as a demonstration. The learners can be given the opportunity to note the characteristic smell of 'pear drops' to illustrate the use of esters in perfumes and flavourings. If samples of other esters are available, learners can smell them and decide whether they resemble fruit flavourings. Carboxylic acids: http://library.thinkquest.org/28751/review/biochem/3.html

Syllabus ref	Learning objectives	Suggested teaching activities
11.5 (e)	**Macromolecules** Describe the condensation polymerisation of nylon (polyamide) and *Terylene* (polyester) using representations shown in the syllabus	The polymerisation of nylon from solutions of its monomers can be demonstrated – 'nylon rope experiment'. Learners can melt nylon granules over a gentle heat on a metal lid or plate. A glass rod can be used to draw a thread from the melted nylon. This is a similar method to that used to make nylon threads for purposes such as fishing lines. Learners should be able to draw the structures of polyesters and polyamides if they are given the formulae of the monomer molecules. They should also practise writing monomer formulae from diagrams of polymer structures. They need to be able to identify the repeating unit from a diagram of a length of polymer chain. This section builds directly on the macromolecules section which dealt with addition polymerisation in Unit 4. www.s-cool.co.uk Click on 'GCSE' → 'Chemistry' →: 'Products from crude oil'
(f)	State some typical uses of synthetic fibres such as nylon and *Terylene*, e.g. clothing; curtain materials; fishing line; parachutes; sleeping bags	Learners can carry out a polymer survey by looking at the labels in their clothes or at the information in a clothing catalogue. Learners can survey the range of fibres used, and classify the fibres as man-made and synthetic. Learners may be interested to know that *Terylene* is being replaced in coat and sleeping bag packing by recycled polymers. Used plastic bags can be melted and spun into fibres that have similar properties to *Terylene*. www.rsc.org/learn-chemistry/resource Look at experiments 10 and 12
(g)	Describe the pollution problems caused by the disposal of non-biodegradable plastics	Learners should recognise that the non-biodegradable nature of many plastics leads to long term environmental problems. Issues to discuss include the need for conserving oil reserves and recycling of plastic waste. Biodegradable plastics have limited uses as they are usually weaker materials. Some of these ideas were met in Unit 3, syllabus learning objective 11(b).
(h)	Identify carbohydrates, proteins and fats as natural macromolecules	The main ideas to address are to compare the structures of natural and man-made polymers in terms of the variability of monomers in the natural molecule.

Syllabus ref	Learning objectives	Suggested teaching activities
(i) (j)	Describe proteins as possessing the same amide linkages as nylon but with different monomer units Describe fats as esters possessing the same linkages as *Terylene* but with different monomer units	Learners should be able to identify whether a macromolecule is a polyamide or polyester by looking at its structure. Examples of structures of natural proteins can be found in A Level Biology textbooks.
(k)	Describe the hydrolysis of proteins to amino acids and carbohydrates (e.g. starch) to simple sugars	This can be carried out as a demonstration. Learners need to know the conditions for the hydrolysis and be able to predict the likely monomers that will form from a given polymer structure. This technique is used as a diagnostic tool in medicine. The resulting amino acids are identified by analysing their R_f values by using chromatography and a locating agent (syllabus learning objective 1.2(c)). Sugars can also be separated by paper chromatography and visualised by drying in an oven.

Past paper and specimen papers
Nov 11 Paper 21 QB7 Jun 11 Paper 21 QB7 Jun 11 Paper 41 Q1 Nov 10 Paper 21 QB8 Jun 10 Paper 41 Q4 Jun 11 Paper 22 QA6 Jun 11 Paper 22 QB10 Jun 11 Paper 42 Q5 Nov 11 Paper 22 QB8 Jun 10 Paper 22 QA5 Past question papers available at http://teachers.cie.org.uk

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