Scheme of work B

**AS Chemistry 7404**

## v1.0

Introduction

This Scheme of work (B) has been prepared by teachers for teachers. We hope you will find it a useful starting point for producing your own schemes; it is available in Word for ease of editing.

The Scheme of Work is designed to be a flexible medium term plan for the teaching of content and development of the skills that will be assessed. It covers the needs of the specification for AS Chemistry 7404 and is designed as an alternative approach to Scheme of work A. This alternative approach groups the teaching topics together in a different, thematic way.

The teaching of investigative and practical skills is embedded within the specification. We have produced a Practical Handbook that provides further guidance on this. There are also opportunities in this Scheme of work, such as the inclusion of assessment opportunities and resources.

We have provided links to some resources. These are illustrative and in no way an exhaustive list. We would encourage teachers to make use of any existing resources, as well as resources provided by [AQA](http://www.aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/teaching-resources) and new textbooks written to support the specification.

GCSE prior knowledge comprises knowledge from the 2011 Core and Additional Science AQA GCSE specifications. Students who studied the separate science GCSE courses will have this knowledge but may also have been introduced to other topics which are relevant to the A-level content.

We know that teaching times vary from school to school. In this scheme of work we have made the assumption that it will be taught over about 30 weeks with 4½ to 5 hours of contact time per week. Teachers will need to fine tune the timings to suite their own students and the time available. It could also be taught by one teacher or by more than teacher with topics being taught concurrently.

**Assessment opportunities** detail past questions that can be used with students as teacher- or pupil self-assessments of your students’ knowledge and understanding. You may also use [Exampro](http://exampro.co.uk) and the specimen assessment materials that are available via our [website](http://www.aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/assessment-resources).

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**AS Chemistry Scheme of Work B: Summary**

**One teacher (30 weeks)**

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| **Themes** | **Topic** | **Number of weeks** |
| Atomic structure and moles  4 weeks | 3.1.1.1 Fundamental particles  3.1.1.2 Mass number and isotopes  3.1.2.1 Relative atomic mass and relative molecular mass | 0.6 |
| 3.1.1.3 Electron configuration, 3.2.1.1 Classification | 1.2 |
| 3.1.2.5 (part) Balanced equations  3.1.2.2 The mole and the Avogadro constant  3.1.2.4 Empirical and molecular formula, reacting mass calculations  3.1.2.5 (part) Balanced equations and reacting mass calculations | 2.2 |
| Structure and bonding  3 weeks | 3.1.3.Types of bonding and physical properties | 1.0 |
| 3.1.3. Shapes of molecules and intermolecular forces | 1.8 |
| 3.2.1.2 Physical properties of Period 3 elements | 0.2 |
| Acids, bases and Group 2  4 weeks | 3.1.2.5 (part) Balanced equations and concentration calculations | 2.6 |
| **Required practical 1** |  |
| 3.2.2 Group 2, the alkaline earth metals | 1.4 |
| Hydrocarbons  5 weeks | 3.3.1.1 Nomenclature  3.3.2. Fractional distillation, cracking and Alkanes | 2.4 |
| 3.1.2.3 The ideal gas equation | 0.4 |
| 3.3.1.3 E/Z isomerism  3.3.4. Alkenes and addition polymers | 2.2 |
| **Required practical 5** |  |
| Energetics  4 weeks | 3.1.4 Enthalpy change, calorimetry, Hess’s law, bond enthalpies | 4.0 |
| **Required practical 2** |  |
| Redox reactions and Group 7  2.4 weeks | 3.1.7 Redox reactions | 0.8 |
| 3.2.3. Halogens | 1.6 |
| **Required practical 4** |  |
| How fast and how far?  Rates and equilibrium  2.6 weeks | 3.1.5 Kinetics | 1.6 |
| **Required practical 3** |  |
| 3.1.6 Equilibrium | 1.0 |
| Further organic chemistry  5 weeks | 3.3.3 Halogenoalkanes | 1.4 |
| 3.3.5 Alcohols | 1.4 |
| 3.3.6 Organic analysis | 1.8 |
| **Required practical 6** |  |

**AS Chemistry Scheme of Work B: Summary**

**Two teachers (30 weeks)**

Teacher 1 (14.6 weeks)

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| **Themes** | **Topic** | | **Number of weeks** |
| Atomic structure and moles  4 weeks | 3.1.1.1 Fundamental particles  3.1.1.2 Mass number and isotopes  3.1.2.1 Relative atomic mass and relative molecular mass | | 0.6 |
| 3.1.1.3 Electron configuration, 3.2.1.1 Classification | | 1.2 |
| 3.1.2.5 (part) Balanced equations  3.1.2.2 The mole and the Avogadro constant  3.1.2.4 Empirical and molecular formula, reacting mass calculations  3.1.2.5 (part) Balanced equations and reacting mass calculations | | 2.2 |
| Acids, bases and Group 2  4 weeks | 3.1.2.5 (part) Balanced equations and concentration calculations | | 2.6 |
| **Required practical 1** |  | |
| 3.2.2 Group 2, the alkaline earth metals | | 1.4 |
| Energetics  4 weeks | 3.1.4 Enthalpy change, calorimetry, Hess’s law, bond enthalpies | | 4.0 |
| **Required practical 2** |  | |
| How fast and how far?  Rates and equilibrium  2.6 weeks | 3.1.5 Kinetics | | 1.6 |
| **Required practical 3** |  | |
| 3.1.6 Equilibrium | | 1.0 |

Teacher 2 (15.4 weeks)

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| **Themes** | **Topic** | **Number of weeks** |
| Structure and bonding  3 weeks | 3.1.3.Types of bonding and physical properties | 1.0 |
| 3.1.3. Shapes of molecules and intermolecular forces | 1.8 |
| 3.2.1.2 Physical properties of Period 3 elements | 0.2 |
| Hydrocarbons  5 weeks | 3.3.1.1 Nomenclature  3.3.2. Fractional distillation, cracking and Alkanes | 2.4 |
| 3.1.2.3 The ideal gas equation | 0.4 |
| 3.3.1.3 E/Z Isomerism  3.3.4.Alkenes and addition polymers | 2.2 |
| **Required practical 5** |  |
| Redox reactions and Group 7  2.4 weeks | 3.1.7 Redox reactions | 0.8 |
| 3.2.3. Halogens | 1.6 |
| **Required practical 4** |  |
| Further organic chemistry  5 weeks | 3.3.3 Halogenoalkanes | 1.4 |
| 3.3.5 Alcohols | 1.4 |
| 3.3.6 Organic Analysis | 1.8 |
| **Required practical 6** |  |

Scheme of work B

**Atomic structure and moles (4 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.1.1**  Fundamental particles.  The structure of atoms. | 0.2 weeks | Describe the structure of atoms in terms of protons, neutrons and electrons.  Recall the relative charges and masses of protons, neutrons and electrons. | Students research how scientists have contributed to our knowledge and understanding of atomic structure over time. | June 2009  Unit 1 Q1a and 1c | History of the atom  <http://www.rsc.org/learn-chemistry/resource/res00001332/the-atom-detectives> |
| **3.1.1.2**  Mass number and isotopes.  Atomic number, mass number, isotopes.  Time of Flight mass spectrometer: Principles of operation and its uses.  **3.1.2.1**  Relative atomic mass and relative molecular mass.  Relative atomic mass and relative molecular mass in terms of 12C.  Relative formula mass. | 0.4 weeks | Determine the number of fundamental particles in atoms and ions using mass number, atomic number and charge.  Explain the existence of isotopes.  Interpret simple mass spectra of elements.  Calculate relative atomic mass from isotopic abundance, limited to mononuclear ions. | Students:  Identify atoms and ions from numbers of protons, neutrons and electrons, and vice versa.  Define relative atomic mass (*A*r) and relative molecular mass (*M*r).  Determine the relative atomic mass of elements using isotope abundance data quoting answers to a suitable number of significant figures for data provided.  Look at mass spectra of compounds to determine the relative formula mass. | SAMS AS  Paper 1 Q2  June 2013  Unit 1 Q1a, 1b,1c and 1f    January 2012  Unit 1 Q7a    June 2010  Unit 1 Q8 | Use of TOF mass spectrometer in space research  <http://sci.esa.int/rosetta/35061-instruments/?fbodylongid=1650>    TOF mass spec tutorial  <http://www.kore.co.uk/tutorial.htm>  AQA Time of flight mass spectrometry Teachers’ Notes and Student guide:  <http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-TN-MASS-SPECTROMETRY.PDF>  <http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-SG-TOFMS.PDF>  <http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-SG-TOFMS-QA.PDF> |
| **3.1.1.3**  Electron configuration.  Electron configurations of atoms and ions up to *Z* = 36 in terms of shells and sub-shells (orbitals) s, p and d.  Ionisation energies (IEs).  **3.2.1.1**  Classification.  An element is classified as s, p, d or f block according to its position in the Periodic Table, which is determined by its proton number. | 1.2 weeks | Give electron configurations in terms of shells and sub-shells for atoms and ions up to *Z*=36  Define first ionisation energy.  Write equations for first and successive ionisation energies.  Explain how first and successive ionisation energies in Period 3 (Na–Ar) and in Group 2 (Be–Ba) give evidence for electron configuration in sub-shells and in shells. | Students:  Write electron configurations for atoms and ions up to *Z*=36 in terms of shells and sub-shells.  Find out about the historical development of the Periodic Table.  Plot graphs of both first IE and successive IEs and use them to identify and explain the trends.  Use successive IE data to determine which group an element is in. | January 2012  Unit 1 Q5a and 5b  June 2013  Unit 1 Q6b,6c and 6d  January 2010  Unit 1 Q1c, 1d and 1e  January 2009  Unit 1 Q1a and 1b | Story of the Periodic Table  <http://www.rsc.org/education/teachers/resources/periodictable/pre16/develop/index.htm>  Molymod models to show shapes of orbitals. |
| **3.1.2.5**  Balanced equations.  Formulae and equations. | 0.6 weeks | Write balanced equations for reactions studied.  Balance equations for unfamiliar reactions when reactants and products are specified. | Students learn the formulae and charges of common ions and use them to write formulae of compounds and balanced equations.  Students use their observations from simple test-tube reactions to identify the products and write balanced equations. |  | Precipitation, acid-base and thermal decomposition reactions as examples of writing formulae and balancing equations. |
| **3.1.2.2**  The mole and the Avogadro constant.  The Avogadro constant as the number of particles in a mole.  The mole as applied to electrons, atoms, molecules, ions, formulas and equations. | 0.2 weeks | Carry out calculations:   * using the Avogadro constant * using mass of substance, *M*r, and amount in moles(concentrations and gas volume calculations are covered later) | Students practice carrying out appropriate calculations.  Practical activity: the number of molecules in a mouthful of water. |  |  |
| **3.1.2.4**  Empirical and molecular formula.  Definition of empirical formula and molecular formula, and the relationship between them. | 0.6 weeks | Calculate empirical formula from data giving composition by mass or percentage by mass.  Calculate molecular formula from the empirical formula and relative molecular mass. | Students carry out appropriate calculations.  Practical activity: Empirical formula of magnesium oxide. | June 2010 Unit 1 Q4a  June 2009 Unit 1 Q2c |  |
| **3.1.2.5**  Balanced equations and associated calculations.  Reacting masses, percentage yield and atom economy. | 0.8 weeks | Use balanced equations to calculate:   * masses * percentage yields * atom economies. | Students carry out appropriate calculations.  Practical activities:  Water of crystallisation of hydrated MgSO4 by heating to constant mass.  Percentage conversion of magnesium carbonate to magnesium oxide. | June 2013 Unit 1 Q7a, 7b and 7c  January 2013 Unit 1 Q5b  June 2012 Unit 1 Q5d and 5ee  January 2011 Unit 1 Q3d | Atom economy and percentage yield  <http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/6.6.1.pdf> |

**Structure and bonding (3 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.3.1**  Ionic bonding.  Ionic bonding involves electrostatic attraction between oppositely charged ions in a lattice.  The formulas of compound ions, eg sulfate, hydroxide, nitrate, carbonate and ammonium. | 0.2 weeks | Predict the charge on a simple ion using the position of the element in the Periodic Table.  Construct formulas for ionic compounds. | Students draw dot and cross diagrams for simple ionic compounds. |  |  |
| **3.1.3.2**  Covalent bonding.  Covalent bonding (single and multiple), co-ordinate bonding. | 0.4 weeks | Describe the nature of a covalent bond and use a line to represent it.  Describe a co-ordinate bond and use an arrow to represent it. | Students draw dot and cross diagrams to represent covalent molecules, including adducts and ions (eg BF3.NH3 and NH4+) which involve the use of co-ordinate bonds. |  |  |
| **3.1.3.3**  Metallic bonding.  Metallic bonding. | 0.2 weeks | Describe the nature of metallic bonding. |  |  | Spot the bonding <http://www.rsc.org/learn-chemistry/resource/res00001097/spot-the-bonding> |
| **3.1.3.4**  Bonding and physical properties.  The four types of crystal structure: Ionic, metallic, macromolecular (giant covalent), molecular.  The structures of the following crystals as examples of these four types of crystal structure: diamond, graphite, ice, iodine magnesium, sodium chloride. | 0.6 weeks | Relate the melting point and conductivity of materials to the type of structure and the bonding present.  Explain the energy changes associated with changes of state.  Draw diagrams to represent these structures. | Practical activity: relationship between physical properties and structure and bonding.  Students could analyse data of unknown compounds/substances and relate this to structure type. | June 2013 Unit 1 Q3  June 2011 Unit 1 Q4  June 2010 Unit 1 Q7  June 2006 Unit 1 Q2  January 2006 Unit 1 Q6  January 2005 Unit 1 Q5a  January 2003 Unit 1 Q1e  June 2004 Unit 1 Q6a | Structure and bonding <http://www.rsc.org/learn-chemistry/resource/res00000119/afl-structure-and-bonding> |
| **3.1.3.5**  Shapes of simple molecules and ions.  Deduce the shape of familiar and unfamiliar examples of species according to valence shell electron pair repulsion (VSEPR) principles. | 0.6 weeks | Explain the shapes of, and bond angles in, simple molecules and ions with up to six electron pairs (including lone pairs of electrons) surrounding the central atom. | Students predict and draw the shapes of familiar and unfamiliar molecules.  Students use balloons to demonstrate shapes of molecules. | June 2011 Unit 1 Q3  January 2010 Unit 1 Q6  June 2013 Unit 1 Q5  June 2006 Unit 1 Q5b  June 2005 Unit 1 Q4  January 2013 Unit 1 Q6 | RSC exercise on VSEPR theory:  <http://www.rsc.org/learn-chemistry/resource/res00000648/shapes-of-molecules-and-ions> |
| **3.1.3.6**  Bond polarity.  Polar bonds and electronegativity. | 0.2 weeks | Use partial charges to show that a bond is polar.  Explain why some molecules with polar bonds do not have a permanent dipole. | Practical activity: deflecting jets. | January 2013  Unit 1 Q3  June 2004  Unit 1 Q6a |  |
| **3.1.3.7**  Forces between molecules and their effect on melting point and boiling point.  Permanent dipole–dipole forces.  Induced dipole–dipole (van der Waals) forces.  Hydrogen bonding including low density of ice and anomalous boiling points of compounds. | 0.6 weeks | Explain the existence of these forces between familiar and unfamiliar molecules.  Explain how melting and boiling points are influenced by these intermolecular forces. | Students predict and explain the relative boiling points of a range of covalent substances.  Students interpret the graph of boiling point against *M*r of covalent hydrides in groups 4 to 7.  Practical activity: making slime.  Practical demonstration: density of ice. | June 2013  Unit 1 Q4  January 2012  Unit 1 Q1  June 2011  Unit 1 Q3d  January 2011  Unit 1 Q1  January 2010  Unit 1 Q3 | Hydrogen bonding activity  <http://www.rsc.org/learn-chemistry/resource/res00000129/afl-what-are-hydrogen-bonds-and-where-are-they-found>  Practical: Slime  <http://www.rsc.org/learn-chemistry/resource/res00000756/pva-polymer-slime>  Practical: Density of ice  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3198-density-of-ice> |
| **3.2.1.2**  Physical properties of Period 3 elements.  The trends in atomic radius, first ionisation energy and melting point of the elements Na–Ar  The reasons for these trends in terms of the structure of and bonding in the elements. | 0.2 weeks | Explain the trends in atomic radius and first ionisation energy.  Explain the melting point of the elements in terms of their structure and bonding. | Students plot data on graphs for atomic radius, first ionisation energy and melting point and explain those trends.  Students give explanations for these trends. | January 2011  Unit 1 Q5  January 2009  Unit 1 Q4 |  |

**Opportunities for skills development**

**Acids, bases and Group 2 (4 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.2.5**  Balanced equations and associated calculations.  The concentration of a substance in solution, measured in mol dm–3 and calculations using concentration, volume and amount of substance in a solution. | 2.6 weeks | Use balanced equations to calculate concentrations and volumes for reactions in solutions.  Construct and/or balance equations using ratios.  Select appropriate titration data (ie identify outliers) in order to calculate mean titres.  Determine uncertainty when two burette readings are used to calculate a titre value. | Practical activities:  Concentration of ethanoic acid in vinegar.  *M*r of succinic acid  Percentage calcium carbonate in indigestion tablets.  Mass of aspirin in an aspirin tablet.  Students perform a range of different types of calculations involving reacting masses and volume of solutions. | June 2004  Unit 1 Q2  January 2004  Unit 1 Q3  January 2002  Unit 1 Q7  January 2009  Unit 1 Q3b  January 2011  Unit 1 Q3  June 2010  Unit 1 Q3 | Indigestion tablets  <http://www.nhs.uk/conditions/antacid-medicines/Pages/Definition.aspx> |
| **Required practical 1**  Make up a volumetric solution and carry out a simple acid–base titration. | | | | | |
| **3.2.2**  Group 2, the alkaline earth metals.  The trends in atomic radius, first ionisation energy and melting point of the elements Mg–Ba  The reactions of the elements Mg–Ba with water.  The use of magnesium in the extraction of titanium from TiCl4  The relative solubilities of the hydroxides of the elements Mg–Ba in water.  The relative solubilities of the sulfates.  Uses of some Group 2 compounds. | 1.4 weeks | Explain the trends in atomic radius and first ionisation energy.  Explain the melting point of the elements in terms of their structure and bonding.  Describe the reactions of Mg– Ba with water.  Describe the relative solubilities of the hydroxides and sulfates.  Recall the use of magnesium in the extraction of Ti  Give the uses of Ca(OH)2. Mg(OH)2, CaO and BaSO4  Explain why BaCl2 solution is used to test for sulfate ions and why it is acidified. | Students plot graphs of atomic radius and first ionisation energy, and explain the trends.  Practical activities:  Reactions of Mg–Ba with water and Mg with steam.  Testing solubilities of hydroxides and sulfates by precipitation reactions  Test a variety of solutions with NaOH/H2SO4 to identify unknown compounds.  Students write full and ionic equations for these reactions and for a variety of other precipitation reactions. | June 2012  Unit 2 Q5  June 2006  Unit 1 Q5a  January 2005  Unit 1 Q5b  January 2012  Unit 2 Q7 | Limestone (RSC)  <http://www.rsc.org/learn-chemistry/resource/res00000494/limestone-in-everyday-life>  Group 2 reactions: making a mind map  <http://www.rsc.org/learn-chemistry/resource/res00000118/afl-group-2> |

**Hydrocarbons (5 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.3.1.1**  Nomenclature.  Represent organic compounds using displayed, structural and skeletal formula.  Use IUPAC system for naming organic compounds.  Define homologous series. | 0.6 weeks | Define structural isomerism.  Draw structural isomers of alkanes with up to 6 carbon atoms and use the IUPAC system to name them.  Understand how to represent structures of alkanes.  Understand what is meant by a homologous series. | Students construct models to illustrate structural isomerism in alkanes.  Students draw and name a variety of different alkanes. | June 2011  Unit 2 Question Q6a and 6b  June 2003  Unit 3 Q4a  January 2003  Unit 3 Q1b and 1c | Molymod models  Naming hydrocarbons activity  <http://www.rsc.org/learn-chemistry/resource/res00000110/afl-naming-hydrocarbons> |
| **3.3.2.1**  Fractional distillation of crude oil.  Crude oil is a mixture of saturated hydrocarbons which can be separated by fractional distillation.  **3.3.2.2**  Cracking.  Thermal and catalytic cracking: why cracking is useful and the type of products formed. | 0.6 weeks | Understand that in fractional distillation the hydrocarbons in crude oil are separated on the basis of their different boiling points.  Recall the conditions for thermal and catalytic cracking.  Understand that cracking involves breaking C-C bonds, and explain why it is economically important. | Practical activity: cracking.  Students write balanced equations for a variety of cracking reactions. | June 2005  Unit 3 Q1a  June 2004  Unit 3 Q5 | Molymod molecular models.  Practical: fractional distillation of crude oil <http://www.nuffieldfoundation.org/practical-chemistry/fractional-distillation-crude-oil>  RSC Videos and animations on fractional distillation of crude oil <http://www.rsc.org/learn-chemistry/resource/res00000027/oil-refining#!cmpid=CMP00002022>  Animations of fractional distillation <http://science.howstuffworks.com/environmental/energy/oil-refining2.htm>  <http://bpes.bp.com/secondary-resources/science/ages-14-to-16/chemical-and-material-behaviour/hydrocarbons-from-crude-oil/> |
| **3.3.2.3**  Combustion of alkanes.  Alkanes as fuels  Complete and incomplete combustion.  Use of catalytic converter in internal combustion engines to remove pollutants. | 0.6 weeks | Write equations for the complete and incomplete combustion of alkanes.  Explain how a number of pollutants including NOx, CO, C and unburned hydrocarbons are formed in the internal combustion engine and how their emissions can be reduced.    Why SO2 may be formed when fuels are burned and how it can be removed from flue gases. | Practical demonstration: methane bubbles.  Students write balanced equations for a variety of combustion reactions. | June 2010  Unit 1 Q4  June 2010  Unit 1 Q5  January 2004  Unit 3 Q2  January 2009  Unit 1 Q6a, 6b,6c and 6d | Methane bubbles  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3224-methane-bubbles>  Video about catalytic converters <http://www.rsc.org/learn-chemistry/resource/res00000378/faces-of-chemistry-catalysts> |
| **3.1.2.3**  The ideal gas equation.  The ideal gas equation *pV* = *nRT* with the variables in SI units. | 0.4 weeks | Use the Ideal gas equation in calculations including rearranging it to find unknown quantities. | Practical activity: Finding the *M*r of a volatile liquid such as hexane.  Students perform a variety of calculations involving the ideal gas equation. | June 2006  Unit 1 Q3  June 2005  Unit 1 Q2b  January 2005  Unit 1 Q2b  January 2004  Unit 1 Q4 |  |
| **3.3.2.4**  Chlorination of alkanes.  The reaction of methane with chlorine. | 0.6 weeks | Write balanced equations for the steps in a free-radical mechanism involving initiation, propagation and termination steps.  Understand that the unpaired electron in a radical is represented by a dot. | Practical activity: Bromination of hexane.  Practical demonstration: chlorination of methane.  Students write equations and mechanism steps for a variety of different reactions between alkanes and halogens. | June 2003  Unit 3 Q2  June 2012  Unit 2 Q6a  January 2006  Unit 3 Q3  June 2011  Unit 2 Q7a | <http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten?cmpid=CMP00001416> |
| **3.3.4.1**  Structure and bonding in alkenes.  Unsaturated hydrocarbons with an electron rich carbon–carbon double bond.  **3.3.1.3**  Isomerism.  *E–Z* isomerism is a form of stereo-isomerism and occurs as a result of restricted rotation about the planar carbon–carbon double bond.  Cahn–Ingold–Prelog (CIP) priority rules. | 0.8 weeks | Define the term stereoisomer.  Draw the structural formulas of *E* and *Z* isomers.  Apply the CIP priority rules to *E* and *Z* isomers. | Students construct models to show structural and stereoisomerism in alkenes.  Students draw and name isomers of C5H10 and C6H12, and identify which exhibit *E–Z* isomerism. | June 2003  Unit 3 Q3a | Molymod models. |
| **Required practical 5**  Distillation of a product from a reaction. | | | | | |
| **3.3.4.2**  Addition reactions of alkenes.  Electrophilic addition reactions of alkenes with HBr, H2SO4 and Br2  The use of bromine to test for unsaturation.  The formation of major and minor products in addition reactions of unsymmetrical alkenes. | 0.8 weeks | Outline the mechanisms for these reactions by drawing the structures of the species involved and curly arrows to represent the movement of electron pairs.  Understand that the formation of a covalent bond is shown by a curly arrow that starts from a lone electron pair or from another covalent bond.  Understand that the breaking of a covalent bond is shown by a curly arrow starting from the bond.  Explain the formation of major and minor products by reference to the relative stabilities of primary, secondary and tertiary carbocation intermediates. | Students write balanced equations for electrophilic addition reactions.  Students write balanced mechanism steps for different alkenes, and identify (and explain the existence of) major and minor products where appropriate.  Practical activity: Use of bromine to test for a carbon–carbon double bond. | June 2012  Unit 2 Q7b  June 2010  Unit 2 Q6a  January 2003  Unit 3 Q2a  January 2005  Unit 3 Q4  January 2002  Unit 3 Q3a, 3b and 3c | Reaction mechanism 1:  <http://www.rsc.org/learn-chemistry/resource/res00001107/reaction-mechanisms?cmpid=CMP00002085> |
| **3.3.4.3**  Addition polymers.  Addition polymers are formed from alkenes.    The repeating unit of addition polymers.  IUPAC rules for naming addition polymers.  The unreactive nature of addition polymers and typical uses of poly(chloroethene), and how its properties can be modified using a plasticiser. | 0.6 weeks | Draw the repeating unit from a monomer structure.  Draw the repeating unit from a section of the polymer chain.  Draw the structure of the monomer from a section of the polymer.  Appreciate that knowledge and understanding of the production and properties of polymers has developed over time. | Students use models to illustrate repeating units in a variety of different polymers.  Students research the historical development of the polymer industry. | January 2010  Unit 2 Q7d | Polythene manufacture:  <http://www.rsc.org/learn-chemistry/resource/res00001027/industrial-process-videos#!cmpid=CMP00001693> |

**Energetics (4 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.4.1**  Enthalpy change.  Endothermic and exothermic.  Define enthalpy change (Δ*H*) and standard conditions. | 0.8 weeks | Define standard enthalpy of combustion (Δc*H*Ɵ).  Define standard enthalpy of formation (Δf*H*Ɵ). | Practical activity:  enthalpy of combustion of alcohols.  Demonstration of a selection of exothermic and endothermic reactions.  Students write equations for formation and combustion reactions.  Students sketch and label enthalpy profile diagrams. | June 2006  Unit 2 Q1a | Spectacular demonstrations:  <http://www.nuffieldfoundation.org/practical-chemistry/spectacular-demonstrations>  An endothermic reaction:  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3195-a-cool-experiment>  An exothermic reaction:  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3218-hot-stuff> |
| **3.1.4.2**  Calorimetry  *q* = m*c*Δ*T* calculations and associated experiments. | 1.4 weeks | Use *q* = *mc*Δ*T* to calculate the molar enthalpy change for a reaction.  Use this equation in related calculations. | Practical activity: Measuring enthalpy changes of various reactions using the cooling curve method (eg neutralisation of NaOH with HCl, displacement reaction between Zn and CuSO4, dissolving KCl in water).  Students perform a variety of calculations. | June 2009  Unit 2 Q3  June 2002  Unit 2 Q2  June 2006  Unit 2 Q1d  January 2011  Unit 2 Q9b | Enthalpy practical:  <http://www.creative-chemistry.org.uk/alevel/module2/documents/N-ch2-11.pdf> |
| **3.1.4.3**  Hess’s Law. | 1.2 weeks | Use Hess’s Law to perform calculations, including calculation of enthalpy changes for reactions from enthalpies of combustion or from enthalpies of formation. | Practical activity: Using Hess’s Law to determine Δ*H* for the thermal decomposition of NaHCO3 or the hydration of MgSO4 or formation of CaCO3  Students practice a range of calculations using Hess’s Law. | June 2011  Unit 2 Q2  June 2002  Unit 2 Q1  June 2009  Unit 2 Q2a  January 2013  Unit 2 Q3a and 4 |  |
| **Required practical 2**  Measurement of an enthalpy change. | | | | | |
| **3.1.4.4**  Bond enthalpies.  Understand the term mean bond enthalpy.  Use mean bond enthalpies to calculate approximate values for Δ*H* for reactions.  Understand why most bond enthalpies are mean values. | 0.6 weeks | Recall the meaning of the term mean bond enthalpy.  Calculate enthalpy changes using mean bond enthalpies.  Understand why most bond enthalpies are mean values. | Students practice a range of calculations using bond enthalpies  (students could compare the calculation of the enthalpy of combustion of a fuel using bond enthalpies with both the theoretical and experimental values). | January 2013  Unit 2 Q6  January 2006  Unit 2 Q1  June 2005  Unit 2 Q1  January 2003  Unit 2 Q2 |  |

**Redox reactions and Group 7 (2.4 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.7**  Oxidation, reduction and redox equations.  Oxidation and reduction in terms of electron transfer.  Rules for assigning oxidation states.  Writing redox half-equations and full equations. | 0.8 weeks | Work out the oxidation state of an element in a compound or ion from the formula.  Write half-equations identifying the oxidation and reduction processes in redox reactions.  Combine half-equations to give an overall redox equation. | Students work out oxidation states of elements in a range of compounds.  Students write half-equations for different oxidation and reduction reactions, and then combine them. | June 2013  Unit 2 Q4a  January 2012  Unit 2 Q5a and 5b    June 2011  Unit 2 Q5a  January 2005  Unit 2 Q2  January 2002  Unit 2 Q4 | Thermit reaction demonstration:  <http://www.sserc.org.uk/index.php/chemistry-resources/chemistry-demonstrations/3565-thermit> |
| **3.2.3.1**  Trends in the properties of the Halogens.  Trends in electronegativity and boiling point down Group 7  Trends in oxidising power of halogens and reducing power of halide ions.  Use of acidified silver nitrate to identify halide ions. | 1.2 weeks | Explain the trend in electronegativity and the boiling point of the elements in terms of their structure and bonding.  Explain why silver nitrate is acidified in the halide test, and why ammonia is used to distinguish between the halides.  Recall observations and write equations for the displacement reactions and redox reactions.  Recall observations and write equations for the halide test reactions. | Students plot data on graphs for electronegativity and boiling point and explain those trends.  Write full and ionic equations for the reactions studied.  Write half equations for the redox reactions studied.  Practical activities:  Test-tube reactions of solutions of the halogens (Cl2, Br2, I2) with solutions containing their halide ions (eg KCl, KBr, KI).  Record observations from reactions of NaCl, NaBr and NaI with concentrated sulfuric acid.  Use acidified silver nitrate followed by ammonia to test for halide ions.  Revision exercise on testing for ions in unknown solutions. | January 2002  Unit 2 Q8  January 2013  Unit 2 Q9  June 2002  Unit 2 Q4  June 2012  Unit 2 Q9  January 2011  Unit 2 Q3a, 3b and 3c |  |
| **Required practical 4**  Carry out simple test-tube reactions to identify cations (Group 2, NH4+) and anions (Group 7, OH–, CO32–, SO42–). | | | | | |
| **3.2.3.2**  Uses of chlorine and chlorate(I).  Reactions of chlorine with water and use of chlorine in water treatment.  Reaction of chlorine with sodium hydroxide and use of this reaction. | 0.4 weeks | Understand the use of chlorine in water treatment and appreciate that its benefits outweigh its toxic effects.  Write equations for the reactions and use oxidation states to identify what has been oxidised and what has been reduced. |  | January 2013  Unit 2 Q10  January 2010  Unit 2 Q10a, 10b and 10c | Chemistry of swimming  <http://www.rsc.org/learn-chemistry/resource/res00000860/chemistry-and-sport-swimming#!cmpid=CMP00000987> |

**How fast and how far?**

**Rates and equilibrium (2.6 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.5.1**  Collision theory.  **3.1.5.2**  Maxwell–Boltzmann distribution.  Define Activation energy.  Maxwell–Boltzmann distribution of molecular energies in gases. | 0.4 weeks | Define the term activation energy.  Explain why most collisions do not lead to a reaction.  Draw and interpret distribution curves for different temperatures. | Practical demonstration:  A selection of demonstrations to illustrate some fast and slow reactions. | June 2013  Unit 2 Q3  January 2012  Unit 2 Q3  June 2006  Unit 2 Q2  January 2002  Unit 2 Q7 | Spectacular demonstrations  <http://www.nuffieldfoundation.org/practical-chemistry/spectacular-demonstrations> |
| **3.1.5.3**  Effect of temperature on reaction rate.  The qualitative effect of temperature changes on the rate of reaction. | 0.4 weeks | Use the Maxwell–Boltzmann distribution to explain why a small temperature increase can lead to a large increase in rate. |  | June 2006  Unit 2 Q2  January 2004  Unit 2 Q2  January 2012  Unit 2 Q3 | Effect of temperature on rate:  <http://www.rsc.org/learn-chemistry/resource/res00000448/the-effect-of-temperature-on-reaction-rate> |
| **Required practical 3**  Investigation of how the rate of a reaction changes with temperature. | | | | | |
| **3.1.5.4**  Effect of concentration and pressure.  The qualitative effect of changes in concentration and pressure on collision frequency. | 0.4 weeks | Explain how a change in concentration or a change in pressure influences the rate of a reaction. | Practical activity: The kinetics of the reaction between CaCO3 and HCl by continuous monitoring.  Students plot graphs of results from other continuous monitoring experiments, and interpret the data. |  |  |
| **3.1.5.5**  Catalysts.  Define catalyst.  Catalysts work by providing an alternative reaction route of lower activation energy. | 0.4 weeks | Use a Maxwell–Boltzmann distribution to help explain how a catalyst increases the rate of a reaction involving a gas. | Practical activity: Reaction between hydrogen peroxide and tartrate ions catalysed by Co(II) ions. | June 2012  Unit 2 Q1  June 2011  Unit 2 Q1  January 2003  Unit 2 Q3  January 2011  Unit 2 Q2b | Hydrogen peroxide and tartrate ions catalysed by Co(II) ions.  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3191-catalyst-at-work> |
| **3.1.6.1**  Chemical equilibria and Le Chatelier’s principle.  Know that at equilibrium the forward and reverse reactions proceed at equal rates and the concentrations of reactants and products remain constant.  State Le Chatelier’s principle. | 0.6 weeks | Use Le Chatelier’s principle to predict qualitatively the effect of changes in temperature, pressure and concentration on the position of equilibrium.  Explain why, for a reversible reaction used in an industrial process, a compromise temperature and pressure may be used. | Practical activity: The effect of concentration and temperature changes on the equilibrium between [Co(H2O)6] 2+ and CoCl42-  Students predict and explain the effect of changes in temperature, pressure and concentration on the position of an equilibrium.  Students explain the use of compromise conditions in a range of industrial processes | June 2013  Unit 2 Q10a  June 2013  Unit 2 Q1a  January 2013  Unit 2 Q2  January 2012  Unit 2 Q2 | Ammonia production  <http://www.rsc.org/learn-chemistry/resource/res00001027/industrial-process-videos#!cmpid=CMP00001682>  Equilibrium between CoCl42-and [Co(H2O)6 ]2+  <http://www.rsc.org/learn-chemistry/resource/res00000001/cobalt-equilibrium> |
| **3.1.6.2**  Equilibrium constant *K*c for homogeneous systems.  The equilibrium constant *K*c can be deduced from the equation for a reversible reaction. | 0.4 weeks | Construct an expression for *K*c for a homogeneous system in equilibrium.  Calculate a value for *K*c from the equilibrium concentrations.  Perform calculations involving *K*c  Predict the qualitative effects of changes of temperature on the value of *K*c | Students practice working out the expression, units and value of *K*c for a variety of different equilibrium reactions.  Students practice calculations to determine equilibrium concentrations and use them to calculate *K*c  Practical activity: Determination of the value of *K*c of an esterification reaction (eg ISA Q: CHM6T June 2011). | June 2013  Unit 4 Q2  June 2012  Unit 4 Q1  January 2013  Unit 4 Q3 |  |

**Further organic chemistry (5 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.3.3.1**  Nucleophilic substitution of halogenoalkanes with OH–, CN– and NH3 | 0.6 weeks | Outline the nucleophilic substitution mechanisms of these reactions.  Explain why the carbon–halogen bond enthalpy influences the rate of reaction. | Practical activities:  Preparation of 2-chloromethylpropane from 2-methylpropan-2-ol  Rates of hydrolysis of halogenobutanes.  Students practice writing balanced equations and mechanism steps for different substitution reactions. | January 2011  Unit 2 Q8a and 8b  June 2010  Unit 2 Q2 | Importance of organic chemistry:  Making medicines  <http://www.rsc.org/learn-chemistry/resource/res00001027/industrial-process-videos#!cmpid=CMP00001689> |
| **3.3.3.2**  Elimination.  The concurrent substitution and elimination reactions of a halogenoalkane (eg 2-bromopropane with potassium hydroxide). | 0.4 weeks | Explain the role of the reagent as both nucleophile and base.  Outline the mechanisms of these reactions | Students practice writing balanced equations and mechanism steps for different elimination reactions.  Students compare substitution and elimination with different halogenoalkanes. | June 2013  Unit 2 Q5    January 2011  Unit 2 Q8    January 2010  Unit 2 Q7    June 2009  Unit 2 Q8  June 2002  Unit 3 Q6 |  |
| **3.3.3.3**  Ozone depletion.  The role of CFCs in ozone depletion and the search for alternatives. | 0.4 weeks | Understand the role of ozone in the atmosphere.  Understand how chlorine free-radicals can be formed in the atmosphere from compounds such as CFCs.  Understand the mechanism for the depletion of ozone by chlorine free-radicals.  Evaluate the role of chemists in the introduction of legislation to ban the use of CFCs and to find replacements. | Students write equations and mechanisms for the formation of chlorine free-radicals and the destruction of ozone.  Students find out about the role of chemists in the introduction of legislation to ban the use of CFCs and in finding replacements. | January 2013  Unit 2 Q7  June 2011  Unit 2 Q7  June 2009  Unit 2 Q11 | RSC resource on CFCs and ozone: <http://www.rsc.org/learn-chemistry/resource/res00000779/mario-molina-puts-ozone-on-the-political-agendas> |
| **3.3.5.1**  Alcohol production.  Hydration of alkenes to make alcohols.  Compare hydration of ethene with fermentation of glucose in the production of ethanol. | 0.4 weeks | Explain the meaning of the term biofuel and discuss the environmental issues of biofuel usage.  Write equations for ethanol produced by fermentation.  Outline the mechanism for the formation of ethanol by the reaction of ethene with steam in the presence of an acid catalyst. | Practical demonstrations: Fermentation of glucose followed by fractional distillation.  Whoosh bottle.  Students write balanced equations and mechanism steps for the dehydration of a variety of alcohols.  Students compare hydration and fermentation processes.  Students research the pros and cons of the use of biofuels. | January 2005  Unit 3 Q5a, 5b and 5c  January 2002  Unit 3 Q7    January 2012  Unit 2 Q9 | Ethanol as a fuel:  <http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3237-whoosh-bottle> |
| **3.3.5.2**  Oxidation of alcohols.  Oxidation reactions of primary, secondary and tertiary alcohols with acidified potassium dichromate(VI).  Testing to distinguish aldehydes and ketones. | 0.8 weeks | Write equations for these oxidation reactions.  Explain how the method used to oxidise a primary alcohol determines whether an aldehyde or carboxylic acid is obtained.  Use chemical tests to distinguish between aldehydes and ketones including Fehling’s solution and Tollens’ reagent. | Practical activities:  Test-tube reactions to illustrate  reactions of primary, secondary and tertiary alcohols with acidified potassium dichromate(VI)  Use of Tollens’ and Fehling’s reagents to distinguish between aldehydes and ketones.  The use of immediate distillation and reflux to obtain ethanal and ethanoic acid by oxidation of ethanol.  Students draw, name and classify alcohols.  Students draw and name aldehydes, ketones and carboxylic acids.  Students write balanced equations for a variety of oxidation reactions. | January 2013  Unit 2 Q5  June 2006  Unit 3 Q5  January 2005  Unit 3 Q3  January 2011  Unit 2 Q3d  January 2011  Unit 2Q9 | Giant silver mirror: <http://www.nuffieldfoundation.org/practical-chemistry/giant-silver-mirror> |
| **3.3.5.3**  Elimination.  Formation of alkenes by acid catalysed dehydration of alcohols. | 0.2 weeks | Identify products of alcohol elimination reactions.  Write equations and outline mechanisms for alcohol elimination reactions.  Understand how addition polymers can be made from alkenes made this way without using monomers derived from crude oil. | Students write balanced equations and mechanism steps for a variety of elimination reaction, using models to aid understanding. | June 2003  Unit 3 Q4b  January 2004  Unit 3 Q5  January 2002  Unit 3 Q2 |  |
| **3.3.6.1**  Identification of functional groups by test-tube reactions. | 0.8 weeks | Identify alcohols, aldehydes, alkenes and carboxylic acid functional groups using reactions in the specification.  Interpret observations from these reactions. | Practical activity: Revise tests for the appropriate functional groups.  Students plan a series of tests to distinguish between unknown compounds. | January 2010  Unit 2 Q6  June 2011  Unit 2 Q6 |  |
| **Required practical 6**  Tests for alcohol, aldehyde, alkene and carboxylic acid. | | | | | |
| **3.3.6.2**  Mass spectrometry to determine the molecular formula of a compound. | 0.4 weeks | Use precise atomic masses and the precise molecular mass to determine the molecular formula of a compound. | Students use relevant data to determine the *M*r from mass spectra. | June 2012  Unit 2 Q3c  January 2010  Unit 2 Q6e  June 2011  Unit 2 Q8c  January 2012  Unit 2 Q6 |  |
| **3.3.6.3**  Infrared spectroscopy.  Use infrared absorptions to identify functional groups.  Know how the “fingerprint” region can be used.  The role of infrared absorption by molecule in global warming. | 0.6 weeks | Use infrared spectra and the Chemistry Data Sheet to identify particular bonds, and functional groups, and also to identify impurities. | Students use relevant data to determine the bonds and functional groups from IR spectra. | June 2012  Unit 2 Q8bii  June 2011  Unit 2 Q6e  January 2012  Unit 2 Q10  June 2009  Unit 2 Q9  January 2010  Unit 2 Q9b | Spectra database  <http://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_list.cgi>  Spectraschool:  <http://www.rsc.org/learn-chemistry/collections/spectroscopy/> |
| **3.3.1.2**  Reaction mechanisms.  The formation of a covalent bond is shown by a curly arrow that starts from a lone electron pair or from another covalent bond.  The breaking of a covalent bond is shown by a curly arrow starting from the bond. | 0.2 weeks | Outline mechanisms by drawing the structures of the species involved and curly arrows to represent the movement of electron pairs. | Students revise the five mechanisms: free radical substitution, electrophilic addition, nucleophilic substitution and elimination (halogenoalkane) and elimination (alcohol). | January 2013  Unit 2 Q7 and 8  January 2011  Unit 2 Q7 and 8 | RSC mechanisms resource: <http://www.rsc.org/learn-chemistry/resource/res00000638/curly-arrows-and-stereoselectivity-in-organic-reactions>  Mechanism Inspector:  <http://www.rsc.org/learn-chemistry/resource/res00000383/investigate-organic-reaction-mechanisms> |
| **3.3.1.3**  Isomerism.  Structural isomerism.  Stereoisomerism. | 0.2 weeks | Define the term structural isomer.  Draw the structures of chain, position and functional group isomers.  Define the term stereoisomer.  Draw the structural formulas of *E* and *Z* isomers. | Students revise the different types of isomerism using different examples from the specification. | June 2013  Unit 2 Q8  June 2012  Unit 2 Q7  June 2011  Unit 2 Q3fi and Q6  June 2003  Unit 3 Q3  January 2003  Unit 3 Q1  June 2002  Unit 3 Q4 | Nomenclature and isomerism in organic chemistry:  <http://www.a-levelchemistry.co.uk/AQA%20A2%20Chemistry/Unit%204/4.4%20Nomenclature%20and%20Isomerism%20in%20Organic%20Chemistry/4.4%20Nonemclature%20and%20Isomerism%20in%20Organic%20Chemistry%20home.htm> |

**Useful resources and websites**

Chemistry Demonstrations <http://www.sserc.org.uk/index.php/chemistry-resources/chemistry-demonstrations>

*Class practicals and other resources*

Royal Society of Chemistry [www.rsc.org](http://www.rsc.org)

Nuffield Foundation <http://www.nuffieldfoundation.org/practical-chemistry>

AS and A-level Chemistry Kerboodle for AQA (subscription required) <https://global.oup.com/education/product/9780198351856/?region=uk>

Creative Chemistry: <http://www.creative-chemistry.org.uk/alevel/>

Knockhardy Powerpoints: <http://www.knockhardy.org.uk/ppoints.htm>

Chemguide: <http://www.chemguide.co.uk/>

*Classroom activities*

Starters for Ten <http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten>

<http://www.rsc.org/learn-chemistry/resource/res00001358/advanced-starters-for-ten>

Doc Brown <http://www.docbrown.info/index.htm>

Chemsheets (subscription required) <http://www.chemsheets.co.uk/>

TES Connect (login required) <https://www.tes.co.uk/teaching-resource/A-level-Chemistry-6143264/>

Teachable.net (some free downloads) <https://teachable.uk/teaching-resources-alevel/>

*Exam questions*

ExamPro (subscription required) <http://www.exampro.co.uk/sec/science.asp>

*Applications of chemistry*

Chemistry Review (subscription required) <http://www.hoddereducation.co.uk/chemistryreviewextras>

Online Archive: (subscription required) <http://www.hoddereducation.co.uk/Product?Product=9781471800870>

RSC: Chemistry in your cupboard <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/>

Extension work

Cambridge Chemistry Challenge: <http://c3l6.com/>

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