Upper 6th Chemistry

3.1.8 Thermodynamics

The further study of thermodynamics builds on the Energetics section and is important in understanding the stability of compounds and why chemical reactions occur. Enthalpy change is linked with entropy change enabling the free-energy change to be calculated.

Prior knowledge:

AS Chemistry

- 3.1.4 – Energetics.

3.1.8.1 Born-Haber Cycles

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Definitions of enthalpy changes used in Born–Haber and solution enthalpy cycles. Using Born–Haber cycles for ionic compounds. Considering covalent character of ionic compounds. Using solution enthalpy cycles for ionic compounds.	1.5 weeks	**Students should be able to:** • define lattice enthalpy (formation and dissociation), enthalpy of formation, ionisation enthalpy, enthalpy of atomisation, bond enthalpy, electron affinity, enthalpy of solution, hydration enthalpy • draw and use Born–Haber cycles to find missing values of enthalpy changes	• Write equations to represent enthalpy changes (AO2 - Apply knowledge and understanding). • Construct Born-Haber cycles and use them to calculate missing enthalpy change values (AO2 - Apply knowledge and understanding; MS2.2 Change the subject of an equation). • Compare and comment on values of enthalpy changes from Born–Haber cycles with those calculated theoretically using the perfect ionic	• June 2013 Unit 5 Question 1 (QS13.5.01) • June 2013 Unit 5 Question 2 (QS13.5.02) • January 2013 Unit 5 Question 2 (QW13.5.02) • June 2011 Unit 5 Question 1 (QS11.5.01)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510 Many suitable calculations can be found at

		• comment on the covalent character of an ionic compounds by comparing lattice enthalpies found using Born–Haber cycles with those calculated theoretically using the perfect ionic model.	model (AO3 - Analyse, interpret and evaluate data to make judgements). • Construct and use cycles involving the solution of ionic compounds in water to find missing enthalpy change values (AO2 - Apply knowledge and understanding MS2.2 Change the subject of an equation). • Rich question – predict the relative magnitude of the lattice enthalpy of the following compounds: aluminium oxide, potassium oxide, sodium chloride, sodium oxide. • Rich question – for an ionic compound with covalent character, deduce whether the lattice enthalpy will have a greater or smaller magnitude than that calculated theoretically from the perfect ionic model.	• January 2010 Unit 5 Question 4 (QW10.5.04)	http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

3.1.8.2 Gibbs free-energy change ΔG and entropy change ΔS

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
To calculate entropy changes for reactions To calculate Gibbs free-energy changes and determine whether reactions are feasible at various temperatures	1.5 weeks	**Students should be able to:** • describe entropy in terms of disorder • predict whether reactions have an increase or decrease in entropy • calculate the entropy change for a reaction • calculate the Gibbs free-energy change for a reaction at a given temperature • determine whether a reaction is feasible at a given temperature • calculate the temperature at which a reaction becomes feasible • use entropy changes to explain why some endothermic reactions are feasible.	• Rank given substances in terms of entropy (AO2 - Apply knowledge and understanding). • Use entropy values to calculate the entropy change for a reaction (AO2 - Apply knowledge and understanding MS2.2 Change the subject of an equation; MS2.3 Substitute numerical values into algebraic equations). • Predict, where possible, whether reactions have an increase or decrease in entropy (AO2 - Apply knowledge and understanding). • Use the equation $\Delta G = \Delta H - T\Delta S$ to determine whether reactions are feasible at given temperatures, and determine the temperature at which reactions become feasible (AO2 - Apply knowledge and understanding; MS2.2 - Change the subject of an equation; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities). • Plot graphs of ΔG versus T to determine ΔH and ΔS (MS3.3 - Determine the slope and intercept of a linear graph). • Forecast how temperature affects the feasibility of reactions given the	• June 2013 Unit 5 Question 3 (QS13.5.03) • January 2012 Unit 5 Question 2 (QW12.5.02) • June 2011 Unit 5 Question 2 (QS11.5.02) • June 2010 Unit 5 Question 6 (QS10.5.06)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510 RSC Classic Chemical Demonstrations - ΔH and ΔS for the vaporization of water using a kettle http://media.rsc.org/Classic%20Chem%20Demos/CCD-57.pdf Many suitable calculations can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			sign of the enthalpy and entropy changes (AO2 - Apply knowledge and understanding). • Apply the equation $\Delta G = \Delta H - T\Delta S$ to state changes to find ΔH, ΔS, melting and/or boiling points (AO2 - Apply knowledge and understanding; MS2.2 - Change the subject of an equation; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities). • Determine ΔH and ΔS for the vaporization of water using a kettle (PS 3.2 - Process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix for each science).		

3.3.11 Amines

Amines are compounds based on ammonia where hydrogen atoms have been replaced by alkyl or aryl groups. This section includes their reactions as nucleophiles

Prior knowledge:

AS Chemistry

- 3.3.1.1 – Nomenclature.

- 3.3.1.2 – Reaction mechanisms.

- 3.3.3.1 – Nucleophilic substitution.

3.3.11.1 Preparation

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Know how primary aliphatic amines are made from halogenoalkanes and from nitriles. Know how aromatic amines are produced and their use in making dyes.	0.2 weeks	**Students should be able to:** • write equations and give conditions for the preparation of primary aliphatic amines from both halogenoalkanes and nitriles • write equations and give conditions for the production of aromatic amines and identify their use in making dyes.	• Identify reagents and conditions and write equations to make specified primary aliphatic amines from halogenoalkanes and nitriles (AO2 - Apply knowledge and understanding). • Identify reagents and conditions and write equations to make specified aromatic amines (AO2 - Apply knowledge and understanding). • Research the use of aromatic amines in making dyes (AO3 - Analyse, interpret and evaluate scientific information).	• June 2013 Unit 4 Question 8 (QS13.4.08) • June 2005 Unit 4 Question 5b (QS05.4.05) • January 2005 Unit 4 Question 1 (QW05.4.01) • June 2004 Unit 4 Question 4a and 4b (QS04.4.04) • January 2004 Unit 4 Question 8 (QW04.4.08)	*Chemistry Review* article: Get real: chemistry in fashion (Volume 11, edition 3)

3.3.11.2 Base Properties

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Compare the base strength of amines.	0.2 weeks	**Students should be able to:** • place amines in order of base strength and explain this order.	• Given pairs of amines, students should identify the stronger base giving reasons for their choice (AO2 - Apply knowledge and understanding).	• January 2005 Unit 4 Question 1d (QW05.4.01) • June 2004 Unit 4 Question 4c (QS04.4.04) • January 2003 Unit 4 Question 6 (QW03.4.06) • June 2013 Unit 4 Question 9a	Data books with base strength values: Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition

					Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510

3.3.11.3 Nucleophilic properties

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand how amines react with halogenoalkanes, acyl chlorides and acid anhydrides, including mechanisms.	0.5 weeks	**Students should be able to:** • identify the various amines and quaternary ammonium salts formed when ammonia and amines react with halogenoalkanes • give the mechanism for reactions of ammonia and amines with halogenoalkanes • recognise the use of quaternary ammonium salts • identify the products of and write equations for acylation reactions of ammonia and amines with acyl chlorides and acid anhydrides • outline the mechanism for the acylation reactions	• Identify the amines and quaternary ammonium salts that can be formed when ammonia and amines react with halogenoalkanes and how changing conditions can affect the main product; outline the mechanism to form these products (AO2 - Apply knowledge and understanding). • Students could research the use of quaternary ammonium salts (AO3 - Analyse, interpret and evaluate scientific information). • Students write equations and mechanisms for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides; some of these reactions could be demonstrated (AO2 - Apply knowledge and understanding). • Practical opportunity: The preparation of N-phenylethanamide.	• January 2006 Unit 4 Question 5 (QW06.4.05) • January 2004 Unit 4 Question 8 (QW04.4.08) • January 2003 Unit 4 Question 6 (QW06.4.05)	*Chemistry Review* article: Two in one: the chemistry of shampoo and conditioner (Volume 22, edition 3)

3.3.12 Polymers

The study of polymers is extended to include condensation polymers. The ways in which condensation polymers are formed are studied, together with their properties and typical uses. Problems associated with the reuse or disposal of both addition and condensation polymers are considered

Prior knowledge:

AS Chemistry

- 3.3.1.1 – Nomenclature.

- 3.3.4.3 – Addition polymers.

3.3.12.1 Condensation polymers

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand how condensation polymers are formed including linkages in polyesters and polyamides. Identify the repeating unit given monomer(s) and vice versa.	0.5 weeks	**Students should be able to:** • identify the repeating unit and linkages in polyesters and polyamides given the monomer(s) • identify monomer(s) needed the make a condensation polymer given the repeating unit • know the repeating units in Terylene, nylon 6,6 and Kevlar • know some uses of condensation polymers • explain the nature of the intermolecular forces	• Draw the structure of repeating units in polyesters and polyamides given the monomer(s) and vice versa (AO2 - Apply knowledge and understanding). • Students could make nylon 6,6 (AO2 - Apply knowledge and understanding); AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d). • Students could each make a model of a monomer using Molymods and then students collectively join them together to make a long polymer	• January 2012 Unit 4 Question 8b (QW12.4.08) • June 2011 Unit 4 Question 4a (QS11.4.04) • June 2006 Unit 4 Question 4a (QS06.4.04) • June 2004 Unit 4 Question 5 (QS04.4.05) • June 2003 Unit 4 Question 5b) (QS03.4.05)	Molymods RSC resource on nylon: http://www.rsc.org/learn-chemistry/resource/res00000026/nylon The discovery of Nylon http://www.rsc.org/learn-chemistry/resource/res00000034/anecdotes-nylon Making nylon: http://www.rsc.org/learn-chemistry/resource/res00000755/making-nylon-the-nylon-rope-trick

		between molecules of condensation polymers.	chain (AO2 - Apply knowledge and understanding).		Sandcastles and mudhuts section 27 – Spare Parts (Hancock) ISBN 9780340543696 *Chemistry Review* article: Tougher than a speeding bullet (Volume 13, edition 4) *Chemistry Review* article: Polyesters: plastics of the future (Volume 17, edition 1) *Chemistry Review* article: Kevlar and composites (Volume 20, edition 2) *Chemistry Review* article: Kevlar – miracle material (Volume 22, edition 4)

3.3.12.2 Biodegradability and disposal of polymers

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand why polyalkenes are not biodegradable. Understand why polyesters and polyamides are biodegradable. Evaluate different methods of disposing of polymers.	0.2 weeks	**Students should be able to:** • explain why polyalkenes cannot be hydrolysed and so are non-biodegradable • explain why polyesters and polyamides can be hydrolysed and so are biodegradable • evaluate the advantages and disadvantages of different methods of disposing of polymers.	• Students can create a summary table to compare and explain the biodegradability of different types of polymers (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Students can research and summarise different methods of disposing of polymers, including recycling, considering advantages, disadvantages and sustainability (AO3 - Analyse, interpret and evaluate scientific information).	• January 2013 Unit 4 Question 4b, 4c and 4d (QW13.4.04) • CHM4 Specimen Paper Question 5d (QSP.4.05) • June 2002 Unit 4 Question 7 (QS02.4.07) • June 2004 Unit 4 Question 5a and 5c (QS04.4.05) • SAM A-level Paper 2 (set 1) Question 7	*Chemistry Review* article: Reclaiming plastic waste (Volume 23, edition 2) Video on recycling plastics: http://www.rsc.org/learn-chemistry/resource/res00001347/recycling-plastics

3.3.13 Amino acids, proteins and DNA

Amino acids, proteins and DNA are the molecules of life. In this section, the structure and bonding in these molecules and the way they interact is studied. Drug action is also considered

Prior knowledge:

AS Chemistry

- 3.1.3.7 – Forces between molecules.

- 3.3.1.1 – Nomenclature.

A-level Chemistry

- 3.3.9 – Carboxylic acids.

- 3.3.11 – Amines.

- 3.3.16 – Chromatography (you might wish to teach this section before using it to test amino acids by thin-layer chromatography here).

3.3.13.1 Amino acids

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the structure of amino acids. Draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions.	0.3 weeks	**Students should be able to:** • draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions.	• Given the structure of the amino acid, students show draw the structure of the species formed in acidic solution, alkaline solution and as a zwitterion (AO2 - Apply knowledge and understanding).	• June 2013 Unit 4 Question 6 (QS13.4.06) • January 2012 Unit 4 Question 7 (QS12.4.07)	Structure of amino acids (rotatable) https://undergrad-ed.chemistry.ohio-state.edu/jmol-viewer/# RSC resource on basic biochemistry http://www.rsc.org/Educatio

				• January 2005 Unit 4 Question 2 (QW05.4.02)	n/Teachers/Resources/cfb/proteins.htm

3.3.13.2 Proteins

Learning objective	**Time taken**	**Learning Outcome**	**Learning activity with opportunity to develop skills**	**Assessment opportunities**	**Resources**
Understand the structure of proteins. Understand how peptide links can be hydrolysed to release amino acids. Know how to use thin-layer chromatography to separate and identify amino acids.	0.5 weeks	**Students should be able to:** • describe the primary, secondary and tertiary structure of proteins, including the importance of hydrogen bonds and S-S bonds • draw the structure of peptides formed from amino acids • know that peptide link can be hydrolysed producing amino acids • identify the amino acids given when a peptide is hydrolysed • know that amino acids can be separated and identified by thin-layer chromatography, including the use of R_f values.	• Draw the structure of peptides formed from joining amino acids together (AO2 - Apply knowledge and understanding). • Identify amino acids formed when peptides are hydrolysed (AO2 - Apply knowledge and understanding). • Identify the primary, secondary and tertiary parts of the structure of some proteins (AO2 - Apply knowledge and understanding). • Students can carry out some thin-layer chromatography of some amino acids to identify an unknown amino acid (AO2 - Apply knowledge and understanding; AT i - Use thin-layer or paper chromatography).	• January 2010 Unit 4 Question 6 (QW10.4.06) • SAMS A level Paper 2 Questions 5 • June 2011 Unit 4 Question 4c (QS11.4.04) • January 2011 Unit 4 Question 4f (QW11.4.04)	Structure of amino acids and proteins (rotatable) https://undergrad-ed.chemistry.ohio-state.edu/jmol-viewer/# RSC resource on basic biochemistry http://www.rsc.org/Education/Teachers/Resources/cfb/proteins.htm

3.3.13.3 Enzymes

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the structure of enzymes. Understand the action of enzymes in terms of active sites. Understand the principle of drug action and the use of computer aided design.	0.2 weeks	**Students should be able to:** • explain that enzymes are proteins which act through a stereospecific active site that binds to a substrate • explain how drugs, which can be designed with the aid of computers, can act to inhibit enzymes by blocking active sites, but that the correct enantiomer is required.	• Use a right handed glove with their right/left hands to model enzyme action (AO2 - Apply knowledge and understanding).		RSC resource on basic biochemistry of enzymes http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm Useful animations on action of enzymes (eg hydrolysis of sucrose) http://doctorprodigious.wordpress.com/hd-animations/

3.3.13.4 DNA

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the structure of the components of DNA (given on data sheet). Understand the nature of nucleotides. Understand the structure of single DNA strands and the arrangement of these together in the double helix structure.	0.3 weeks	**Students should be able to:** • identify the components of DNA • explain how the two DNA strands interact with hydrogen bonds between base pairs.	• Make a 2D or 3D model of DNA using cut out components (AO2 - Apply knowledge and understanding). • Label a diagram of DNA to show the components and the hydrogen bonding between base pairs (AO1 - Demonstrate knowledge and understanding of scientific ideas).	• SAMs A-level Paper 2 (set 1) Question 8	How Stuff Works on the structure of DNA http://science.howstuffworks.com/life/cellular-microscopic/dna1.htm Simple animation showing the structure of DNA: http://www.youtube.com/watch?v=qy8dk5iS1f0 Useful animations on biochemistry http://doctorprodigious.wordpress.com/hd-animations/ *Chemistry review* article: Why is DNA helical? (Volume 1, edition 1)

3.3.13.5 Action of anti-cancer drugs

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand how DNA replicates and how anti-cancer drug cisplatin prevents this.	0.2 weeks	**Students should be able to:** • describe how DNA replicates in simple terms • explain how the anti-cancer drug cisplatin prevents DNA replication • explain why some drugs can have adverse effects and appreciate the balance between benefits and adverse effects of any drug.	• Write notes to accompany a sequence of diagrams showing DNA replication (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Write notes to accompany a diagram showing the action of cisplatin (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Evaluate the benefits and adverse effects of using drugs such as cisplatin (AO3 - Analyse, interpret and evaluate scientific information).	• SAMs A-level Paper 2 (set 1) Question 8	Useful animations on biochemistry (DNA replication) http://doctorprodigious.wordpress.com/hd-animations/ Youtube video on action of cisplatin http://www.youtube.com/watch?v=Wq_up2uQRDo Cisplatin – molecule of the month http://www.chm.bris.ac.uk/motm/cisplatin/htmlonly/ *Chemistry review* article: Metals in medicine (Volume 8, edition 2) *Chemistry review* article: Curing cancer with chemistry (Volume 18, edition 3 *Chemistry review* article: Cisplatin: from accidental discovery to wonder drug (Volume 21, edition 4)

3.3.14 Organic synthesis

The formation of new organic compounds by multi-step syntheses using reactions included in the specification is covered in this section

Prior knowledge:

AS Chemistry

- All organic chemistry topics.

A-level Chemistry

- 3.3.8–3.3.13

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Devise synthetic routes to make specified compounds.	1.0 weeks	**Students should be able to:** • devise synthetic routes, with up to four steps, to make specific organic compounds using the reactions in the specification • explain why processes are designed to avoid solvents, non-hazardous starting materials and have steps with high atom economy.	• Devise synthetic routes, including reaction conditions, to make organic compounds using reactions in the specification (AO2 - Apply knowledge and understanding). • Describe features of processes that improve sustainability (A03 - Analyse, interpret and evaluate scientific information).	• Specimen Paper CHM4 Question 8 (QSP.4.08) • Specimen Paper CHM4 Question 9 (QSP.4.09) • June 2006 Unit 4 Question 6 (QS06.4.06) • January 2003 Unit 4 Question 7 (QW03.4.07) • June 2002 Unit 4 Question 7 (QS02.4.07)	RSC synthesis resource http://www.rsc.org/learn-chemistry/resource/res00000003/synthesis-explorer *Chemistry review* article: New tricks for stacking bricks: modern approaches to organic synthesis (Volume 12, edition 3) *Chemistry review* article: Salbutamol: saving your breath (Volume 18, edition 4)

3.3.15 Nuclear magnetic resonance spectroscopy

Chemists use a variety of techniques to deduce the structure of compounds. In this section, nuclear magnetic resonance spectroscopy is added to mass spectrometry and infrared spectroscopy as an analytical technique. The emphasis is on the use of analytical data to solve problems rather than on spectroscopic theory.

Prior knowledge:

AS Chemistry

- 3.3.1.1 – Nomenclature.

- 3.3.6 – Organic analysis.

This section could be taught before the A-level Organic Chemistry topics allowing the technique to be re-visited and to be part of practice questions throughout the teaching of the A-level Organic topics.

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Using ^{1}H and ^{13}C NMR to deduce information about the structure of organic molecules. Understand similarities and differences between ^{1}H and ^{13}C NMR. Understand the use of TMS and suitable solvents.	2.0 weeks	**Students should be able to:** • understand the use of TMS and the δ scale for chemical shift • understand the use of deuterated solvents or CCl_4 • use the n+1 rule to deduce spin-spin splitting patterns of adjacent, non-equivalent	• Predict the number, position, relative intensity and splitting of signals in the ^{1}H NMR spectrum of compounds (AO2 - Apply knowledge and understanding). • Predict the number and position of signals in the ^{13}C NMR spectrum of compounds (AO2 - Apply knowledge and understanding). • Use data from NMR, and other analytical methods on the	• June 2013 Unit 4 Question 7 (QS13.4.07) • January 2013 Unit 4 Question 5 (QS13.4.05) • June 2012 Unit 4 Question 8 (QS12.4.08)	RSC Spectral School: http://www.rsc.org/learn-chemistry/collections/spectroscopy?uol_r=3ae0be55 RSC Spectroscopy resource: http://www.rsc.org/learn-chemistry/resource/res00000847/spectroscopy Database of spectra for organic compounds

		protons in aliphatic compounds • deduce the structure of compounds using ^{1}H NMR to deduce structures including the number, position, relative intensity and splitting of signals • deduce the structure of compounds using ^{13}C NMR to deduce structures including the number and position of signals.	specification, to deduce the structure of compounds (AO2 - Apply knowledge and understanding; MS3.1 Translate information between graphical, numerical and algebraic forms).	• January 2011 Unit 4 Question 5 (QW11.4.05) • January 2003 Unit 4 Question 5 (QW03.4.05) • January 2002 Unit 4 Question 4 (QW02.4.04)	http://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi CLEAPSS Spectra (Secondary Science Guide L202) http://www.cleapss.org.uk/secondary/secondary-science/secondary-science-guides?start=20 (Subscription required)

3.3.16 Chromatography

Chromatography provides an important method of separating and identifying components in a mixture. Different types of chromatography are used depending on the composition of mixture to be separated

Prior knowledge:

AS level Chemistry

- 3.3.13 Amino acids, proteins and DNA (this section requires use of thin-layer chromatography for analysis of amino acids – it could be taught before or after this section)

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Describe the similarities and differences between thin-layer, column and gas chromatography. Explain how chromatography works. Use chromatography to separate and identify substances. **Required practical 12** Separation of species by thin-layer chromatography Research method for TLC	0.6 weeks	**Students should be able to:** • describe the similarities and differences between thin-layer, column and gas chromatography • explain how chromatography works • use retention times and R_f values to identify substances • describe the use of mass spectroscopy to analyse substances separated by gas chromatography.	• Produce a summary to compare similarities and differences between thin-layer, column and gas chromatography (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Separate mixtures and identify substances (eg amino acids) by thin-layer chromatography (AO2 - Apply knowledge and understanding; AT i - Use thin-layer or paper chromatography). • Use retention time and R_f data to identify substances separated by chromatography.	• January 2011 Unit 4 Question 4f (QW11.4.04)	AQA Chromatography Teachers' Notes: http://filestore.aqa.org.uk/resources/chemistry/AQA-7405-TN-CHROMATOGRAPHY.PDF RCS video on TLC http://www.rsc.org/learn-chemistry/resource/res00001074/thin-layer-chromatography Modern Chemical Techniques RSC resource: http://www.rsc.org/learn-chemistry/resource/res00001301/chromatography

					Chemistry Review articles: How pure is your aspirin? (Volume 6, edition 3) What is chromatography? (Volume 8, edition 2) Antarctic atmospheric chemistry (Volume 13, edition 2) Drugs on money (Volume 13, edition 4) Thin-layer chromatography (Volume 14, edition 3) Body oddities: the chemical reactions of eating (Volume 21, edition 1) Body oddities: the chemical reactions of eating (Volume21, edition 4)

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