Scheme of work B

**A-level Chemistry 7405**

## 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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**A-level Chemistry Scheme of Work B: Summary**

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| **Themes** | **Topic** | **Number of weeks** |
| Further organic chemistry 1:  7 weeks | 3.3.7 Optical isomerism | 0.4 |
| 3.3.8 Aldehydes and ketones | 1.2 |
| 3.3.10 Aromatic chemistry | 2.4 |
| 3.3.9 Carboxylic acids and derivatives | 3.0 |
| **Required practical 10** |  |
| Further physical chemistry 1  8 weeks | 3.1.9 Rate equations | 3.8 |
| **Required Practical 7** |  |
| 3.1.10 *K*p | 1 |
| 3.1.12 Acids and bases | 3.2 |
| **Required practical 9** |  |
| Further organic chemistry 2  5 weeks | 3.3.11 Amines | 1 |
| 3.3.16 Chromatography | 0.6 |
| 3.3.12 Polymers | 0.4 |
| 3.3.13 (part) Amino acids and proteins | 0.6 |
| **Required practical 12** |  |
| 3.3.13 (part) Enzymes and DNA | 0.4 |
| 3.3.14 Organic synthesis | 0.4 |
| 3.3.15 NMR | 1.6 |
| Further physical chemistry 2  4.4 weeks | 3.1.8 Thermodynamics | 2.0 |
| 3.1.11.1 Electrode potentials and cells | 2.0 |
| **Required practical 8** |  |
| 3.1.11.2 Commercial applications of electrochemical cells | 0.4 |

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| Further inorganic chemistry  6.6 weeks | 3.2.4 Period 3 elements and oxides | 1 |
| 3.2.5 Transition elements | 3.6 |
| 3.2.6 Reactions of ions in aqueous solution | 2.0 |
| **Required practical 11** |  |

Scheme of work B

**Further organic chemistry (7 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.3.7**  Optical isomerism.  Understand the cause and nature of optical isomerism.  Know the similarities and differences between enantiomers.  Understand the formation of racemic mixtures. | 0.4 weeks | Draw the structural formulae and displayed formulae of enantiomers in both 2D and 3D.  Understand how racemic mixtures (racemates) are formed and why they are optically inactive.  Know the meaning of the terms: chiral, enantiomer, racemic mixture. | Students make models of optically active molecules eg alanine, limonene, carvone and draw 3D representations.    Practical activities:  EP2.5 Heinemann Salters Support Pack 2nd Edition ‘A testing smell’  The effect of polarized light on a solution of sucrose | January 2005  Unit 4 Q3d  June 2002  Unit 4 Q5a | Optical isomerism in ibuprofen: <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/nurofen/3>  Molymod models |
| **3.3.8**  Aldehydes and ketones  Know and understand:  The oxidation of aldehydes.  The reduction of aldehydes and ketones with NaBH4, including mechanism.  The reaction of aldehydes and ketones with KCN then acid, including mechanism. | 1.2 | Write oxidation reactions of aldehydes using [O] as the oxidant.  Write overall equations for reduction reactions using [H] as the reductant.  Outline the nucleophilic addition mechanism for  reduction reactions with NaBH4 (the nucleophile should be shown as H–).  Write overall equations for the formation of  hydroxynitriles using HCN  Outline the nucleophilic addition mechanism for the reaction with KCN followed by dilute acid.  Explain why nucleophilic addition reactions of KCN, followed by dilute acid, can produce a mixture of enantiomers.  Know the hazards of KCN | Students revisit Tollens’ and Fehling’s’ tests for aldehydes.  Students write oxidation equations for a range of aldehydes.    Students write equations and mechanisms with NaBH4 and HCN for a variety of aldehydes and ketones.  Students use Molymod models to show how a racemic mixture is formed when ethanal reacts with HCN (students could make stop-motion animation to demonstrate this principle).  Practical activities:  Test-tube reactions of Tollens’ reagent and Fehling’s solution to distinguish between aldehydes and ketones.  Reduction of benzil with NaBH4 | January 2010  Unit 4 Q4  June 2005  Unit 4 Q3a  June 2004  Unit 4 Q6d and 6e  January 2002  Unit 4 Q6a  June 2002  Unit 4 Q5b | Giant silver mirror <http://www.nuffieldfoundation.org/practical-chemistry/giant-silver-mirror>  Molymod models |
| **3.3.10**  Aromatic chemistry.  **3.3.10.1**  Bonding.  Understand the nature of the bonding in benzene ring.  **3.3.10.2**  Electrophilic substitution.  Know and understand electrophilic substitution (nitration and acylation) reactions: equations, conditions, mechanisms. | 2.4 | Use thermochemical evidence from enthalpies of hydrogenation to account for the extra delocalisation stability.  Explain why substitution reactions occur in preference to addition reactions.  Outline the electrophilic substitution mechanisms of nitration, including the generation of the nitronium ion and acylation using AlCl3 as a catalyst.  Understand the importance of these reactions. | Students work out the molecular formula of benzene from percentage by mass data and attempt to draw structures of C6H6 (non-cyclic and cyclic).  Students consider Kekule’s proposed structure and its limitations.  Students calculate the enthalpy change for hydrogenation of cyclohexa-1,3,5-triene and compare with actual value for benzene, and sketch enthalpy level diagram  Students name a variety of organic compounds.  Students write equations and mechanisms for a variety of electrophilic substitution reactions.  Practical activity:  Nitration of methyl benzoate (to include purification by recrystallisation and melting point determination). | June 2011  Unit 4 Q8a and 8b  January 2004  Unit 4 Q7a  January 2012  Unit 4 Q9a  January 2011  Unit 4 Q6  June 2010  Unit 4 Q8 | Kekule’s dream:  <http://humantouchofchemistry.com/biting-ones-own-tail-the-history-of-benzene.htm>  Molymod model of benzene to show delocalisation and the pi bond.    Olympiad question on TNT from 2011 (Q3 stretch and challenge)  <http://www.rsc.org/learn-chemistry/resource/res00001641/chemistry-olympiad-past-papers> |
| **3.3.9.1**  Carboxylic acids and esters.  Know and understand:  Carboxylic acids are weak acids.  Know how esters are made from carboxylic acids and alcohols and how they are hydrolysed.  Know some uses of esters, and that vegetable oils and animal fats are esters of fatty acids and glycerol.  Know how soap and biodiesel are made from vegetable oil and animals fats. | 2 | Know how to draw the structure of and name carboxylic acids and esters.  Know how carboxylic acids react with carbonates (and write equations).  Write equations for the reaction of carboxylic acids with alcohols to form esters.  Know some common uses of esters.  Write equations for the hydrolysis of esters in acidic and alkaline conditions.  Understand the structure of animal fats and vegetable oils.  Know how soap and biodiesel are made and write equations for these reactions for specified fats/oils. | Students draw and name a variety of carboxylic acids and esters.  Students write equations for a range of esterification and hydrolysis reactions.  Students write equations for making soap and biodiesel.  Practical activity:   * making esters * making soap * making biodiesel * hydrolysis of methyl benzoate (purification of benzoic acid by recrystallisation followed by determination of melting point). | January 2013  Unit 4 Q3  June 2010  Unit 4 Q7a and 7d    January 2010  Unit 4 Q5  June 2005  Unit 4 Q1 | Esters in fruit  <http://www.rsc.org/Education/EiC/issues/2012May/whats-in-your-strawberries.asp>  How detergents work  <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/finish/6>  Soap  <http://www.rsc.org/Education/Teachers/Resources/Contemporary/student/pop_detergent.html>  Biodiesel: <http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm>  Esters practicals  <http://www.nuffieldfoundation.org/practical-chemistry/esters> |
| **Required practical 10**  10(a) Preparation of a pure organic solid.  Test the purity of an organic solid by measuring its melting point.  10(b) Preparation of a pure organic liquid. | | | | | |
| **3.3.9.2**  Acylation.  Draw the structure of and name acid anhydrides, acyl chlorides and amides.  Know and understand the acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides, including the mechanism for acyl chlorides. | 1 | Write equations and outline the mechanism of nucleophilic addition–elimination reactions of acyl chlorides with water, alcohols, ammonia and primary amines.  Understand the advantages of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin. | Students draw structures and name different acid anhydrides, acyl chlorides and amides.  Students write equations and mechanisms steps for a range of addition-elimination reactions.  Teacher demonstration: Reaction of ethanoic anhydride with water, ammonia, ethanol and phenylamine.  Practical activity:  The preparation of aspirin | January 2012  Unit 4 Q10a  June 2006  Unit 4 Q1  June 2005  Unit 4 Q7  June 2003  Unit 5 Q8b  June 2010  Unit 4 Q7b and 7c | Aspirin  <http://www.rsc.org/learn-chemistry/content/filerepository/CMP/00/000/045/Aspirin.pdf>  Aspirin screen experiment (not a suitable replacement for required practical 10)  <http://www.rsc.org/learn-chemistry/resource/res00001644/aspirin-screen-experiment> |

**Further physical Chemistry 1 (8 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.9**  Rate equations.  **3.1.9.1**  Rate equations.  Know and understand:  The rate equation is of the form  Rate = *k*[A]m [B]n  **3.1.9.2**  Determination.  Rate equations are determined by experiment and give us information about the reaction steps and the rate-determining step.  Rate can be determined using concentration-time graphs.  Rate-concentration graphs can be used to deduce order for a reagent.  That the rate constant varies with temperature as shown by the equation: *k* = Ae-*E*a/*RT* | 3.5 weeks | Define the terms order of reaction and rate constant.  Perform calculations using the rate equation.  Explain the qualitative effect of changes in temperature on the rate constant *k*  Use concentration–time graphs to deduce the rate of a reaction.  Use initial concentration–time data to deduce the initial rate of a reaction.  Use rate–concentration data or graphs to deduce the order (0, 1 or 2) with respect to a reactant.  Derive the rate equation for a reaction from the orders with respect to each of the reactants.  Use the orders with respect to reactants to provide information about the rate-determining/limiting step of a reaction.  Know how to use a rearranged Arrhenius equation with experimental data to plot a straight line graph with slope –*E*a/*R* | Students use initial rate data to deduce the order of reaction and derive the rate equation.  Students calculate the rate constant from data for a zero order reaction.  Students calculate rates from concentration-time graphs by drawing tangents.  Students use data to deduce the rate-determining step.  Students use data to deduce the activation energy using the Arrhenius equation and a suitable graph.  Practical activities:  Iodine clock (KI and H2O2): initial rate.  Iodine/propanone/acid reaction: initial rate and continuous monitoring using a colorimeter.  Enzyme catalysed decomposition of H2O2 continuous monitoring by gas collection.  Activation energy for thiosulfate/acid reaction. | June 2006  Unit 4 Q5  June 2003  Unit 4 Q1    June 2013  Unit 4 Q1  January 2013  Unit 4 Q1    January 2011  Unit 4 Q1    January 2010  Unit 4 Q3  January 2006  Unit 4 Q1    January 2003  Unit 4 Q1 | Iodine clock reaction:  Demo: <http://www.rsc.org/learn-chemistry/resource/res00000744/iodine-clock-reaction>  Video:  <https://www.youtube.com/watch?v=kw-Lt9-WmTg>  Activation energy and Arrhenius equation:  <http://www.chem1.com/acad/webtext/dynamics/dynamics-3.html> |
| **Required practical 7**  Measuring the rate of reaction:   * by an initial rate method * by a continuous monitoring method. | | | | | |
| **3.1.10**  Equilibrium constant *K*p for homogeneous systems.  Know how to calculate partial pressures using mole fractions and total pressure.  Write expressions for, and calculate *K*p including units.  Predict qualitatively how changes in conditions affect the position of an equilibrium and the value of *K*p  Understand the effect of a catalyst affects an equilibrium and *K*p | 1.0 weeks | Derive partial pressure from mole fraction and total pressure.  Construct an expression for *K*p for a homogeneous system in equilibrium.  Perform calculations involving *K*p  Predict the qualitative effects of changes in temperature and pressure on the position of equilibrium and on the value of *K*p  Understand that, whilst a catalyst can affect the rate of attainment of an equilibrium, it does not affect the value of the equilibrium constant. | Students use data to calculate mole fractions and *K*p values for a range of gaseous reactions.  Students predict the qualitative effects of changing temperature and pressure on the position of equilibrium and the value of *K*p  Practical demonstration: Effect of temperature and pressure on the NO2/N2O4 equilibrium  <http://www.rsc.org/learn-chemistry/resource/res00001739/le-chateliers-principle-the-equilibrium-between-nitrogen-dioxide-and-dinitrogen-tetroxide?cmpid=CMP00005253> | June 2004  Unit 4 Q3  January 2007  Unit 4 Q2  June 2007  Unit 4 Q1  January 2008  Unit 4 Q3  June 2008  Unit 4 Q3  January 2009  Unit 4 Q3  June 2009  Unit 4 Q2 | Revision of *K*c: Starter for 10  <http://www.rsc.org/learn-chemistry/resource/res00001358/advanced-starters-for-ten#!cmpid=CMP00002943> |
| **3.1.12**  Acids and bases.  **3.1.12.1**  Brønsted–Lowry acid–base equilibria in aqueous solution.  The idea of acids as proton donors and bases as proton acceptors. | 3.2 weeks | Define an acid as a proton donor and a base as a proton acceptor. | **Students:**   * revise reactions of acids and bases in terms of proton transfer * complete titration calculations * perform a range of calculations to involving the pH and concentration of strong acids, strong bases, weak acids and buffer solutions * interpret pH curves and select suitable indicators from given data * describe qualitatively the action of a variety of buffer solutions.   **Practical activities:**   * test-tube reactions of acids and bases * how to calibrate and use a pH meter * use pH meters to produce pH curves * determine *K*a for a weak acid by measuring the pH at the half equivalence point | January 2013  Unit 4 Q2  June 2011  Unit 4 Q2  June 2010  Unit 4 Q5  January 2012  Unit 4 Q4  January 2006  Unit 4 Q2  June 2013  Unit 4 Q3    June 2005  Unit 4 Q2    June 2003  Unit 4 Q3  January 2005  Unit 4 Q8  January 2002  Unit 4 Q3 | RSC pH simulator: <http://www.rsc.org/learn-chemistry/resource/res00001458/ph-scale-simulation-rsc-funded>  pH curve simulators:  <http://chem-ilp.net/labTechniques/AcidBaseIdicatorSimulation.htm>  <http://terpconnect.umd.edu/~toh/models/TitrationDemo.html>  Uses of weak acids**:**  <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/harpic/4>  <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/gaviscon/8>  Buffer solutions in nature:  <https://www.youtube.com/watch?v=3oTbgE88PMI> |
| **3.1.12.2**  Definition and determination of pH.  Know how to calculate the pH of strong acids from concentration and vice versa. | Convert concentration of hydrogen ions into pH and vice versa.  Calculate the pH of a solution of a strong acid from its concentration. |
| **3.1.12.3**  The ionic product of water, *K*w  Understand how to use *Kw* to calculate the pH of strong bases. | Know that water is slightly dissociated.  Know the expression for the ionic product of water, *K*w  Use *K*w to calculate the pH of a strong base from its concentration. |
| **3.1.12.4**  Weak acids and bases *K*a for weak acids.  Understand the term **weak** in relation to acids and bases.  Know how to use *K*a to find the pH of weak acids from the concentration and vice versa.  Relate *K*ato p*Ka* | Construct an expression for *K*a  Perform calculations relating the pH of a weak acid to the concentration of the acid and the dissociation constant, *K*a  Convert *K*a into p*K*a and vice versa. |
| **3.1.12.5**  pH curves, titrations and indicators.  Sketch pH curves and choose suitable indicators for titrations. | Sketch and explain the shapes of typical pH curves.  Perform titration calculations.  Use pH curves to select an appropriate indicator. |
| **3.1.12.6**  Buffer action.  Know what buffer solutions are, how they are made and what they are used for.  Explain how acidic and basic buffer solutions work.  Calculate the pH of acidic buffer solutions. | Explain qualitatively the action of acidic and basic buffers.  Calculate the pH of acidic buffer solutions. |
| **Required practical 9**  To investigate how pH changes when a weak acid reacts with a strong base. | | | | | |

**Further organic chemistry 2 (5 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.3.11**  Amines.  **3.3.11.1**  Preparation.  Know two routes to make primary aliphatic amines are made.  Know how aromatic amines are produced and their use in making dyes.  **3.3.11.2**  Base properties.  Understand the basic nature of amines and why different amines have different base strengths.  **3.3.11.3**  Nucleophilic properties.  Understand that amines are nucleophiles in their reactions with halogenoalkanes (nucleophilic substitution), acyl chlorides and acid anhydrides, (addition-elimination), including mechanisms. | 1.0 weeks | 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.  Place amines in order of base strength and explain this order.  Identify primary, secondary and tertiary amines and quaternary ammonium salts formed when ammonia and amines react with halogenoalkanes and give the main use of quaternary ammonium salts as surfactants.  Give the mechanism for reactions of ammonia and amines with halogenoalkanes.  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. | Students write equations for the preparation of a range of amines.  Students write equations and mechanism steps for nucleophilic substitution reactions and addition-elimination reactions starting with different amines.  Students identify order of base strength for different amines.  Practical demonstration:  Basic nature of amines  The preparation of N-Phenylethanamide | June 2013  Unit 4 Q8  June 2005  Unit 4 Q5  January 2005  Unit 4 Q1  June 2004  Unit 4 Q4  January 2004  Unit 4 Q8  January 2003  Unit 4 Q6 | Chemistry of shampoos and conditioners:  <http://www.hoddereducation.co.uk/media/Documents/Magazines/Sample%20Articles/CR-V22.pdf> |
| **3.3.12**  Polymers.  **3.3.12.1**  Condensation polymers.  Know the repeating units in polyesters (eg Terylene) and polyamides (eg nylon 6,6 and Kevlar) and the linkages between these repeating units.  Know some typical uses of these polymers.  **3.3.12.2** Biodegradability and disposal of polymers.  .  Understand the inert nature and non-biodegradability of polyalkenes.  Understand the biodegradable nature of polyamides and polyesters due to hydrolysis.  The advantages and disadvantages of different methods of disposal, including recycling. | 0.4 weeks | Write equations for the formation of polyamides and polyesters.  Draw the repeating unit from monomer structure(s).  Draw the repeating unit from a section of the polymer chain.  Draw the structure(s) of the monomer(s) from a section of the polymer.  Explain why polyalkenes are chemically inert but polyesters and polyamides can be hydrolysed. | Students make models of a polyamide and a polyester.  Students write equations and draw repeat units for a variety of different polyamides and polyesters.  Practical activity:  Making nylon | January 2012  Unit 4 Q8b  June 2011  Unit 4 Q4a and 4b    June 2006  Unit 4 Q4a  June 2004  Unit 4 Q5  January 2013  Unit 4 Q4b, 4c and 4d  June 2002  Unit 4 Q7 | History of Kevlar:  <http://science360.gov/obj/tkn-video/0ff49ec9-e5a0-4503-9eb0-4f2994eeafa2>  RSC resource on nylon: <http://www.rsc.org/learn-chemistry/resource/res00000026/nylon> |
| **3.3.16** Chromatography.  Thin-layer chromatography.  Column chromatography.  Gas chromatography.  GC-MS. | 0.6 weeks | Understand the different types of chromatography.  Calculate Rf values from a thin-layer chromatogram.  Compare retention times and Rf values with standards to identify different substances. | Students explain how the different types of chromatography are used to separate and identify compounds in a mixture.  Students interpret given chromatograms.    Students use data to calculate Rf values revise mass spectrometry. | January 2011 Unit 4 Q4f | RCS video on TLC:<http://www.rsc.org/learn-chemistry/resource/res00001074/thin-layer-chromatography>  GC-MS video:  <https://www.youtube.com/watch?v=08YWhLTjlfo>  AQA Chromatography Teachers’ Notes:  <http://filestore.aqa.org.uk/resources/chemistry/AQA-7405-TN-CHROMATOGRAPHY.PDF> |
| **3.3.13.1**  Amino acids.  Draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions. | 0.6 weeks | Draw the structures of amino acids as zwitterions and the ions formed from amino acids in acid and alkaline solution. |  | June 2013  Unit 4 Q6  January 2012  Unit 4 Q7  January 2005  Unit 4 Q2  June 2011  Unit 4 Q4c | Amino acids, proteins and enzymes:  <http://www.rsc.org/Education/Teachers/Resources/cfb/proteins.htm>  AQA Biochemistry Teachers’ Notes:  <http://www.aqa.org.uk/resources/science/as-and-a-level/chemistry-7404-7405/teach/teaching-notes> |
| **3.3.13.2**  Proteins.  Know 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. | Draw structures of a peptide formed from up to three amino acids, and of amino acids formed by hydrolysis of a peptide.  Identify primary, secondary and tertiary structures in diagrams and explain how these structures are maintained by hydrogen bonding and S–S bonds.  Calculate Rf values from a chromatogram. | Students make models of dipeptides and then hydrolyse them.  Students draw structures of a range of tripepetides.  Practical activity:  Separation and identification of amino acids by TLC | January 2010  Unit 4 Q6  January 2013  Unit 4 Q4 | Chemistry of hair removal products:  <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/veet> |
| **Required practical 12**  Separation of species by thin-layer chromatography. | | | | | |
| **3.3.13.3**  Enzymes.  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. | 0.4 weeks | Understand the action of enzymes and the use of drugs as an enzyme inhibitor.  Explain why a stereospecific active site can only bond to one enantiomeric form of a substrate or drug. |  |  | RSC resource on enzyme action  <http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm>  Animation on action of enzymes <http://doctorprodigious.wordpress.com/hd-animations/> |
| **3.3.13.4**  DNA.  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. | Know the structure of DNA in terms of sugar-phosphate backbone and complementary base-pairs.  Explain how hydrogen bonding between base pairs leads to the two complementary strands of DNA. | Students make a 2D or 3D model of DNA using cut out components. |  | Structure of DNA:  <http://www.youtube.com/watch?v=qy8dk5iS1f0>  How Stuff Works on the structure of DNA <http://science.howstuffworks.com/life/cellular-microscopic/dna1.htm> |
| **3.3.13.5**  Action of anti-cancer drugs.  Understand how DNA replicates and how anti-cancer drug cisplatin prevents this. | Explain why cisplatin prevents DNA replication.  Explain why such drugs can have adverse effects. | Students research the use of chemistry in cancer treatment.  Write notes to accompany a sequence of diagrams showing DNA replication.  Write notes to accompany a diagram showing the action of  cisplatin.  Evaluate the benefits and adverse effects of using drugs such as cisplatin. | Jan 2010  Unit 5 Q6 | Animation on DNA replication: <http://doctorprodigious.wordpress.com/hd-animations/>  Cisplatin – molecule of the month: <http://www.chm.bris.ac.uk/motm/cisplatin/htmlonly/>  Video on action of cisplatin: <http://www.youtube.com/watch?v=Wq_up2uQRDo> |
| **3.3.14**  Organic synthesis.  Devise synthetic routes to make specified compounds. | 0.4 weeks | 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. | Students produce flow-charts for synthetic pathways involving the reactions in the specification.  Students use them to devise synthetic routes to make a range of different compounds. | June 2006  Unit 4 Q6  January 2003  Unit 4 Q7  June 2002  Unit 4 Q7  Specimen Paper  Unit 4 Q8 | RSC synthesis resource:  <http://www.rsc.org/learn-chemistry/resource/res00000003/synthesis-explorer>  Synthesis of ibuprofen: <http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/nurofen/3> |
| **3.3.15**  NMR  Use 1H and 13C NMR to deduce information about the structure of organic molecules.  Understand similarities and differences between 1H and 13C NMR  Understand the use of TMS and suitable solvents. | 1.8 weeks | Understand the use of TMS and the δ scale for chemical shift.  Understand the use of deuterated solvents or CCl4  Deduce the structure of compounds using 1H NMR including the number, position, relative intensity and splitting of signals (n+1 rule).  Deduce the structure of compounds using 13C NMR to deduce structures, including the number and position of signals. | Students predict the number, position, relative intensity and splitting of signals in the 1H NMR spectrum of compounds.  Students predict the number and position of signals in the 13C NMR spectrum of compounds.    Students use data from NMR, and other analytical methods on the specification, to deduce the structure of a variety of different organic compounds. | June 2013  Unit 4 Q7    January 2013  Unit 4 Q5    June 2012  Unit 4 Q8    January 2011  Unit 4 Q5    January 2003  Unit 4 Q5    January 2002  Unit 4 Q4 | NMR technique:  <https://www.youtube.com/watch?v=uNM801B9Y84>  Database of spectra for organic compounds:  <http://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi>  Spectra school:  <http://www.rsc.org/learn-chemistry/collections/spectroscopy> |

**Further physical chemistry 2 (4.4 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.1.8**  Thermodynamics.  **3.1.8.1**  Born–Haber cycles.  Define enthalpy changes used in Born-Haber and solution enthalpy cycles.  Use Born-Haber cycles for ionic compounds.  Consider covalent character of ionic compounds.  Use solution enthalpy cycles for ionic compounds. | 1.0 weeks | Know definitions for lattice enthalpy (both formation and dissociation) enthalpy of formation, enthalpy of atomisation, bond enthalpy, electron affinity, ionisation energy.  Construct Born–Haber cycles to calculate lattice  enthalpies using these enthalpy changes or to calculate one of the other enthalpy changes.  Compare lattice enthalpies from Born–Haber cycles with those from calculations based on a perfect ionic model to provide evidence for covalent character in ionic compounds.  Construct energy cycles linking lattice enthalpies, hydration energies and enthalpies of solution.  Define the term enthalpy of hydration.  Perform calculations of an enthalpy change using these cycles. | Students write equations to represent enthalpy changes including:  enthalpy of formation, ionisation enthalpy, enthalpy of atomisation, bond enthalpy, electron affinity, lattice enthalpy (formation and dissociation).  Students construct Born–Haber cycles for a range of ionic compounds and use them to calculate the unknown enthalpy value.  Students construct solution enthalpy cycles for different ionic compounds.  Practical activity:  Find the enthalpy of solution of KCl, CaCl2, FeCl3, LiCl and NaCl | June 2013  Unit 5 Q1  June 2013  Unit 5 Q 2a and 2b    January 2013  Unit 5 Q2  June 2011  Unit 5 Q1  January 2010  Unit 5 Q4 | Lattice Enthalpy data  <http://www.rsc.org/Education/Teachers/Resources/Databook/int_born_haber.htm>  Knock Hardy Powerpoint  [www.knockhardy.org.uk/ppoints\_htm\_files/BHaberpps.pps](http://www.knockhardy.org.uk/ppoints_htm_files/BHaberpps.pps) |
| **3.1.8.2**  Gibbs free-energy and entropy.  Understand the concept of disorder/entropy.  Understand that the balance between entropy and enthalpy determines the feasibility of a reaction given by the relationship:  Δ*G* = Δ*H* – *T*Δ*S*  For a reaction to be feasible, the value of Δ*G* must be zero or negative. | 1.0 weeks | Predict the sign of an entropy change and calculate entropy changes from absolute entropy values.  Use the relationship  Δ*G* = Δ*H* – *T*Δ*S* to calculate Δ*G* and how this is related to the feasibility of a reaction.  Deduce how Δ*G* varies with temperature.  Determine the temperature at which a reaction becomes feasible. | Students predict the sign of the entropy change for some given reactions.  Calculate Δ*S* and Δ*H* for different reactions, and use the values to calculate Δ*G* at 298 K.  Use the Δ*G* values to predict the feasibility of reactions.  Determine the temperature at which a reaction becomes feasible.  Use graphs to deduce how Δ*G* varies with temperature.  Practical activities:  Find Δ*S* vaporisation of water.  Carry out test-tube reactions to deduce the signs of Δ*H*, Δ*S* and Δ*G* for different reactions and check observations by calculating values. | June 2013  Unit 5 Q3  January 2012  Unit 5 Q2  June 2011  Unit 5 Q2  June 2010  Unit 5 Q6 | Tutorial on the direction of chemical reactions  <http://www.rsc.org/learn-chemistry/resources/the-quantum-casino/tutorial/direction_chemical_reactions.php?section=tutorial&article=1> |
| **3.1.11**  Electrode potentials  **3.1.11.1**  Electrode potentials and cells  Understand that a potential difference is set up between two half cells (electrodes) that are joined by a salt bridge.  Understand that electrode potentials are measured relative to the standard hydrogen electrode and under standard conditions.  Know that the electrochemical series can be used to calculate the EMF of cells and understand how to predict the direction of simple redox reactions. | 2.0 weeks | Use IUPAC cell notation to represent cells.  Understand that potentials are measured relative to the standard hydrogen electrode.  The potential of an electrode is affected by conditions.  Know the standard conditions under which potentials are measured.  Know that electrode potential are listed in order in the electrochemical series.  Use the electrochemical series to predict the direction of simple redox reactions. | Students draw electrochemical cells for different combinations of half cells, and use *E*Ɵ values to calculate EMFs.  Students use the electrochemical series to predict and explain the direction of redox reactions.  Students use Le Chatelier’s Principle to predict how changing concentration affects electrode potential values, and plan an experiment to test these predictions.  Practical activities:  Students could make some cells and measuring their EMFs,  predicting and testing the direction of redox reactions.  Students could plan and carry out an experiment to investigate the effect of changing concentration or temperature on a voltaic cell such as the Zn/Cu cell | January 2013  Unit 5 Q7  January 2012  Unit 5 Q4  June 2006  Unit 5 Q4  January 2004  Unit 5 Q4  June 2011  Unit 5 Q5 | Knockhardy electrochemistry powerpoint:  <http://www.knockhardy.org.uk/sci_htm_files/08e0.pdf> |
| **Required practical 8**  Measuring the EMF of an electrochemical cell. | | | | | |
| **3.1.11.2**  Commercial applications of electrochemical cells  That cells can be used as a source of energy.  Rechargeable cells eg the lithium cell.  Fuel cells eg the alkaline hydrogen/oxygen fuel cell.  The benefits and risks of using hydrogen fuel cells. | 0.4 weeks | Know the reactions occurring in a lithium cell and in an alkaline hydrogen fuel cell.  Classify cells as non-rechargeable, rechargeable or fuel cells.  Use given electrode data to deduce the reactions occurring in cells and deduce the EMF of a cell.  Explain how the electrode reactions can be used to generate an electric current. | Students explain the differences between different types of cells.  Students write half-equations for a variety of different examples and calculate the EMF in each case.  Practical demonstration of a hydrogen-oxygen fuel cell. | June 2013  Unit 5 Q5  June 2012  Unit 5 Q5 | Toyota fuel cell video:  <https://www.youtube.com/watch?v=g35I61FjKiI>  Fuel cell article:  <http://www.rsc.org/chemistryworld/Issues/2006/March/FuelCells.asp> |

**Further inorganic chemistry (6.6 weeks)**

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| **Learning objective** | **Time taken** | **Learning outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **3.2.4**  Properties of Period 3 elements and their oxides.  The reactions of Na and Mg with water.  The trend in the reactions of the elements Na to S with oxygen.  The trends in melting point of oxides of Na-S    Reactions of oxides with water and the acid-base nature of the oxides. | 1.0 weeks | Know the reactions of Na and Mg with water.  Know the reactions of the elements Na-S with oxygen.  Explain the trend in the melting point of the oxides of the elements Na–S in terms of their structure and bonding.  Explain the trends in the reactions of the oxides with water in terms of the type of bonding present in each oxide.  Write equations for the reactions that occur between the oxides of the elements Na–S and given acids and bases. | Students make predictions about the various reactions and trends.  Teacher demonstration of reactions specified.  Students record their observations during the teacher demonstrations and attempt to construct appropriate equations.  Students could add Period 3 oxides to water and test their pH. | June 2013  Unit 5 Q4  January 2013  Unit 5 Q4  June 2012  Unit 5 Q1  January 2012  Unit 5 Q3  June 2011  Unit 5 Q4 | Video illustrating various reactions of Period 3:  <https://www.youtube.com/playlist?list=PLZR14tg_tCuZI6eV1ZJ7w88yIKGLQlOb2> |
| **3.2.5**  Transition metals.  **3.2.5.1**  General properties of transition metals.  The electron configuration of transition metals and their ions.  The characteristic properties of transition metals.  The terms complex, ligand and co-ordination number. | 0.2 weeks | Write the electron configuration of first row transition metals and their ions.  Describe what a transition metal is in terms of electron configuration.  Describe the characteristic properties of transition metals.  Define the terms ligand, complex and co-ordination number. | Students use Starter for 10 exercises to revise electron configuration and redox.  Students write electron configuration for different transition metal atoms and ions.  Students deduce the oxidation state of the metal, the ligands and co-ordination number in a series of complexes. | January 2005  Unit 2 Q2  June 2003  Unit 2 Q2  January 2003  Unit 5 Q4 | Introduction to transition metals:  [www.knockhardy.org.uk/ppoints\_htm\_files/transmpps.pps](http://www.knockhardy.org.uk/ppoints_htm_files/transmpps.pps)  This can be shown in stages as each section is covered  Starter for Ten:  <http://www.rsc.org/learn-chemistry/resource/res00001358/advanced-starters-for-ten> |
| **3.2.5.2**  Substitution reactions.  The different types of ligands.  Ligand substitution reactions.  Oxygen transport by haemoglobin.  The chelate effect. | 0.6 weeks | Explain the difference between and give examples of monodentate, bidentate and multidentate ligands.  Explain what happens in a ligand substitution reaction and why there may be a change in co-ordination number.  Describe what haem is, how oxygen is carried in blood and why carbon monoxide is toxic.  Describe and explain the chelate effect in terms of enthalpy and entropy changes. | Students write equations for a variety of ligand substitution reactions and identify changes in coordination number  research the role of haemoglobin in the blood.  Practical activity:  Ligand substitution reactions of copper(II) and cobalt(II) ions.  Investigate substitution reactions using bidentate and multidentate ligands in the context of the chelate effect. | January 2005  Unit 5 Q6b  June 2004  Unit 5 Q4b  June 2002  Unit 5 Q6  June 2010  Unit 5 Q4 | Chelates:  <http://scifun.chem.wisc.edu/chemweek/chelates/chelates.html> |
| **3.2.5.3**  Shapes of complex ions.  The shapes of complexes with 2/4/6 ligands.  How complexes can show cis-trans (*E–Z*) or optical isomerism. | 0.4 weeks | Sketch examples of octahedral, tetrahedral, square planar and linear complexes.  Know how some complexes can show cis-trans (*E–Z*)­ or optical isomerism.  Know the complexes in cisplatin and Tollens’ reagent. | Students draw and make models of complexes including  ones with bidentate ligands and  ones which show cis-trans isomerism.  Explain how optical isomers can form and draw examples. | June 2011  Unit 5 Q6  January 2011  Unit 5 Q4c  January 2004  Unit 5 Q10b  June 2003  Unit 5 Q3 | Knockhardy powerpoint:  [www.knockhardy.org.uk/ppoints\_htm\_files/transmpps.pps](http://www.knockhardy.org.uk/ppoints_htm_files/transmpps.pps) |
| **3.2.5.4**  Formation of coloured ions  Understand why transition metal ions are coloured and what affects the colour.  Use colorimetry to measure concentration of solutions. | 0.6 weeks | Explain why transition metal complexes are coloured.  Describe factors that affect the colour of transition metal ions.  Describe how colorimetry can be used to find the concentration of coloured ions in solution. | Explain using diagrams and the equation ∆*E* = *hν* (= *hc*/λ) why transition metal complexes are coloured and what factors affect the colour.  Use a graph of absorption versus concentration to determine the concentration of the solution.  Practical activity:  Using a colorimeter to determine the concentration of copper(II) ions in a solution. | June 2013  Unit 5 Q6  January 2013  Unit 5 Q8  June 2011  Unit 5 Q7  June 2010  Unit 5 Q4 | Colorimetry:: <http://www.docbrown.info/page07/appendixtrans09.htm>  Chemguide  <http://www.chemguide.co.uk/inorganic/complexions/colour.html> |
| **3.2.5.5**  Variable oxidation states.  Know what happens when vanadate(V) is reduced by zinc in acidic solution.  How the redox potential for a transition metal is affected by the pH and ligand.  The reduction of silver(I) in Tollens’ reagent to test for aldehydes  Redox titrations, including calculations, of MnO4– with Fe2+ and C2O42– in acidic solution. | 1.2 weeks | Describe and explain what happens when vanadate(V) ions are reduced by zinc in acidic solution.  Understand how the redox potential of a transition metal ion is affected by changes in pH and ligand.  Describe and explain the use of Ag(NH3)2+ in Tollens’ reagent to distinguish between aldehydes and ketones.  Perform titrations and associated calculations for redox reactions of MnO4– with Fe2+ and C2O42– in acidic solution. | Students predict what reducing agent will reduce vanadium(V) to vanadium(II) using *E*Ɵ values.  Students compare redox potentials for Cr3+ and Fe3+ at different pH values and different ligands.  Students revise the use of Tollens’ reagent to test for aldehydes.  Students carry out a range of different calculations involving redox titrations.  Practical activities:  Reduction of vanadium(V) to vanadium(II) by zinc, and its subsequent oxidation using manganate(VII)  Various redox titrations eg the percentage iron in ion tablets, the *M*r of ethanedioic acid, the *M*r of an unknown hydrated iron(II) salt. | January 2012  Unit 5 Q7  June 2012  Unit 5 Q6  June 2003  Unit 5 Q2 | Video of vanadium(V) reduction:  <https://www.youtube.com/watch?v=eDXumSZfHfA> |
| **3.2.5.6**  Catalysts.  Understand what heterogeneous catalysts are and how they work, including examples and how they can become poisoned.  Understand what homogeneous catalysts are, with specific examples. | 0.6 weeks | Describe what a heterogeneous catalyst is and the role of active sites and the support medium.  Explain, with the aid of equations, how V2O5, acts as a catalyst in the Contact Process.  Describe the use of Fe in the Haber process.  Explain how heterogeneous catalysts can become poisoned.  Describe what a homogeneous catalyst is and understand how reactions proceed through an intermediate species.  Describe, with the aid of equations, how Fe2+ catalyses the reaction between I– and S2O82– and how the reaction between C2O42– and MnO4– is autocatalytic | Students revise how catalysts increase reaction rate.  Students research the use of transition metals as catalysts and compare homogeneous and heterogeneous catalysis.  Practical activities:  Using a colorimeter to investigate autocatalysis in which Mn2+ catalyses the reaction between C2O42– and MnO4–  Investigating the reaction between I– and S2O82– using different catalysts. | January 2013  Unit 5 Q6  January 2012  Unit 5 Q6  January 2011  Unit 5 Q4  January 2010  Unit 5 Q1  June 2006  Unit 5 Q9  June 2013  Unit 5 Q8  June 2012  Unit 5 Q8b  June 2011  Unit 5 Q8a  June 2003  Unit5 Q3 | Knockhardy powerpoint:  [www.knockhardy.org.uk/ppoints\_htm\_files/transmpps.pps](http://www.knockhardy.org.uk/ppoints_htm_files/transmpps.pps) |
| **3.2.6**  Reactions of ions in aqueous solution.  The nature of metal-aqua ions.  The relative acidity of metal-aqua ions.  The reaction of metal-aqua ions (Fe2+, Cu2+, Al3+, Fe3+) with bases OH–, NH3, CO32–  The character of metal hydroxides as basic or amphoteric. | 2.0 weeks | Understand that metal ions exist as metal-aqua ions in aqueous solution.  The hydrolysis of metal-aqua ions in aqueous solution giving acidic solutions.  Explain why [M(H2O)6]3+ ions are more acidic than [M(H2O)6]2+ ions.  Describe and explain reactions of [M(H2O)6]2+ (M = Cu, Fe) and [M(H2O)6]3+ (M = Al, Fe) with the bases OH–, NH3, CO32–  Describe if and how metal hydroxides (Cu(II), Fe(II), Al(III), Fe(III)) react with H+ and OH–, and whether these metal hydroxides are basic or amphoteric. | Students record observations and write equations for the relevant reactions based on their practical work.  Students predict equations and acid-base behaviour for other similar reactions (eg Co(H2O)6]2+ and [Cr(H2O)6]3+  Students revise tests for cations and anions met in first year.  Practical activities:  Test-tube reactions of M(H2O)6]2+ (M = Cu, Fe) and [M(H2O)6]3+ (M = Al, Fe) with OH–, NH3, and CO32–  Test-tube reactions of metal hydroxides with acid and alkali to illustrate basic or amphoteric nature.  Test-tube reactions to identify unknowns (including NH4+, SO42–, CO32–, Cl–, Br–, I–).  Test-tube reactions of iron(II) and iron(III) ions with reagents such as Mg, Na2CO3 to exemplify the difference in pH. | January 2013  Unit 5 Q5  Specimen Paper CHM5 Q8  June 2004  Unit 5 Q4  June 2013  Unit 5 Q7  June 2012  Unit 5 Q7  January 2012  Unit 5 Q8  June 2011  Unit 5 Q8b  June 2012  Unit 5 Q8a | AQA Reactions of metal ions in aqueous solution resource:  <http://filestore.aqa.org.uk/resources/chemistry/AQA-7405-REACTIONS-OF-METAL-IONS.PDF> |
| **Required practical 11:**  Carry out simple test-tube reactions to identify transition metal ions in aqueous solution. | | | | | |

**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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