Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
The cause and nature of optical isomerism. The similarities and differences in the properties of enantiomers. The formation of racemic mixtures.	0.4 weeks	**Students should be able to:** • explain the cause of optical isomerism • identify molecules that exhibit optical isomerism/that are optically active. • draw pairs of optical isomers in 3D • describe how enantiomers affect plane polarised light • explain what a racemic mixture is, how they can be formed, and their effect on plane polarised light.	• Students make models of mirror image molecules of some chiral and non-chiral molecules to see if they are non-superimposable or not (AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes). • Students identify whether molecules exhibit optical isomerism, and where they do draw the two enantiomers in 3D (AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes). • Students could see how passing polarised light through a solution of sucrose affects the plane of the light (PS 1.2 - Apply scientific knowledge to practical contexts). • Students could use Molymod models to show how a racemic mixture is formed when ethanol reacts with HCN (AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3	• January 2005 Unit 4 Question 3d (QW05.4.03) • June 2002 Unit 4 Question 5 (QW02.4.05)	Molymod models *Chemistry Review* article: Looking in the mirror (Volume 10, edition 3)

			- Understand the symmetry of 2D and 3D shapes).		

3.3.8 Aldehydes and ketones

Aldehydes, ketones, carboxylic acids and their derivatives all contain the carbonyl group which is attacked by nucleophiles. This section includes the addition reactions of aldehydes and ketones

Prior knowledge:

AS Chemistry
- 3.3.1.1 – Nomenclature
- 3.3.1.2 – Reaction mechanisms
- 3.3.5.2 – Oxidation of alcohols

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Know about the oxidation of aldehydes. Know about the reduction of aldehydes and ketones with $NaBH_4$, including mechanism. Know about the reaction of aldehydes and ketones with KCN then acid, including mechanism.	0.6 weeks	**Students should be able to:** • write equations and know reagents and conditions to oxidise aldehydes to carboxylic acids • know how to distinguish aldehydes and ketones • write equations, know reagents and conditions and outline the mechanism to reduce aldehydes and ketones to alcohols with $NaBH_4$ • write equations, know reagents and conditions and outline the mechanism for reaction of aldehydes and ketones with KCN and acid	• Students write equations for the oxidation of aldehydes (using reagents acidified potassium dichromate(VI) / Tollen's reagent / Fehling's solution) (AO2 - Apply knowledge and understanding). • Students could carry out test-tube reactions of Tollens' reagent and Fehling's solution to distinguish aldehydes and ketones (AO2 - Apply knowledge and understanding; AT b - Use water bath for heating; AT d - Use laboratory apparatus for a variety of experimental techniques including qualitative tests organic functional groups; AT k). • Students write equations and mechanisms for the reduction of aldehydes and ketones using $NaBH_4$ (AO2 - Apply knowledge and understanding).	• January 2010 Unit 4 Question 4 (QW10.4.04) • June 2005 Unit 4 Question 3a (QS05.4.03) • June 2004 Unit 4 Question 6d and 6e (QS04.4.06) • January 2002 Unit 4 Question 6a (QW02.4.06)	Molymod models Giant silver mirror http://www.nuffieldfoundation.org/practical-chemistry/giant-silver-mirror RSC mechanisms resource: http://www.rsc.org/learn-chemistry/resource/res00000638/curly-arrows-and-stereoselectivity-in-organic-reactions Mechanism animations http://science.jbpub.com/organic/movies/

		• understand why reaction of aldehydes and ketones with KCN followed by acid can form a racemic mixture • students understand the hazards of using KCN	• Students write equations and mechanisms for the reaction of aldehydes and ketones with KCN followed by acid (AO2 - Apply knowledge and understanding). • Students could use Molymod models to show how a racemic mixture is formed when ethanol reacts with HCN (AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes). • Students could research why KCN/HCN are highly toxic (AO3 - Analyse, interpret and evaluate scientific information).		

3.3.9 Carboxylic acids and derivatives

Carboxylic acids are weak acids but strong enough to liberate carbon dioxide from carbonates. Esters occur naturally in vegetable oils and animal fats. Important products obtained from esters include biodiesel, soap and glycerol.

Prior knowledge:

AS Chemistry
- 3.3.1.1 – Nomenclature.
- 3.3.1.2 – Reaction mechanisms.
- 3.3.5.2 – Oxidation of alcohols.

3.3.9.1 Carboxylic acids and esters

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Draw the structure of and name carboxylic acids and esters. Know that carboxylic acids are weak acids. Know how esters are made from carboxylic acids. Know some uses of esters. Know how esters are hydrolysed. Know that vegetable oils and animal fats are esters of fatty acids and glycerol	1.5 weeks	**Students should be able to:** • draw the structure of and name carboxylic acids and esters • know how carboxylic acids react with carbonates • 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 or alkaline conditions • understand the structure of animals fats and vegetable oils	• Students draw and name carboxylic acids and esters (AO2 - Apply knowledge and understanding). • Students write equations for, and make esters by reactions of alcohols with carboxylic acids in test tubes; or an ester could be collected and purified using a separating funnel and distillation (AO2 - Apply knowledge and understanding; AT g - Purify a liquid product, including use of separating funnel; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d). • Students research uses of esters and the presence of esters in fruit	• January 2013 Unit 4 Question 3a (QW13.4.03) • June 2010 Unit 4 Question 7a and 7d (QS10.4.07) • January 2010 Unit 4 Question 5 (QW10.4.05) • June 2005 Unit 1 Question 1a and 1d (QS05.4.01)	Making soap from castor oil: http://www.nuffieldfoundation.org/practical-chemistry/making-soaps-and-detergents Method and guidance for making biodiesel – CLEAPSS leaflet PS 67-10 Molecule of the month: Esters in fruits http://www.chm.bris.ac.uk/motm/ethylacetate/ethylv.htm

Know how soap and biodiesel are made from vegetable oil and animals fats		• know how soap and biodiesel are made and write equations for these reactions for specified fats/oils.	(AO2 - Apply knowledge and understanding). • Students write equations for the hydrolysis of given esters in acidic and alkaline conditions (AO2 - Apply knowledge and understanding). • Students make soap by hydrolysis of castor oil (AO2 - Apply knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d). • Students make biodiesel (AO2 - Apply knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d). • Students write equations for production of soap and/or biodiesel from specified fats/oils (AO2 - Apply knowledge and understanding). • Students could identify an unknown ester by determination of boiling point followed by hydrolysis and then purifying and finding the melting point of the carboxylic acid formed (eg for example methyl benzoate) (AO3 - Analyse, interpret and evaluate scientific information; AT d - Use laboratory apparatus for a variety of experimental techniques including distillation and heating under reflux, including setting up glassware using retort stand and clamps; AT d - Use laboratory		Biofuels website: http://www.thesolarspark.co.uk/the-science/renewable-energy/bio/ Biofuels website: http://www.biofuels.co.uk/ Press report about problems with biofuels: http://www.telegraph.co.uk/earth/energy/biofuels/10520736/The-great-biofuels-scandal.html BP biofuels resources: http://bpes.bp.com/secondary-resources/science/ages-14-to-16/energy-electricity-and-forces/biofuels-and-the-future

			apparatus for a variety of experimental techniques including filtration, including use of fluted filter paper, or filtration under reduced pressure; AT k).		

3.3.9.2 Acylation

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Draw the structure of and name acid anhydrides, acyl chlorides and amides. Understand acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides, including the mechanism for acyl chlorides. **Required practical 10** Preparation of - a pure organic solid and test of its purity - a pure organic liquid. Aspirin research and melting point.	2.0 weeks	**Students should be able to:** • draw the structure of and name acid anhydrides, acyl chlorides and amides • identify the products of and write equations for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides • outline the mechanism for the acylation reactions of acyl chlorides • state advantages of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin • prepare and purity an organic solid and test its purity.	• Students draw and name acid anhydrides, acyl chlorides and amides (AO2 - Apply knowledge and understanding). • Students write equations and outline mechanisms for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides; some of these reactions could be demonstrated. • Students prepare, purify and test the purity of aspirin by melting point determination (AO2 - Apply knowledge and understanding; AT d - Use laboratory apparatus for a variety of experimental techniques including distillation and heating under reflux, including setting up glassware using retort stand and clamps; AT d - Use laboratory apparatus for a variety of experimental techniques including filtration, including use of fluted filter paper, or filtration under reduced pressure; AT k.	• January 2012 Unit 4 Question 10a (QW12.4.10) • June 2006 Unit 4 Question 1 (QS06.4.01) • June 2005 Unit 4 Question 7 (QS05.4.07) • June 2003 Unit 5 Question 8b (QS03.5.08)	RSC resource on aspirin: http://www.rsc.org/learn-chemistry/resource/res00000056/aspirin Aspirin Pre-lab Screen Experiment: http://www.rsc.org/learn-chemistry/resource/res00001644/aspirin-screen-experiment RSC mechanisms resource: http://www.rsc.org/learn-chemistry/resource/res00000638/curly-arrows-and-stereoselectivity-in-organic-reactions Mechanism animations http://science.jbpub.com/organic/movies/

3.3.10 Aromatic Chemistry

Aromatic chemistry takes benzene as an example of this type of molecule and looks at the structure of the benzene ring and its substitution reactions

Prior knowledge:

AS Chemistry
- 3.3.1.1 – Nomenclature.
- 3.3.1.2 – Reaction mechanisms.

3.3.10.1 Bonding

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the structure of benzene and evidence for delocalisation.	0.2 weeks	**Students should be able to:** • describe the structure of benzene and explain how delocalisation makes benzene more stable than the theoretical cyclohexa-1,3,5-triene • use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability • explain why benzene undergoes substitution reactions in preference to addition reactions.	• Name a range of aromatic compounds with common functional groups (AO2 - Apply knowledge and understanding). • Draw enthalpy diagrams to show the relative stability of cyclohexane, cyclohexene, cyclohexa-1,4-diene, benzene and the theoretical cyclohexa-1,3,5-triene (AO2 - Apply knowledge and understanding).	• June 2011 Unit 4 Question 8a (QS11.4.08) • January 2004 Unit 4 Question 7a (QW04.4.07)	*Chemistry Review* article: The structure of benzene (Volume 1, edition 1) *Chemistry Review* article: Who discovered the structure of benzene (Volume 5, edition 1)

3.3.10.2 Electrophilic substitution

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Know nitration and Friedel-Crafts acylation reactions of aromatic compounds,	1.0 week	**Students should be able to:**	• Write equations (including for the formation of electrophiles) and mechanisms for nitration and Friedel-Crafts acylation reactions	• January 2012 Unit 4 Question 9a (QW12.4.09)	*Chemistry review* article: Probably the most important reactions in the

including the mechanism and usefulness.		• write equations and outline mechanisms for nitration and Friedel-Crafts acylation reactions of aromatic compounds. (including equations for the formation of electrophiles) • understand the usefulness of nitration and Friedel-Crafts acylation reactions	given the starting material and products (AO2 - Apply knowledge and understanding). • Students could carry out the preparation of methyl 3-nitrobenzoate by nitration of methyl benzoate, purification by recrystallisation and determination of melting point (AT d - Use laboratory apparatus for a variety of experimental techniques including filtration, including use of fluted filter paper, or filtration under reduced pressure; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances).	• January 2011 Unit 4 Question 6 (QW11.4.06) • June 2010 Unit 4 Question 8 b) (QS10.4.08) • January 2006 Unit 4 Question 7 (QW06.4.07) • June 2011 Unit 4 Question 8b	world (Volume 15, edition 2)

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the concept of and calculate partial pressures using mole fractions. Write expressions for and calculate K_p including units. Perform calculations involving K_p. Predict how changes in conditions affect the position of an equilibrium and the value of K_p. The effect of a catalyst affects an equilibrium and K_p.	2.0 weeks	**Students should be able to:** • calculate equilibrium quantities, mole fractions and partial pressures for equilibrium mixtures • write an expression for K_p for a reaction and calculate the value of K_p with units • predict and justify how changes in temperature and pressure affect the position of an equilibrium, and how this may or may not affect the value of K_p • understand how a catalyst affects an equilibrium and the value of K_p.	• Given initial amounts of substances and one substance at equilibrium, find the quantity of each reagent at equilibrium (AO2 - Apply knowledge and understanding). • Calculate mole fractions and then partial pressures in order to determine K_p, with units (AO2 - Apply knowledge and understanding; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities). • For given equilibria with enthalpy change data, predict the effect on the position of an equilibrium and the value of K_p (AO2 - Apply knowledge and understanding).	• January 2007 Unit 4 Question 2 (QW04.4.02) • June 2007 Unit 4 Question 1 (QS07.4.01) • January 2008 Unit 4 Question 3 (QW08.4.03) • June 2008 Unit 4 Question 3 (QS08.4.03) • January 2009 Unit 4 Question 3 (QW09.4.03) • June 2009 Unit 4 Question 2 (QS09.4.02)	Calculations for A level Chemistry (Ramsden) ISBN 9780748758395 Many suitable calculations can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
The idea of acids as proton donors and bases as proton acceptors.	0.2 weeks	**Students should be able to:** • define Brønsted–Lowry acids and bases • identify species as Brønsted–Lowry acids or	• Identify which species acts as the acid and which as the base in Brønsted-Lowry acid-base reactions (AO2 - Apply knowledge and understanding).	• June 2012 Unit 4 Question 3a and 3b (QS12.4.03)	Theory of acids history websites: http://www.bbc.co.uk/dna/ptop/plain/A708257

		bases in proton transfer reactions.			http://pubs.acs.org/subscribe/archive/tcaw/12/i03/pdf/303chronicles.pdf RSC acid-base simulator: http://www.rsc.org/learn-chemistry/resource/res00001457/acid-base-solutions-rsc-funded

3.1.12.2 Definition and determination of pH

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Calculate the pH of strong acids from concentration and vice versa.	0.4 weeks	**Students should be able to:** • calculate pH of a strong acid from its concentration • calculate the concentration of a strong acid from its pH • calculate the pH of when a strong acid is diluted.	• Identify acids as being strong or weak and monoprotic or diprotic (AO2 - Apply knowledge and understanding). • Calculate the pH of strong acids from the acid concentration, including examples where the acids are diluted (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Calculate the concentration of strong acids from the pH (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities	• June 2009 Unit 4 Question 3a (QS09.4.03)	RSC pH simulator: http://www.rsc.org/learn-chemistry/resource/res00001458/ph-scale-simulation-rsc-funded Some suitable problems can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			that range over several orders of magnitude).		
Extension					Estimate the number of H^+ ions in a drop of water http://www.rsc.org/learn-chemistry/resource/res00000665/h-ions-in-water

3.1.12.3 The ionic product of water K_w

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Use K_w to calculate the pH of strong bases.	0.3 weeks	**Students should be able to:** • show that $K_w = [H^+][OH^-]$ • use K_w to find the pH of strong bases from its concentration, and vice versa • calculate the pH of water at different temperatures	• Derive the expression $K_w = [H^+][OH^-]$ (AO1 - Demonstrate knowledge and understanding). • Calculate the pH of strong bases from the base concentration and vice versa, including dilutions (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Calculate the pH of water at different temperatures (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Explain how the pH and neutrality of water is or is not affected by changes in temperature (AO2 -	• January 2013 Unit 4 Question 2a (QW13.4.02) • June 2011 Unit 4 Question 2a (QS11.4.02) • June 2010 Unit 4 Question 5a and 5b (QS10.4.05)	RSC pH simulator: http://www.rsc.org/learn-chemistry/resource/res00001458/ph-scale-simulation-rsc-funded Some suitable problems can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			Apply knowledge and understanding).		

3.1.12.4 Weak acids and bases; K_a for weak acids

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the term *weak* in relation to acids and bases. Use K_a to find the pH of weak acids from the concentration and vice versa. Relate K_a to pK_a	0.3 weeks	**Students should be able to:** • write expressions for K_a for stated weak acids • perform calculations linking K_a to concentration and pH • convert K_a values to pK_a and vice versa • calculate the pH of water at different temperatures.	• Explain the difference between strong and weak acids and bases (AO1 - Demonstrate knowledge and understanding). • Derive expressions for K_a for stated acids (AO1 - Demonstrate knowledge and understanding). • Perform calculations linking K_a to concentration and pH (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Convert K_a values to pK_a and vice versa, and use these values to rank acids in order of strength (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Measure K_a of a weak acid by measuring pH at half neutralisation (AO2 - Apply knowledge and understanding; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; PS 4.1 - Know and understand how to use a	• January 2012 Unit 4 Question 4b (QW12.4.04) • January 2006 Unit 4 Question 2a and 2b (QW06.4.02)	RSC acid-base simulator: http://www.rsc.org/learn-chemistry/resource/res00001457/acid-base-solutions-rsc-funded RSC pH simulator: http://www.rsc.org/learn-chemistry/resource/res00001458/ph-scale-simulation-rsc-funded Creative problem solving in Chemistry – weak acids: http://www.rsc.org/learn-chemistry/resource/res00000677/a-weak-acid Some suitable problems can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			wide range of experimental and practical instruments, equipment and techniques; AT d).		

3.1.12.5 pH curves, titrations and indicators

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Calculate the pH of the solution formed when strong or weak acids react with strong bases. Sketch pH curves and choose suitable indicators for titrations. **Required practical 9** Investigate how pH changes when a weak acid reacts with a strong base and when a strong acid reacts with a weak base. Use of data logger and plot curve.	1.0 weeks	**Students should be able to:** • calculate pH of a mixture of a strong acid with a strong base • calculate the pH of a mixture of a weak acid with a strong base • sketch pH curves for titrations of strong/weak acids with strong/weak bases • choose a suitable indicator for acid-base titrations.	• Perform calculations to find the pH of mixtures of strong/weak acids with strong bases, with either excess acid or base (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Produce pH curves by experiment (AO2 - Apply knowledge and understanding; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; AT d, k, a). • Sketch pH curves for given acid and base combinations, and choose a suitable indicator (AO2 - Apply knowledge and understanding).	• June 2013 Unit 4 Question 3 (QS13.4.03) • June 2011 Unit 4 Question 1 (QS11.4.01) • CHEM4 Specimen Paper Question 3 (QSP 4.03) • June 2005 Unit 4 Question 2 (QS05.4.02) • June 2005 Unit 5 Question 2 (QS05.5.02) • June 2003 Unit 4 Question 3 (QW03.4.03)	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 Some suitable problems can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)
Extension			• Write spreadsheets to calculate the pH during a titration and to plot the pH curve (AO2 - Apply knowledge and understanding)		

3.1.12.6 Buffer action

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
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.	0.6 weeks	**Students should be able to:** • describe what a buffer solution is and how it is made • explain qualitatively how acidic/basic buffer solutions work • know some uses of buffer solutions • calculate the pH of a buffer solution.	• Describe how buffer solutions are made, how they work and what they are used for (AO2 - Apply knowledge and understanding). • Calculate the pH of a buffer solution given details about quantities of the reagents it is made from, and changes in pH when small amounts of acid/alkali are added to buffer solutions (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude). • Students could prepare a solution of a specific pH and then test the solution to check its pH and buffer action (AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; AT e - Use volumetric flask, including accurate technique for making up a standard solution; PS 1.1 - Solve problems set in practical contexts; PS 4.1 - Know and understand how to use a wide range of experimental	• January 2013 Unit 4 Question 2 (QW13.4.02) • January 2011 Unit 4 Question 2 (QW11.4.02) • CHEM4 Specimen Paper Question 4 (QSP 4.04) • January 2005 Unit 4 Question 8 (QW05.4.08) • January 2002 Unit 4 Question 3 (QW02.4.03)	Sandcastles & mudhuts – buffering action in blood (Hancock) ISBN 9780340543696 Some suitable problems can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			and practical instruments, equipment and techniques).		