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)

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 between molecules of condensation polymers.	• 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 chain (AO2 - Apply knowledge and understanding).	• 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

					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)