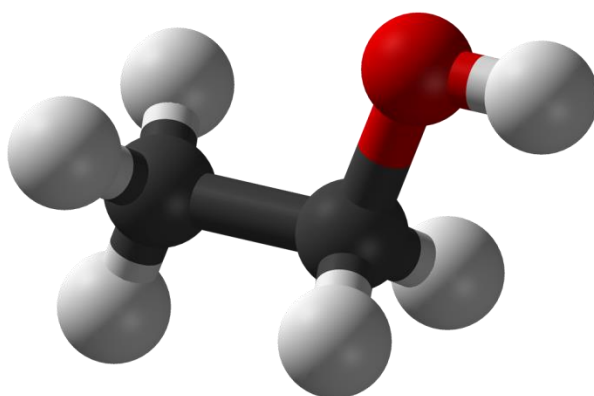


# A-level Chemistry



## 3.3 Organic Chemistry (Y13)



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Lesson Date(s)	Topic	Learning Outcomes From Specification	Key Words & Equations	Notes (Revision tips, exam technique tips, priorities for revision etc.)
	3.3.7 Optical Isomerism	<p>Optical isomerism is a form of stereoisomerism and occurs as a result of chirality in molecules, limited to molecules with a single chiral centre.</p> <p>An asymmetric carbon atom is chiral and gives rise to optical isomers (enantiomers), which exist as non superimposable mirror images and differ in their effect on plane polarised light.</p> <p>A mixture of equal amounts of enantiomers is called a racemic mixture (racemate).</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>draw the structural formulas and displayed formulas of enantiomers</li> <li>understand how racemic mixtures (racemates) are formed and why they are optically inactive.</li> </ul>		

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	3.3.8 Aldehydes & Ketones	<p>Aldehydes are readily oxidised to carboxylic acids.</p> <p>Chemical tests to distinguish between aldehydes and ketones including Fehling's solution and Tollens' reagent.</p> <p>Aldehydes can be reduced to primary alcohols, and ketones to secondary alcohols, using NaBH<sub>4</sub> in aqueous solution. These reduction reactions are examples of nucleophilic addition.</p> <p>The nucleophilic addition reactions of carbonyl compounds with KCN, followed by dilute acid, to produce hydroxynitriles.</p> <p>Aldehydes and unsymmetrical ketones form mixtures of enantiomers when they react with KCN followed by dilute acid.</p> <p>The hazards of using KCN. arrows to represent the movement of electron pairs.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>write overall equations for reduction reactions using [H] as the reductant</li> <li>outline the nucleophilic addition mechanism for reduction reactions with NaBH<sub>4</sub> (the nucleophile should be shown as H<sup>-</sup>)</li> <li>write overall equations for the formation of hydroxynitriles using HCN</li> <li>outline the nucleophilic addition mechanism for the</li> </ul>		

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		<p>reaction with KCN followed by dilute acid</p> <p>explain why nucleophilic addition reactions of KCN, followed by dilute acid, can produce a mixture of enantiomers.</p>		
	<p>3.3.9.1</p> <p>Carboxylic Acids &amp; Esters</p>	<p>The structures of carboxylic acids and esters.</p> <p>Carboxylic acids are weak acids but will liberate CO<sub>2</sub> from carbonates.</p> <p>Carboxylic acids and alcohols react, in the presence of an acid catalyst, to give esters.</p> <p>Common uses of esters (eg in solvents, plasticisers, perfumes and food flavourings).</p> <p>Vegetable oils and animal fats are esters of propane-1,2,3-triol (glycerol).</p> <p>Esters can be hydrolysed in acid or alkaline conditions to form alcohols and carboxylic acids or salts of carboxylic acids.</p> <p>Vegetable oils and animal fats can be hydrolysed in alkaline conditions to give soap (salts of long-chain carboxylic acids) and glycerol.</p> <p>Biodiesel is a mixture of methyl esters of long-chain carboxylic acids.</p> <p>Biodiesel is produced by reacting vegetable oils with methanol in the presence of a catalyst.</p>		

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	3.3.9.2 Acylation	<p>The structures of:</p> <ul style="list-style-type: none"> <li>acid anhydrides</li> <li>acyl chlorides</li> <li>amides.</li> </ul> <p>The nucleophilic addition–elimination reactions of water, alcohols, ammonia and primary amines with acyl chlorides and acid anhydrides.</p> <p>The industrial advantages of ethanoic anhydride over ethanoyl chloride in the manufacture of the drug aspirin.</p> <p>Students should be able to outline the mechanism of nucleophilic addition–elimination reactions of acyl chlorides with water, alcohols, ammonia and primary amines</p> <p><b>Required practical 10</b>  <b>Preparation of:</b>  <b>a pure organic solid and test of its purity</b>  <b>a pure organic liquid..</b></p>		

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	3.3.10.1  Aromatic Chemistry - Bonding	<p>The nature of the bonding in a benzene ring, limited to planar structure and bond length intermediate between single and double.</p> <p>Delocalisation of p electrons makes benzene more stable than the theoretical molecule cyclohexa-1,3,5-triene.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability</li> <li>explain why substitution reactions occur in preference to addition reactions.</li> </ul>		
	3.3.10.2  Aromatic Chemistry – Electrophilic Substitution	<p>Electrophilic attack on benzene rings results in substitution, limited to monosubstitutions.</p> <p>Nitration is an important step in synthesis, including the manufacture of explosives and formation of amines.</p> <p>Friedel–Crafts acylation reactions are also important steps in synthesis.</p> <p>Students should be able to outline the electrophilic substitution mechanisms of:</p> <ul style="list-style-type: none"> <li>nitration, including the generation of the nitronium ion</li> <li>acylation using <math>\text{AlCl}_3</math> as a catalyst.</li> </ul>		

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	3.3.11.1  Amines - Preparation	<p>Primary aliphatic amines can be prepared by the reaction of ammonia with halogenoalkanes and by the reduction of nitriles.</p> <p>Aromatic amines, prepared by the reduction of nitro compounds, are used in the manufacture of dyes.</p>		
	3.3.11.2  Amines – Base Properties	<p>Amines are weak bases.</p> <p>The difference in base strength between ammonia, primary aliphatic and primary aromatic amines.</p> <p>Students should be able to explain the difference in base strength in terms of the availability of the lone pair of electrons on the N atom.</p>		

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	3.3.11.3 Amines – Nucleophilic Properties	<p>Amines are nucleophiles.</p> <p>The nucleophilic substitution reactions of ammonia and amines with halogenoalkanes to form primary, secondary, tertiary amines and quaternary ammonium salts.</p> <p>The use of quaternary ammonium salts as cationic surfactants.</p> <p>The nucleophilic addition–elimination reactions of ammonia and primary amines with acyl chlorides and acid anhydrides.</p> <p>Students should be able to outline the mechanisms of:</p> <ul style="list-style-type: none"> <li>these nucleophilic substitution reactions</li> <li>the nucleophilic addition–elimination reactions of ammonia and primary amines with acyl chlorides.</li> </ul>		



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	3.3.12.1 Condensation Polymers	<p>Condensation polymers are formed by reactions between:</p> <p>dicarboxylic acids and diols</p> <p>dicarboxylic acids and diamines</p> <p>amino acids.</p> <p>The repeating units in polyesters (eg Terylene) and polyamides (eg nylon 6,6 and Kevlar) and the linkages between these repeating units.</p> <p>Typical uses of these polymers.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>draw the repeating unit from monomer structure(s)</li> <li>draw the repeating unit from a section of the polymer chain</li> <li>draw the structure(s) of the monomer(s) from a section of the polymer</li> <li>explain the nature of the intermolecular forces between molecules of condensation polymers.</li> </ul>		

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	3.3.12.2 Biodegradability & Disposal of Polymers	<p>Polyalkenes are chemically inert and non-biodegradable.</p> <p>Polyesters and polyamides can be broken down by hydrolysis and are biodegradable.</p> <p>The advantages and disadvantages of different methods of disposal of polymers, including recycling.</p> <p>Students should be able to explain why polyesters and polyamides can be hydrolysed but polyalkenes cannot.</p>		
	3.3.13.1 Amino Acids	<p>Amino acids have both acidic and basic properties, including the formation of zwitterions.</p> <p>Students should be able to draw the structures of amino acids as zwitterions and the ions formed from amino acids:</p> <p style="padding-left: 40px;">in acid solution</p> <p style="padding-left: 40px;">in alkaline solution.</p>		

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	3.3.13.2 Proteins	<p>Proteins are sequences of amino acids joined by peptide links.</p> <p>The importance of hydrogen bonding and sulfur–sulfur bonds in proteins.</p> <p>The primary, secondary (<math>\alpha</math>-helix and <math>\beta</math>-pleated sheets) and tertiary structure of proteins.</p> <p>Hydrolysis of the peptide link produces the constituent amino acids.</p> <p>Amino acids can be separated and identified by thin-layer chromatography.</p> <p>Amino acids can be located on a chromatogram using developing agents such as ninhydrin or ultraviolet light and identified by their R<sub>f</sub> values.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>draw the structure of a peptide formed from up to three amino acids</li> <li>draw the structure of the amino acids formed by hydrolysis of a peptide</li> <li>identify primary, secondary and tertiary structures in diagrams</li> <li>explain how these structures are maintained by hydrogen bonding and S–S bonds</li> <li>calculate R<sub>f</sub> values from a chromatogram.</li> </ul>		

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	3.3.13.3 Enzymes	<p>Enzymes are proteins.</p> <p>The action of enzymes as catalysts, including the concept of a stereospecific active site that binds to a substrate molecule.</p> <p>The principle of a drug acting as an enzyme inhibitor by blocking the active site.</p> <p>Computers can be used to help design such drugs.</p> <p>Students should be able to explain why a stereospecific active site can only bond to one enantiomeric form of a substrate or drug.</p>		

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	3.3.13.4 DNA	<p>The structures of the phosphate ion, 2-deoxyribose (a pentose sugar) and the four bases adenine, cytosine, guanine and thymine are given in the Chemistry Data Booklet.</p> <p>A nucleotide is made up from a phosphate ion bonded to 2-deoxyribose which is in turn bonded to one of the four bases adenine, cytosine, guanine and thymine.</p> <p>A single strand of DNA (deoxyribonucleic acid) is a polymer of nucleotides linked by covalent bonds between the phosphate group of one nucleotide and the 2-deoxyribose of another nucleotide. This results in a sugar-phosphate-sugar-phosphate polymer chain with bases attached to the sugars in the chain.</p> <p>DNA exists as two complementary strands arranged in the form of a double helix.</p> <p>Students should be able to explain how hydrogen bonding between base pairs leads to the two complementary strands of DNA.</p>		

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	3.3.13.5 Action of Anticancer Drugs	<p>The Pt(II) complex cisplatin is used as an anticancer drug.</p> <p>Cisplatin prevents DNA replication in cancer cells by a ligand replacement reaction with DNA in which a bond is formed between platinum and a nitrogen atom on guanine.</p> <p>Appreciate that society needs to assess the balance between the benefits and the adverse effects of drugs, such as the anticancer drug cisplatin.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>explain why cisplatin prevents DNA replication</li> <li>explain why such drugs can have adverse effects.</li> </ul>		
	3.3.14 Organic Synthesis	<p>The synthesis of an organic compound can involve several steps.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>explain why chemists aim to design processes that do not require a solvent and that use non-hazardous starting materials</li> <li>explain why chemists aim to design production methods with fewer steps that have a high percentage atom economy</li> <li>use reactions in this specification to devise a synthesis, with up to four steps, for an organic compound.</li> </ul>		

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	<p>3.3.15</p> <p>Nuclear Magnetic Resonance Spectroscopy</p>	<p>Appreciation that scientists have developed a range of analytical techniques which together enable the structures of new compounds to be confirmed.</p> <p>Nuclear magnetic resonance (NMR) gives information about the position of <math>^{13}\text{C}</math> or <math>^1\text{H}</math> atoms in a molecule.</p> <p><math>^{13}\text{C}</math> NMR gives simpler spectra than <math>^1\text{H}</math> NMR.</p> <p>The use of the <math>\delta</math> scale for recording chemical shift. Chemical shift depends on the molecular environment.</p> <p>Integrated spectra indicate the relative numbers of <math>^1\text{H}</math> atoms in different environments.</p> <p><math>^1\text{H}</math> NMR spectra are obtained using samples dissolved in deuterated solvents or <math>\text{CCl}_4</math></p> <p>The use of tetramethylsilane (TMS) as a standard.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>explain why TMS is a suitable substance to use as a standard</li> <li>use <math>^1\text{H}</math> NMR and <math>^{13}\text{C}</math> NMR spectra and chemical shift data from the Chemistry Data Booklet to suggest possible structures or part structures for molecules</li> <li>use integration data from <math>^1\text{H}</math> NMR spectra to determine the relative numbers of equivalent protons in the molecule</li> <li>use the n+1 rule to deduce the spin-spin splitting patterns of adjacent, non-equivalent protons, limited to doublet, triplet and quartet formation in aliphatic compounds..</li> </ul>		

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	3.3.16 Chromatography	<p>Chromatography can be used to separate and identify the components in a mixture.</p> <p>Types of chromatography include:</p> <p>thin-layer chromatography (TLC) – a plate is coated with a solid and a solvent moves up the plate</p> <p>column chromatography (CC) – a column is packed with a solid and a solvent moves down the column</p> <p>gas chromatography (GC) – a column is packed with a solid or with a solid coated by a liquid, and a gas is passed through the column under pressure at high temperature.</p> <p>Separation depends on the balance between solubility in the moving phase and retention by the stationary phase.</p> <p>Retention times and Rf values are used to identify different substances.</p> <p>The use of mass spectrometry to analyse the components separated by GC.</p> <p>Students should be able to:</p> <ul style="list-style-type: none"> <li>calculate Rf values from a chromatogram</li> <li>compare retention times and Rf values with standards to identify different substances.</li> </ul> <p><b>Required practical 12</b> <b>Separation of species by thin-layer chromatography.</b></p>		



