A' Level Chemistry – 3.3.8 Aldehydes & Ketones

West Kirby Grammar School

Learning about this topic is important because:
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.

This builds on:
3.3.1 Introduction to Organic Chemistry, 3.3.7 Optical Isomers, 3.3.5 Alcohols

This leads to:
3.3.9 Carboxylic Acids & Derivatives

We will learn:

- Aldehydes are readily oxidised to carboxylic acids.
- Chemical tests to distinguish between aldehydes and ketones including Fehling's solution and Tollens' reagent.
- Aldehydes can be reduced to primary alcohols, and ketones to secondary alcohols, using NaBH4 in aqueous solution. These reduction reactions are examples of nucleophilic addition.
- The nucleophilic addition reactions of carbonyl compounds with KCN, followed by dilute acid, to produce hydroxynitriles.
- Aldehydes and unsymmetrical ketones form mixtures of enantiomers when they react with KCN followed by dilute acid.
- The hazards of using KCN.

We will develop/practise skills including:

Writing overall equations for reduction reactions using [H] as the reductant

Outlining the nucleophilic addition mechanism for reduction reactions with NaBH4 (the nucleophileshould be shown as H^-)

Writing overall equations for the formation of hydroxynitriles using HCN

Outlining 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.

Some of the vocabulary that we will use includes:

Reduction	Nucleophile	Hydroxynitrile
Oxidation	Addition	Enantiomers

You could learn more about this topic by:

AQA Chemistry A-level Organic II Revision - PMT (physicsandmathstutor.com)

Your teacher will assess your knowledge & understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:

End of topic assessed question, retrieval questions, mini white boards, exercise questions, exam questions.

A' Level Chemistry – 3.3.9 Carboxylic Acids

West Kirby Grammar School

Learning about this topic is important because:
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.

This builds on:
3.3.1 Introduction to Organic Chemistry, 3.3.7 Optical Isomers, 3.3.5 Alcohols, 3.3.8 Aldehydes and Ketones

This leads to:
3.3.10 Aromatic Chemistry

We will learn:

- The structures of: carboxylic acids and esters.
- Carboxylic acids are weak acids but will liberate CO2 from carbonates.
- Carboxylic acids and alcohols react, in the presence of an acid catalyst, to give esters.
- Common uses of esters (eg in solvents, plasticisers, perfumes and food flavourings).
- Vegetable oils and animal fats are esters of propane-1,2,3-triol (glycerol).
- Esters can be hydrolysed in acid or alkaline conditions to form alcohols and carboxylic acids or salts of carboxylic acids.
- Vegetable oils and animal fats can be hydrolysed in alkaline conditions to give soap (salts of long-chain carboxylic acids) and glycerol.
- Biodiesel is a mixture of methyl esters of long-chain carboxylic acids. Biodiesel is produced by reacting vegetable oils with methanol in the presence of a catalyst.
- The structures of: acid anhydrides, acyl chlorides and amides.
- The nucleophilic addition–elimination reactions of water, alcohols, ammonia and primary amines with acyl chlorides and acid anhydrides.
- The industrial advantages of ethanoic anhydride over ethanoyl chloride in the manufacture of the drug aspirin.
-

We will develop/practise skills including:

Give the structural, displayed and skeletal formulas of carboxylic acids, esters, acyl chlorides, acid anhydrides and amides

Name carboxylic acids, esters, acyl chlorides, acid anhydrides and amides using IUPAC rules.

Give equations for reactions of:

- carboxylic acids and alcohols to form esters
- Acid and base catalysed hydrolysis of esters
- Hydrolysis of triglycerides to form glycerol and carboxylate salts (saponification)
- Triglycerides with methanol to form biodiesel in an transesterification reaction
- Acyl chlorides with water, alcohols, ammonia and primary amines
- Acid anhydrides with water, alcohols, ammonia and primary amines

Outlining the mechanism of nucleophilic addition–elimination reactions of acyl chlorides with water, alcohols, ammonia and primary amines.

Some of the vocabulary that we will use includes:

You could learn more about this topic by:

A' Level Chemistry – 3.3.9 Carboxylic Acids

Hydrolysis Ester Carboxylic acid Carboxylate salt Acyl chloride Acid anhydride Nucleophilic addition-elimination	Carboxylic Acids
Your teacher will assess your knowledge & understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are: End of topic assessed question, retrieval questions, mini white boards, exercise questions, exam questions.	

A2 Chemistry – 3.3.16 Chromatography

West Kirby Grammar School

Learning about this topic is important because:
Chromatography is an important method for separating and identifying the components of a mixture. Different techniques suit different mixtures, while chromatographic data and mass spectrometry can be combined to identify unknown substances in analytical, pharmaceutical and forensic work.

This builds on:
3.3.6 Organic Analysis (identifying compounds using analytical evidence)
3.3.13 Amino Acids, Proteins and DNA (TLC, locating agents and Rf values)
3.3.14 Organic Synthesis (separating and checking products)
3.3.15 NMR Spectroscopy (combining analytical techniques)

This leads to:
Required Practical 12 (separation of species by thin-layer chromatography); synoptic analytical, organic and practical questions in Papers 2 and 3

We will learn:

- Chromatography can separate and identify the components of a mixture.
- In thin-layer chromatography (TLC), a plate is coated with a solid stationary phase and a solvent moves up the plate.
- In column chromatography (CC), a column is packed with a solid stationary phase and a solvent moves down it.
- In gas chromatography (GC), a carrier gas passes under pressure at high temperature through a column containing a solid, or a solid coated with a liquid.
- Separation depends on the balance between solubility in the moving phase and retention by the stationary phase.
- Rf values and retention times can identify substances by comparison with standards; mass spectrometry can analyse components separated by GC.

We will develop/practise skills including:

- Identifying the moving and stationary phases in TLC, column chromatography and GC.
- Explaining different rates of movement using relative solubility in the moving phase and retention by the stationary phase.
- Carrying out TLC safely: applying small spots above the solvent, covering the chamber, marking the solvent front and locating separated spots.
- Calculating Rf = distance moved by substance ÷ distance moved by solvent front.
- Comparing Rf values and GC retention times with standards, while recognising that values depend on the conditions used.
- Interpreting a gas chromatogram and explaining how GC–MS uses mass spectra to identify separated components.

Some of the vocabulary that we will use includes:
chromatography, chromatogram, stationary phase, moving phase, mobile phase, retention, solubility, TLC, column chromatography, GC, carrier gas, solvent front, Rf value, retention time, standard, developing agent, GC–MS, mass spectrum

You could learn more about this topic by:
PMT - 3.16 Chromatography Questions
Chemguide - Chromatography

Your teacher will assess your knowledge and understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
Required Practical 12, Rf calculations, chromatogram interpretation, an end-of-topic assessed question, retrieval questions, mini whiteboards, exercise questions and exam questions.

AS Chemistry – 3.3.10 Aromatic Chemistry

West Kirby Grammar School

Learning about this topic is important because:

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.

This builds on:
GCSE – Organic Chemistry, AS – Introduction to Organic Chemistry, halogenoalkanes, Alkenes

This leads to:
3.3.11 Amines

We will learn:
What is the structure and bonding in a molecule of benzene?
What evidence is there of this being the true structure?
How does bond enthalpy data show that benzene is more stable that cyclohexa-1,3,5-triene?
Why does benzene undergo substitution reactions rather than addition?
What is the mechanism for the electrophilic substitution of benzene?
Why is nitration of benzene important?
What are the reactants, conditions and mechanisms for the Freidel-Crafts acylation of aromatic compounds?

We will develop/practise skills including:
Naming and drawing aromatic compounds using IUPAC nomenclature

Outlining curly arrow mechanisms for electrophilic substitution reactions of aromatic compounds

Giving the steps, reactants, conditions and mechanisms of the Freidel-Crafts acylation of aromatic compounds

Predicting the products of reactions of aromatic compounds given the reactants and reaction conditions

Some of the vocabulary that we will use includes:

Benzene, phenol / phenyl, electrophile, nitration, acylation, delocalisation

You could learn more about this topic by:
AQA A-Level Chemistry - Aromatic Chemistry 1 (Benzene Structure) - YouTube
AQA A-Level Chemistry - Aromatic Chemistry 2 (Nitration) - YouTube
AQA A-Level Chemistry - Aromatic Chemistry 3 (Friedel-Crafts Acylation) - YouTube

Your teacher will assess your knowledge & understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:

End of topic assessed question, retrieval questions, mini white boards, exercise questions.

AS Chemistry – 3.3.10 Aromatic Chemistry

West Kirby Grammar School

A2 Chemistry – 3.3.11 Amines

West Kirby Grammar School

Learning about this topic is important because:
Amines are compounds based on ammonia in which hydrogen atoms have been replaced by alkyl or aryl groups. Their lone pair of electrons makes them weak bases and nucleophiles, so amines are important in organic synthesis and in the manufacture of dyes, medicines and polymers.

This builds on:
3.1.12 Acids and Bases (weak bases)
3.3.3 Halogenoalkanes (nucleophilic substitution)
3.3.9 Carboxylic Acids and Derivatives (acylation)
3.3.10 Aromatic Chemistry (nitro compounds)

This leads to:
3.3.12 Polymers (diamines and polyamides); 3.3.13 Amino Acids, Proteins and DNA; 3.3.14 Organic Synthesis

We will learn:

- How primary aliphatic amines are prepared from halogenoalkanes and by reducing nitriles.
- How aromatic amines are prepared by reducing nitro compounds, and why they are used to manufacture dyes.
- Why amines are weak bases, and how the base strengths of ammonia, primary aliphatic amines and primary aromatic amines compare.
- How ammonia and amines react with halogenoalkanes to form primary, secondary and tertiary amines and quaternary ammonium salts.
- How quaternary ammonium salts act as cationic surfactants.
- How ammonia and primary amines react with acyl chlorides and acid anhydrides by nucleophilic addition–elimination.

We will develop/practise skills including:

- Naming and drawing primary, secondary and tertiary amines, plus quaternary ammonium ions.
- Writing equations for the preparation and reactions of amines, including suitable reagents and conditions.
- Explaining differences in base strength using the availability of the lone pair of electrons on nitrogen.
- Outlining nucleophilic substitution mechanisms for reactions of ammonia and amines with halogenoalkanes.
- Outlining nucleophilic addition–elimination mechanisms for reactions of ammonia and primary amines with acyl chlorides, and predicting products with acid anhydrides.

Some of the vocabulary that we will use includes:
Amine, primary, secondary, tertiary, aliphatic, aromatic, alkyl, aryl, weak base, nucleophile, lone pair, quaternary ammonium salt, cationic surfactant, nucleophilic substitution, nucleophilic addition–elimination, amide

You could learn more about this topic by:
AQA Chemistry A-level Organic II Revision - PMT
Chemguide - Amines

Your teacher will assess your knowledge and understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
End-of-topic assessed question, retrieval questions, mini whiteboards, exercise questions and exam questions.

A2 Chemistry – 3.3.12 - Polymers

West Kirby Grammar School

Learning about this topic is important because:
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.

This builds on:
3.3.4 Alkenes (Addition Polymers)
3.3.9 Carboxylic Acids and Derivatives (Esterification)
3.3.10 Aromatic Chemistry (Kevlar etc.)
3.3.11 Amines
3.3.13 Amino Acids, Proteins and DNA (Natural Polymers - Condensation)

This leads to:
3.3.14 Organic Synthesis

We will learn:
Condensation polymers are formed by reactions between dicarboxylic acids and diols, dicarboxylic acids and diamines, amino acids.
The repeating units in polyesters (eg Terylene) and polyamides (eg nylon 6,6 and Kevlar) and the linkages between these repeating units.
Typical uses of these polymers.
Polyalkenes are chemically inert and non-biodegradable.
Polyesters and polyamides can be broken down by hydrolysis and are biodegradable.
The advantages and disadvantages of different methods of disposal of polymers, including recycling.
Why polyesters and polyamides can be hydrolysed but polyalkenes cannot.

We will develop/practise skills including:
Drawing the repeating unit from monomer structure(s)

Drawing the repeating unit from a section of the polymer chain

Drawing the structure(s) of the monomer(s) from a section of the polymer

Some of the vocabulary that we will use includes:
Addition, condensation, hydrolysis, polymerisation, polymer, repeating unit, biodegradable, non-biodegradable, terylene, nylon, Kevlar

You could learn more about this topic by:
AQA A-Level Chemistry - Polymers - YouTube

Your teacher will assess your knowledge & understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
End of topic assessed question, retrieval questions, mini white boards, exercise questions

A2 Chemistry – 3.3.14 Organic Synthesis

West Kirby Grammar School

Learning about this topic is important because:
The formation of new organic compounds by multi-step syntheses using reactions from across the specification is covered in this section. Organic synthesis is used to make medicines, polymers, dyes and other useful materials, so chemists must balance effectiveness with safety, efficiency and environmental impact.

This builds on:
3.1.2 Amount of Substance (percentage atom economy)
3.3.1 Introduction to Organic Chemistry (nomenclature and mechanisms)
3.3.2 to 3.3.6 Organic Chemistry I (functional-group reactions and analysis)
3.3.7 to 3.3.13 Organic Chemistry II (advanced reactions and mechanisms)

This leads to:
3.3.15 Nuclear Magnetic Resonance Spectroscopy; 3.3.16 Chromatography; synoptic organic synthesis and analysis questions in Papers 2 and 3

We will learn:

- How reactions from earlier organic topics can be linked to form a multi-step synthetic route.
- How each step transforms a functional group and produces an intermediate needed for the next reaction.
- Why chemists aim to design processes that avoid solvents and use non-hazardous starting materials.
- Why routes with fewer steps are preferred and how additional steps can increase waste and cost while reducing overall yield.
- Why a high percentage atom economy is desirable and how it reduces the production of waste.
- How alternative routes to the same target molecule can be compared for sustainability, safety and efficiency.

We will develop/practise skills including:

- Identifying the functional groups in starting materials, intermediates and target molecules.
- Selecting suitable reactions, reagents and conditions and predicting the products formed.
- Devising a synthesis of up to four steps, showing the structure of each intermediate.
- Working forwards from a starting material or backwards from a target molecule to plan a route.
- Calculating and comparing percentage atom economy, and distinguishing atom economy from percentage yield.
- Evaluating routes using the number of steps, solvent use, hazards, waste and overall efficiency.

Some of the vocabulary that we will use includes:
Organic synthesis, synthetic route, target molecule, intermediate, functional-group transformation, reagent, conditions, catalyst, solvent, hazardous, multi-step, atom economy, percentage yield, by-product, waste, sustainable chemistry

You could learn more about this topic by:
PMT - 3.14 Organic Synthesis Questions
Chemguide - Organic Mechanisms

Your teacher will assess your knowledge and understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
End-of-topic assessed question, synthesis route practice, retrieval questions, mini whiteboards, exercise questions and exam questions.

A2 Chemistry – 3.3.15 NMR Spectroscopy

West Kirby Grammar School

Learning about this topic is important because:
Chemists use a range of analytical techniques to deduce and confirm the structures of compounds. Nuclear magnetic resonance spectroscopy adds detailed information about carbon and hydrogen environments to evidence from mass spectrometry and infrared spectroscopy, allowing unknown compounds and products of synthesis to be identified.

This builds on:
3.3.1 Introduction to Organic Chemistry (structures, nomenclature and isomerism)
3.3.2 to 3.3.13 Organic Chemistry (functional groups and molecular environments)
3.3.6 Organic Analysis (mass spectrometry and infrared spectroscopy)
3.3.14 Organic Synthesis (confirming the identity of products)

This leads to:
3.3.16 Chromatography; combined structure-determination and organic synthesis problems in Papers 2 and 3

We will learn:

- NMR gives information about the different environments of 13C or 1H atoms in a molecule.
- Chemically equivalent atoms produce the same signal; the number of signals therefore reveals the number of distinct environments.
- 13C NMR spectra are simpler than 1H NMR spectra.
- Chemical shift is recorded on the delta scale in ppm and depends on the molecular environment of the atom.
- Integration gives the relative numbers of 1H atoms in each environment.
- Spin-spin splitting is caused by adjacent, non-equivalent protons and can be predicted using the n+1 rule.
- 1H NMR samples are dissolved in deuterated solvents or CCl4, with tetramethylsilane (TMS) used as the standard.

We will develop/practise skills including:

- Explaining why TMS is a suitable standard, including its single sharp peak at delta = 0, inertness, volatility and solubility in organic solvents.
- Using 13C NMR spectra and chemical-shift data to identify carbon environments and suggest structures.
- Using 1H NMR chemical shifts and integration ratios to identify proton environments and part structures.
- Applying the n+1 rule to predict and interpret singlet, doublet, triplet and quartet splitting patterns in aliphatic compounds.
- Predicting the number, relative area and splitting of signals expected from a proposed structure.
- Combining molecular formula, mass-spectrometry, IR and NMR evidence to deduce an unknown structure.

Some of the vocabulary that we will use includes:
NMR, 13C NMR, 1H NMR, chemical environment, chemical shift, delta scale, ppm, TMS, standard, deuterated solvent, integration, equivalent protons, spin-spin splitting, n+1 rule, singlet, doublet, triplet, quartet

You could learn more about this topic by:
PMT - 3.15 NMR Spectroscopy Questions
Chemguide - NMR Spectroscopy

Your teacher will assess your knowledge and understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
End-of-topic assessed question, structure-deduction problems, retrieval questions, mini whiteboards, exercise questions and exam questions.

A2 Chemistry – 3.1.12 Acids and Bases

West Kirby Grammar School

Learning about this topic is important because:
Acid–base chemistry is central to domestic, environmental, biological and industrial processes. Quantitative ideas such as pH, acid strength and buffer action allow chemists to measure, predict and control acidity across a very wide range of hydrogen-ion concentrations.

This builds on:
GCSE Chemistry (pH, neutralisation, strong and weak acids, concentrated and dilute solutions)
3.1.2 Amount of Substance (moles, concentrations and titration calculations)
3.1.6 Chemical Equilibria (dynamic equilibrium, Le Chatelier's principle and Kc)
Mathematical skills (standard form, logarithms and rearranging equations)

This leads to:
3.2.4 Period 3 oxides; 3.2.6 reactions of ions in aqueous solution; 3.3.11 amine basicity; 3.3.13 amino acids; Required Practical 9 and synoptic questions in Papers 1 and 3

We will learn:

- A Brønsted–Lowry acid is a proton donor, a base is a proton acceptor, and acid–base equilibria transfer protons.
- pH is a logarithmic measure of hydrogen-ion concentration: $pH = -\log_{10}[H^+]$.
- Water is slightly dissociated; $K_w = [H^+][OH^-]$, and the value of K_w varies with temperature.
- Strong acids and bases dissociate completely, whereas weak acids and bases dissociate only slightly in aqueous solution.
- Ka measures weak-acid dissociation and $pKa = -\log_{10}Ka$; a larger Ka or smaller pKa indicates a stronger acid.
- The four combinations of strong and weak monoprotic acids and bases give characteristic pH curves; indicator ranges must lie within the steep pH change.
- Acidic buffers contain a weak acid and its salt; basic buffers contain a weak base and its salt, and both resist pH change.

We will develop/practise skills including:

- Writing proton-transfer equations and identifying the acid, base and conjugate acid–base pairs.
- Converting between pH and $[H^+]$, and calculating the pH of strong-acid solutions.
- Using Kw to calculate $[H^+]$ and the pH of strong-base solutions at a stated temperature.
- Constructing Ka expressions, calculating weak-acid pH, and converting between Ka and pKa.
- Completing acid–base titration calculations and sketching and explaining all four typical pH curves.
- Selecting a suitable indicator from its transition range and interpreting equivalence and half-equivalence points.
- Explaining acidic and basic buffer action and calculating the pH of acidic buffers, including after small additions of acid or base.
- Using a pH probe to collect, plot and evaluate data for Required Practical 9.

Some of the vocabulary that we will use includes:
Brønsted–Lowry acid, base, proton donor, proton acceptor, conjugate pair, strong, weak, dissociation, pH, hydrogen-ion concentration, Kw, Ka, pKa, monoprotic, titration curve, equivalence point, half-equivalence, indicator, transition range, buffer, acidic buffer, basic buffer

You could learn more about this topic by:
PMT - 1.12 Acids and Bases Questions
Chemguide - Acid–Base Equilibria

Your teacher will assess your knowledge and understanding throughout the topic by looking at your work, questioning, discussion and giving you feedback in lots of different ways. The key pieces of work in this topic are:
Required Practical 9, pH/Ka/Kw/buffer calculations, titration-curve and indicator problems, an end-of-topic assessed question, retrieval questions, mini whiteboards, exercise questions and exam questions.