

Synthesis

1	Method for making an aldehyde	An aldehyde is made when a primary alcohol is oxidised using acidified potassium dichromate (distillation) . It is necessary to immediately distill off the aldehyde at its boiling point so that it does not fully oxidise to form a carboxylic acid
2	Example of making an aldehyde	Oxidation of primary alcohol to aldehyde , e.g. methanol to methanal $\text{CH}_3\text{OH} + [\text{O}] \longrightarrow \text{HCHO} + \text{H}_2\text{O}$
3	Method for making a ketone	A ketone is made when a secondary alcohol is oxidised using excess acidified potassium dichromate (reflux) . Acidified potassium dichromate is itself reduced in the reaction (oxidising agent) so there will be a colour change from orange to green .
4	Example of making a ketone	Oxidation of secondary alcohol to ketone , e.g. propan-2-ol to propanone $\text{CH}_3\text{C}(\text{OH})\text{HCH}_3 + [\text{O}] \longrightarrow \text{CH}_3\text{COCH}_3 + \text{H}_2\text{O}$
5	What about tertiary alcohols?	Note that tertiary alcohols are resistant to oxidation with acidified potassium dichromate
6	Reduction half equation	$\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{e}^- \longrightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$

Key features & characteristics

1	Structure	Aldehydes have the functional group R-CHO and ketones RCOR' .
2	Functional group Isomerism	Aldehydes and ketones are functional group isomers of each other. This means they have the same molecular formula but different structural formulas .
3	Positional isomerism	Some ketones may have positional isomerism of the functional group—the pentanones are the first ketones to exhibit positional isomerism as pentan-2-one & pentan-3-one exist
4	Chemical tests to distinguish between aldehydes & ketones	Use Tollens' reagent (contains $[\text{Ag}(\text{NH}_3)_2]^+$ and heat in a water bath. An aldehyde will form a silver mirror but a ketone will show no colour change. The Ag^+ ions are reduced to Ag metal and the aldehyde is oxidised to a carboxylic acid . Alternatively, add Fehling's solution (contains Cu^{2+} in alkaline solution) and heat in a water bath. An aldehyde will form an orange-red precipitate but there will be no observable change with a ketone. The Cu^{2+} ions are reduced to Cu^+ ions and the aldehyde is oxidised to a carboxylic acid: $\text{RCHO} + [\text{O}] \longrightarrow \text{RCOOH}$

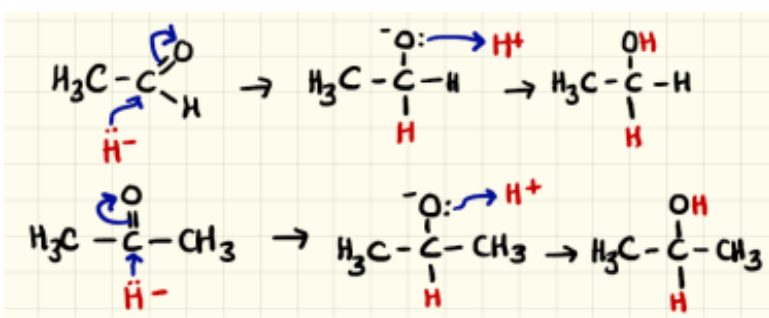
Key Vocabulary

1	Carbonyl compounds	Compounds that contain the carbonyl functional group (C=O). For example, aldehydes and ketones. The position of the group is different in aldehydes and ketones
2	Aldehyde	Compound containing the carbonyl group at the end of the carbon chain. Their names end in -al (RCHO). The C of the CHO group is carbon atom number 1
3	Ketones	Compound containing the carbonyl group in the middle of the carbon chain. Their names end in -one , & often have a number to show which carbon the carbonyl group is on (RCOR')
4	Nucleophilic addition	When a nucleophile attacks a molecule and adds itself as an extra group
5	Nucleophile	A species that is a lone pair donor
6	Polar	A covalent bond between 2 atoms where the pair of electrons are shared unequally due to a difference in electronegativity

Making carboxylic acids from an aldehyde

1	Method to convert aldehyde to carboxylic acid	If you fully oxidise a primary alcohol using excess acidified potassium dichromate and reflux or oxidise an aldehyde with Tollens' reagent or Fehling's solution , you will produce the corresponding carboxylic acid
2	Example equation	$\text{CH}_3\text{CHO} + [\text{O}] \longrightarrow \text{CH}_3\text{COOH}$ [O] represents oxidising agent
3	Example half-equation	$\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^-$

Nucleophilic addition (reduction)

1	Reagent & conditions	Sodium tetrahydridoborate (III) (NaBH_4) in aqueous methanol
2	Nucleophile	The nucleophile is the hydride ion (H^-)
3	Products	The <u>aldehyde</u> is reduced to form its corresponding PRIMARY ALCOHOL and the <u>ketone</u> is reduced to form its corresponding SECONDARY ALCOHOL
4	Example	$\text{CH}_3\text{CH}_2\text{COCH}_3 + 2[\text{H}] \longrightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
5	Mechanism examples with ethanal and propanone	

Why do nucleophiles attack aldehydes & ketones?

1	The carbonyl group is planar...
2	...so the nucleophile attacks the carbonyl group with equal probability from above and below..
3	..so that equal amounts of each enantiomer are formed (racemate).
4	The racemate has no effect on plane polarised light as each enantiomer rotates the plane of plane polarised light in opposite directions but by equal amounts so that there is no overall effect (optically inactive).

Reactions & Mechanisms

1	Aldehydes & ketones both undergo NUCLEOPHILIC ADDITION mechanisms
2	This is because the C=O (carbonyl) bond is polar due to oxygen having a greater electronegativity compared to carbon . This means the electron deficient carbon atom is susceptible to attack by a nucleophile.
3	This is an addition reaction because the double C=O bond opens up to add the nucleophile into the molecule.
4	There are 2 reactions to remember: a) REDUCTION using NaBH_4 to make alcohols and b) reaction with KCN to make a hydroxynitrile

Nucleophilic addition (with KCN)

Reflux with **aqueous alcoholic KCN**. The nucleophile is **CN^-** . The product is a **HYDROXYNITRILE**. HCN is not usually used as it is a gas and toxic. KCN is also toxic and as HCN is produced *in situ*, the reaction should be carried out in a **fume cupboard**.

