Edexcel IAL Chemistry A-Level

Topic 15 - Carbonyls, Carboxylic Acids and Chirality

Flashcards

What is optical isomerism?

What is optical isomerism?

Optical isomerism is a type of stereoisomerism found in molecules that contain a chiral centre. Optical isomers, or enantiomers, are non-superimposable, mirror images of each other.

What is chirality?

What is chirality?

In organic chemistry, a chiral centre is when a carbon atom is bonded to four different groups.

What is optical activity?

What is optical activity?

The ability of an optical isomer to rotate plane polarised monochromatic light.

How can the two different enantiomers of a compound be identified?

How can the two different enantiomers of a compound be identified?

Each enantiomer rotates plane polarised light in an opposite direction.

What is a racemic mixture?

What is a racemic mixture?

A mixture containing equal amounts of each enantiomer of a compound.

Describe the optical activity of a racemic mixture

Describe the optical activity of a racemic mixture

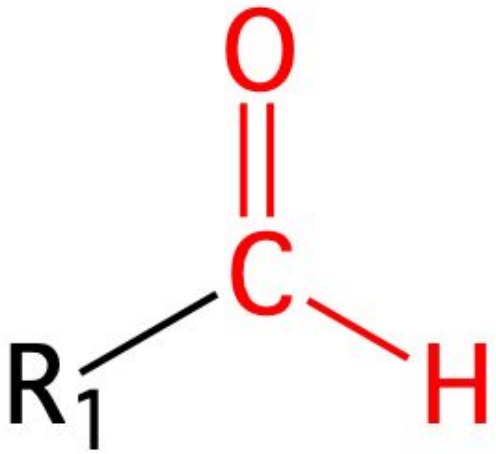
A racemic mixture will have no effect on plane polarised light. This is because each enantiomer will rotate the light in opposite directions by the same amount so there will be no overall rotation since the enantiomers are in equal quantities.

What is an aldehyde? Give an example.

What is an aldehyde? Give an example.

An aldehyde is a carbonyl compound. The functional group is -CHO.

They have the suffix -al, e.g. methanal, ethanal and propanal.

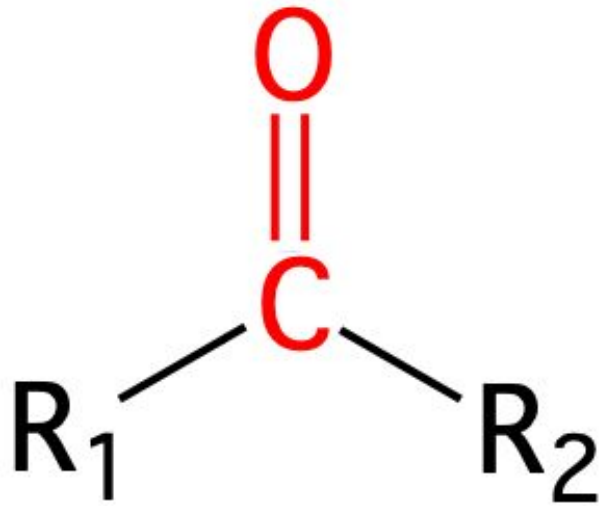


What is a ketone? Give an example.

What is a ketone? Give an example.

A ketone is a carbonyl compound. They consist of a C=O group between two alkyl groups.

They have the suffix -one, e.g. propanone, butan-2-one, pentan-3-one.



Why do aldehydes and ketones not form intermolecular hydrogen bonds?

Why do aldehydes and ketones not form intermolecular hydrogen bonds?

Aldehydes and ketones do not form hydrogen bonds between molecules because there are no hydrogen atoms bonded to oxygen atoms in their structures (there are no -OH groups).

How does the inability of aldehydes and ketones to form intermolecular hydrogen bonds affect their physical properties?

How does the inability of aldehydes and ketones to form intermolecular hydrogen bonds affect their physical properties?

Aldehydes and ketones have relatively low boiling points because they do not have hydrogen bonds between molecules. Their boiling points are affected by the strength of the London and dipole-dipole intermolecular forces.

Explain the solubility of aldehydes and ketones

Explain the solubility of aldehydes and ketones

Aldehydes and ketones are able to form hydrogen bonds with water molecules because the electronegative oxygen from the carbonyl is attracted to the slightly positive hydrogen atom on the water molecule. This means aldehydes and ketones are soluble in water.

How do aldehydes and ketones react with Fehling's solution?

How do aldehydes and ketones react with Fehling's solution?

Warm the sample with blue Fehling's solution.

- If an aldehyde is present, the blue solution will form a brick red precipitate.
- Ketones don't react with Fehling's solution. The solution will remain blue.

How do aldehydes and ketones react with Tollens' reagent?

How do aldehydes and ketones react with Tollens' reagent?

Warm the sample with Tollens' reagent.

- If an aldehyde is present, a silver mirror will form on the walls of the test tube. The aldehyde is oxidised to a carboxylic acid.
- Ketones do not react with Tollens' reagent, so no silver mirror will form.

How do aldehydes and ketones react with acidified dichromate(VI) ions?

How do aldehydes and ketones react with acidified dichromate(VI) ions?

- Aldehydes are oxidised by acidified dichromate(VI) ions under reflux to form carboxylic acids. There will be a colour change from **orange** to **green**:

$$CH_3CHO + [O] \rightarrow CH_3COOH$$

- Ketones do not react with acidified dichromate(VI) ions. The solution will remain **orange**.

How do aldehydes react with $LiAlH_4$?

How do aldehydes react with LiAlH4?

Aldehydes are reduced to primary alcohols.

The reducing agent, $LiAlH_4$ is represented by [H]:

$$CH_3CHO + 2[H] \rightarrow CH_3CH_2OH$$

How do ketones react with $LiAlH_4$?

How do ketones react with LiAlH4?

Ketones are reduced to secondary alcohols.

The reducing agent, $LiAlH_4$ is represented by [H]:

$$CH_3COCH_3 + 2[H] \rightarrow CH_3CH(OH)CH_3$$

What qualitative test can be used to test for the presence of a carbonyl group?

What qualitative test can be used to test for the presence of a carbonyl group?

- React with 2,4-DNPH.
- Carbonyl compounds will produce a yellow/orange/red precipitate.

How do carbonyl compounds undergo nucleophilic addition of HCN?

How do carbonyl compounds undergo nucleophilic addition of HCN?

Aldehydes and ketones are reduced by HCN to form hydroxynitriles:

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$$

$$CH_3COCH_3 + HCN \rightarrow CH_3C(OH)CNCH_3$$

How do carbonyl compounds react with iodine in the presence of an alkali?

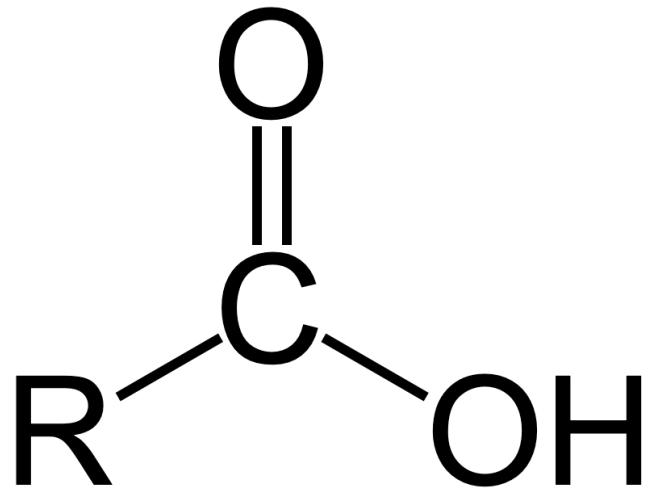
How do carbonyl compounds react with iodine in the presence of an alkali?

- Add iodine solution and a little NaOH solution (to remove the colour of the iodine) to an aldehyde or ketone containing a CH_3COR group.
- A positive result is the formation of a pale yellow precipitate of triiodomethane, CHI_3.

What is a carboxylic acid and why is it a weak acid?

What is a carboxylic acid and why is it a weak acid?

A carboxylic acid is an organic compound with the -COOH functional group.



It is a weak acid because it only partially dissociates in water to form $-COO^-$ and H^+.

What are some examples of molecules with a carboxylic acid functional group?

What are some examples of molecules with a carboxylic acid functional group?

- Benzoic acid
- Methanoic acid
- Ethanoic acid
- Propanoic acid
- Butanoic acid

Explain the physical properties of carboxylic acids

Explain the physical properties of carboxylic acids

- They have much higher boiling points than corresponding hydrocarbons, aldehydes, ketones and alcohols due to having two groups that form hydrogen bonds with other carboxylic acids (the C=O and -OH groups).
- Generally carboxylic acids are soluble in water as they can form hydrogen bonds with water molecules. Their solubility in water decreases as chain length increases.

By which 2 methods can you prepare carboxylic acids?

By which 2 methods can you prepare carboxylic acids?

- Oxidation of primary alcohols.
- Acid hydrolysis of nitriles.

How do you prepare carboxylic acids by the oxidation of alcohols?

How do you prepare carboxylic acids by the oxidation of alcohols?

The alcohol must be a primary alcohol.

Heat alcohol under reflux with acidified potassium dichromate(VI). There will be colour change from **orange** to green.

$$CH_3CH_2OH + 2[O] \rightarrow CH_3COOH + H_2O$$

How do you prepare carboxylic acids by the oxidation of aldehydes?

How do you prepare carboxylic acids by the oxidation of aldehydes?

- Heat the aldehyde under reflux with acidified potassium dichromate(VI).
- There will be a colour change from **orange** to **green**.

$$CH_3CHO + [O] \rightarrow CH_3COOH$$

How are carboxylic acids produced by the acid hydrolysis of nitriles?

How are carboxylic acids produced by the acid hydrolysis of nitriles?

Heat under reflux with dilute HCl:

$$CH_3CN + 2H_2O + HCl \rightarrow CH_3COOH + NH_4Cl$$

How do carboxylic acids react with $LiAlH_4$?

How do carboxylic acids react with $LiAlH_4$?

Carboxylic acids are reduced to primary alcohols.

The reducing agent, $LiAlH_4$, is shown as [H]:

$$CH_3COOH + 4[H] \rightarrow CH_3CH_2OH + H_2O$$

How do carboxylic acids react with metals?

How do carboxylic acids react with metals?

Carboxylic acids react with metals to form a salt and hydrogen gas.

$$2CH_3COOH + 2Na \rightarrow 2CH_3COO^-Na^+ + H_2$$

How do carboxylic acids react with alkalis?

How do carboxylic acids react with alkalis?

Carboxylic acids react with alkalis to form a salt and water.

$$CH_3COOH + NaOH \rightarrow CH_3COO^-Na^+ + H_2O$$

How do carboxylic acids react with carbonates?

How do carboxylic acids react with carbonates?

Carboxylic acids react with carbonates to form a salt, water and carbon dioxide.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COO^-Na^+ + H_2O + CO_2$$

How do carboxylic acids react with phosphorus(V) chloride?

How do carboxylic acids react with phosphorus(V) chloride?

Carboxylic acids react with phosphorus(V) chloride to form an acyl chloride and other compounds:

$$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$$

How do carboxylic acids react to form esters?

How do carboxylic acids react to form esters?

Carboxylic acids are heated with primary or secondary alcohols and concentrated sulfuric acid, to form esters in a process called esterification:

$$CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$$

What is an ester?

What is an ester?

A carboxylic acid derivative with the functional group -COO- where the hydrogen at the end of the -COOH group has been replaced with an alkyl group.

Normally made from the reaction between an alcohol and carboxylic acid.

E.g. Methanol, CH_3OH and Ethanoic acid CH_3COOH react to form Methyl Ethanoate, CH_3COOCH_3.

How do esters undergo acid hydrolysis?

How do esters undergo acid hydrolysis?

Heat under reflux with dilute aqueous acid. The ester will be hydrolysed into a carboxylic acid and alcohol.

The reaction is slow and reversible.

$$CH_3COOCH_3 + H_2O \rightleftharpoons CH_3COOH + CH_3OH$$

How do esters undergo base hydrolysis?

How do esters undergo base hydrolysis?

Heat under reflux with a dilute alkali. The ester will be hydrolysed into the salt of the carboxylic acid, and the alcohol. The reaction is one-way and faster than acid hydrolysis.

$$CH_3COOCH_3 + NaOH \rightarrow CH_3COO^-Na^+ + CH_3OH$$

How are polyesters formed?

How are polyesters formed?

By condensation reactions between carboxylic acid and alcohol functional groups, forming an ester link between them.

Polyesters can form from:

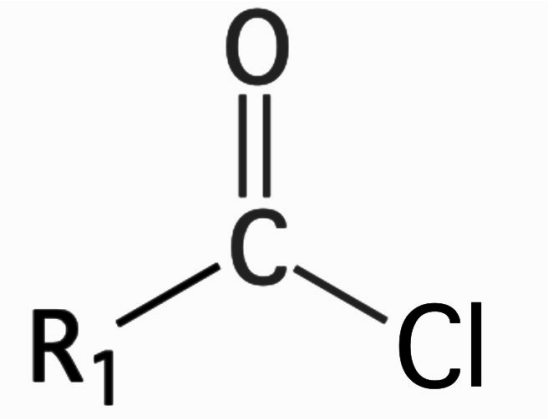
- Alternative diol and dicarboxylic acid monomers reacting together.
- Monomers with both an alcohol and carboxylic acid group reacting with each other.

What is an acyl chloride?

What is an acyl chloride?

A carboxylic acid derivative where the -OH in the -COOH group has been replaced by a chlorine atom.

E.g. CH_3COCl → Ethanoyl chloride



How do acyl chlorides react with water ?

How do acyl chlorides react with water ?

Acyl chlorides react with cold water to form carboxylic acids and hydrochloric acid:

$$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$$

How do acyl chlorides react with alcohols?

How do acyl chlorides react with alcohols?

Acyl chlorides react with alcohols to form esters and hydrochloric acid:

$$CH_3COCl + CH_3OH \rightarrow CH_3COOCH_3 + HCl$$

How do acyl chlorides react with concentrated ammonia?

How do acyl chlorides react with concentrated ammonia?

Acyl chlorides react with ammonia to form primary amides and hydrochloric acid:

$$CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$$

How do acyl chlorides react with primary amines?

How do acyl chlorides react with primary amines?

Acyl chlorides react with primary amines to form secondary amides and hydrochloric acid:

$$CH_3COCl + CH_3NH_2 \rightarrow CH_3CONHCH_3 + HCl$$

Why is the formation of polyesters important?

Why is the formation of polyesters important?

Polyesters can be used in many industries. For example, they can be used to make plastic bottles or clothing fabrics.

How can you use a combination of spectroscopic techniques to determine the structure of organic molecules?

How can you use a combination of spectroscopic techniques to determine the structure of organic molecules?

1. Mass spectrum (to determine molecular formula).
2. Infrared spectrum (to determine type of molecule/functional group).
3. ^{13}C NMR spectrum & ^{1}H NMR spectrum (to determine the exact structure of the molecule).

What is the effect of infrared radiation on molecules?

What is the effect of infrared radiation on molecules?

- Bonds vibrate at their own frequency.
- They will only absorb IR radiation of the same frequency at which they vibrate at.
- Absorbing IR causes them to vibrate (stretch or bend) more.

How can the way molecules respond to IR radiation be used in analysis?

How can the way molecules respond to IR radiation be used in analysis?

- A vibration of a bond at a specific frequency indicates the presence of a specific group.
- Frequency is proportional to wavenumber (measured in cm^{-1}).
- For example, if there is a peak at around 1000-1300 cm^{-1} then a C-O bond is very likely to be present as that is the usual frequency absorbed by C-O bonds.

What does a proton NMR tell you about a compound?

What does a proton NMR tell you about a compound?

- The chemical shift values can be compared with a data book to identify the types of proton environment in a molecule.
- The number of peaks represents the number of different proton environments.
- The relative peak areas show the relative number of protons in each environment.
- The splitting pattern shows the number of adjacent non-equivalent protons.

How can NMR be used to identify a molecule?

How can NMR be used to identify a molecule?

NMR allows you to identify the different fragments in the molecule which can then be used to predict the structure of the molecule.

What is the n+1 rule in proton NMR?

What is the n+1 rule in proton NMR?

The number of peaks in the splitting pattern is equal to the number of adjacent non-equivalent protons + 1.

What does a ^{13}C spectrum tell you about a compound?

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- The chemical shift values can be compared with a data book to identify the types of carbon environment in a molecule.
- The number of peaks represents the number of different carbon environments.

Name the first four splitting patterns that appear on proton NMR spectra. Use the n+1 rule to explain what they mean

Name the first four splitting patterns that appear on proton NMR spectra. Use the n+1 rule to explain what they mean

Multiplet name	Number of peaks (n+1)	Number of adjacent protons (n)
Singlet	1	0
Doublet	2	1
Triplet	3	2
Quartet	4	3

What are the ratios of peak heights in the following splitting patterns on a proton NMR spectrum: doublet, triplet and quartet?

What are the ratios of peak heights in the following splitting patterns on a proton NMR spectrum: doublet, triplet and quartet?

Doublet - 1:1

Triplet - 1:2:1

Quartet - 1:3:3:1

What is chromatography?

What is chromatography?

Chromatography is a physical technique that separates components of a mixture by using a mobile phase and a stationary phase.

How does chromatography work?

How does chromatography work?

Chromatography is able to separate a mixture because the different substances have different solubilities in the mobile phase. This causes the substances to separate.

What is an Rf value?

What is an Rf value?

An Rf value is the ratio between the distance travelled by the dissolved substance (the solute) and the distance travelled by the solvent.

How can you use chromatography to see if a certain substance is present in a mixture?

How can you use chromatography to see if a certain substance is present in a mixture?

Run a pure sample of this substance alongside the unknown mixture.

If the Rf value of the pure substance matches the value of one of the spots from the mixture, it is likely to be present.

How do you calculate Rf values?

How do you calculate Rf values?

$$Rf = \frac{\text{Distance travelled by substance}}{\text{Distance travelled by solvent}}$$

What is HPLC and why is it used?

What is HPLC and why is it used?

High performance liquid chromatography is the separation of a mixture into its constituent components using a pressurised column. It allows identification of the substances by the comparison of R_f values.

What is gas-liquid chromatography?

What is gas-liquid chromatography?

A type of chromatography used to separate and analyse compounds that are in the liquid or gaseous phase.

How is gas-liquid chromatography carried out?

How is gas-liquid chromatography carried out?

- The mixture is injected into the column (lined with a high boiling point liquid on a porous support) where it evaporates and is carried through the column by an inert carrier gas.
- Compounds move through the column at different rates due to differing solubilities and volatilities.
- Compounds pass through a detector at the end of the column. This produces a gas chromatogram.
- Each peak = different compound.

What is retention time?

What is retention time?

The time taken from the injection of the mixture to the detection of a compound.

What does the retention time of a compound allow you to do?

What does the retention time of a compound allow you to do?

Compare the time to known values to help identify the compound.