AQA Chemistry A-level

Topic 3.9 - Carboxylic Acids and Derivatives

Flashcards

What is a carboxylic acid? Functional group?

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-COOH (C=O and C-OH)

How do you name carboxylic acids?

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-oic acid

Are carboxylic acids soluble in water? Why? What influences their solubility

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Yes. Acid group can form hydrogen bonds with water molecules

What are the intermolecular forces in carboxylic acids?

What are the intermolecular forces in carboxylic acids?

Hydrogen bonds in solid state - very strong.

What are esters (what are they formed from)? Functional group, general formula?

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Functional group, general formula?

Formed from carboxylic acids and alcohols.

RCOOR’ (C=O, C-O-C)

Write an equation for the reaction of ethanoic acid with propan-1-ol

Write an equation for the reaction of ethanoic acid with propan-1-ol

$$CH_3COOH + CH_3CH_2CH_2OH \rightarrow CH_3COOCH_2CH_2CH_3 + H_2O$$

How do you name esters?

How do you name esters?

Start with the group that has replaced the hydrogen, then acid part e.g. propyl (from alcohol) ethanoate (from carboxylic acid).

What characteristic physical properties do esters have?

What characteristic physical properties do esters have?

Volatile, pleasant fruity smells e.g. apple, pear drops

What are some uses of esters?

What are some uses of esters?

Flavourings, perfumes (both for longer chains), solvents (short chains), plasticisers.

What are some common natural esters?

What are some common natural esters?

Fats and oils

In what way is the carboxylic acid group polarised? (Diagram)

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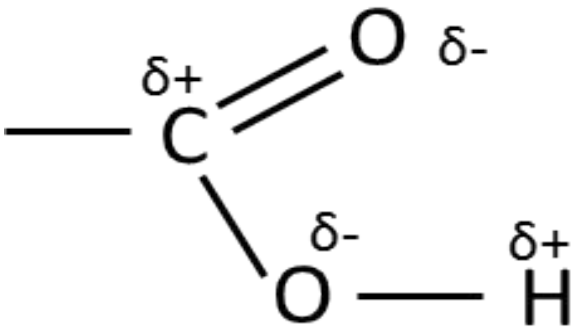
(Diagram)



Write an equation for the equilibrium formed by a ethanoic acid in solution

Write an equation for the equilibrium formed by a ethanoic acid in solution

$$CH_3COOH\ (aq) \rightleftharpoons CH_3COO^-\ (aq) + H^+\ (aq)$$

What happens to the negative charge on the ethanoate ion in terms of electrons?

What happens to the negative charge on the ethanoate ion in terms of electrons?

Electrons delocalise so the negative charge is shared across the whole of the carboxylate group

How could you distinguish carboxylic acids from other -OH containing compounds?

How could you distinguish carboxylic acids from other -OH containing compounds?

Add $NaHCO_3$, acids will produce sodium salt, water and carbon dioxide.

Write an equation for the reaction of ethanoic acid with NaOH

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

Write an equation for the reaction of ethanoic acid with Na_2CO_3.

Write an equation for the reaction of ethanoic acid with Na_2CO_3.

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

What catalyst is needed for the formation of esters from alcohols and carboxylic acids?

What catalyst is needed for the formation of esters from alcohols and carboxylic acids?

Concentrated strong acid e.g. H_2SO_4

What catalyst is needed for the hydrolysis of esters?

What catalyst is needed for the hydrolysis of esters?

Dilute strong acid e.g. H_2SO_4

What is an alternative method of hydrolysis?

What is an alternative method of hydrolysis?

Base hydrolysis

What are the advantages of base hydrolysis?

What are the advantages of base hydrolysis?

Reaction goes to completion due to neutralisation by base - more product in the mixture than acid catalysed hydrolysis.

Which alcohol forms the esters that make up animal and vegetable oils?

Which alcohol forms the esters that make up animal and vegetable oils?

Glycerol / propane-1,2,3-triol

What is the difference between oil and fat?

What is the difference between oil and fat?

Oils are liquid at room temperature, fats are solids; fats are usually saturated, oils are not

What are the products of hydrolysing fats and oils?

What are the products of hydrolysing fats and oils?

Propane-1,2,3-triol and sodium salts of the acids that make up the ester (hydrolysed with NaOH)

What are the uses of these products (Propane-1,2,3-triol and sodium salts)?

What are the uses of these products (Propane-1,2,3-triol and sodium salts)?

Soaps and cleaning products

What does the long hydrocarbon chain of the carboxylate ion do?

What does the long hydrocarbon chain of the carboxylate ion do?

Mixes with grease

What does the COO^- group do?

What does the COO^- group do?

Mixes with water

How does the carboxylate ion with a long carbon chain make a good cleaning agent?

How does the carboxylate ion with a long carbon chain make a good cleaning agent?

Means that grease can be removed from water

What is the systematic name of glycerol?

What is the systematic name of glycerol?

propane-1,2,3-triol

What are some common uses of glycerol?

What are some common uses of glycerol?

Used in pharmaceutical and cosmetic preparations e.g. to stop creams drying out

Solvent in many medicines, present in toothpaste

Solvent in food industry e.g. food colourings

Plasticising various materials like sheets and gaskets, cellophane and paper

How do you make biodiesel (general equation and conditions)?

How do you make biodiesel (general equation and conditions)?

NaOH catalyst, 60ºC

Lipids (fats/oils - esters) + $3CH_3OH \rightarrow$ 3 methyl esters + glycerol

What does transesterification mean?

What does transesterification mean?

Converting one type of ester to another

What kind of crops is biodiesel made from?

What kind of crops is biodiesel made from?

Rapeseed oil or soybean oil

How is the reaction mixture of biodiesel purified and separated?

How is the reaction mixture of biodiesel purified and separated?

Settling tank or centrifuge; remove remainder with water. Add acid to neutralise excess alkali catalyst. Solid soap is formed - easy to remove

What is a problem with producing biodiesel?

What is a problem with producing biodiesel?

Crops that could be used to make food are being used to make fuel - are the resources being best used?

What are carboxylic acid derivatives?

What are carboxylic acid derivatives?

Molecules that have the acyl group as part of their structure, formed from carboxylic acids

Name two acid derivatives and give their functional groups

Name two acid derivatives and give their functional groups

Acyl chlorides: RCOCl

Acid anhydrides: RCOOCR / $(RCO)_2O$

Draw the mechanism for the acylation of a nucleophile by an acid derivative.

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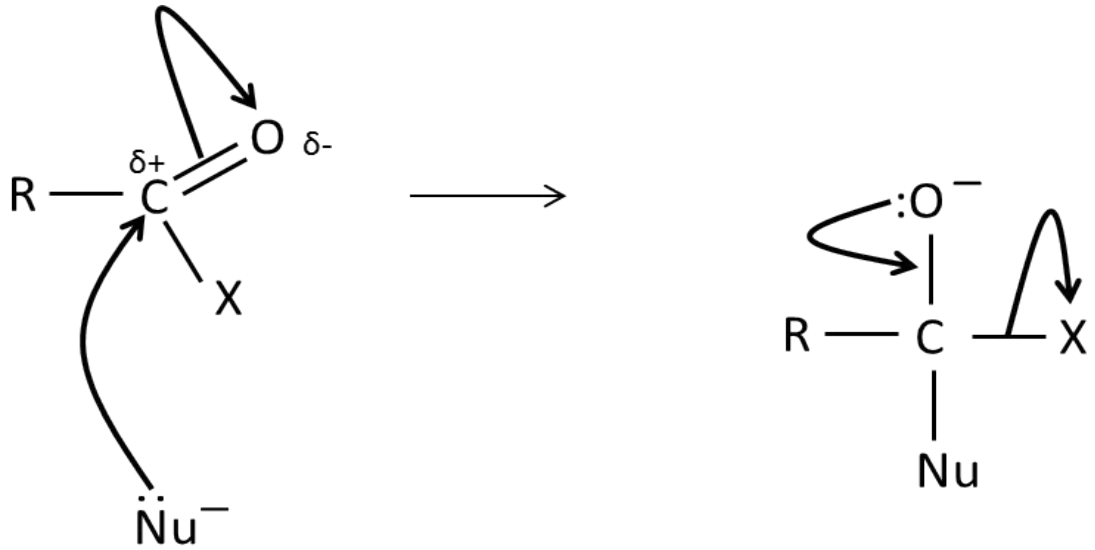

Which factors determine how readily the acylation of a nucleophile by an acid derivative occurs? (3)

Which factors determine how readily the acylation of a nucleophile by an acid derivative occurs? (3)

Magnitude of the delta + charge on the carbonyl carbon, which depends on the electronegativity of the atom/group being substituted.

How easily the atom/group being substituted is lost

How good the nucleophile is (how readily it will donate electrons)

What effect do the Cl and O atoms in acyl chlorides/acid anhydrides have on the partial charge of the carbonyl carbon?

What effect do the Cl and O atoms in acyl chlorides/acid anhydrides have on the partial charge of the carbonyl carbon?

Increase the partial + charge by attracting electrons; this means that they react more readily with nucleophiles

Are acyl chlorides or acid anhydrides more reactive?

Are acyl chlorides or acid anhydrides more reactive?

Acyl chlorides

What is the name of the mechanism by which acyl chlorides and acid anhydrides acylate nucleophiles?

What is the name of the mechanism by which acyl chlorides and acid anhydrides acylate nucleophiles?

Addition-elimination

If the nucleophile is ammonia for the acylation of acyl chlorides or acid anhydrides, what are the products of the reaction?

If the nucleophile is ammonia for the acylation of acyl chlorides or acid anhydrides, what are the products of the reaction?

An amide

Write an equation for the reaction of ethanoyl chloride and ammonia

Write an equation for the reaction of ethanoyl chloride and ammonia

$$CH_3COCl + 2NH_3 \rightarrow CH_3CONH_2 + NH_4Cl$$

Draw the mechanism for the reaction of ethanoyl chloride and ammonia

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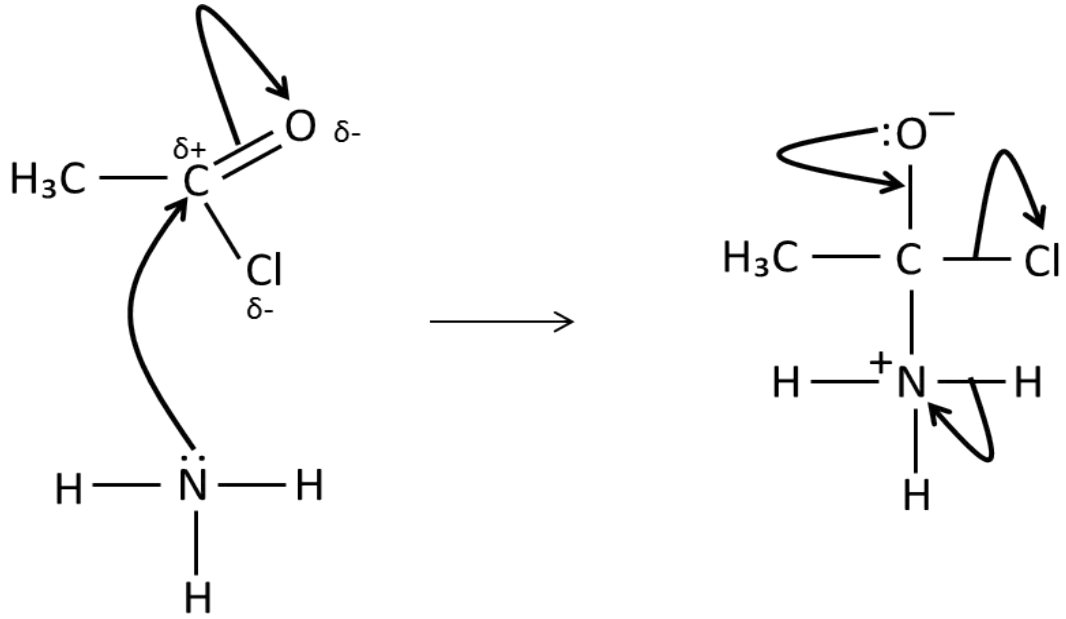

If the nucleophile is a primary amine, what are the products of the acylation of acyl chlorides or acid anhydrides?

If the nucleophile is a primary amine, what are the products of the acylation of acyl chlorides or acid anhydrides?

N-substituted amide

Write an equation for the reaction of ethanoyl chloride and methylamine

Write an equation for the reaction of ethanoyl chloride and methylamine

$$CH_3COCl + CH_3NH_2 \rightarrow CH_3CONHCH_3 + CH_3NH_3Cl$$

Draw the mechanism for the reaction of ethanoyl chloride and methylamine.

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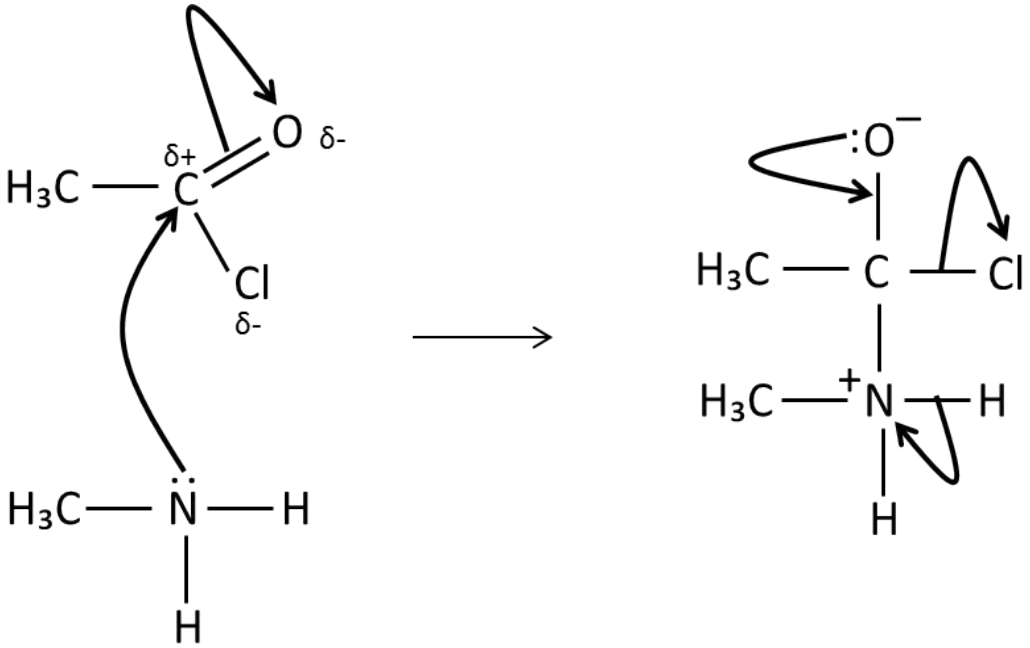


If the nucleophile is an alcohol, what are the products of the acylation of acyl chlorides or acid anhydrides?

If the nucleophile is an alcohol, what are the products of the acylation of acyl chlorides or acid anhydrides?

An ester

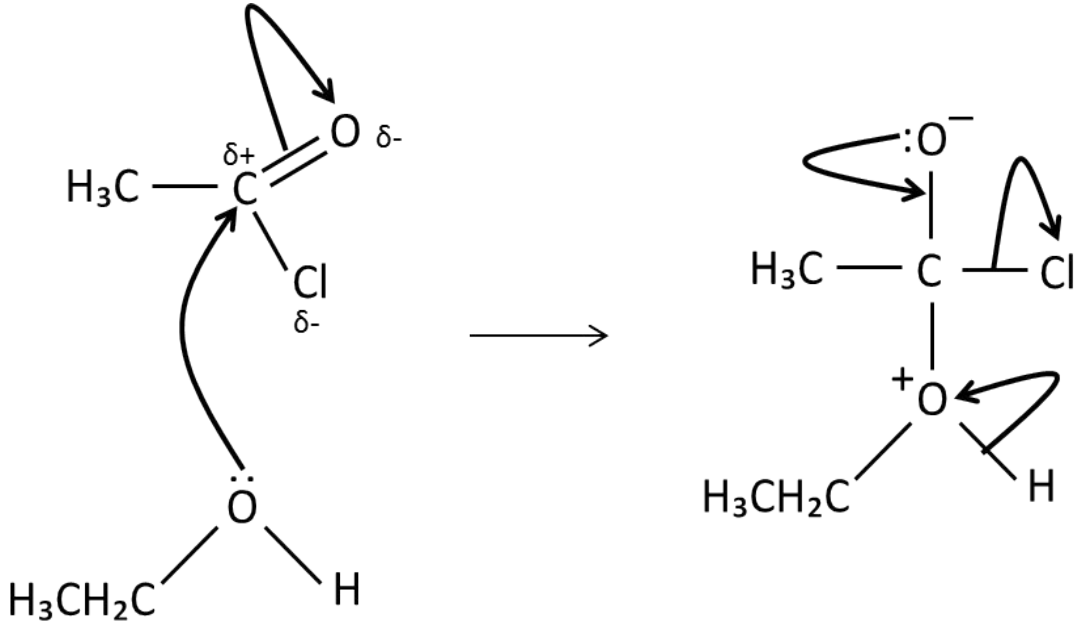
Write an equation for the reaction of ethanoyl chloride and ethanol

Write an equation for the reaction of ethanoyl chloride and ethanol

$$CH_3COCl + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + HCl$$

Draw the mechanism for the reaction of ethanoyl chloride and ethanol

Draw the mechanism for the reaction of ethanoyl chloride and ethanol



If the nucleophile is water, what are the products of the acylation of acyl chlorides or acid anhydrides?

If the nucleophile is water, what are the products of the acylation of acyl chlorides or acid anhydrides?

Carboxylic acid (hydrolyses ester linkage)

What is the name of this reaction (the acylation of acyl chlorides/acid anhydrides with water as a nucleophile)?

What is the name of this reaction (the acylation of acyl chlorides/acid anhydrides with water as a nucleophile)?

hydrolysis

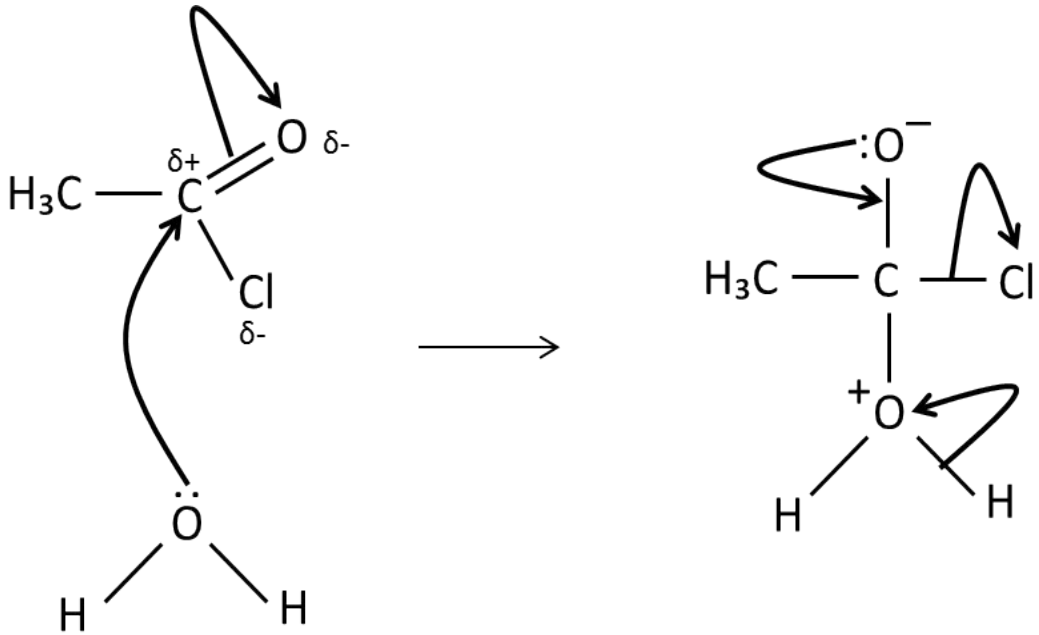
Write an equation for the reaction of ethanoyl chloride and water.

Write an equation for the reaction of ethanoyl chloride and water.

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

Draw the mechanism for the reaction of ethanoyl chloride and water.

Draw the mechanism for the reaction of ethanoyl chloride and water.



What is a commercially important acylation reaction?

What is a commercially important acylation reaction?

The manufacture of aspirin

What are the advantages of using ethanoic anhydride as an acylating agent over ethanoyl chloride?

What are the advantages of using ethanoic anhydride as an acylating agent over ethanoyl chloride?

It is cheaper, less corrosive and does not react as readily with water.

It is safer, as ethanoic acid is produced, rather than HCl, which is corrosive.

What would you observe in a melting point determination if the sample was not pure?

What would you observe in a melting point determination if the sample was not pure?

Sample melts over a large range (more than 3ºC).

Sample's melting point is below the accepted value due to impurities disrupting structure

Why might the melting point appear different to the true value?

Why might the melting point appear different to the true value?

Temperature of the material in the machine might be different to the temperature shown on the thermometer - apparatus error.

When removing flue gases, what are the issues?

When removing flue gases, what are the issues?

Disposal of large amounts of $CaSO_3$ and CO_2 is produced.

What conditions are needed to form methyl esters from an acid anhydride or acyl chloride?

What conditions are needed to form methyl esters from an acid anhydride or acyl chloride?

React with methanol and heat gently under reflux

When purifying by recrystallisation, why is the minimum volume of hot solvent used?

When purifying by recrystallisation, why is the minimum volume of hot solvent used?

So that a saturated solution is created, so that as many crystals will fall out of solution as possible when it is cooled

Why is the solution filtered hot when purifying by recrystallisation?

Why is the solution filtered hot when purifying by recrystallisation?

To remove insoluble impurities and ensure that the crystals do not form in the filter paper

Why is the solution cooled in an ice bath when purifying by recrystallisation?

Why is the solution cooled in an ice bath when purifying by recrystallisation?

To ensure that as many crystals as possible fall out of solution - yield is higher

Why are the crystals washed with cold water when purifying by recrystallisation?

Why are the crystals washed with cold water when purifying by recrystallisation?

To remove soluble impurities

How would you separate the crystals from the reaction mixture when purifying by recrystallisation?

How would you separate the crystals from the reaction mixture when purifying by recrystallisation?

Filter under reduced pressure using a Buchner funnel

Why might percentage yield be below 100% (practical reasons)?

Why might percentage yield be below 100% (practical reasons)?

Product is lost during filtration, drying and weighing - spills, not all transferred from one piece of apparatus to the other

Product is left dissolved in the solution - some does not crystallise. Some left on filter paper. Sample still wet