

Carboxylic acids and derivatives

A-Level Chemistry 9701 · Topic 18 revision notes

Everything from the 2 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Carboxylic acids

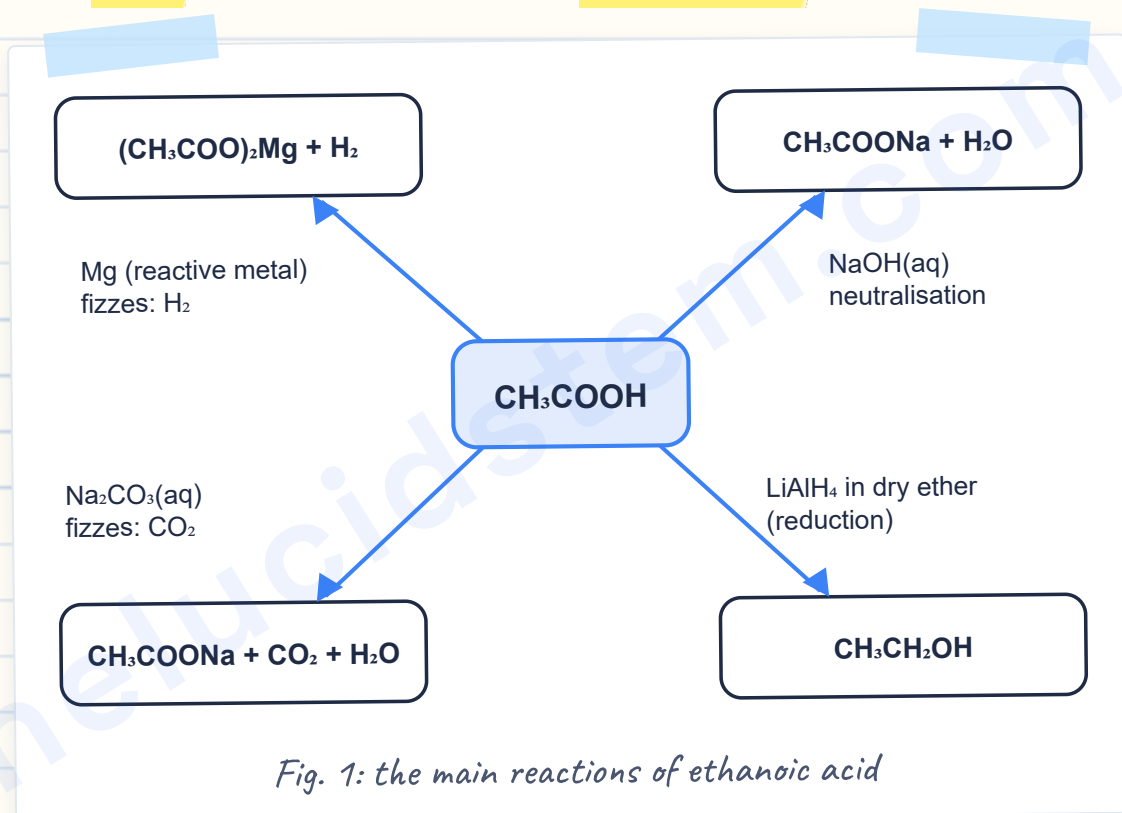
2. Esters

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1 Carboxylic acids

Syllabus 18.1

A carboxylic acid contains the **carboxyl group**, -COOH . It is made by **oxidising a primary alcohol or an aldehyde** with acidified $\text{K}_2\text{Cr}_2\text{O}_7$, **heating under reflux**; by **hydrolysing a nitrile** with dilute acid under reflux (the C of the CN group becomes the COOH carbon); or by **hydrolysing an ester**. Carboxylic acids are **weak acids**: they only partly dissociate, $\text{RCOOH} \rightleftharpoons \text{RCOO}^- + \text{H}^+$. They still show all the typical acid reactions: **reactive metals** give a salt and hydrogen, **alkalis** give a salt and water, and **carbonates** give a salt, water and **carbon dioxide**. That fizzing with sodium carbonate is the test that separates them from alcohols. **LiAlH_4** in dry ether reduces them to **primary alcohols**.



Made by oxidation or hydrolysis; reacts as a weak acid.

- ✓ **Make:** primary alcohol or aldehyde + $K_2Cr_2O_7/H^+$, reflux; nitrile or ester + dilute acid, reflux.
- ✓ **Metal:** salt + H_2 ; **alkali:** salt + H_2O .
- ✓ **Carbonate:** salt + $CO_2 + H_2O$, the test against alcohols.
- ✓ **$LiAlH_4$:** reduces $RCOOH$ to RCH_2OH .

Watch out!

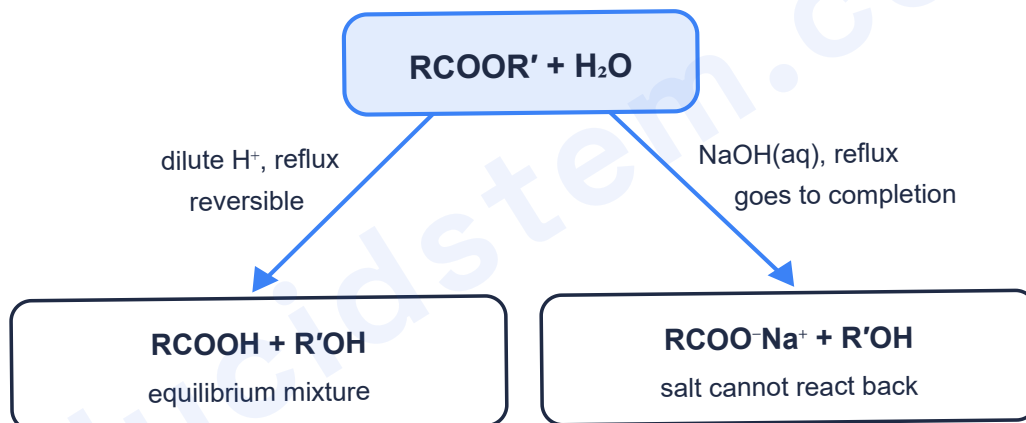
Only carbonates and hydrogencarbonates separate acids from alcohols: sodium and PCl_5 react with any $-OH$ group. Carboxylic acids are **weak** (partly dissociated), not dilute; a weak acid still reacts completely with excess metal, alkali or carbonate. Keep the 2 : 1 acid to Mg and acid to Na_2CO_3 ratios. Reduction needs **$LiAlH_4$** , not $NaBH_4$, and gives a **primary** alcohol. A nitrile keeps its CN carbon, so count carbons carefully.

2 Esters

Syllabus 18.2

An **ester**, RCOOR' , forms when a **carboxylic acid** reacts with an **alcohol**, heated with a few drops of **concentrated H_2SO_4** as a catalyst; water is the other product and the reaction is **reversible**. Esters are named **alkyl alkanoate**: the alcohol part first, then the acid part, so $\text{CH}_3\text{COOC}_2\text{H}_5$ is ethyl ethanoate. **Acid hydrolysis** (dilute acid, heat under reflux) is the reverse of esterification and reaches equilibrium. **Alkaline hydrolysis** with NaOH(aq) under reflux **goes to completion**, giving the **carboxylate salt** and the alcohol, because the carboxylate ion cannot react with the alcohol. **Fats and oils** are triesters of glycerol (propane-1,2,3-triol); boiling them with NaOH is **saponification** and gives soap. Esters are used as **flavourings, perfumes and solvents**.

two ways to hydrolyse an ester, RCOOR'



then acidify the salt: $\text{RCOO}^- + \text{H}^+ \rightarrow \text{RCOOH}$

e.g. $\text{CH}_3\text{COOC}_2\text{H}_5 + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{C}_2\text{H}_5\text{OH}$

Fig. 1: acid and alkaline hydrolysis of an ester compared

**Acid plus alcohol, reversible;
alkali goes all the way.**

- ✓ **Make:** $\text{RCOOH} + \text{R}'\text{OH}$, conc. H_2SO_4 , catalyst, warm, reversible.
- ✓ **Name:** alcohol part first, then -oate.
- ✓ **Acid hydrolysis:** dilute H^+ , reflux, equilibrium.
- ✓ **NaOH hydrolysis:** complete, gives $\text{RCOO}^-\text{Na}^+ + \text{R}'\text{OH}$; fats give soap.

Watch out!

Name the **alcohol part first**:

$\text{CH}_3\text{COOC}_2\text{H}_5$ is ethyl ethanoate,
and HCOOCH_3 is methyl

methanoate. Concentrated H_2SO_4
is a **catalyst** in esterification, but
in alkaline hydrolysis the NaOH is
a **reactant** that is used up.

Alkaline hydrolysis gives the **salt**
(RCOO^-Na^+), not the free acid,
until you acidify. One fat molecule
uses **three** NaOH and gives **three**
soap molecules.