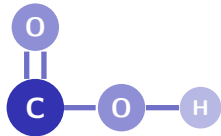


Carboxylic Acids & Derivatives

A-Level Chemistry ■ Topic 18

A-Level Chemistry



What we will cover

- 1 Carboxylic acid reactions
- 2 Esterification
- 3 Esters
- 4 Hydrolysis of esters



vinegar is ethanoic acid

Making a carboxylic acid

From an alcohol

Oxidation of a **primary alcohol** with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ or KMnO_4 , under **reflux** so it goes all the way.

From an aldehyde

The same oxidation, one step later: an **aldehyde** is the halfway product, and reflux takes it to the acid.

From a nitrile

Hydrolysis of a **nitrile** with dilute acid or alkali, then acidifying.

From an ester

Hydrolysis of an **ester** with dilute acid or alkali and heat, then acidifying.

Distillation stops at the aldehyde; **reflux** returns the vapour to the flask and gives the acid. The apparatus is the answer.

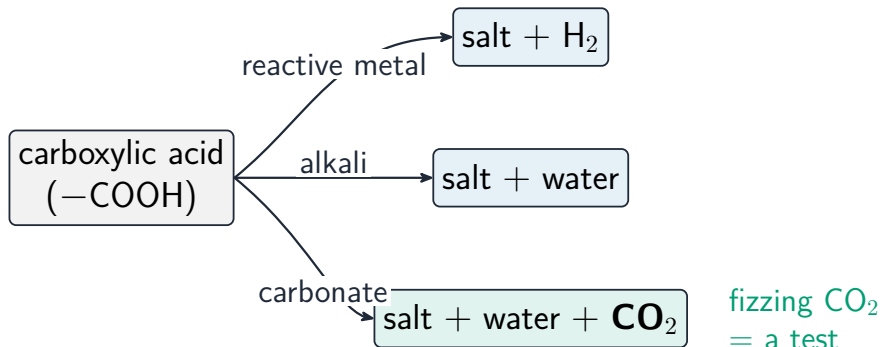


Carboxylic acid reactions

A **carboxylic acid** ($-\text{COOH}$) is a weak acid:

- $+\text{ metal} \rightarrow \text{salt} + \text{H}_2$
- $+\text{ alkali} \rightarrow \text{salt} + \text{water}$
- $+\text{ carbonate} \rightarrow \text{salt} + \text{water} + \text{CO}_2$ (the fizz is a test)

Carboxylic acid reactions, in detail



Carboxylic acids behave as acids: a salt with a metal (+ H_2), with an alkali (+ water), or with a carbonate (+ water + CO_2 – the fizz is a test)

Two reactions that change the group, and three that prove it is an acid

Reactive metal

A **redox** reaction: salt + hydrogen. $2\text{CH}_3\text{COOH} + \text{Mg} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2$

Alkali

A **neutralisation** : salt + water.

Carbonate

Salt + water + carbon dioxide – the **fizz** is the test for a carboxylic acid.

Esterification

With an alcohol and concentrated H_2SO_4 as catalyst: an ester.

Reduction

Reduction by LiAlH_4 takes it back to a **primary alcohol**.

The first three are acid behaviour; the last two rebuild the functional group. Sort any reaction into that pair first.



Esterification

An **ester** forms by **condensation** of an alcohol + a carboxylic acid (conc. H_2SO_4 catalyst).

The $-\text{OH}$ (acid) and $-\text{H}$ (alcohol) leave as water, making the $\text{C}-\text{O}-\text{C}$ ester link. The reaction is reversible.

Esterification, in detail



the -OH (acid) and -H (alcohol) leave as **water**; the C-O-C ester link forms
(concentrated H_2SO_4 catalyst; reversible)

An **ester** forms by **condensation** of an alcohol + a carboxylic acid (conc. H_2SO_4 catalyst).

Esters

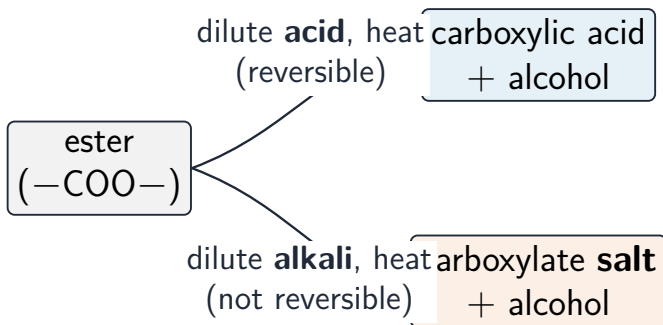
An **ester** has the —COO— group. Named from the alcohol then the acid: ethanol + ethanoic acid $\rightarrow$ **ethyl ethanoate**. Sweet or fruity smell – flavourings, solvents, perfumes.

Making one: alcohol + carboxylic acid $\rightleftharpoons$ ester + water, with conc. H_2SO_4 as catalyst (and dehydrating agent).

Hydrolysis of esters

Hydrolysis splits the ester apart:

- dilute **acid** (reversible) $\rightarrow$ the acid + alcohol
- dilute **alkali** (not reversible) $\rightarrow$ the carboxylate **salt** + alcohol



Esters, continued



Esters give many fruits and perfumes their sweet smell

Exam tips

- Carboxylic acids react with carbonates to give **CO₂** (fizzing) – this distinguishes them from phenols.
- Explain acid strength via the **delocalised carboxylate ion**; electron-withdrawing groups (e.g. Cl) increase strength.
- **Esterification** (with concentrated H₂SO₄) is reversible; name esters as *alkyl alkanoate*.
- Know the products of **acid vs alkaline** hydrolysis of an ester (they differ).



Worked example – naming an ester

Name the ester from ethanoic acid and propan-1-ol, and give the conditions.

- acid + alcohol $\rightleftharpoons$ ester + water, with concentrated H_2SO_4 catalyst, heated under reflux.
- $\text{CH}_3\text{COOH} + \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \rightleftharpoons \text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$
- The alcohol gives the first word, the acid the second (ending -oate).
- Name: propyl ethanoate.

Ester name = alcohol part first, acid part second.

The reaction is reversible, so the yield is never 100% – acyl chlorides do it better.

Topic 18 – key takeaways

1

Acidity

salt + H_2 /water/ CO_2 with
metal/alkali/carbonate

2

Esterification

alcohol + acid $\rightarrow$ ester + water

3

Esters

$-\text{COO}-$ group; sweet smell

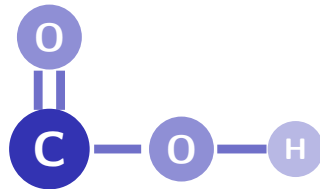
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Hydrolysis

acid (reversible) vs alkali (salt)

Check yourself

- 1 What gas tests for a carboxylic acid with a carbonate?
- 2 What small molecule leaves in esterification?
- 3 Which functional group does an ester have?
- 4 Alkaline hydrolysis of an ester gives which two products?

**Answers**

1. carbon dioxide 2. water 3. —COO— 4. a carboxylate salt and an alcohol