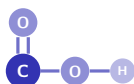


Carboxylic Acids & Derivatives

A-Level Chemistry • Topic 18

A-Level Chemistry



Carboxylic Acids & Derivatives

What we will cover

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



vinegar is ethanoic acid

Carboxylic Acids & Derivatives

Making a carboxylic acid

From an alcohol Oxidation 氧化 of a primary alcohol 醇 with acidified $K_2Cr_2O_7$ or $KMnO_4$, under reflux 回流 so it goes all the way.

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

From a nitrile Hydrolysis 水解 of a nitrile 腈 with dilute acid or alkali, then acidifying.

From an ester Hydrolysis of an ester 酯 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.

1

Carboxylic acids

Carboxylic Acids & Derivatives

↳ Carboxylic acids

Carboxylic acid reactions

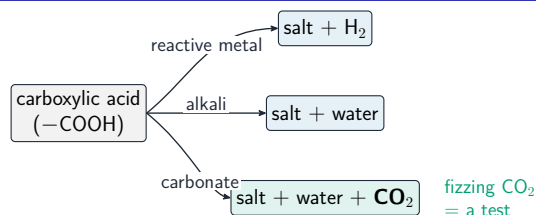
A **carboxylic acid** 羧酸 ($-COOH$) is a weak acid:

- + metal $\rightarrow$ salt + H_2
- + alkali $\rightarrow$ salt + water
- + carbonate $\rightarrow$ salt + water + CO_2 (the fizz is a test)

Carboxylic Acids & Derivatives

↳ Carboxylic acids

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 氧化还原 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 中和: salt 盐 + 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 还原 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.

2 Esters

Esterification

An **ester** 酯 forms by **condensation** 缩合 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 $-\text{OH}$ (acid) and $-\text{H}$ (alcohol) leave as **water**; the $\text{C}-\text{O}-\text{C}$ ester link forms (concentrated H_2SO_4 catalyst; reversible)

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

Esters

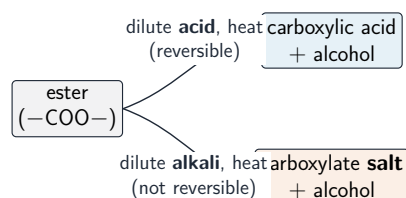
An **ester** 酯 has the $-\text{COO}-$ group. Named from the alcohol then the acid: ethanol + ethanoic acid $\rightarrow$ **ethyl ethanoate**. Sweet or fruity smell – flavourings, solvents, perfumes.

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

Hydrolysis of esters

Hydrolysis 水解 splits the ester apart:

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



Esters, continued



Esters give many fruits and perfumes their sweet smell

Exam tips

- Carboxylic acids react with carbonates to give CO_2 (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 H_2SO_4) is reversible; name esters as *alkyl alkanoate*.
- Know the products of **acid vs alkaline** hydrolysis of an ester (they differ).

3

Recap

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

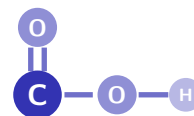
$-\text{COO}-$ group; sweet smell

4 Hydrolysis

acid (reversible) vs alkali (salt)

Check yourself

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



Answers 1. carbon dioxide 2. water 3. $-\text{COO}-$ 4. a carboxylate salt and an alcohol