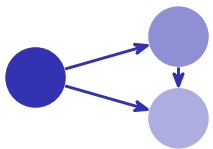
Organic Synthesis

A-Level Chemistry ▪ Topic 21

A-Level Chemistry



What we will cover

1. Identifying functional groups
2. The reaction map
3. Planning a route

built in many steps

1 Tests and routes

Identifying functional groups

Each test points to one **functional group** 官能团:

- bromine water decolourised $\rightarrow$ alkene
- $AgNO_3$ precipitate $\rightarrow$ halogenoalkane
- dichromate orange$\rightarrow$green $\rightarrow$ alcohol
- fizz with carbonate $\rightarrow$ carboxylic acid

Identifying functional groups, in detail

add this	you see	functional group
bromine water	orange $\rightarrow$ colourless	**C=C (alkene)**
silver nitrate	a precipitate forms	**halogenoalkane**
acidified $K_2Cr_2O_7$	orange $\rightarrow$ green	**$1^\circ/2^\circ$ alcohol**
2,4-DNPH	orange precipitate	**aldehyde / ketone**
a carbonate	fizzes (CO_2 given off)	**carboxylic acid**

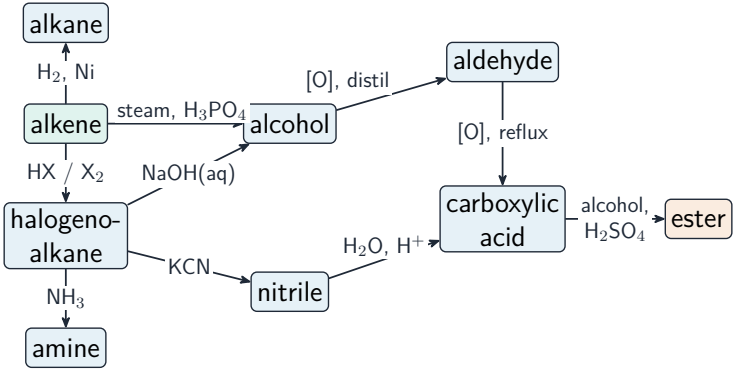
The standard identification tests: each reagent gives a characteristic observation that points to one functional group

The reaction map

Each arrow turns one functional group into another.

> Learn it as a map you can travel around. **KCN** 氰化钾 is the only AS step that adds a carbon.

The reaction map, in detail



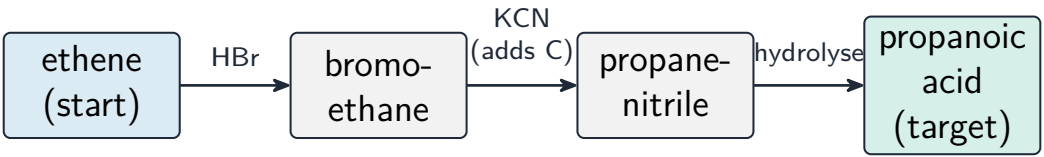
Each arrow turns one functional group into another.

Planning a route

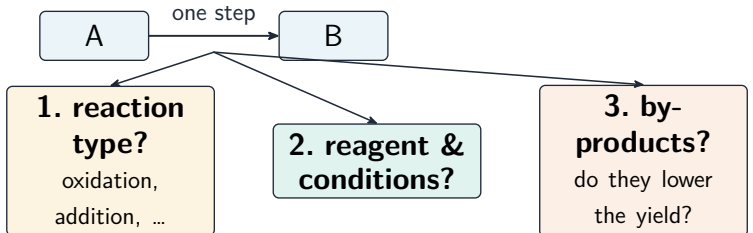
To devise a **synthetic route** 合成路线:

- compare target vs start (group? carbons?)
- work backwards, one reaction at a time
- write each step's **reagent** 试剂 & conditions

plan backwards from the target



Analysing a route



e.g. a halogenoalkane → amine also makes further-substituted amines, so the simple-amine yield is low

> For every step in a given route, ask its reaction type, reagent and by-products

Analysing a route, continued

name the reaction type at each step

oxidation	loses electrons / gains O or loses H (e.g. alcohol → acid)
reduction	gains electrons / loses O or gains H
substitution	one atom or group swaps for another
addition	two molecules join; a C=C double bond opens
elimination	a small molecule is removed; a C=C forms

also give the **reagent** for each step, and watch for **by-products** (e.g. amines over-substitute)

> Name the reaction type at each step: oxidation, reduction, substitution, addition or elimination

Planning a synthesis backwards

what this topic adds	no new reactions – it asks you to join up the ones you already know
1. compare	count the carbons in target and starting material, and note which **functional groups** 官能团 each has
2. work backwards	ask what could have made the target in one step
3. repeat	ask the same of that intermediate, until you reach the starting material
the carbon-changing steps	KCN adds one carbon; hydrolysis or reduction of the nitrile keeps it
the group ladder	alcohol → **aldehyde** 醛 → carboxylic acid → **ester** 酯; halogenoalkane → **amine** 胺 or nitrile

Working backwards from the target is faster than forwards from the start, because the target has only a few possible immediate precursors.

Exam tips

- Learn the **reagents and conditions** for each conversion – that is exactly what synthesis questions test.
- Plan multi-step routes by functional group and watch the **carbon count** (KCN adds one carbon).
- Choose the **shortest valid route** and state every reagent and condition.

2 Recap

Worked example – planning a synthesis

Suggest a two-step route from 1-bromopropane to propanoic acid, with reagents and conditions.

- Count the carbons first: 3 in, 3 out – so no carbon-adding step is needed.
- Step 1: reflux with aqueous NaOH ⇒ nucleophilic substitution ⇒ propan-1-ol.
- Step 2: reflux with acidified $K_2Cr_2O_7$ ⇒ oxidation ⇒ propanoic acid.
- Reflux (not distil) in step 2, or you stop at propanal.

Count carbons first. Same number ⇒ substitute and oxidise. One more carbon ⇒ go via the nitrile (KCN in ethanol), then hydrolyse.

Topic 21 – key takeaways

1 Tests

each reagent identifies one functional group

2 Map

arrows convert one group to another

3 Plan backwards

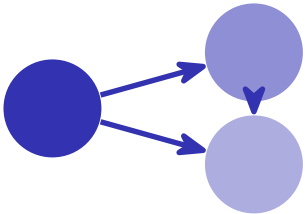
from the target to the start

4 Add a carbon

the KCN step is the key

Check yourself

1. What test confirms a carboxylic acid?
2. Which way should you plan a synthesis?
3. Which reagent lengthens the carbon chain?
4. What must you state for each step?



Answers **1.** fizz (CO_2) with a carbonate **2.** backwards from the target **3.** KCN **4.** the reagent and conditions