

Organic synthesis

A-Level Chemistry

Organic synthesis

This topic does not add new reactions. Instead it asks you to **join up** the reactions you already know, so you can build a target molecule in several steps.



Medicines are built up from simple starting materials by multi-step organic synthesis

Identifying functional groups

A molecule may have more than one **functional group** 官能团. Use the test reactions from the syllabus to identify each one, and then predict how the molecule will behave. For example:

- decolourises bromine water → a C=C double bond (an **alkene** 烯烃).
- gives a precipitate with silver nitrate → a **halogenoalkane** 卤代烷.
- orange K₂Cr₂O₇ turns green → a primary or secondary **alcohol** 醇.
- orange precipitate with 2,4-DNPH → an **aldehyde** 醛 or **ketone** 酮.
- fizzes with a carbonate → a **carboxylic acid** 羧酸.

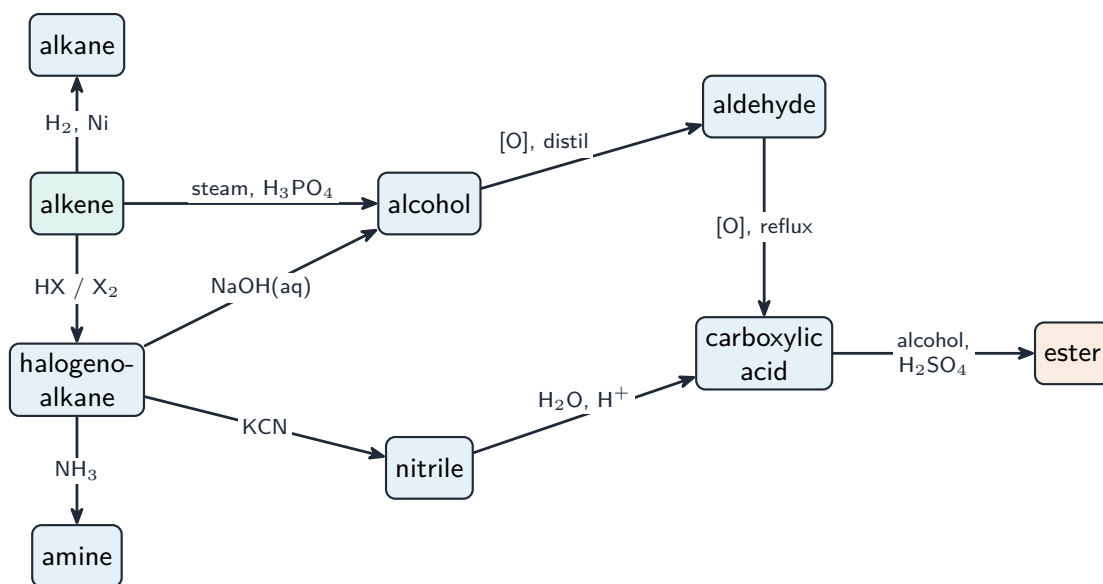
add this	you see	functional group
bromine water	orange → colourless	C=C (alkene)
silver nitrate	a precipitate forms	halogenoalkane
acidified K ₂ Cr ₂ O ₇	orange → green	1°/2° alcohol
2,4-DNPH	orange precipitate	aldehyde / ketone
a carbonate	fizzes (CO ₂ given off)	carboxylic acid

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

A map of the AS reactions

Each row turns one functional group into another. Learn it as a map you can travel around:

Start	Reagent and conditions	Product
alkene	H_2 , Ni	alkane
alkene	HX, or X_2	halogenoalkane
alkene	steam, H_3PO_4	alcohol
halogenoalkane	$\text{NaOH}(\text{aq})$, heat	alcohol
halogenoalkane	KCN in ethanol, heat	a nitrile 腈 (adds one carbon)
halogenoalkane	NH_3 in ethanol, pressure	an amine 胺
alcohol	$\text{K}_2\text{Cr}_2\text{O}_7$, distil / reflux	aldehyde / carboxylic acid
alcohol	concentrated acid, heat	alkene
aldehyde or ketone	NaBH_4	alcohol
aldehyde or ketone	HCN, KCN	hydroxynitrile
nitrile	dilute acid, heat	carboxylic acid
carboxylic acid + alcohol	concentrated H_2SO_4	an ester 酯



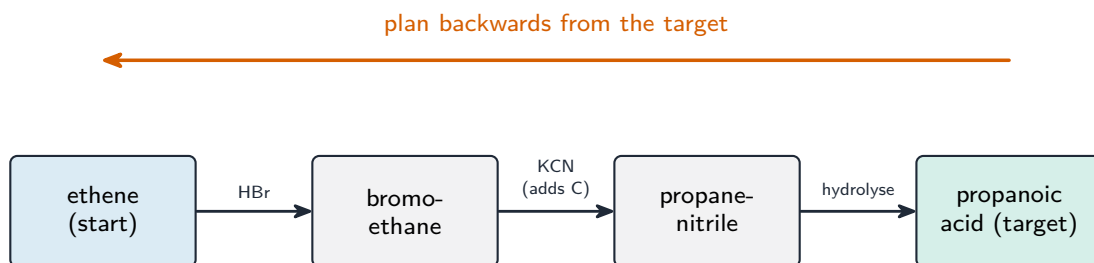
*A map of the AS reactions: each arrow turns one functional group into another.
Work backwards from your target to plan a route*

Planning a multi-step route

To devise a **synthetic route** 合成路线:

1. compare the target with the starting material — what has changed (the functional group, the number of carbons)?
2. work **backwards** from the target: which single reaction could make it, and from what?
3. repeat until you reach the starting material.
4. write each step with its **reagent** 试剂 and conditions.

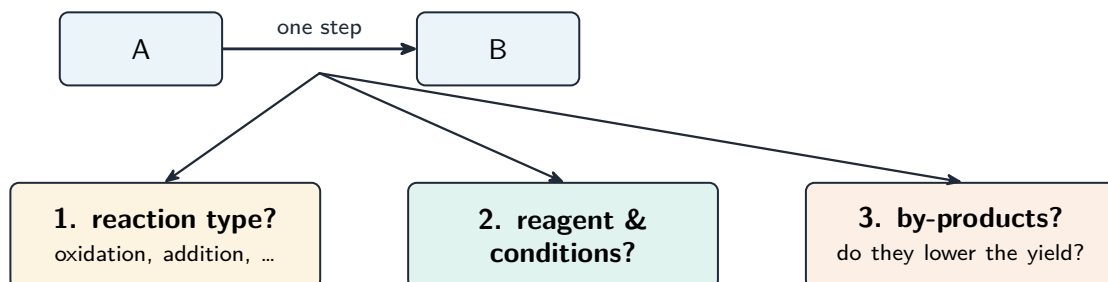
If you need to add a carbon, the KCN step is the key — it is the only AS reaction that lengthens the chain.



Plan a route by working backwards from the target, one reaction at a time, until you reach the starting material

Analysing a route

When you are given a route, for each step state the **type of reaction** (such as **oxidation** 氧化, **reduction** 还原, substitution, addition or elimination) and the reagent used. Also think about possible **by-products** 副产物 — for example, making an amine from a halogenoalkane also gives a mixture of further-substituted amines, so the yield of the simple amine is low.



e.g. a halogenoalkane $\rightarrow$ 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

name the reaction type at each step

oxidation	loses electrons / gains O or loses H (e.g. alcohol $\rightarrow$ 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

Worked example. Devise a route from propene to propanone, CH_3COCH_3 . Work **backwards** from the target. A ketone comes from oxidising a **secondary** alcohol, so the step before propanone is propan-2-ol with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ under reflux. Propan-2-ol comes from propene by adding **steam** over an H_3PO_4 catalyst - and Markovnikov's rule conveniently puts the OH on the **middle** carbon, which is exactly the secondary alcohol needed. So the route is: propene, then steam with H_3PO_4 , giving propan-2-ol; then acidified $\text{K}_2\text{Cr}_2\text{O}_7$ under reflux, giving propanone. Give a **reagent and**

its conditions on every arrow: a route with the right intermediates but no reagents scores very little.

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.