

21.1 Organic synthesis

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS functional group 官能团 • synthetic route 合成路线 • multi-step 多步 • reagent 试剂
 • carboxylic acid 羧酸

Objective

Build the skills to answer exam questions on **organic synthesis** 有机合成 — identifying **functional groups** 官能团 by their test reactions, and devising **multi-step** 多步 synthetic routes.

You must be able to:

- identify functional groups in a molecule from the standard tests
- devise multi-step synthetic routes using the reactions in the syllabus
- analyse a route in terms of reaction type and reagents

1 Worked examples

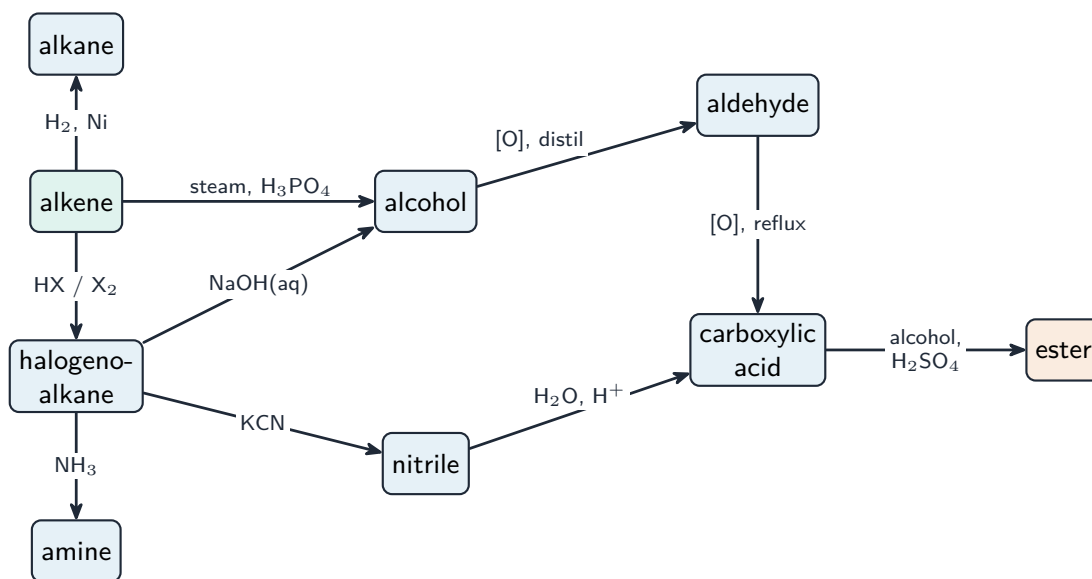
■ Identifying functional groups

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

Each test points to one functional group

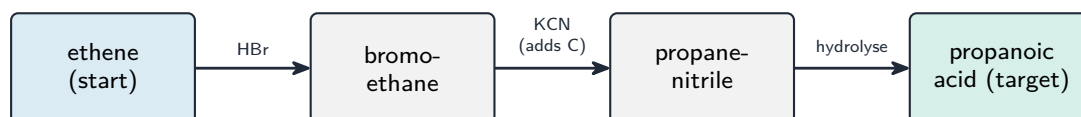
- decolourises bromine water → alkene ($C=C$); precipitate with $AgNO_3$ → halogenoalkane; $K_2Cr_2O_7$ orange→green → primary/secondary alcohol; orange ppt with 2,4-DNPH → carbonyl; fizzes with a carbonate → carboxylic acid.

■ The reaction map and planning backwards



Learn the AS reactions as a map you can travel around to plan a synthesis

plan backwards from the target



To plan: work backwards from the target, choosing a known reaction for each step (watch the carbon count — KCN/HCN add one carbon)

2 Practice

2.1 State the test and result that identifies a carboxylic acid.

[2]

2.2 State the reagent and condition to convert an alkene into an alcohol.

[2]

3 Exam-style questions

3.1 A compound decolourises bromine water and gives an orange precipitate with 2,4-DNPH. It contains: [1]

- **A** a C=C bond and a carbonyl group
 - **B** an alcohol only
 - **C** a carboxylic acid only
 - **D** a halogenoalkane only
-

3.2 Which reagent adds **one** carbon to a chain? [1]

- **A** NaOH(aq)
 - **B** KCN in ethanol
 - **C** H₂ / Ni
 - **D** concentrated H₂SO₄
-

3.3 Devise a two-step synthesis of propan-1-ol from 1-bromopropane that adds **no** carbons. Give the reagents and conditions for each step. [2]

3.4 Devise a synthesis of propanoic acid (CH₃CH₂COOH) from bromoethane (C₂H₅Br), giving the reagents for each step. (*Hint: you need to add one carbon.*) [3]

Solutions

2.1 add a carbonate (e.g. sodium carbonate); fizzing / effervescence of CO_2 .

2.2 steam (H_2O gas) with a phosphoric acid (H_3PO_4) catalyst.

3.1 A. Bromine water $\rightarrow$ $\text{C}=\text{C}$; 2,4-DNPH $\rightarrow$ a carbonyl group.

3.2 B. KCN adds one carbon (forming a nitrile).

3.3 react 1-bromopropane with $\text{NaOH}(\text{aq})$ and heat $\rightarrow$ propan-1-ol (nucleophilic substitution). (*One step suffices; a longer route via the alkene then steam also scores.*)

3.4 step 1: react bromoethane with KCN in ethanol, heat $\rightarrow$ propanenitrile, $\text{C}_2\text{H}_5\text{CN}$ (adds one carbon); step 2: warm the nitrile with dilute acid (hydrolysis) $\rightarrow$ propanoic acid.