Exercise walk-through

Organic synthesis ▪ 21.1

eXercise

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

Method — Identifying functional groups

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

Method — Identifying functional groups

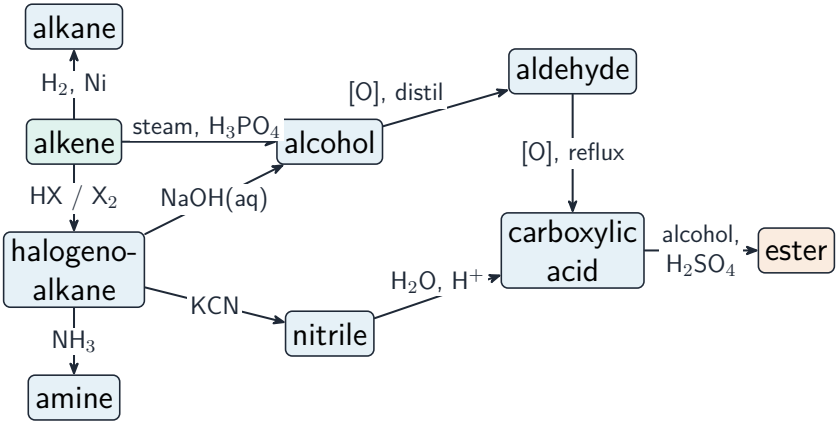
add this	you see	functional group
bromine water	orange $\rightarrow$ colourless	**C=C (alkene)**
silver nitrate	a precipitate forms	**halogenoalkane**
acidified $K_2Cr_2O_7$	orange $\rightarrow$ green	**$1^\circ/2^\circ$ alcohol**
2,4-DNPH	orange precipitate	**aldehyde / ketone**
a carbonate	fizzes (CO_2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

A table of test reagent, observation, and the functional group it identifies

Method — The reaction map and planning backwards

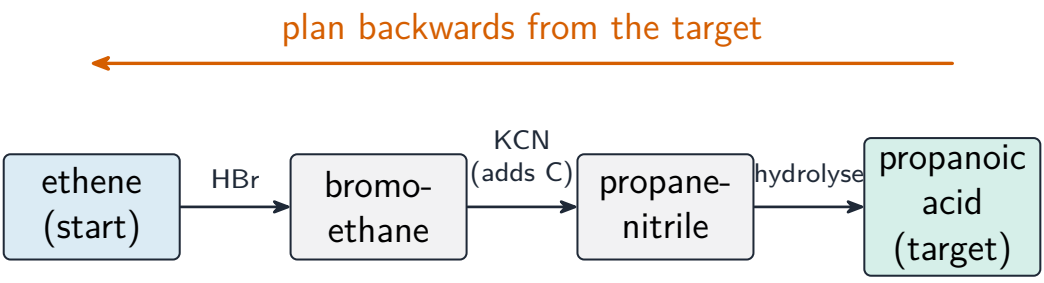
To plan: work backwards from the target, choosing a known reaction for each step (watch the carbon count — KCN/HCN add one carbon)

Method — The reaction map and planning backwards



A map linking functional groups by the reagents that interconvert them

Method — The reaction map and planning backwards



Working backwards from the target to the starting material, step by step

Practice 2.1 ▪ 2 marks

State the test and result that identifies a carboxylic acid.

Solution 2.1

Method: Identifying functional groups

Worked steps

add a carbonate (e.g. sodium carbonate) B1; fizzing / effervescence of CO B1.

Practice 2.2 ▪ 2 marks

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

Solution 2.2

Method: Identifying functional groups

Worked steps

steam (H O gas) with a phosphoric acid (H PO) catalyst B1 B1.

Exam-style 3.1 ▪ 1 mark

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

A a C=C bond and a carbonyl group

B an alcohol only

C a carboxylic acid only

D a halogenoalkane only

Solution 3.1

Method: Identifying functional groups

A a C=C bond and a carbonyl group ✓

B an alcohol only

C a carboxylic acid only

D a halogenoalkane only

Worked steps

A. Bromine water → C=C; 2,4-DNPH → a carbonyl group.

Exam-style 3.2 ▪ 1 mark

Which reagent adds **one** carbon to a chain?

A NaOH(aq)

B KCN in ethanol

C H / Ni

D concentrated H SO

Solution 3.2

A NaOH(aq)

B KCN in ethanol ✓

C H / Ni

D concentrated H SO

Worked steps

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

Exam-style 3.3 ▪ 2 marks

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

Solution 3.3

Method: The reaction map and planning backwards

Worked steps

react 1-bromopropane with NaOH(aq) and heat → propan-1-ol (nucleophilic substitution) M1 A1. *(One step suffices; a longer route via the alkene then steam also scores.)*

Exam-style 3.4 ▪ 3 marks

Devise a synthesis of propanoic acid (CH CH COOH) from bromoethane (C H Br), giving the reagents for each step. *(Hint: you need to add one carbon.)*

Solution 3.4

Method: The reaction map and planning backwards

Worked steps

step 1: react bromoethane with KCN in ethanol, heat $\rightarrow$ propanenitrile, C H CN (adds one carbon) **M1**; step 2: warm the nitrile with dilute acid (hydrolysis) **M1** $\rightarrow$ propanoic acid **A1**.