A-LEVEL CHEMISTRY • EXERCISE SHEET

36.1 Organic synthesis

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

Objective

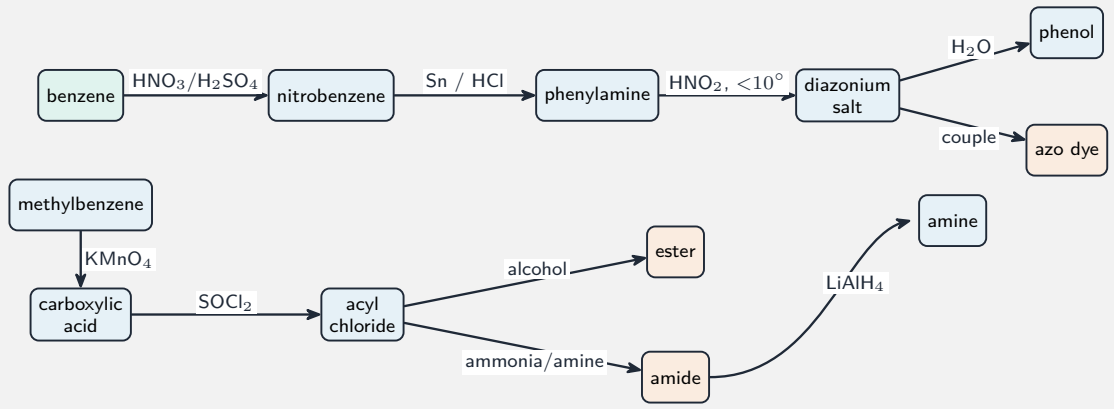
Build the skills to answer exam questions on **organic synthesis** 有机合成—joining known reactions to build a target, working **backwards** from the product, and analysing a route.

You must be able to:

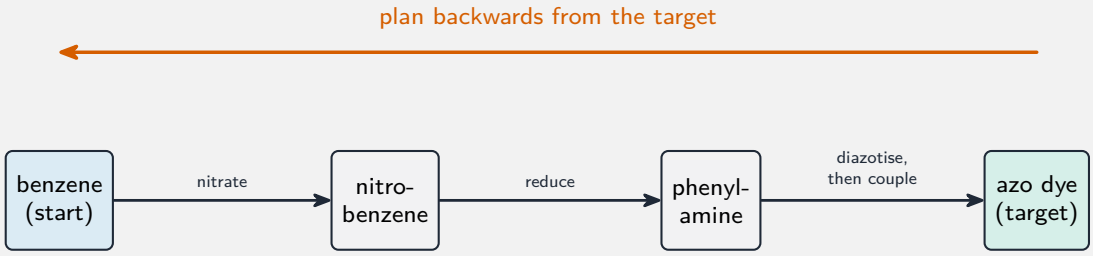
- choose reagents and conditions for each step of a synthesis
- devise a multi-step route by working backwards from the target
- state the reaction type at each step and identify likely by-products

1 Worked examples

Planning a route



Two main chains: the aromatic chain (top) and the acyl-chloride chain (bottom). Work backwards from your target



Plan a synthesis by retrosynthesis

- **work backwards:** which single reaction makes the target, and from what? Repeat until you reach the start.
- **key steps:** benzene →(HNO /H SO)→ nitrobenzene →(Sn/HCl, NaOH)→ phenylamine →(HNO , <10 °C)→ diazonium salt.
- carboxylic acid →(SOCl)→ acyl chloride →(alcohol)→ ester / →(amine)→ amide.
- nitrile/amide →(LiAlH)→ amine; halogenoalkane →(KCN)→ nitrile (**adds one carbon**).

2 Practice

2.1 Give the reagents to convert benzene into nitrobenzene. [2]

2.2 State the reagent that reduces a nitrile to an amine. [1]

3 Exam-style questions

3.1 To lengthen a carbon chain by one carbon, a halogenoalkane is reacted with: [1]

- **A** NH_3
- **B** KCN
- **C** $LiAlH_4$
- **D** H_2O

3.2 In planning a synthesis, the best strategy is to: [1]

- **A** work forwards from any reagent
- **B** work backwards from the target molecule
- **C** guess reagents at random
- **D** use only one reaction

3.3 Devise a synthesis of **phenylamine** from benzene, giving the reagents and conditions for each step. [3]

3.4 A two-step synthesis converts bromoethane into propylamine via a nitrile.

(a) Give the reagents for each step. [2]

(b) State **one** by-product/limitation of making an amine directly from a halogenoalkane and ammonia. [1]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **36.1 Organic synthesis** material in the Library, or try these in **Practice mode**:

- 9701/41 N25 —Q9 (multi-step synthesis)
- 9701/41 N25 —Q8 (aromatic synthesis)

Solutions

2.1 concentrated HNO_3 and concentrated H_2SO_4; warm, 25–60 °C.

2.2 $LiAlH_4$ (or H_2/Ni).

3.1 B. KCN adds a –CN group, lengthening the chain by one carbon.

3.2 B. Work backwards from the target molecule.

3.3 nitrate benzene with conc. HNO_3 + conc. H_2SO_4 → nitrobenzene; reduce with Sn and conc. HCl; add NaOH(aq) to free phenylamine.

3.4 (a) KCN (in ethanol) to give propanenitrile; then $LiAlH_4$ (or H_2/Ni) to reduce it to propylamine.
(b) the direct halogenoalkane + ammonia route also makes secondary/tertiary amines (over-substitution), lowering the yield of the primary amine.