36. Organic synthesis

36.1 Organic synthesis

Paper 4

Question Paper

1 Four esters, **A**, **B**, **C** and **D**, with the molecular formula $C_6H_{12}O_2$ are shown in Fig. 7.1.

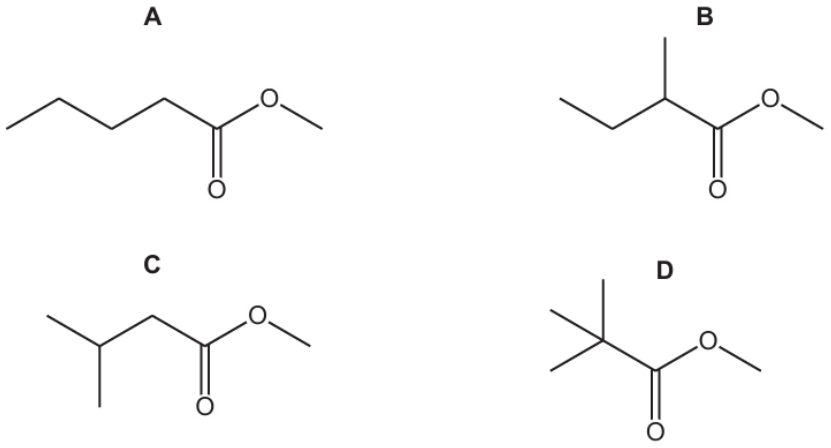


Fig. 7.1

(d) Compound **F**, $C_6H_8O_3$, shows stereoisomerism and effervesces with $Na_2CO_3(aq)$.

Compound **F** reacts with alkaline $I_2(aq)$ to form yellow precipitate **G** and compound **H**.

Compound **F** reacts with $LiAlH_4$ to form compound **J**, $C_6H_{12}O_2$.

Compound **F** reacts with $SOCl_2$ to form compound **K**, $C_6H_7O_2Cl$.

Compound **K** reacts with propan-2-ol to form compound **L**.

Draw the structures of compounds **F**, **G**, **H**, **J**, **K** and **L** in the boxes in Fig. 7.3.

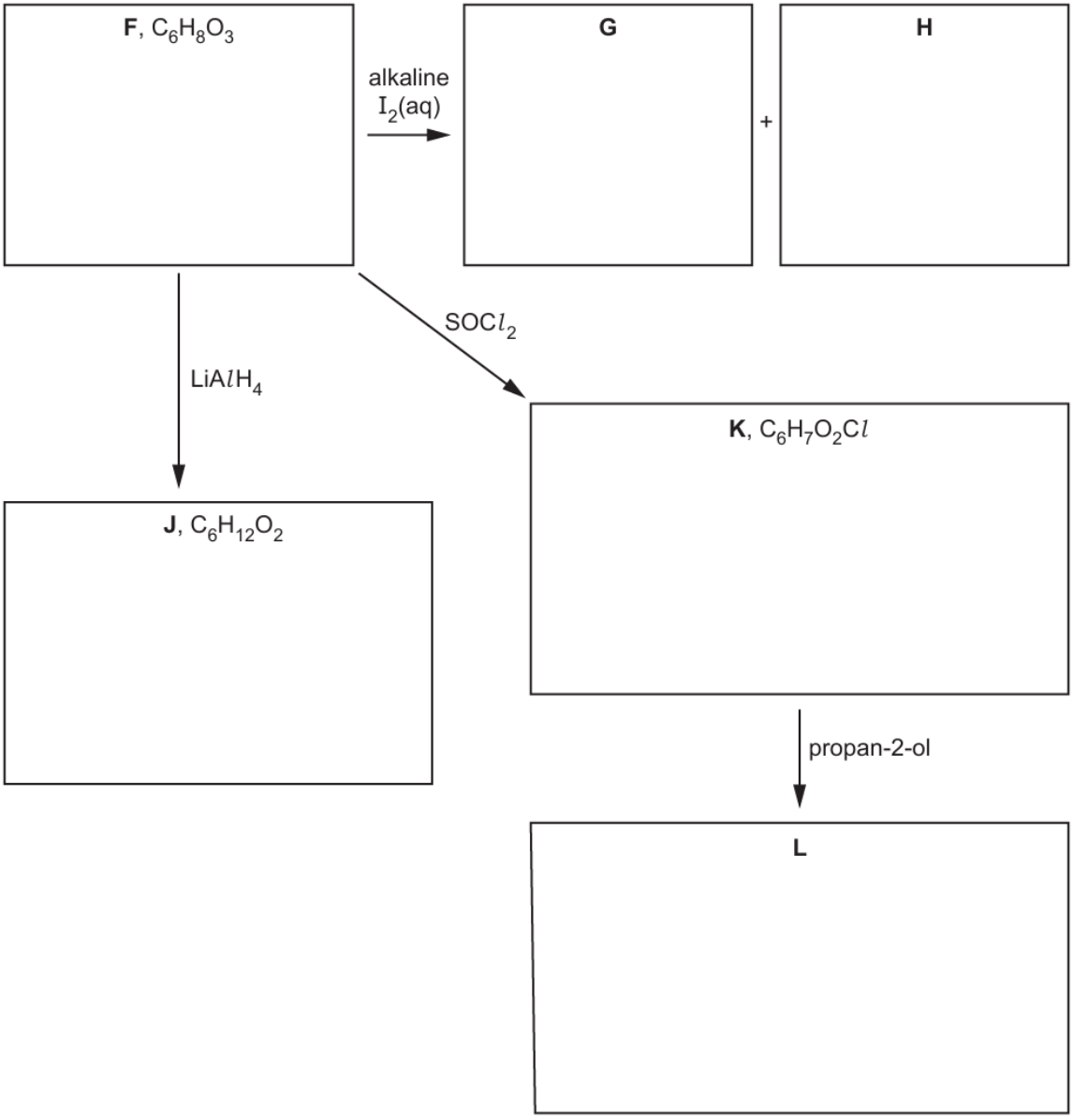


Fig. 7.3

[6]

2 **(d)** The complex $[Cr(OCH_2CH_2NH_2)_3]^-$ is formed by reacting $Cr^{2+}(aq)$ with the conjugate base of 2-aminoethanol.

A synthesis of 2-aminoethanol is shown in Fig. 2.2.

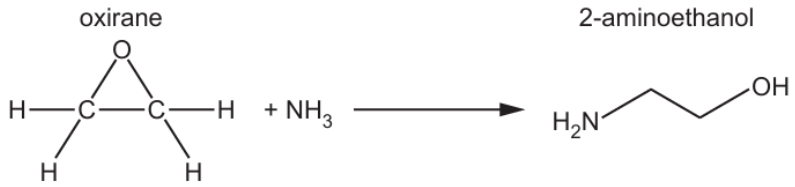


Fig. 2.2

(i) Suggest the mechanism for step 1 of the reaction of oxirane with ammonia in Fig. 2.3.

Include all relevant curly arrows, lone pairs of electrons, charges and partial charges.

Draw the structure of the organic intermediate.

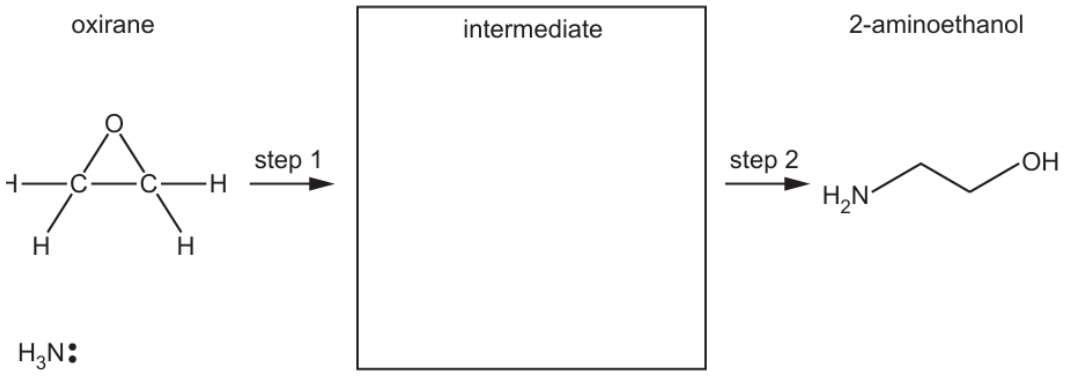


Fig. 2.3

[3]

(ii) A small amount of by-product **E**, shown in Fig. 2.4, is produced during the reaction shown in Fig. 2.2.

E

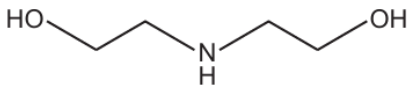


Fig. 2.4

Suggest how the formation of by-product **E** can be minimised.

.....

..... [1]

(iii) Compound **F**, C_4H_9NO, can be formed from the reaction of by-product **E**, $C_4H_{11}NO_2$, with concentrated H_2SO_4.

Compound **F** is a **saturated** and basic organic compound.

Suggest a structure for compound **F**. State the type of reaction undergone by **E** to form **F**.

F

type of reaction .....

[2]

3 **(d)** Isocyanic acid, HNCO, can form cyanuric acid, $C_3H_3N_3O_3$, under certain conditions.

$C_3H_3N_3O_3$ has a cyclic structure containing alternating carbon and nitrogen atoms in the ring system.

Suggest a structure for cyanuric acid.

[1]

4 **(b)** Compound **H** can be prepared from the reaction of **J** with an excess of hot aqueous acid.

J

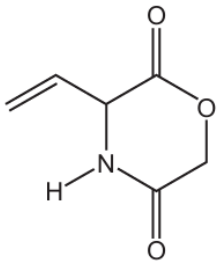


Fig. 6.1

(i) Complete Fig. 6.2 to show the equation for this reaction.

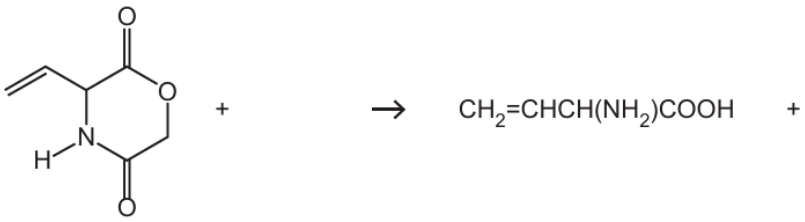


Fig. 6.2

[1]

(ii) Name the type of reaction in **(b)(i)**.

..... [1]

5 **(b)** Compound **T**, $C_5H_9O_2Cl$, is a useful synthetic intermediate.

Fig. 8.1 shows some reactions of **T**.

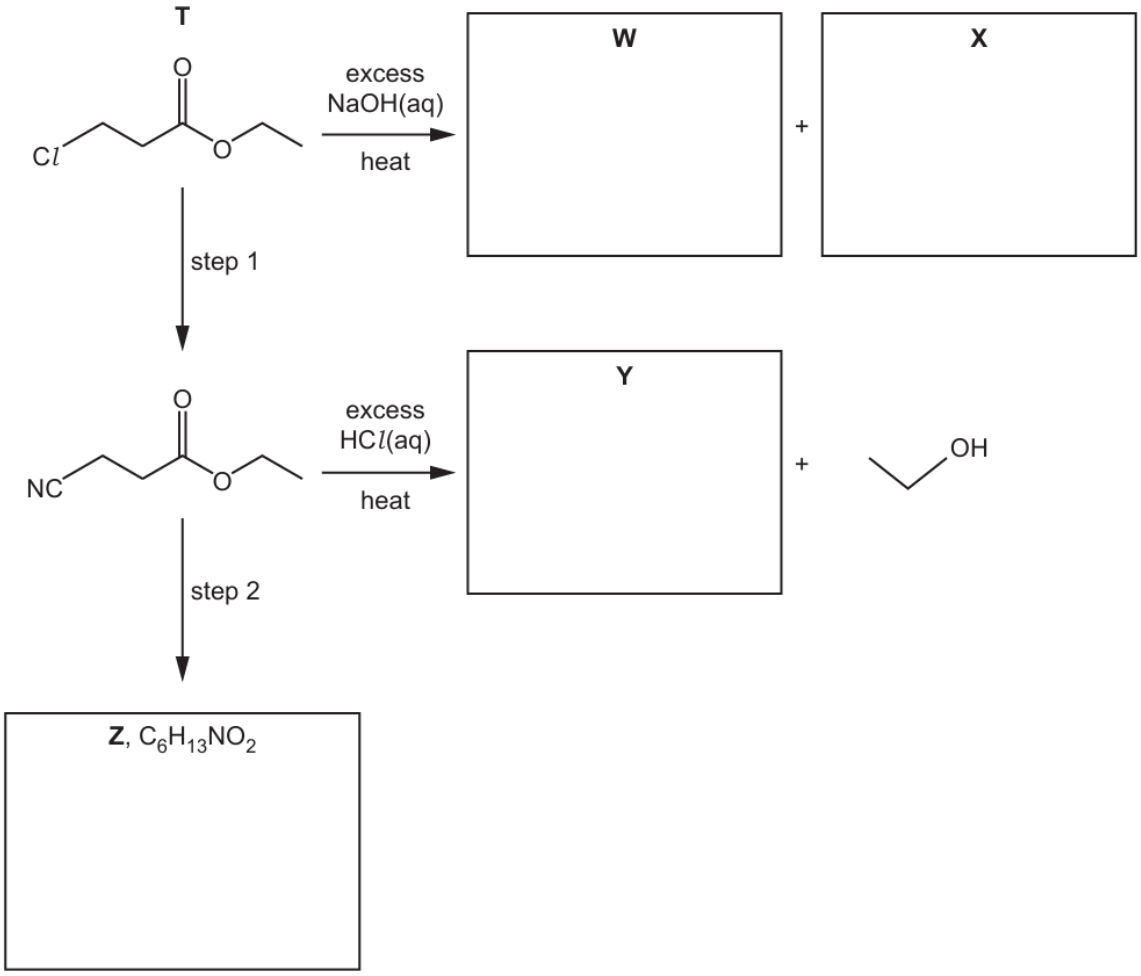


Fig. 8.1

(i) Give the systematic name for **T**.

..... [1]

(ii) Draw the structures of **W**, **X**, **Y** and **Z** in Fig. 8.1. [4]

(iii) State the reagents and conditions for steps 1 and 2 in Fig. 8.1.

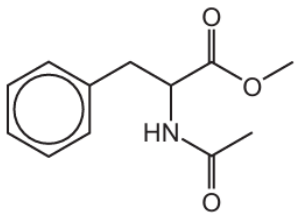
step 1 .....

step 2 .....

[2]

6 **(b)** **P** can be used to make compound **Q** in a single step reaction.

Q

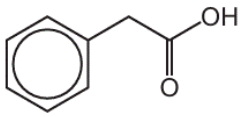


(ii) When an ester is treated with $LiAlH_4$ in dry ether the ester linkage is cleaved by the addition of four hydrogen atoms and two alcohols are produced.

Draw the structures of the compounds formed when **Q** is treated with an **excess** of $LiAlH_4$ in dry ether.

[3]

7 The structure of phenylethanoic acid is shown.



(d) A three-step synthesis of phenylethanoic acid from methylbenzene is shown.

(i) State reagents and conditions for step 1.

..... [1]

(ii) Suggest the structure of compound **Q**.

[1]

(iii) State reagents and conditions for steps 2 and 3.

step 2 .....

step 3 .....

[2]

(iv) Draw the structure of an organic by-product that forms in step 1.

[1]

8 Butylamine, $CH_3CH_2CH_2CH_2NH_2$, can be synthesised from different organic compounds by using suitable reagents. Each reaction involves one step.

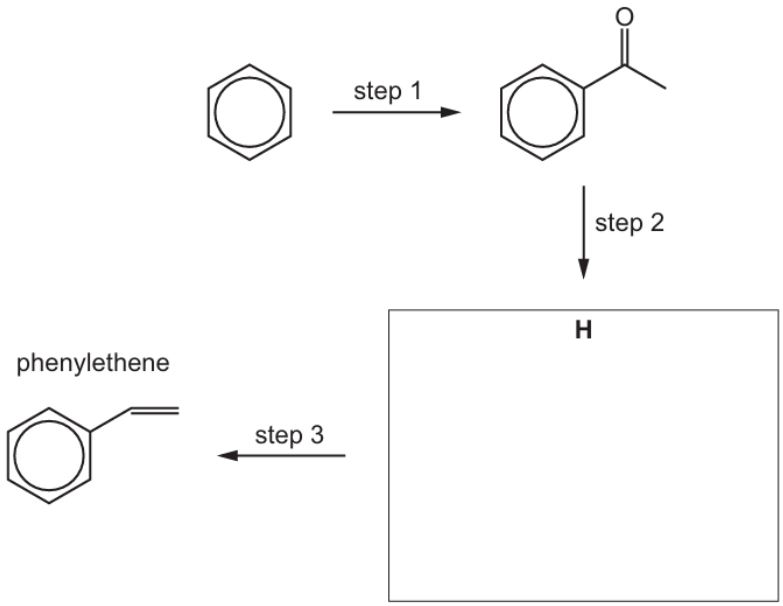
(a) Complete the table to describe three different syntheses.

- One of the three syntheses should involve a nucleophilic substitution reaction.
- The starting organic compound for each synthesis should contain a different functional group.
- A different reagent should be used for each synthesis.

starting organic compound	reagent and conditions

[6]

9 **(f)** The alkene phenylethene can be prepared from benzene in three steps.



(i) Deduce the identity of compound **H** and draw its structure in the box. [1]

(ii) Suggest reagents and conditions for each of the steps 1–3.

step 1 .....

step 2 .....

step 3 .....

[3]