34.1 AMINES

Learning outcomes

Candidates should be able to:

1. recall the reactions (reagents and conditions) by which primary and secondary amines are produced:
   (a) reaction of halogenoalkanes with NH_3 in ethanol heated under pressure
   (b) reaction of halogenoalkanes with primary amines in ethanol, heated in a sealed tube/under pressure
   (c) the reduction of amides with $LiAlH_4$
   (d) the reduction of nitriles with $LiAlH_4$ or H_2/Ni
2. describe the condensation reaction of ammonia or an amine with an acyl chloride at room temperature to give an amide
3. describe and explain the basicity of aqueous solutions of amines

Reaction of halogenoalkanes with NH_3 in ethanol heated under pressure

1. Ethylamine is a primary amines.

ethylamine

$CH_3CH_2NH_2$

Several methods can be used to form ethylamine.
(i) Ethylamine is a product of the reaction of bromoethane with ammonia.
Name the mechanism of this reaction and state the conditions used.

mechanism .....

conditions ..... [2]

(ii) The reaction in (i) also forms secondary and tertiary amines.
Suggest the identity of a secondary or tertiary amine formed by the reaction in (a)(ii).

..... [1]

Reaction of halogenoalkanes with primary amines

2. Tulobuterol is produced from Q as shown in Fig. 5.5.

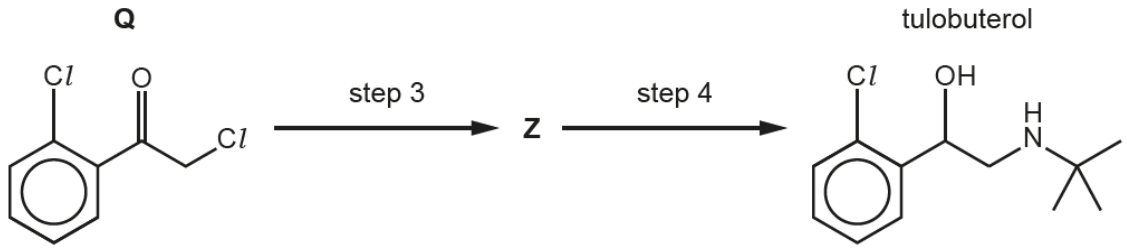


Fig. 5.5

Suggest reagents and conditions for steps 3 and 4.

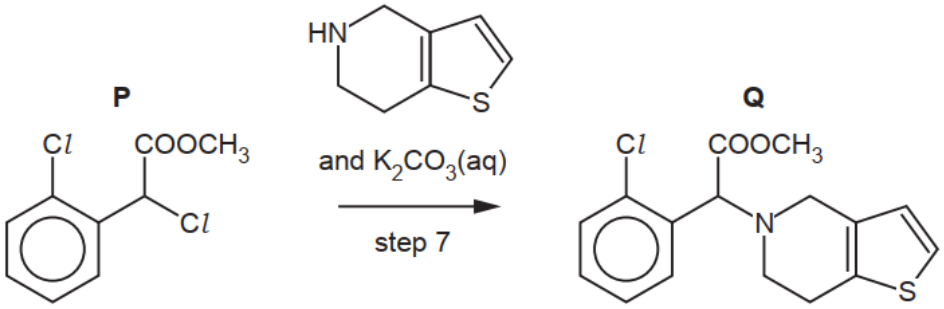
step 3 .....

step 4 .....

Draw the structure of Z in the box. [3]

Z

3. Compound **Q** can be synthesised from chlorobenzene in seven steps, using the route shown in Fig. 5.1.
Step 7 takes place when P is heated with a weak base such as K_2CO_3(aq).



(I) Suggest why a strong base such as NaOH(aq) is **not** used for this reaction.

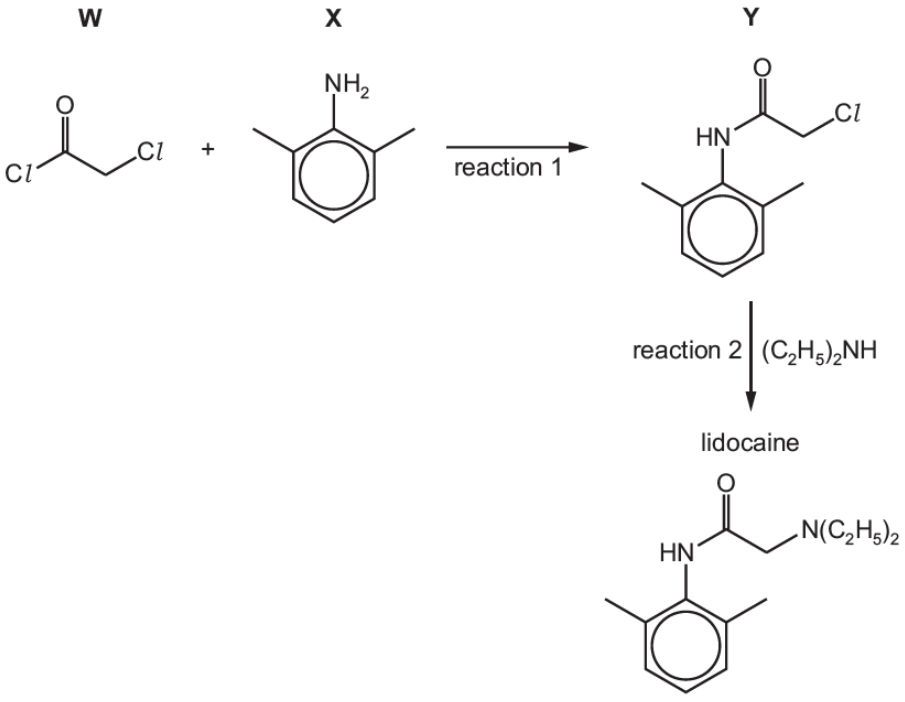
.....

..... [1]

(ii) Give two reasons why it might be desirable to synthesise a single optical isomer of Q for use as a drug.

[MS= any two of:
• reduced / different biological activity of 'other' enantiomer **ORA**
• avoids need to separate the optical isomers to form the pure active isomer
• lower dosage required **OR** (drug is) more potent
• higher yield (of biologically-active molecule)
• *no / less* (harmful) side effects **OR** *other isomer* can have side effects]

4. Lidocaine is used as an anaesthetic. A synthesis of lidocaine is shown in Fig. 6.1.



(a) W can be formed by reacting $HOCH_2COOH$ with an excess of $SOCl_2$.
Write an equation for this reaction.

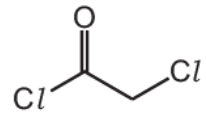
..... [1]

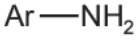
(b) After **W** and **X** have reacted together, an excess of $CH_3COONa(aq)$ is added to the reaction mixture.
Suggest why.

.....

..... [1]

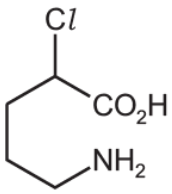
(c) The reaction of **W** with **X**, reaction 1, follows an addition–elimination mechanism.
Complete the mechanism for the reaction of **W** with **X**.
Include all relevant curly arrows, lone pairs of electrons, charges, and partial charges.
Use $Ar–NH_2$ to represent **X**. [4]





5. After several further stages, **Z** is produced.

Z



In the final stage of the synthesis, **Z** reacts via a nucleophilic substitution mechanism to form proline.

(vi) Complete the diagram to describe the reaction mechanism of the final stage. Draw curly arrows, ions and charges, partial charges and lone pairs of electrons, as appropriate.
Draw the structure of any organic intermediate ion.

Z proline

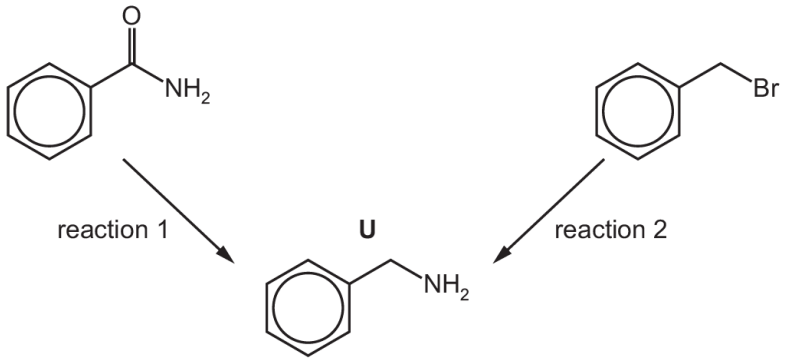
[3]

Reduction of amides

6. Ethylamine forms when ethanamide, CH_3CONH_2, is reduced by $LiAlH_4$.
Write an equation for this reaction. Use [H] to represent one atom of hydrogen from the reducing agent.

..... [1]

7. Compound U can be prepared by two different methods as shown.



(i) Suggest reagents and conditions for reaction 1 and for reaction 2.

reaction 1 .....

reaction 2 ..... [2]

(ii) State the type of reaction in reaction 1 and name the mechanism in reaction 2.

type of reaction in reaction 1 .....

mechanism of reaction 2 ..... [2]

8. State the reactants and conditions for two different types of reactions that both produce diethylamine, $CH_3CH_2NHCH_2CH_3$.

reaction one .....

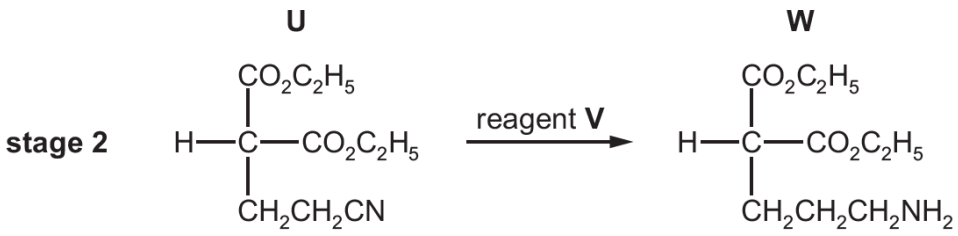
.....

reaction two .....

..... [4]

Reduction of nitriles

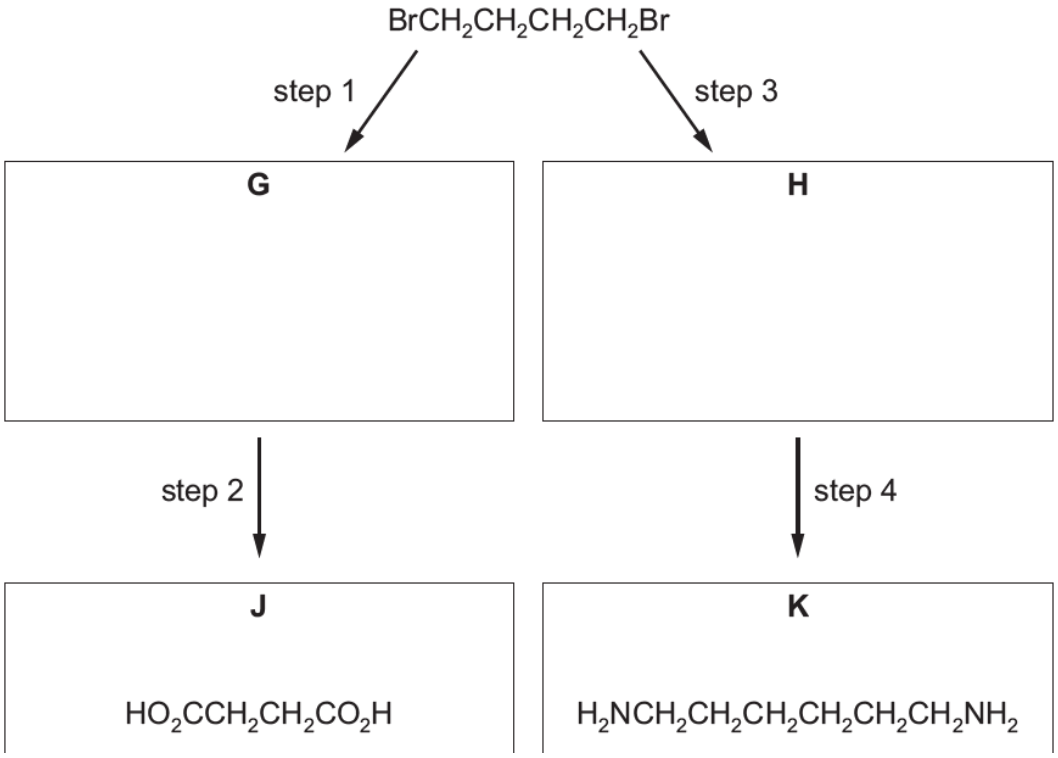
9. In stage 2, U reacts with reagent V to form W.



(iii) Suggest a suitable reagent V.

..... [1]

10. 1,4-dibromobutane, $Br(CH_2)_4Br$, is used in the synthesis of the dicarboxylic acid J and diamine K as shown.



(i) Draw the structures of G and H in the boxes. [2]

(ii) Suggest reagents and conditions for each of steps 1 to 4.

step 1 .....

step 2 .....

step 3 .....

step 4 ..... [4]

11. Compound **T**, $C_5H_9O_2Cl$, is a useful synthetic intermediate.
Fig. 8.1 shows some reactions of **T**.

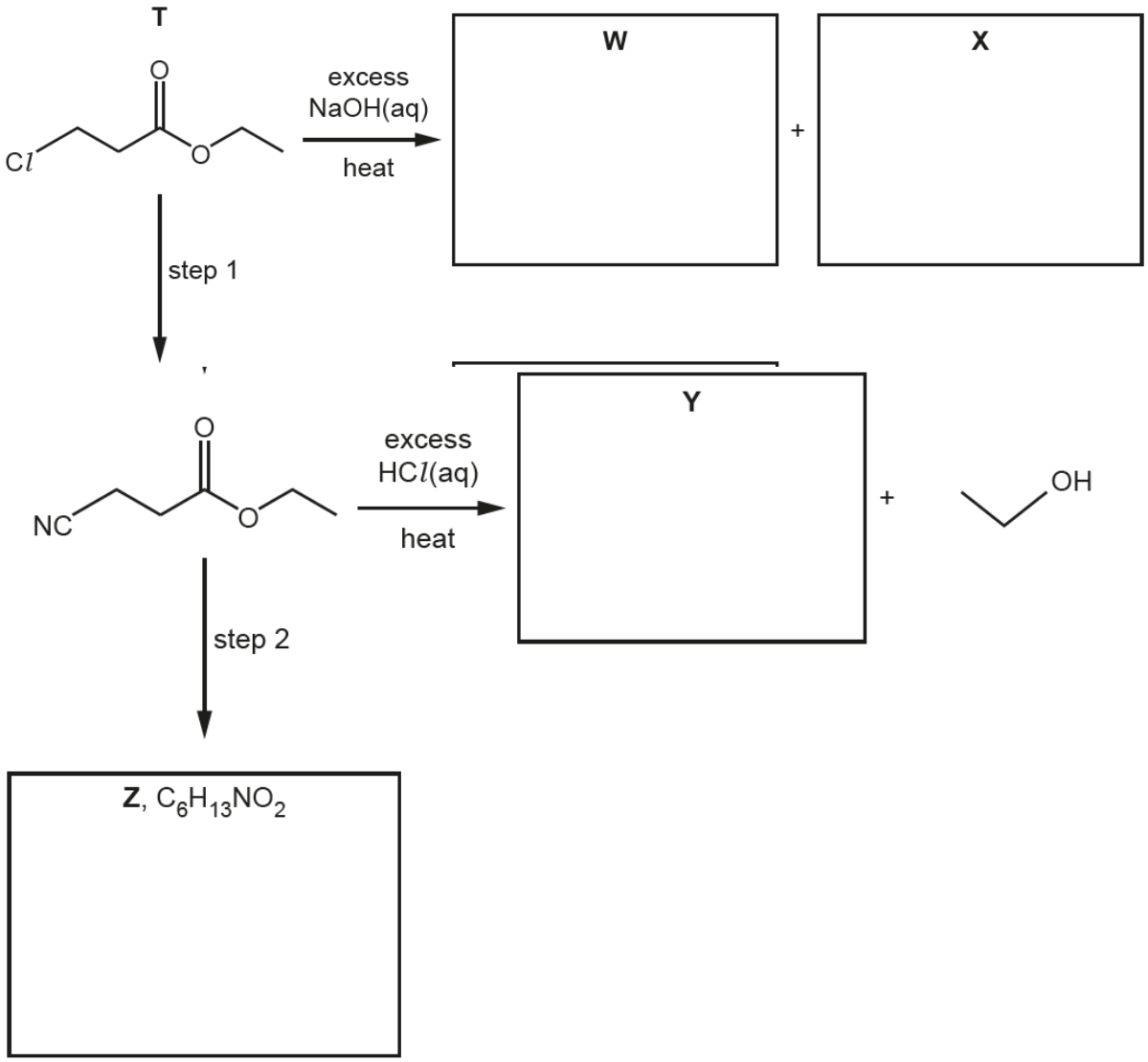


Fig: 8.1

(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]

12. 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]

13. Fig. 9.1 shows the preparation of 2-phenylethylamine, $C_6H_5CH_2CH_2NH_2$, by three different routes.

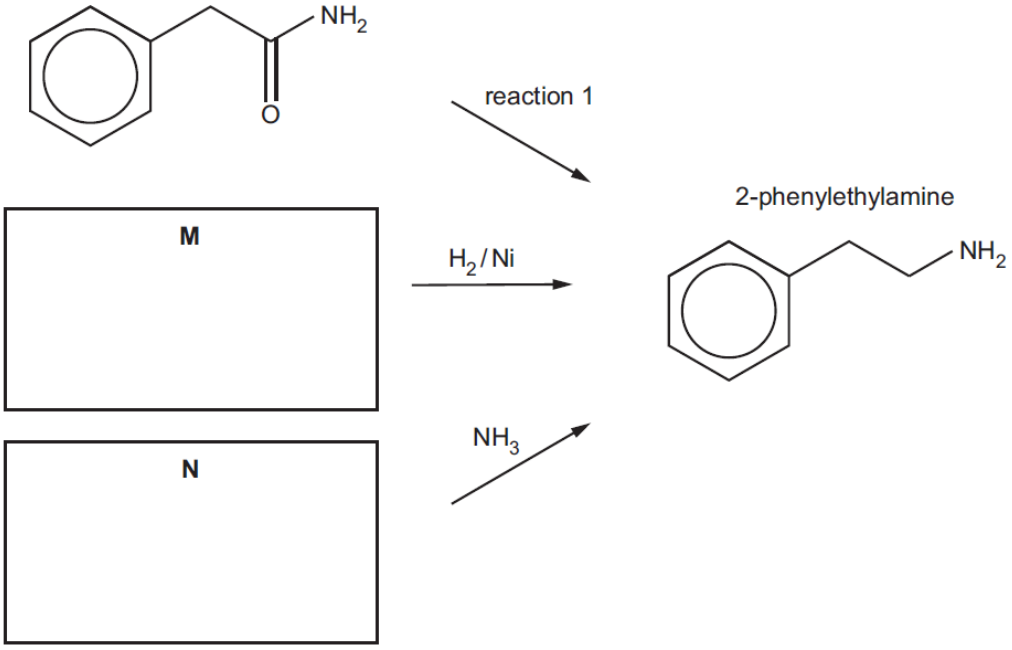


Fig:9.1

(i) Suggest structures for compounds M and N and draw them in the boxes in Fig. 9.1. [2]

(ii) Give the reagents and conditions for reaction 1.

..... [1]

14. Identify an organic compound that can be converted into $CH_3CH_2CH_2NH_2$ by a reduction reaction. State the reagent for this reaction.

organic compound .....

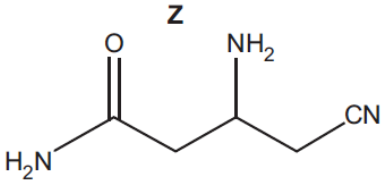
reagent ..... [2]

Condensation with acyl chlorides

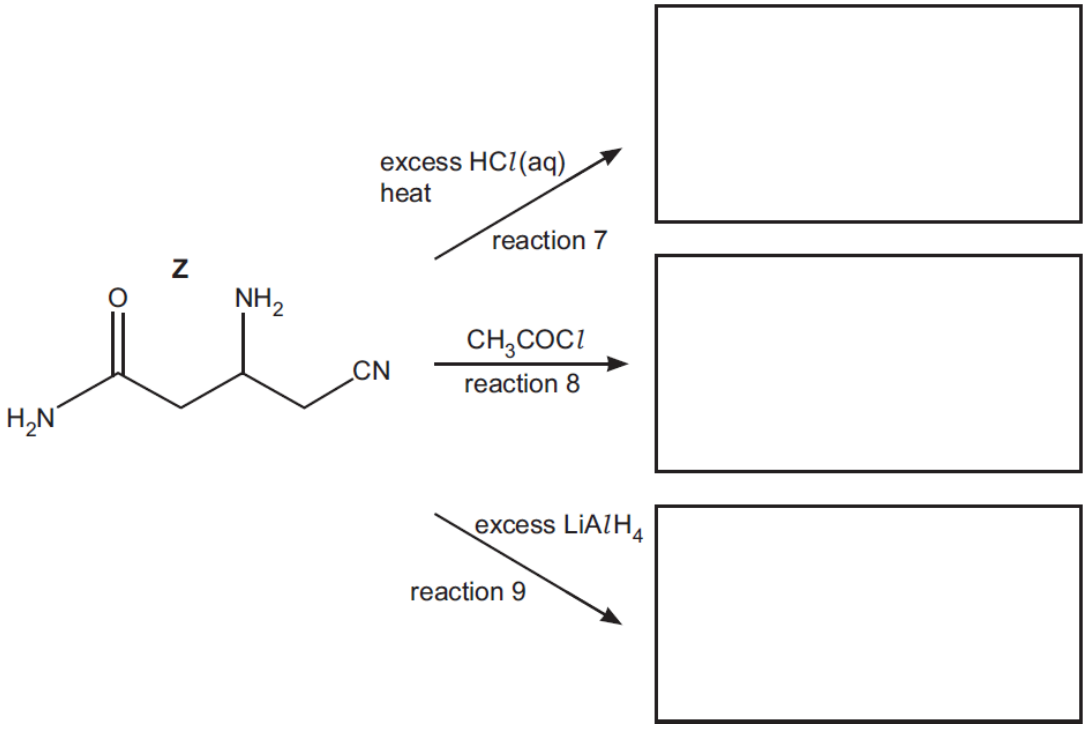
(studied in previous chapter 33.3 acyl chlorides)

Reaction of primary amines with acyl chloride

15. Compound Z is used in organic synthesis.



Z can undergo different reactions, as shown in Fig. 6.1.



(i) Name the two types of reaction occurring in reaction 7 in Fig. 6.1.

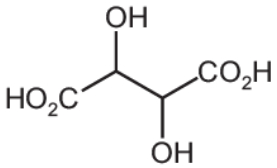
..... and ..... [1]

Draw the structures of the organic products of reactions 7, 8 and 9 in Fig. 6.1. [4]

Basicity

16. Complete the following table to show the structures of the organic products formed when tartaric acid reacts separately with each reagent. Identify each type of reaction.

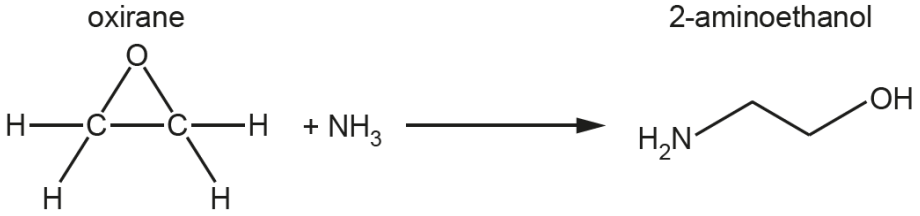
tartaric acid



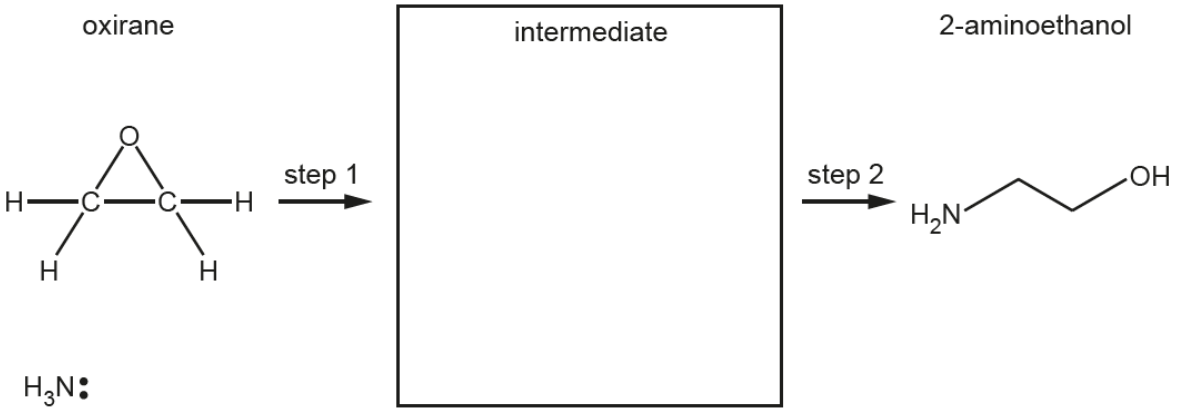
Tartaric acid reacts with the amine 1-phenylethylamine, $C_6H_5CH(NH_2)CH_3$, to form an ionic salt.
Draw the structure of the salt formed in this reaction. Include the charges on the ions.

[1]

17. 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.



(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. [3]



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

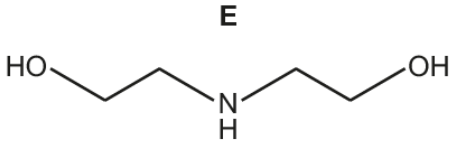


Fig. 2.4

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]