15. Halogen compounds

15.1 Halogenoalkanes

Paper 2

Question Paper

1 $CH_3(CH_2)_5CHBrCH_3$ exists as a pair of stereoisomers.

(b) A sample of $CH_3(CH_2)_5CHBrCH_3$ reacts with NaOH to make $CH_3(CH_2)_5CH(OH)CH_3$ in an S_N1 mechanism.

Complete Fig. 4.1 to show the mechanism for the reaction of $CH_3(CH_2)_5CHBrCH_3$ and NaOH.

Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.

Fig. 4.1

[3]

(d) $CH_3(CH_2)_5CHBrCH_3$ is heated with **D** to produce three different molecules, **E**, **F** and **G**.

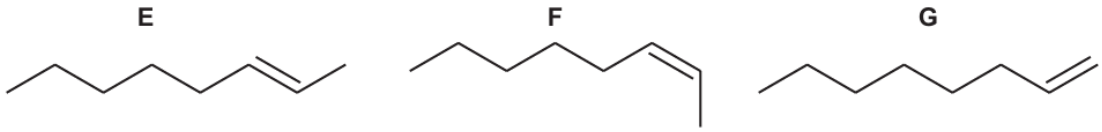


Fig. 4.2

(i) Name the type of reaction.

..... [1]

(ii) Identify **D** and the conditions used.

..... [1]

2 Chlorine is one of the elements in Group 17 of the Periodic Table.

(c) $CHCl_3$ is another halogenoalkane. $CHCl_3$ forms when propanone reacts with NaClO.

NaClO is made from chlorine in a disproportionation reaction.

(iii) Write numbers in the boxes to balance the equation showing the reaction of propanone with NaClO.

CH_3COCH_3 + ☐ NaClO → ☐ $CHCl_3$ + ☐ CH_3COONa + ☐ NaOH

[1]

(iv) Aqueous $AgNO_3$ dissolved in ethanol reacts with an aqueous solution of $CHCl_3$.

State what is observed in this reaction. Explain your answer.

.....

.....

..... [2]

3 Bromoalkanes are used widely in industry, although there is increasing concern about their environmental impact.

Fig. 4.1 shows a reaction scheme involving 1,2-dibromoethane.

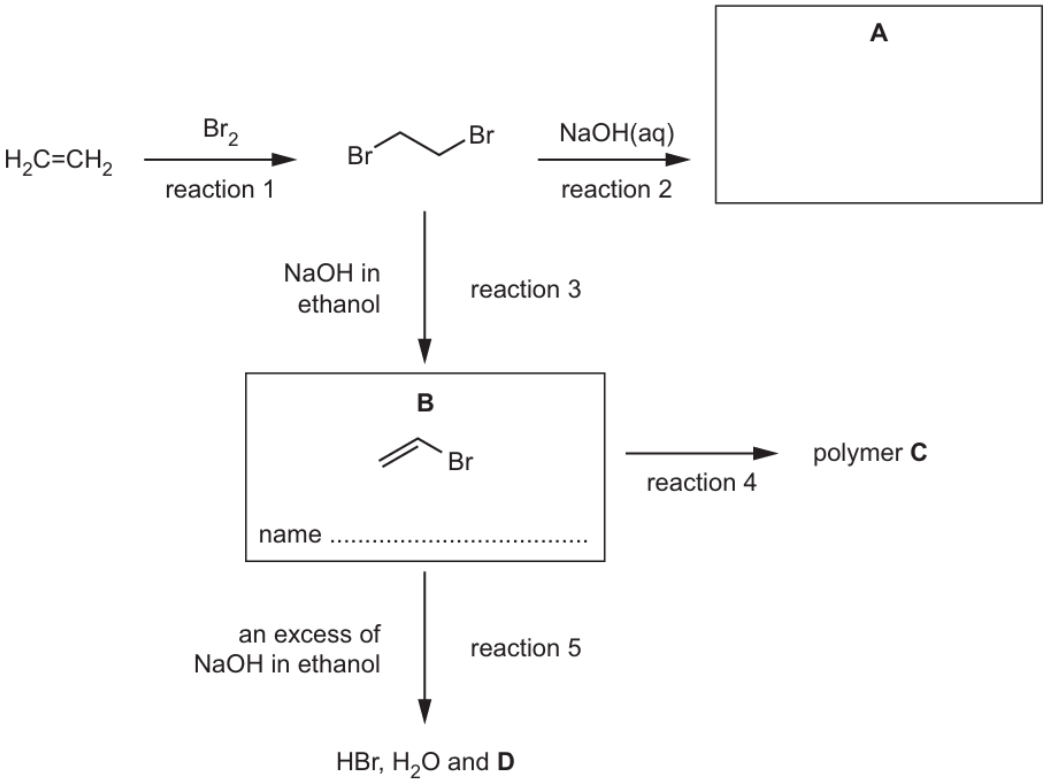


Fig. 4.1

(c) (i) Complete Fig. 4.1 to:

- draw the structure of compound **A**
- name compound **B**.

[2]

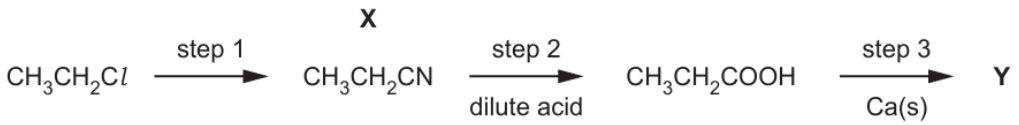
4 Chlorine is a very reactive element.

(e) $CHCl_3$ and HF are used to form $CHClF_2$ in a substitution reaction.

Construct an equation for this reaction.

..... [1]

5 Fig. 3.1 describes a sequence of reactions that can be used to produce a food additive, compound **Y**, from CH_3CH_2Cl.



$CH_3CH_2Cl \xrightarrow{\text{step 1}} CH_3CH_2CN \xrightarrow[\text{dilute acid}]{\text{step 2}} CH_3CH_2COOH \xrightarrow[\text{Ca(s)}]{\text{step 3}} \mathbf{Y}$

Fig. 3.1

(a) (i) State the reagent and conditions for step 1 in Fig. 3.1.

..... [1]

6 Fig. 5.1 shows three reactions of 2-bromopropane, $CH_3CH(Br)CH_3$.

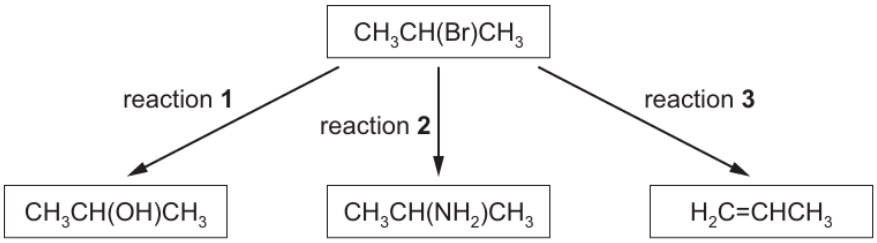


Fig. 5.1

(a) Complete Table 5.1 for each reaction, by:

- stating the reagent and conditions used
- identifying the type of reaction that occurs.

Table 5.1

reaction	reagent and conditions	type of reaction
1		
2		
3		

[6]

(b) A sample of 2-iodopropane, $CH_3CH(I)CH_3$, reacts under the same conditions as reaction **1** to produce $CH_3CH(OH)CH_3$.

Explain why 2-iodopropane reacts at a faster rate than 2-bromopropane.

.....

.....

..... [2]

(c) Fig. 5.2 shows how butan-1-ol can be made from 1-bromopropane in three steps.

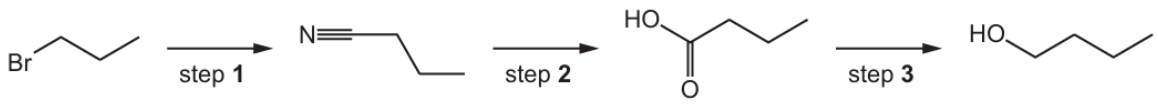


Fig. 5.2

(i) In step **1**, 1-bromopropane reacts with CN^- to form butanenitrile.

Complete Fig. 5.3 to show the mechanism for step **1**. Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.

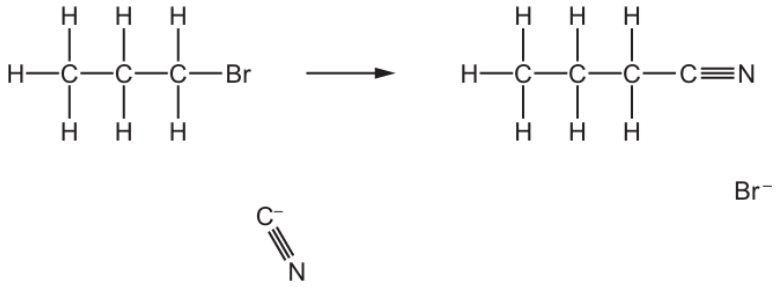


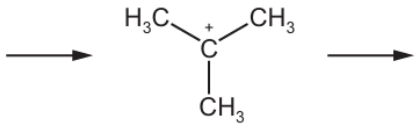
Fig. 5.3

[2]

7 Species such as NH_4^+, CO_3^{2-} and PO_4^{3-} are examples of molecular ions.

(e) OH^-(aq) reacts with 2-bromo-2-methylpropane in an S_N1 reaction.
The molecular ion $(CH_3)_3C^+$ forms as the intermediate in this reaction.

(i) Draw the mechanism for the S_N1 reaction of OH^- with 2-bromo-2-methylpropane.
Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.
Draw the structures of the organic reactant and organic product.



[3]

(ii) 2-bromo-2-methylpropane is a tertiary bromoalkane.

Define tertiary bromoalkane.

.....

..... [1]

(iii) Organic compound **M** forms when 2-bromo-2-methylpropane is heated with **ethanolic** OH^-.

Draw the structure of **M**.

[1]

8 Propene, C_3H_6, reacts with H_2O in the presence of an acid catalyst to form an alcohol with molecular formula C_3H_8O.

(e) 2-bromopropane reacts to form propene, hydrogen bromide and water under certain conditions.

(i) Name this type of reaction.

..... [1]

(ii) Describe the reagents and conditions needed to favour this reaction.

reagents .....

conditions .....

[2]

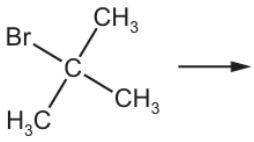
9 A large excess of 2-bromo-2-methylpropane is added to 0.0010 mol of NaOH(aq), which contains a few drops of phenolphthalein indicator. A stopwatch is started as soon as the substances are mixed. The time taken for the pink colour to disappear is recorded.

The experiment is repeated at different temperatures, keeping all concentrations and volumes of reagents constant.

temperature /°C	time taken for pink colour to disappear / s
20	300
25	65
35	20

(c) (i) Draw the mechanism to show the reaction of 2-bromo-2-methylpropane with OH^-(aq). Show the intermediate formed in this reaction.

Include all charges, partial charges, lone pairs and curly arrows as appropriate.



[3]

(ii) Name the mechanism for this reaction.

..... [1]

(d) The original experiment is repeated at 25 °C with 2-chloro-2-methylpropane instead of 2-bromo-2-methylpropane. All other variables remain constant.

Predict the effect of using 2-chloro-2-methylpropane compared to 2-bromo-2-methylpropane on the time taken for the pink colour to disappear. Explain your answer.

.....

.....

..... [2]

10 **S** is a secondary alcohol with molecular formula $C_4H_{10}O$.

(b) **S** is converted to **V** in a three-step reaction sequence.

In step 1, the secondary alcohol **S** reacts with PBr_3 to produce **T**, which has molecular formula C_4H_9Br.

(iii) State the reagent(s) and conditions for step 2.

.....

..... [2]

11 **(b)** The reaction of **Q** with NaOH(aq) tends to proceed via an S_N2 mechanism.

(i) Suggest the structural formula of the straight-chain halogenoalkane **Q**.

[1]

(ii) Explain why the reaction tends to proceed via an S_N2 mechanism rather than an S_N1 mechanism.

.....

.....

..... [2]

(c) Two different halogenoalkanes, **P** and **R**, both with the molecular formula C_4H_9Cl, are separately dissolved in ethanol and heated under reflux with sodium hydroxide.

The major organic product of each of these reactions is methylpropene.

(i) Name the type of reaction occurring.

..... [1]

(ii) Write an equation, using molecular formulae, to represent the reaction occurring.

..... [1]

(iii) Draw the skeletal formula of methylpropene.

[1]

(iv) Give the names of **P** and **R**.

..... [2]

12 Trihalomethanes are organic molecules in which three of the hydrogen atoms of methane are replaced by halogen atoms, for example $CHCl_3$.

(b) $CHClF_2$ was used as an alternative to chlorofluorocarbons (CFCs). $CHClF_2$ should no longer be used because it was found to contribute to the *enhanced greenhouse effect*.

(i) Give the meaning of the term *enhanced greenhouse effect*.

.....

..... [1]

(ii) Explain how $CHClF_2(g)$ may contribute to this effect.

.....

.....

..... [2]

(iii) Suggest another environmental problem associated with the use of $CHClF_2$.

..... [1]