

1 A student carries out an investigation on some halogenoalkanes.

(a) She decided to hydrolyse 1-bromopentane and 1-chloropentane using aqueous sodium hydroxide.

State and explain the difference in the rates of hydrolysis of 1-bromopentane and 1-chloropentane.

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..... [2]

(b) A student wants to determine the structure of an unknown iodoalkane **B**.

She knows that the molecular formula of **B** is C_4H_9I .

The student heats **B** with aqueous sodium hydroxide. A reaction mixture forms containing the organic compound **C** and $I^-(aq)$.

(i) Draw all of the possible structural isomers for **B**.

[4]

(ii) What is the molecular formula for compound **C**?

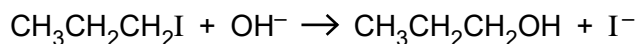
..... [1]

(iii) The student purifies compound **C** and splits it into two portions.

- She heats one portion of **C** with concentrated sulfuric acid. The product of this reaction is methylpropene.
- To the other portion of **C**, she adds acidified potassium dichromate(VI) and heats the mixture under reflux. The product of this reaction is compound **D**.
- The infrared spectrum for compound **D** is shown at the top of page 19.

- 2 A student carried out an investigation to compare the rates of hydrolysis of 1-iodopropane and 1-bromopropane. The student heated hot aqueous sodium hydroxide with each halogenoalkane and found that 1-iodopropane was hydrolysed faster.

The equation for the reaction with 1-iodopropane is shown below.



- (a) (i) Outline the mechanism for this hydrolysis of 1-iodopropane.

Show curly arrows and relevant dipoles.

[3]

- (ii) State the name of this type of mechanism.

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- (b) Explain why 1-iodopropane is hydrolysed faster than 1-bromopropane.

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- (c) Chlorofluoroalkanes, CFCs, were developed from fluoroalkanes and were used in aerosols and as refrigerants. Under the Montreal Protocol, CFCs are now largely banned because of their ozone-depleting properties. CFCs have now been replaced in many applications.

Suggest **two** reasons why there is still concern about ozone depletion.

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(d) Fluoroalkenes are used to make polymers. For example, PVF, $(\text{CH}_2\text{CHF})_n$, is used to make non-flammable interiors of aircraft.

(i) Draw **two** repeat units of the polymer PVF showing all bonds.

[1]

(ii) Draw the structure of the monomer of PVF.

[1]

(e) Once polymers have been used, they become waste.

Outline **two** ways that waste polymers are processed usefully, rather than just dumped in landfill sites.

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[Total: 12]

3 Chlorofluorocarbons, CFCs, were once used as propellants in aerosols. CFCs contribute to ozone depletion in the upper atmosphere.

(a) A CFC has the formula CF_2Cl_2 .

State the three-dimensional shape of a CF_2Cl_2 molecule and the F-C-Cl bond angle.

shape

bond angle [2]

(b) Two reasons that CF_2Cl_2 was used as an aerosol propellant are that it has low reactivity and will not hydrolyse in water.

(i) State **one** other reason why CF_2Cl_2 was developed for use as an aerosol.

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..... [1]

(ii) Suggest why CF_2Cl_2 does **not** hydrolyse in water.

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(c) Explain, with the aid of equations, how the presence of CFCs in the upper atmosphere leads to ozone depletion.

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..... [3]

(d) Why are scientists concerned about ozone depletion?

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..... [1]

(e) International agreements have reduced the use of CFCs. However the concentration of atmospheric CFCs has hardly changed.

Suggest **two** reasons why.

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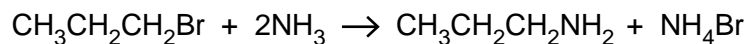
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[Total: 10]

4 This question is about halogenated hydrocarbons.

- (a) Halogenoalkanes undergo nucleophilic substitution reactions with ammonia to form amines. Amines contain the -NH_2 functional group.

For example, 1-bromopropane reacts with ammonia to form propylamine, $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$.

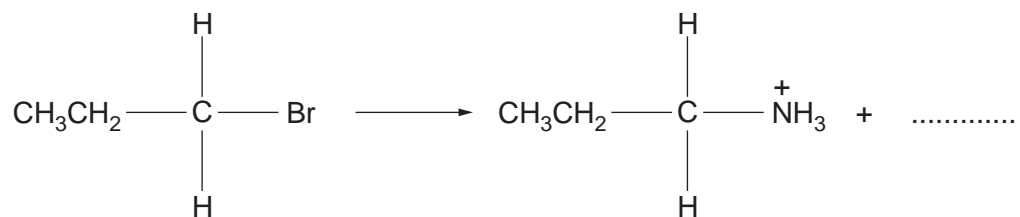


- (i) Iodoethane is reacted with ammonia.

Write an equation for this reaction.

..... [2]

- (ii) The first step in the mechanism of the reaction between $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ and NH_3 is shown below. It is incomplete.



Complete the mechanism.

Include relevant dipoles, lone pairs, curly arrows and the missing product.

[3]

(b) A student investigates the rate of hydrolysis of six halogenoalkanes.

The student mixes 5 cm³ of ethanol with five drops of halogenoalkane. This mixture is warmed to 50 °C in a water bath. The student adds 5 cm³ of aqueous silver nitrate, also heated to 50 °C, to the halogenoalkane. The time taken for a precipitate to form is recorded in a results table.

The student repeats the whole experiment at 60 °C instead of 50 °C.

halogenoalkane	time taken for a precipitate to form / s	
	at 50 °C	at 60 °C
CH ₃ CH ₂ CH ₂ CH ₂ Cl	243	121
CH ₃ CH ₂ CH ₂ CH ₂ Br	121	63
CH ₃ CH ₂ CH ₂ CH ₂ I	40	19
CH ₃ CH ₂ CHBrCH ₃	89	42
(CH ₃) ₂ CHCH ₂ Br	110	55
(CH ₃) ₃ CBr	44	21

Describe and explain the factors that affect the rate of hydrolysis of halogenoalkanes.

Include ideas about

- the halogen in the halogenoalkanes
- the groups attached to the carbon of the carbon–halogen bond (the type of halogenoalkane)
- the temperature of the hydrolysis.



In your answer you should link the evidence with your explanation.

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(c) Poly(tetrafluoroethene), PTFE, and poly(chloroethene), PVC, are halogenated plastics.

(i) Write an equation, using displayed formulae, for the reaction to form PTFE from its monomer.

[3]

(ii) The combustion of waste polymers can be used for energy production.
What problem is caused by disposing of PTFE and PVC in this way?

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..... [1]

[Total: 16]