

F322: Chains, Energy and Resources

Halogenoalkanes

56 Marks

1. 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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[Total 2 marks]

2. A student reacted 8.72 g of bromobutane with an excess of OH^- . The student produced 4.28 g of butan-1-ol.

In this reaction the hydroxide ion acts as a nucleophile.

- (i) What name is given to this type of reaction?

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[1]

- (ii) Explain the term *nucleophile*.

.....

[1]

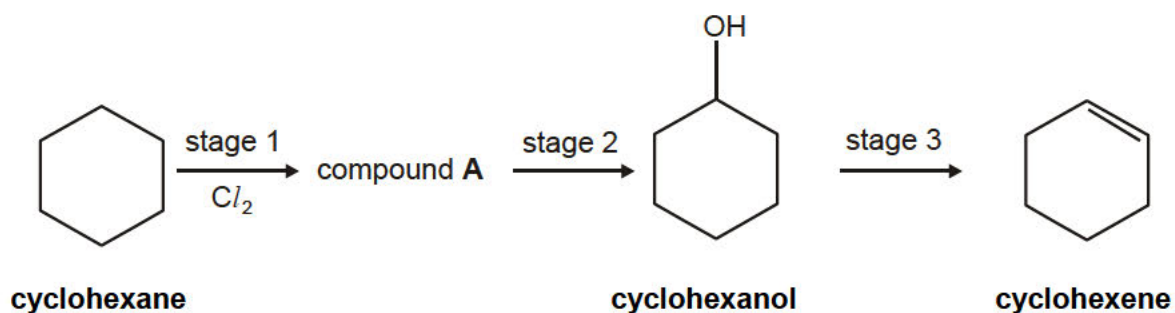
- (iii) Outline the mechanism for this reaction.

Show curly arrows and relevant dipoles.

[4]

[Total 6 marks]

3. (a) Cyclohexane can be converted into cyclohexene via a three-stage synthesis.



- (i) In stage 1, cyclohexane reacts with chlorine to form the organic product, compound **A**.

Show the structure of compound **A**.

[1]

- (ii) Stage 3 involves the dehydration of an alcohol.

State a suitable reagent for dehydrating an alcohol.

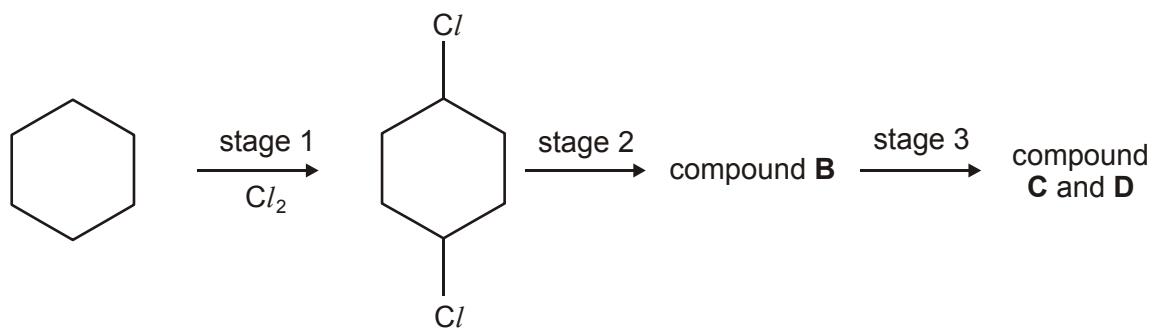
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[1]

- (iii) Write a balanced equation for the dehydration of cyclohexanol, $\text{C}_6\text{H}_{11}\text{OH}$.

[1]

- (b) The reaction in stage 1 is difficult to control. One other possible chlorinated product is 1,4-dichlorocyclohexane. This is shown below.



cyclohexane

1,4-dichlorocyclohexane

1,4-Dichlorocyclohexane reacts in the same way as compound **A** in stages 2 and 3.

- (i) Suggest the structure of compound **B**.

[1]

- (ii) Two cyclic alkenes, **C** and **D** are formed in stage 3. **C** and **D** are structural isomers. Suggest the structures of **C** and **D**.

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[2]

[Total 6 marks]

4. Trifluorochloromethane, CF_3Cl , is an example of a chlorofluorocarbon, CFC, that was commonly used as a propellant in aerosols. Nowadays, CFCs have limited use because of the damage caused to the ozone layer.

(i) Draw a diagram to show the shape of a molecule of CF_3Cl .

[1]

(ii) Predict an approximate value for the bond angles in a molecule of CF_3Cl .

bond angle

[1]

(iii) Suggest a property that made CF_3Cl suitable as a propellant in an aerosol.

.....

[1]

(iv) When CFCs are exposed to strong ultraviolet radiation in the upper atmosphere, homolytic fission takes place to produce free radicals.

Explain what is meant by the term *homolytic fission*.

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[2]

(v) Suggest which bond is most likely to be broken when CF_3Cl is exposed to ultraviolet radiation. Explain your answer.

bond

reason

[1]

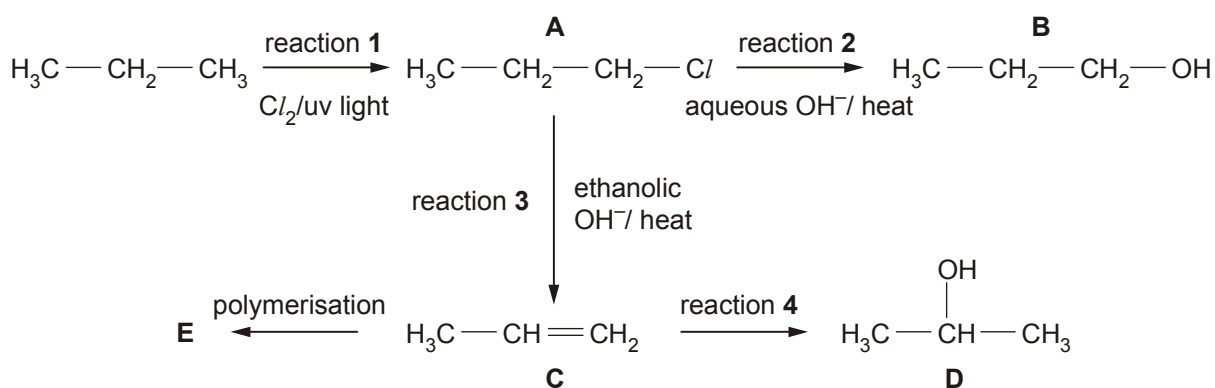
(vi) Identify the **two** free radicals most likely to be formed when CF_3Cl is exposed to ultraviolet radiation.

..... and

[2]

[Total 8 marks]

5. Propane, C₃H₈, is used in the reaction sequence shown below.



(a) The reaction sequence shows several important reaction mechanisms. Select from reactions 1 to 4, the reaction that shows

(i) free radical substitution, reaction

[1]

(ii) electrophilic addition, reaction

[1]

(iii) elimination, reaction

[1]

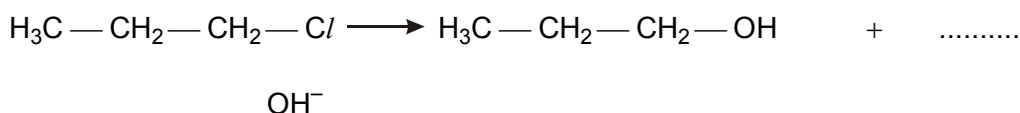
(b) In reaction 2, the aqueous OH⁻ acts as a nucleophile.

(i) State what is meant by the term *nucleophile*.

.....

[1]

(ii) Complete, with the aid of curly arrows, the mechanism involved in reaction 2. Show any relevant dipoles.



[4]

- (c) Compounds **B** and **D** are structural isomers of each other.

- (i) State what is meant by the term *structural isomers*.

.....

[2]

- (ii) Draw the skeletal formulae of compounds **B** and **D**.

Compound B	Compound D

[2]

- (d) Compound **C** can be polymerised to form compound **E**.

- (i) State the type of polymerisation.

[1]

- (ii) Name compound **E**.

[1]

- (iii) Draw a section of compound **E**. Show **two** repeat units.

[1]

[Total 15 marks]

6. In this question, one mark is available for the quality of spelling, punctuation and grammar.

The rates of hydrolysis of chloroethane, bromoethane and iodoethane are different.

- Describe how you would monitor the reaction rates.
- Explain why chloroethane, bromoethane and iodoethane react at different rates.

Use suitable equations in your answer.

[Total 6 marks]

7. In 1930, an American engineer, Thomas Midgley, demonstrated a new refrigerant. As part of his demonstration, he inhaled a lung full of dichlorodifluoromethane, CCl_2F_2 , and used it to blow out a candle.

Use Midgley's demonstration to suggest **two** properties of CCl_2F_2 . Explain, with a reason, **two** other uses of chemicals such as CCl_2F_2 , other than as a refrigerant.

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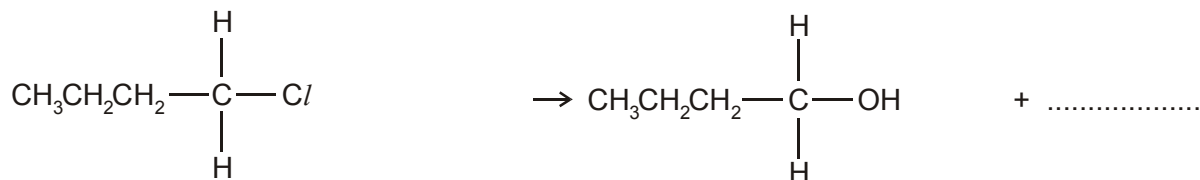
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[Total 4 marks]

8. Halogenoalkanes, such as 1-chlorobutane, are hydrolysed with hot aqueous alkali, $\text{OH}^-(\text{aq})$, to form alcohols.

(a) Describe, with the aid of curly arrows, the mechanism of the hydrolysis of 1-chlorobutane with $\text{OH}^-(\text{aq})$ ions to produce butan-1-ol. Show any relevant lone pairs of electrons and dipoles.



[4]

(b) Another halogenoalkane, **H**, has a relative molecular mass of 127 and has the following composition by mass:
C, 37.8%; H, 6.3%; Cl, 55.9%.

(i) Show that the empirical formula of compound **H** is $\text{C}_2\text{H}_2\text{Cl}$.

[2]

(ii) Deduce the molecular formula of compound **H**.

[1]

(iii) Compound **H** can also be hydrolysed with hot aqueous alkali to form butane-1,3-diol. Draw the structure of butane-1,3-diol

[1]

(iv) Deduce the structure of compound **H**.

[1]

[Total 9 marks]