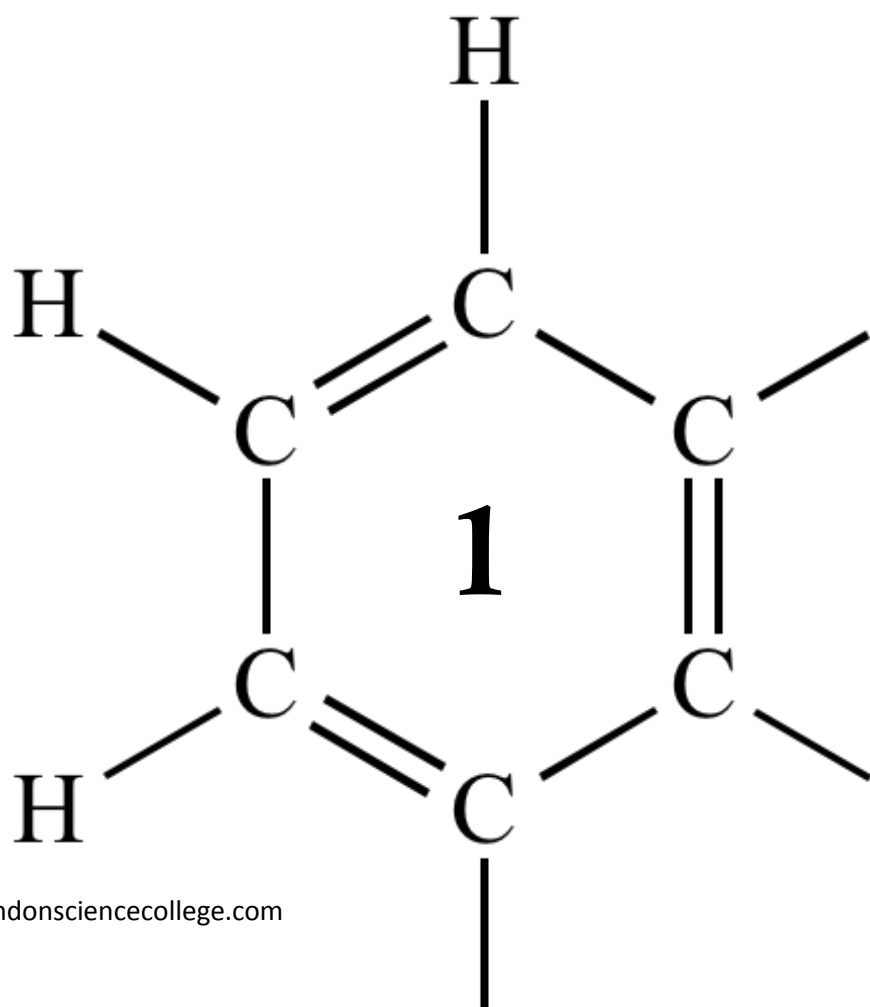


AQA AS CHEMISTRY
HALOALKANES



1

Refrigerants are substances used to cool refrigerators and freezers. Until recently, many of the compounds used as refrigerants were chlorofluorocarbons (CFCs), but these are now known to form chlorine radicals. CFCs have been phased out in many countries by international agreement.

(a) Write **two** equations to show how chlorine radicals react with ozone molecules in the upper atmosphere.

1

2

(2)

(b) Chloropentafluoroethane is a CFC that has been used as a refrigerant.

Draw its displayed formula.

(1)

(c) 1,1,1-trifluoroethane (CF_3CH_3) is one of the molecules that has been used as a refrigerant in place of CFCs.

Explain why 1,1,1-trifluoroethane does not lead to the depletion of the ozone in the upper atmosphere.

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(1)

- (d) One of the steps in the synthesis of 1,1,1-trifluoroethane (CF_3CH_3) is the reaction of 1,1-difluoroethane (CHF_2CH_3) with fluorine in a free-radical substitution reaction.

Write **two** equations to represent the propagation steps in this conversion of CHF_2CH_3 into CF_3CH_3

Propagation step 1

.....

Propagation step 2

.....

(2)

- (e) A refrigerator contains 1.41 kg of 1,1,1-trifluoroethane (CF_3CH_3).

Calculate the number of molecules of 1,1,1-trifluoroethane in the refrigerator.

Give your answer to an appropriate number of significant figures.

(The Avogadro constant $L = 6.022 \times 10^{23} \text{ mol}^{-1}$)

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(2)

- (f) There are growing concerns about the use of 1,1,1-trifluoroethane as a refrigerant as it is a greenhouse gas that absorbs some of Earth's infrared radiation.

Give **one** reason why bonds in molecules such as carbon dioxide and 1,1,1-trifluoroethane absorb infrared radiation.

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(1)

(Total 9 marks)

2

Pentanenitrile can be made by reaction of 1-bromobutane with potassium cyanide.

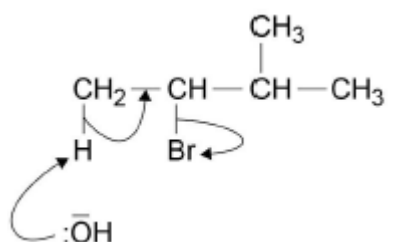
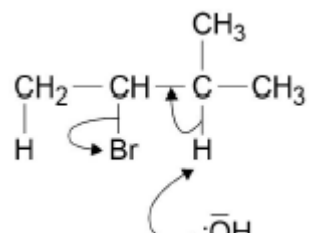
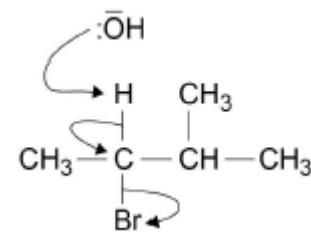
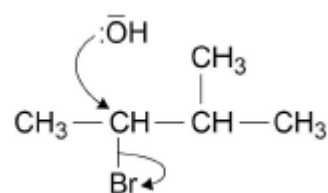
Which of these is the correct name for the mechanism of this reaction?

- A Electrophilic addition
- B Electrophilic substitution
- C Nucleophilic addition
- D Nucleophilic substitution

(Total 1 mark)

3

Which of the following is a correct mechanism for the formation of 2-methylbut-2-ene from 2-bromo-3-methylbutane?

- A 
- B 
- C 
- D 

(Total 1 mark)

4

Haloalkanes are used as refrigerants, solvents and anaesthetics.

(a) Trichloromethane (CHCl_3) is a haloalkane that can be formed by heating a mixture of chloromethane (CH_3Cl) and chlorine.

(i) Write an overall equation for the formation of trichloromethane by the reaction of chloromethane with chlorine.

..... (1)

(ii) Name the mechanism for this formation of trichloromethane.

..... (1)

(iii) Dichloromethane (CH_2Cl_2) is an intermediate in this formation of trichloromethane.

Write an equation for each of the following steps in the mechanism for the reaction of dichloromethane with chlorine.

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step leading to the formation of a compound with formula $\text{C}_2\text{H}_2\text{Cl}_4$

..... (4)

(b) Chlorotrifluoromethane (CClF_3) is used as a refrigerant, but is being phased out due to concerns about ozone depletion in the upper atmosphere. In the upper atmosphere, CClF_3 decomposes in the presence of UV light forming a reactive intermediate that catalyses the decomposition of ozone.

(i) Write an equation to show how CClF_3 decomposes to form the reactive intermediate.

..... (1)

(ii) Write two equations to show how this reactive intermediate is involved in catalysing the decomposition of ozone.

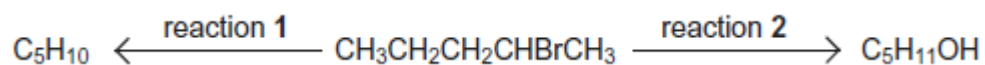
1

2

(2)
(Total 9 marks)

5

Two reactions of 2-bromopentane, (CH₃CH₂CH₂CHBrCH₃) are shown.



The C₅H₁₀ formed in reaction 1 exists as a mixture of three isomers, one of which is pent-1-ene. Two of the isomers are a pair of stereoisomers. All three isomers decolourise bromine.

- (a) The same reagent is used in both reactions. The product is determined by the choice of conditions.

State the reagent and the conditions for each of reaction 1 and reaction 2.

State the role of the reagent in each reaction.

Name and outline the mechanism of reaction 1 for the formation of pent-1-ene.

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(8)

(b) All three isomers of C_5H_{10} contain the same functional group.

Draw the displayed formula of pent-1-ene.

Draw the structures of the pair of stereoisomers and give their full IUPAC names.

Explain the origin of the stereoisomerism shown.

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(5)

- (c) The rates of hydrolysis of two chloroalkanes can be investigated by adding aqueous silver nitrate to the chloroalkanes. During the hydrolysis reactions, chloride ions are liberated slowly. Precipitates of silver chloride are formed.

Outline a method to compare the rate of hydrolysis of 1-chlorobutane with that of 2-chlorobutane. State how the method would ensure a fair test.

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(4)
(Total 17 marks)

6

2-bromo-2-methylpentane is heated with potassium hydroxide dissolved in ethanol. Two structural isomers are formed.

- (a) State the meaning of the term **structural isomers**.

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.....

.....

(1)

(b) Name and draw the mechanism for the formation of **one** of the isomers.

Name of mechanism

Mechanism

(5)
(Total 6 marks)

7

CCl_4 is an effective fire extinguisher but it is no longer used because of its toxicity and its role in the depletion of the ozone layer. In the upper atmosphere, a bond in CCl_4 breaks and reactive species are formed.

(a) Identify the condition that causes a bond in CCl_4 to break in the upper atmosphere. Deduce an equation for the formation of the reactive species.

Condition

Equation

.....

(2)

(b) One of the reactive species formed from CCl_4 acts as a catalyst in the decomposition of ozone.

Write **two** equations to show how this species acts as a catalyst.

Equation 1

.....

Equation 2

.....

(2)

- (c) A small amount of the freon CF_3Cl with a mass of $1.78 \times 10^{-4} \text{ kg}$ escaped from a refrigerator, into a room of volume 100 m^3 . Assuming that the freon is evenly distributed throughout the air in the room, calculate the number of freon molecules in a volume of 500 cm^3 .

Give your answer to the appropriate number of significant figures.

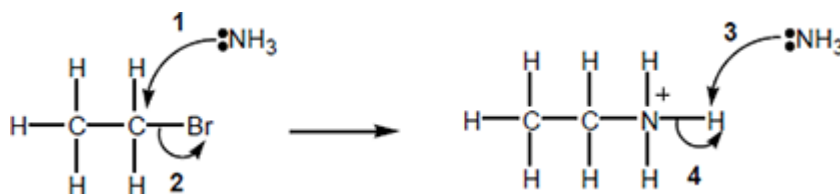
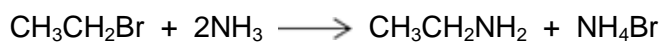
The Avogadro constant = $6.02 \times 10^{23} \text{ mol}^{-1}$.

Number of molecules =

(3)
(Total 7 marks)

8

This question is about a method that can be used to prepare ethylamine.



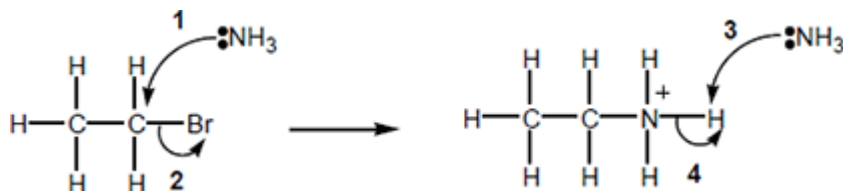
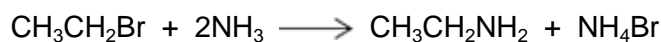
Which of the curly arrows in the mechanism is **not** correct?

- A 1
- B 2
- C 3
- D 4

(Total 1 mark)

9

This question is about a method that can be used to prepare ethylamine.



Which statement about the reaction is **not** correct?

- A Ethylamine is a primary amine.
- B The mechanism is a nucleophilic substitution.
- C Using an excess of bromoethane will prevent further reaction to form a mixture of amine products.
- D Ammonium bromide is an ionic compound.

(Total 1 mark)

10

Why are fluoroalkanes unreactive?

- A Fluorine is highly electronegative.
- B The F^- ion is very stable.
- C They are polar molecules.
- D The C-F bond is very strong.

(Total 1 mark)

11

There are many uses of halogenated organic compounds despite environmental concerns.

- (a) Bromotrifluoromethane is used in fire extinguishers in aircraft.
Bromotrifluoromethane is formed when trifluoromethane reacts with bromine.



The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

- (i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Br_2

Initiation step

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First propagation step

.....

Second propagation step

.....

A termination step

.....

(4)

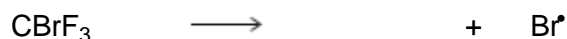
- (ii) State **one** condition necessary for the initiation of this reaction.

.....

(1)

- (b) Bromine-containing and chlorine-containing organic compounds may have a role in the decomposition of ozone in the upper atmosphere.

- (i) Draw an appropriate **displayed formula** in the space provided to complete the following equation to show how CBrF_3 may produce bromine atoms in the upper atmosphere.



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(1)

- (ii) In the upper atmosphere, it is more likely for CBrF_3 to produce bromine atoms than it is for CClF_3 to produce chlorine atoms.

Suggest **one** reason for this.

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(1)

- (iii) Bromine atoms have a similar role to chlorine atoms in the decomposition of ozone. The overall equation for the decomposition of ozone is



Write **two** equations to show how bromine atoms ($\text{Br}\bullet$) act as a catalyst in the decomposition of ozone.

Explain how these two decomposition equations show that bromine atoms behave as a catalyst.

Equation 1

.....

Equation 2

.....

Explanation

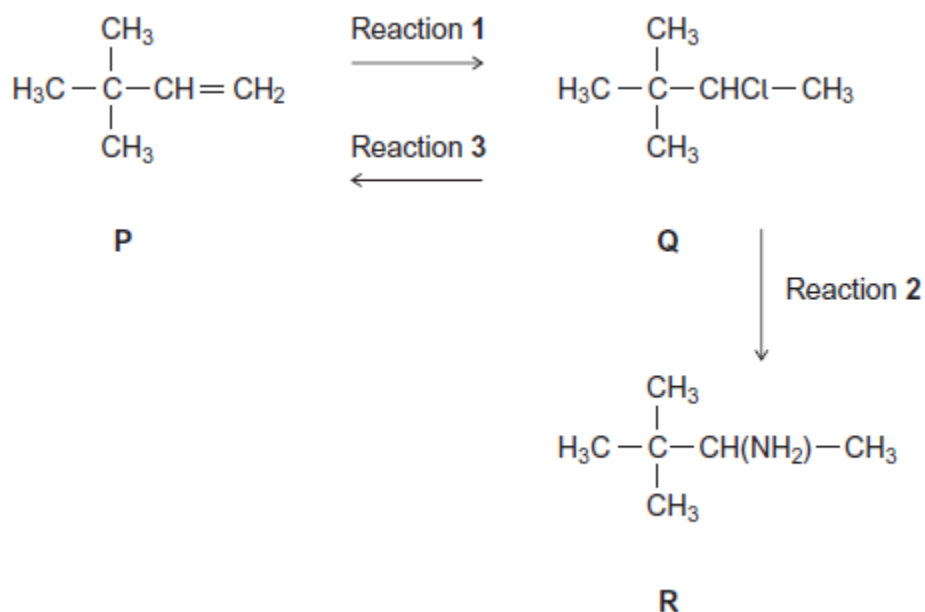
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(3)
(Total 10 marks)

12

Consider the following scheme of reactions.



- (a) Give the IUPAC name for compound
- P**
- and that for compound
- Q**
- .

P**Q****(2)**

- (b) The conversion of
- P**
- into
- Q**
- in Reaction 1 uses HCl

Name and outline a mechanism for this reaction.

.....

(5)

- (c) The conversion of
- Q**
- into
- R**
- in Reaction 2 uses NH
- ₃

Name and outline a mechanism for this reaction.

.....

(5)

(d) State the type of reaction shown by Reaction 3.

Identify a reagent for this reaction.

Give **one** condition necessary for a high yield of product when **Q** is converted into **P**.

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.....

(3)

(e) Hydrogen bromide (HBr) could be used in the overall conversion of **P** into **R**, instead of using HCl

Hydrogen bromide is made by the reaction of NaBr with concentrated phosphoric acid.
Concentrated sulfuric acid is **not** used to make HBr from NaBr

Write an equation for the reaction of NaBr with H_3PO_4 to produce HBr and Na_3PO_4 only.

Identify **two** toxic gases that are formed, together with HBr, when NaBr reacts with concentrated H_2SO_4

State the role of H_2SO_4 in the formation of these two toxic gases.

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(4)

(Total 19 marks)