Q1.

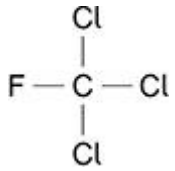
CFCs were used as refrigerants and in aerosols.

The scientists Rowland and Molina published research in 1974 to show that CFCs are responsible for the destruction of ozone molecules in the upper atmosphere.

A few years later, other scientists discovered that the concentration of ozone in the upper atmosphere was decreasing.

In 1987 there was an agreement by many countries to restrict the use of CFCs.

(a) The molecule CFC-11 was commonly used as a refrigerant.



Use IUPAC rules to name CFC-11

_____

(1)

(b) A molecule of CFC-11 breaks down in the upper atmosphere to form a chlorine free radical.

Give the equation for this reaction.

_____

(1)

(c) A typical refrigerator contained 0.50 kg of CFC-11 (M_r = 137.5).

One molecule of CFC-11 causes the destruction of approximately 100 000 molecules of ozone.

Use these data to estimate the number of molecules of ozone that can be destroyed by 0.50 kg of CFC-11
Give your answer in standard form.

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

Number of molecules of ozone _____

(2)

(d) State the benefit to life on Earth of ozone in the upper atmosphere.

_____

_____

_____

(1)

(e) Suggest **one** reason why the use of CFCs was not restricted until several years after Rowland and Molina published their research.

_____

_____

_____

(1)

(f) CFC-11 is a greenhouse gas that can contribute to global warming.

State and explain how CFC-11 is able to contribute to global warming.

_____

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q2.

Which compound is **not** formed by reacting 3-bromo-3-methylhexane with warm, ethanolic potassium hydroxide?

A 2-ethylpent-1-ene ⬭

B 3-methylhex-1-ene ⬭

C 3-methylhex-2-ene ⬭

D 3-methylhex-3-ene ⬭

(Total 1 mark)

Q3.

The question below refers to the reaction of 1-bromopropane with a solution of potassium cyanide in aqueous ethanol.

What is the organic product of this reaction?

A propylamine ⬭

B butylamine ⬭

C propanenitrile ⬭

D butanenitrile ⬭

(Total 1 mark)

Q4.

The question below refers to the reaction of 1-bromopropane with a solution of potassium cyanide in aqueous ethanol.

The reactions of 1-bromopropane and 1-chloropropane with potassium cyanide in aqueous ethanol occur at different rates under the same conditions.

Which row correctly shows the compound that has a faster rate of reaction and the correct reason for this?

	Compound	**Reason**	
A	1-bromopropane	C–Br bond weaker than C–Cl bond	⬭
B	1-bromopropane	C–Br bond stronger than C–Cl bond	⬭
C	1-chloropropane	C–Br bond weaker than C–Cl bond	⬭
D	1-chloropropane	C–Br bond stronger than C–Cl bond	⬭

(Total 1 mark)

Q5.

Bromoethane reacts with potassium cyanide to form compound D.

$$CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$$

Compound **D**

(a) Outline the mechanism for this reaction.

(2)

(b) Give the IUPAC name of **D**.

_____

(1)

(c) Calculate the percentage atom economy for the formation of **D** in this reaction.

Give your answer to the appropriate number of significant figures.

% atom economy _____

(2)

(Total 5 marks)

Q6.

Which compound can react with ammonia to produce propylamine?

A $CH_3CH{=}CH_2$ ⬭

B $CH_3CH_2CH_2OH$ ⬭

C $CH_3CH_2CH_2Br$ ⬭

D $CH_3CH_2CH_3$ ⬭

(Total 1 mark)

Q7.

Which compound could **not** be produced by reacting 2-bromo-3-methylbutane with sodium hydroxide?

A 2-methylbut-1-ene ⬭

B 3-methylbut-1-ene ⬭

C 2-methylbut-2-ene ⬭

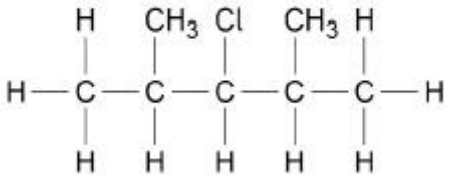
D 3-methylbutan-2-ol ⬭

(Total 1 mark)

Q8.

Compound **A** is a halogenoalkane.

Compound A



(a) Name Compound **A**.

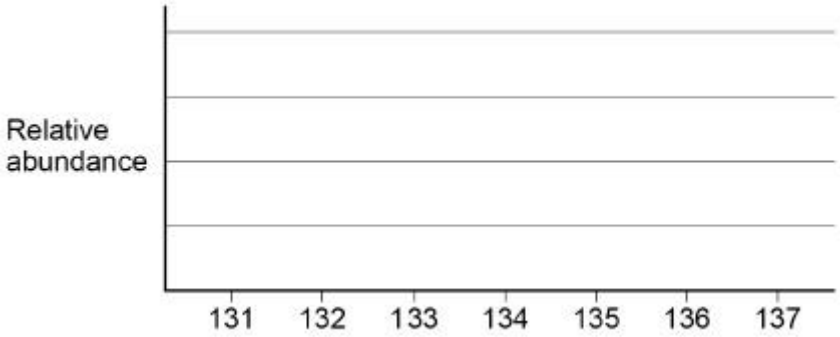
_____

(1)

(b) Compound **A** has a relative molecular mass (Mr) of 134.5
The main isotope of hydrogen is ^{1}H
The main isotope of carbon is ^{12}C
Chlorine consists of two common isotopes, ^{35}Cl and ^{37}Cl, of which 75% is ^{35}Cl
The mass spectrum of **A** was recorded when **A** was ionised by electron impact to form $\mathbf{A}^{+}$ ions.

Draw, on **Figure 1**, the peaks for the main molecular ions in the mass spectrum of **A**.

Figure 1



(2)

(c) Reaction of **A** with warm, dilute aqueous sodium hydroxide forms alcohol **B**.

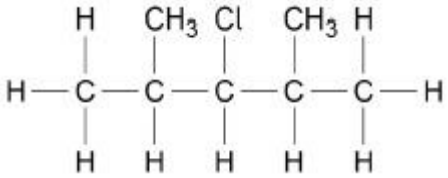
Name the mechanism for this reaction.

Outline the mechanism using the structure of **A** shown.
Include the structure of the product, alcohol **B**.

Mechanism

_____

Outline of mechanism



(4)

(d) Reaction of **A** with hot, ethanolic potassium hydroxide gives alkene **C**.

Name the mechanism for this reaction.
State the role of the hydroxide ions.

Outline the mechanism using the structure of **A** shown.
Include the structure of the product, alkene **C**.

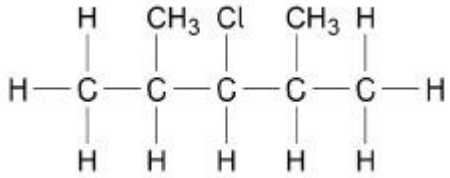
Mechanism

_____

Role of hydroxide ions

_____

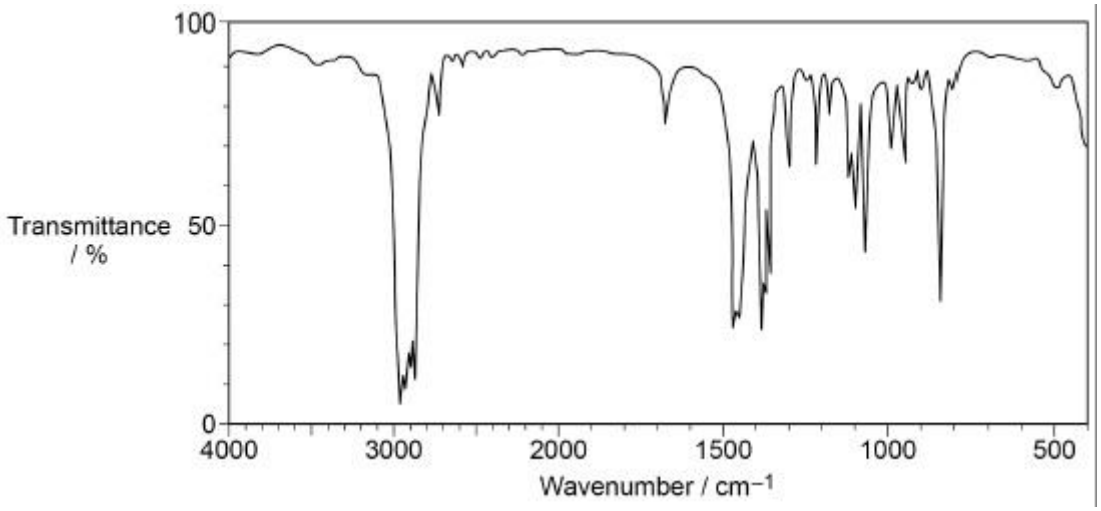
Outline of mechanism



(6)

(e) The infrared spectrum in **Figure 2** is that of either alcohol **B** or alkene **C**.

Figure 2



Tick the box that shows the correct compound.
Explain your answer with reference to a bond and the wavenumber of its absorption.

Alcohol **B** ☐ Alkene **C** ☐

Explanation

_____

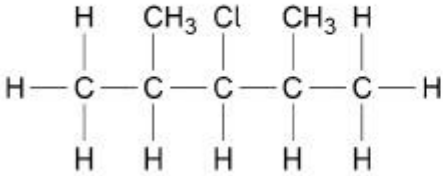
_____

_____

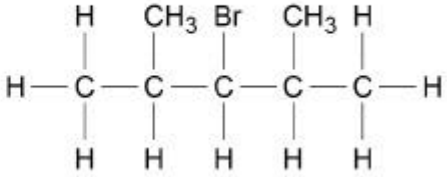
(1)

(f) Compound **D** reacts with dilute aqueous sodium hydroxide in a similar way to **A** to form alcohol **B**.

Compound A



Compound D



Explain why **D** reacts more quickly than **A** with dilute aqueous sodium hydroxide at the same temperature.

_____

_____

_____

_____

_____

(1)

(Total 15 marks)

Q9.

Which species could act as a nucleophile?

A BH_3 ⬭

B NH_4^+ ⬭

C PH_3 ⬭

D SiH_4 ⬭

(Total 1 mark)

Q10.

2-Methylpropan-1-ol can be prepared by reacting 1-bromo-2-methylpropane with dilute aqueous sodium hydroxide.

(a) Name and outline the mechanism for this reaction.

Name of mechanism

_____

Mechanism

(3)

(b) When 2.0 cm^3 of 1-bromo-2-methylpropane (M_r = 136.9) were reacted with an excess of sodium hydroxide, 895 mg of 2-methylpropan-1-ol (Mr = 74.0) were obtained.

The density of 1-bromo-2-methylpropane is 1.26 g cm^{-3}

Calculate the percentage yield for this reaction.

Percentage yield _____

(3)

(c) When 1-bromo-2-methylpropane reacts with hot, concentrated ethanolic potassium hydroxide rather than dilute aqueous sodium hydroxide, a different product is formed.

Name this organic product and name the mechanism for this reaction.

Name of organic product

_____

Name of mechanism

_____

(2)

(Total 8 marks)

Q11.

Which compound has the fastest rate of reaction with potassium cyanide to form pentanenitrile?

A 1-bromobutane ⬭

B 1-chlorobutane ⬭

C 1-fluorobutane ⬭

D 1-iodobutane ⬭

(Total 1 mark)

Q12.

Which of the following mechanisms does **not** occur in reactions of bromoethane?

A Electrophilic addition ⬭

B Elimination ⬭

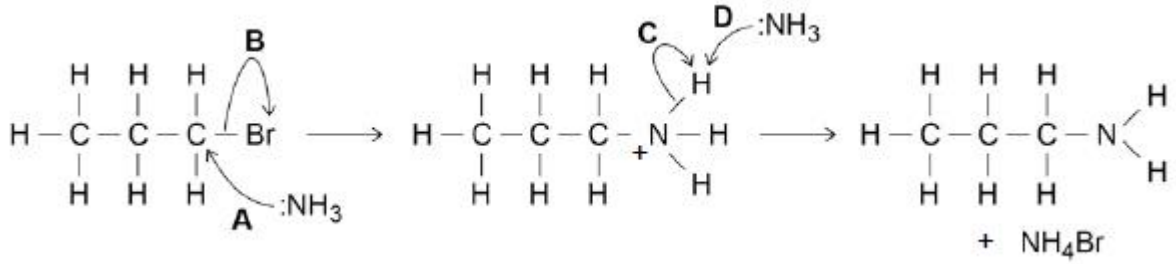
C Nucleophilic substitution ⬭

D Radical substitution ⬭

(Total 1 mark)

Q13.

Which of the arrows, labelled **A**, **B**, **C** or **D** in the mechanism in the diagram, is **not** correct?



A ⬭

B ⬭

C ⬭

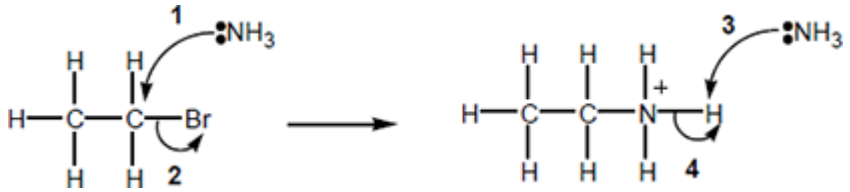
D ⬭

(Total 1 mark)

Q14.

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

$$CH_3CH_2Br + 2NH_3 \longrightarrow CH_3CH_2NH_2 + NH_4Br$$



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

A 1 ⬭

B 2 ⬭

C 3 ⬭

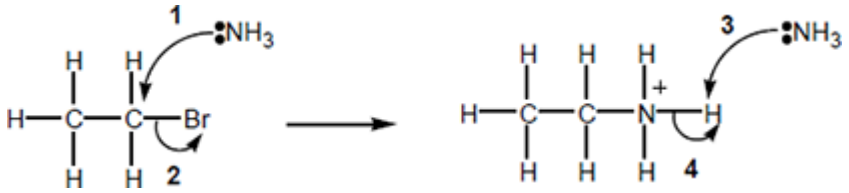
D 4 ⬭

(Total 1 mark)

Q15.

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

$$CH_3CH_2Br + 2NH_3 \longrightarrow CH_3CH_2NH_2 + NH_4Br$$



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)

Q16.

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)