Q1.

This question is about $CFCl_3$

$CFCl_3$ used to be the propellant in most aerosol cans.

(a) Use IUPAC rules to name $CFCl_3$

_____

(1)

(b) Give an equation for each of the **two** propagation steps in the conversion of $CHFCl_2$ into $CFCl_3$

Equation 1

_____

Equation 2

_____

(2)

(c) In the presence of ultraviolet radiation, $CFCl_3$ breaks down in the upper atmosphere to form chlorine free radicals.

Give an equation for this reaction.

_____

(1)

(d) Chlorine free radicals catalyse the decomposition of ozone.

Give **two** equations to show how chlorine free radicals decompose ozone.

Equation 1

_____

Equation 2

_____

(2)

(e) The production and use of CFCs have been banned in many countries because they decrease the amount of ozone in the upper atmosphere.

State why ozone in the upper atmosphere is important for life on Earth.

_____

_____

(1)

(Total 7 marks)

Q2.

This question is about reactions of halogenoalkanes with hydroxide ions.

(a) Outline the mechanism for the nucleophilic substitution reaction of 1-bromobutane with sodium hydroxide.

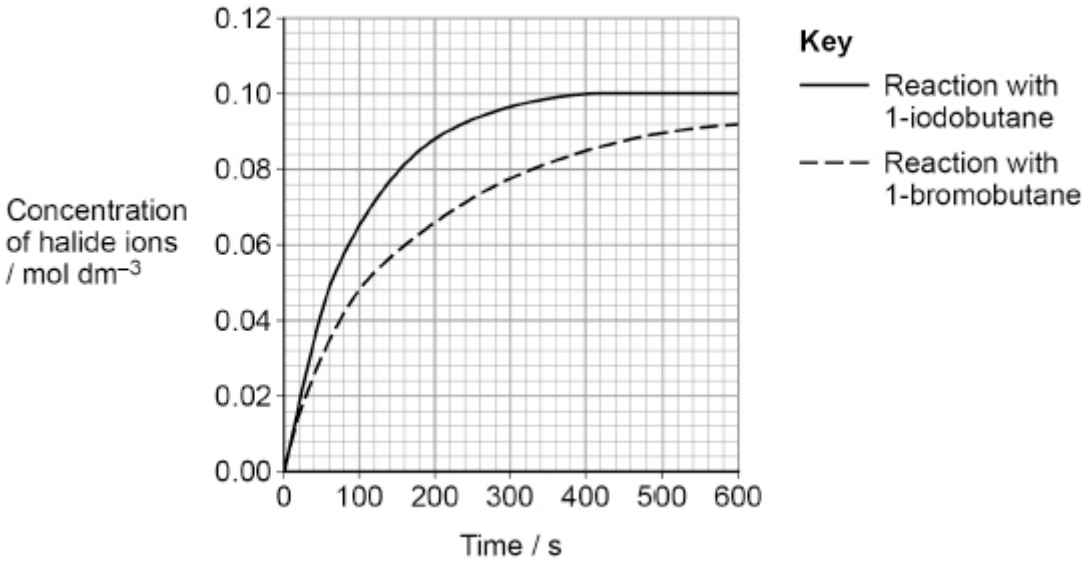
(2)

A student investigated the rate of nucleophilic substitution of halogenoalkanes with hydroxide ions.

Identical concentrations of 1-bromobutane and 1-iodobutane were reacted separately with sodium hydroxide solution under the same conditions.

The concentration of halide ions was monitored during each experiment.

The graph below shows the student's results.



(b) State how the graph shows that the rate of reaction of 1-iodobutane is faster than the rate of reaction of 1-bromobutane.

State why the rates are different.

_____

_____

_____

_____

_____

(2)

(Total 4 marks)

Q3.

This question is about isomers.

Hex-2-ene has the molecular formula C_6H_{12}

(a) Draw the displayed formula of a **position** isomer of hex-2-ene that exists as *E* and *Z* isomers.

(1)

(b) Draw the displayed formula of a **chain** isomer of hex-2-ene that does **not** exist as *E* and *Z* isomers.

(1)

Butanal has the molecular formula C_4H_8O

(c) Draw the skeletal formula of a **functional group** isomer of butanal that has an absorption in the range 1680–1750 cm^{-1} in its infrared spectrum.

(1)

(d) Draw the skeletal formula of a structural isomer of butanal that has an absorption in the range 3230–3550 cm^{-1} in its infrared spectrum.

(1)

(e) Several saturated halogenoalkanes contain 17.8% carbon, 3.0% hydrogen and 79.2% bromine by mass.

Calculate the empirical formula of these compounds.

Give the IUPAC names of **two** saturated halogenoalkanes that have this empirical formula.

Empirical formula _____

Names of halogenoalkanes

1 _____

2 _____

(4)

(Total 8 marks)

Q4.

This question is about the synthesis of propylamine ($CH_3CH_2CH_2NH_2$) by the reaction of 1-iodopropane ($CH_3CH_2CH_2I$) with an excess of ammonia.

$$CH_3CH_2CH_2I + 2\ NH_3 \rightarrow CH_3CH_2CH_2NH_2 + NH_4I$$

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

Name of mechanism _____

Outline of mechanism

(5)

(b) 1-iodopropane is a liquid at room temperature.

Calculate the number of molecules in 5.0 cm^3 of 1-iodopropane (M_r = 169.9). Give your answer in standard form.

For 1-iodopropane, density = 1.75 g cm^{-3}

The Avogadro constant, L = 6.022 x 10^{23} mol^{-1}

Number of molecules _____

(2)

(c) In an experiment, 10.3 g of 1-iodopropane (M_r = 169.9) are reacted with an excess of ammonia. 2.3 g of propylamine (M_r = 59.0) are produced.

Calculate the percentage yield in this experiment.

Percentage yield _____

(2)

(Total 9 marks)

Q5.

Under suitable conditions, 2-bromobutane reacts with sodium hydroxide to produce a mixture of five products, **A**, **B**, **C**, **D** and **E**.

Products **A**, **B** and **C** are alkenes.

A is a structural isomer of **B** and **C**.

A does not exhibit stereoisomerism.

B and **C** are a pair of stereoisomers.

Products **D** and **E** are alcohols.

D and **E** are a pair of enantiomers.

(a) Give the names of the **two** concurrent mechanisms responsible for the formation of the alkenes and the alcohols.

Mechanism to form alkenes _____

Mechanism to form alcohols _____

(2)

(b) Define the term stereoisomers.

_____

_____

_____

(2)

(c) Deduce the name of isomer **A**.

Explain why **A** does **not** exhibit stereoisomerism.

Name _____

Explanation _____

_____

_____

(2)

(d) Outline the mechanism for the reaction of 2-bromobutane with sodium hydroxide to form alkene **A**.

(3)

(e) Deduce the name of isomer **B** and the name of isomer **C**.

Explain the origin of the stereoisomerism in **B** and **C**.

Name _____

_____

Explanation _____

_____

_____

(2)

(f) Draw 3D representations of enantiomers **D** and **E** to show how their structures are related.

(2)

(g) A student compares the rates of hydrolysis of 1-chlorobutane, 1-bromobutane and 1-iodobutane.

The suggested method is:

- add equal volumes of the three halogenoalkanes to separate test tubes
- add equal volumes of aqueous silver nitrate to each test tube
- record the time taken for a precipitate to appear in each test tube.

State and explain the order in which precipitates appear.

Order in which precipitates appear _____

_____

_____

Explanation _____

_____

_____

_____

_____

(2)

(Total 15 marks)