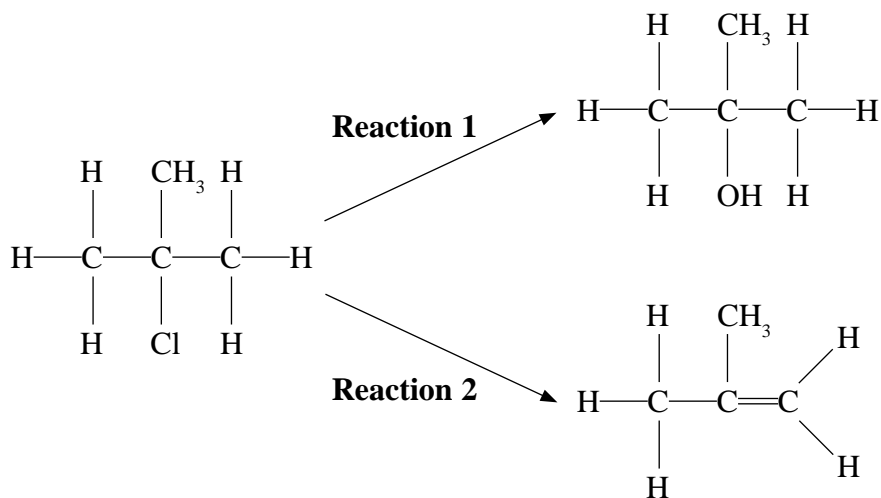


1 When 2-chloro-2-methylpropane is heated in a mixture of water and ethanol at 65 °C, two types of reaction occur. A mixture of two organic products, 2-methylpropan-2-ol and 2-methylpropene, is formed.



(a) (i) Name the two reaction types that are taking place.

(2)

Reaction 1

Reaction 2

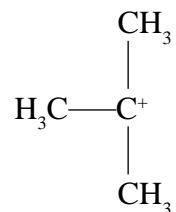
*(ii) Explain how the two products form, by describing the role of the water in each case.

(4)

Reaction 1

Reaction 2

(b) A proposed mechanism for **Reaction 1** involved the formation of the carbocation,



(i) What type of bond breaking must have occurred during the carbocation formation?

(1)

(ii) Suggest why 1-chlorobutane reacts with water via a different mechanism.

(2)

(c) Another halogenoalkane, 2-chlorobutane, behaves in a similar way to 2-chloro-2-methylpropane but in **Reaction 2** can form three different alkenes. Suggest how **three** different alkenes can form and give their displayed formulae.

(4)

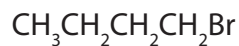
(d) Suggest why 2-fluoro-2-methylpropane would react more slowly than 2-chloro-2-methylpropane in **Reaction 1**.

What reagent could you use instead of water to increase the rate of this reaction involving 2-fluoro-2-methylpropane? Explain why the reagent would have this effect.

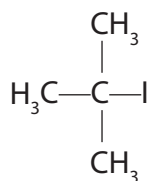
(3)

(Total for Question = 16 marks)

2 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.



X



Y

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

Name of product.....

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)

(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

.....

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

.....

Observation with **Y**

.....

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

.....

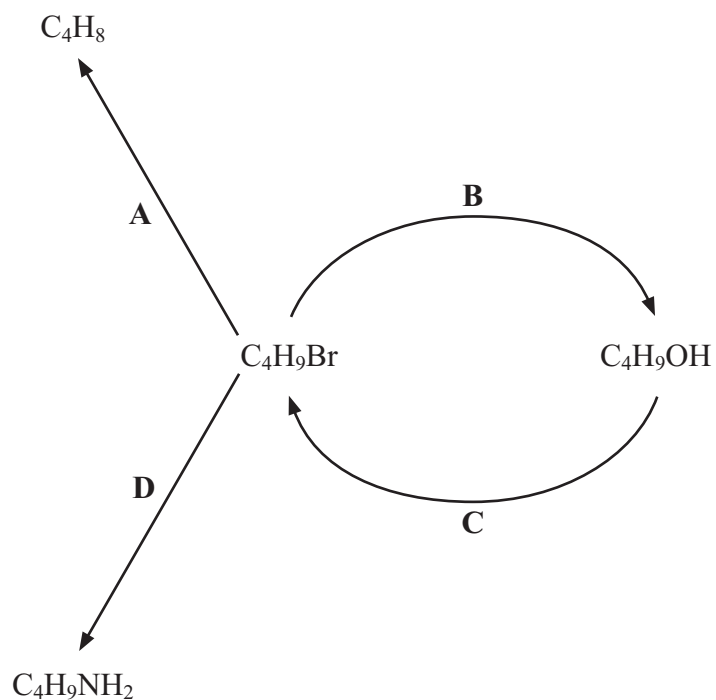
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.....

(Total for Question = 12 marks)

3 Halogenoalkanes are important intermediates in organic chemistry. The scheme below summarises some important reactions of a halogenoalkane.



(a) Identify the reagents and any specific conditions required for the reactions in the diagram. (You may assume that a suitable temperature is maintained in each reaction.)

(4)

A

B

C

D

(b) (i) Classify the type of reaction in each of **A** and **D**.

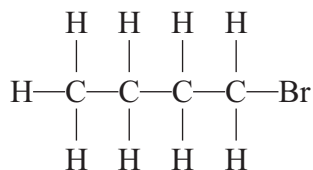
(2)

A

D

- *(ii) Reaction **B** can proceed via two possible reaction mechanisms, depending on the structure of the original compound. For each of the two isomers of C_4H_9Br shown below, draw the structure of the intermediate or transition state which is formed during the reaction. Explain in each case why the specified structure is more favourable.

(4)



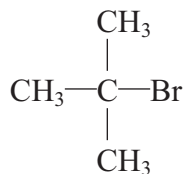
Intermediate or transition state

Explanation

.....

.....

.....



Intermediate or transition state

Explanation

.....

.....

.....

.....

.....

(iii) If C_4H_9I is used instead of C_4H_9Br in reaction **D**, the rate of formation of $C_4H_9NH_2$ increases. Explain why the rate of reaction increases.

(1)

.....

.....

.....

(c) Halogenoalkanes are widely used as refrigerants and belong to the class of refrigerants that cool by change of state (typically by boiling).

(i) Suggest how halogenoalkanes cool by change of state.

(1)

.....

.....

.....

(ii) Suggest **two** characteristics or properties desirable in a refrigerant.

(2)

1

.....

.....

2

.....

.....

(Total for Question 14 marks)

4 Chloroethane, C_2H_5Cl , can be made from either ethane or ethene.

(a) (i) What reagent and condition would be used to make chloroethane from **ethane**?

(2)

Reagent

Condition

(ii) State the type of reaction and mechanism by which this reaction occurs.

(2)

(b) (i) What reagent would be used to make chloroethane from **ethene**?

(1)

(ii) Show, in full, the mechanism for this reaction in which **ethene** is converted to chloroethane.

(3)

(c) Which method of making chloroethane has

(3)

- a higher atom economy?
- a higher percentage yield?

Explain your answers.

Higher atom economy

Higher percentage yield

(d) The compound chloroethene, $\text{CH}_2=\text{CHCl}$, forms an addition polymer.

- (i) Draw a diagram, using dots or crosses, to show the arrangement of electrons in chloroethene. Only the outer shell electrons need be shown.

(2)

- (ii) Chloroethene can form an addition polymer. Write the displayed formula of poly(chloroethene) showing two repeat units.

(1)

*(iii) Poly(chloroethene) is commonly known as PVC. Almost a quarter of the PVC which is manufactured is used to make water pipes, which were formerly made of metal.

Give TWO factors which have to be considered when deciding which material, PVC or metal, contributes to more sustainable uses of resources in the long term.

(2)

(Total for Question = 16 marks)