EXTRA QUESTIONS FOR 2.8 HALOALKANES

1. Methylbenzene is converted into (chloromethyl)benzene in a free radical substitution reaction.

$$C_6H_5CH_3 + Cl_2 \rightarrow C_6H_5CH_2Cl + HCl$$

(i) Write an equation for the initiation step.

.....

(1)

(ii) Write equations for the **two** propagation steps.

(2)

(iii) Give the formula of another possible organic product of the reaction.

.....

(1)

(Total 4 marks)

2. The reaction of bromine with ethane is similar to that of chlorine with ethane. Three steps in the bromination of ethane are shown below.

Step **1** $Br_2 \longrightarrow 2Br^{\bullet}$

Step **2** $Br^{\bullet} + CH_3CH_3 \longrightarrow CH_3CH_2^{\bullet} + HBr$

Step **3** $CH_3CH_2^{\bullet} + Br_2 \longrightarrow CH_3CH_2Br + Br^{\bullet}$

(a) (i) Name this type of mechanism.

.....

(ii) Suggest an essential condition for this reaction.

.....

(iii) Steps **2** and **3** are of the same type. Name this type of step.

.....

(iv) In this mechanism, another type of step occurs in which free-radicals combine. Name this type of step. Write an equation to illustrate this step.

Type of step .....

Equation.....

(5)

(b) Further substitution in the reaction of bromine with ethane produces a mixture of liquid organic compounds.

(i) Name a technique which could be used to separate the different compounds in this mixture.

.....

(ii) Write an equation for the reaction between bromine and ethane which produces hexabromoethane, C_2Br_6, by this substitution reaction.

.....

(2)

(Total 7 marks)

3. (a) Dichloromethane, CH_2Cl_2, is one of the products formed when chloromethane, CH_3Cl_l, reacts with chlorine.

(i) Name the type of mechanism involved in this reaction and write an equation for each of the steps named below.

Name of type of mechanism .....

Initiation step

.....

First propagation step

.....

Second propagation step

.....

(ii) Write an overall equation for the formation of dichloromethane from chloromethane.

.....

(5)

(b) A compound contains 10.1% carbon and 89.9% chlorine by mass. Calculate the molecular formula of this compound, given that its relative molecular mass (M_r) is 237.0

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.....

(3)

(c) Suggest the formulae of two bromine-containing organic compounds formed when dibromomethane, CH_2Br_2, reacts with bromine.

Compound 1 .....

Compound 2 .....

(2)

(Total 10 marks)

4. (a) When 3-bromo-2,3-dimethylpentane, $(CH_3)_2CHCBr(CH_3)CH_2CH3$, reacts with aqueous potassium hydroxide, an alcohol is formed.

(i) Name the type of reaction taking place and give the role of the reagent.

Type of reaction .....

Role of reagent .....

(ii) Outline a mechanism for the reaction, showing clearly the structure of the alcohol formed.

(5)

(b) When 3-bromo-2,3-dimethylpentane reacts with ethanolic potassium hydroxide, three structurally isomeric alkenes are formed.

(i) Name the type of reaction taking place and give the role of the reagent.

Type of reaction .....

Role of reagent .....

(ii) One of the reaction products is 2,3-dimethylpent-2-ene.

Give the structure of this alkene and outline a mechanism for its formation.

Structure of alkene

Mechanism

(iii) Give the structures and names of the other two alkenes which are also formed.

Structure of second alkene

Name .....

Structure of third alkene

Name .....

(10)
(Total 15 marks)

5. Bromoethane, CH_3CH_2Br, reacts with sodium hydroxide in an elimination reaction to form ethene.

(i) Outline a mechanism for this elimination reaction.

(ii) Suggest **one** reason why this method for making ethene is not used in industry.

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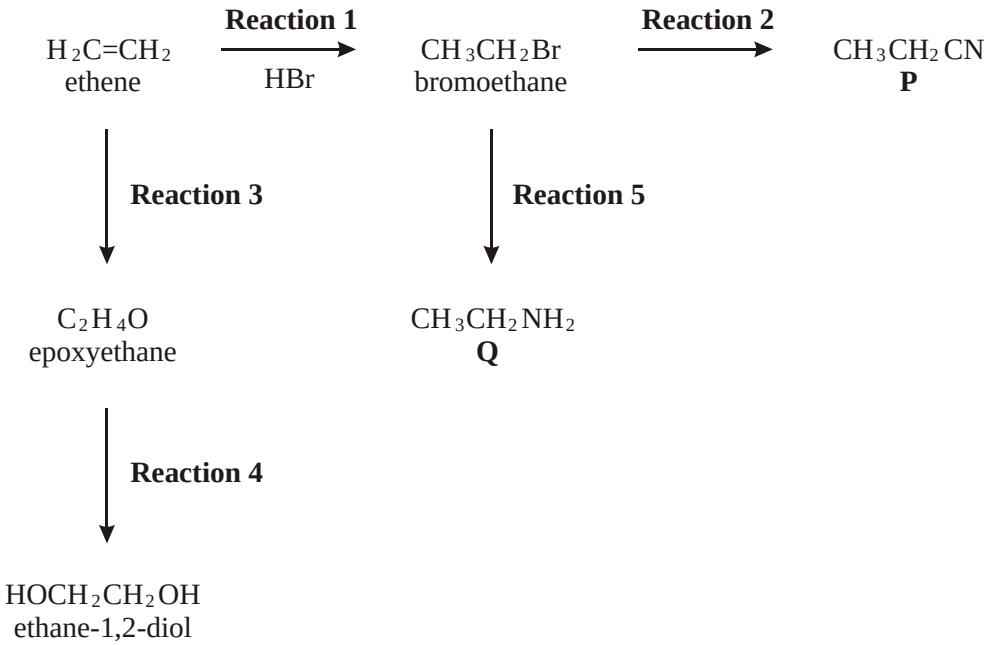
(4)
(Total 4 marks)

6. Consider the following scheme of reactions.



In **Reactions 2** and **5**, bromoethane undergoes nucleophilic substitution.

(i) Identify a reagent for **Reaction 2**. Name the organic product, **P**.

*Reagent for **Reaction 2*** .....

*Name of product **P*** .....

(ii) Identify a reagent for **Reaction 5**. Name the organic product, **Q**.

*Reagent for **Reaction 5*** .....

*Name of product **Q*** .....

(iii) Outline a mechanism for **Reaction 5**.

(8)
(Total 8 marks)

7. (a) Draw the structure of 2-bromo-3-methylbutane.

(1)

(b) (i) Draw the structure of methylbut-2-ene.

(ii) Methylbut-2-ene is formed when 2-bromo-3-methylbutane is treated with ethanolic potassium hydroxide. Name and outline the mechanism for this reaction.

Name of mechanism .....

Mechanism

(5)

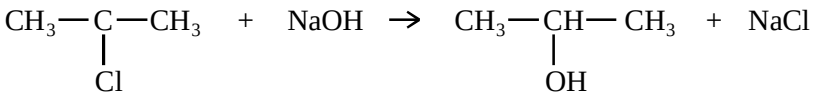
(c) Name the isomer of methylbut-2-ene which is also formed when 2-bromo-3-methylbutane is treated with ethanolic potassium hydroxide.

.....

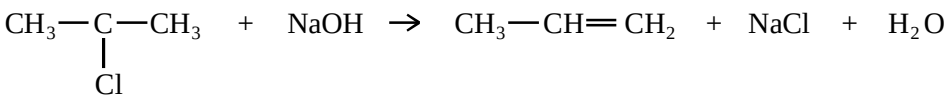
(1)
(Total 7 marks)

8. When 2-chloropropane reacts with sodium hydroxide, two different reactions occur. Each reaction produces a different organic product.

Reaction 1



Reaction 2



(i) Outline a mechanism for **Reaction 1** and state the role of the hydroxide ion in this reaction.

Mechanism

Role of the hydroxide ion .....

(ii) Outline a mechanism for **Reaction 2** and state the role of the hydroxide ion in this reaction.

Mechanism

Role of the hydroxide ion .....

(7)

(Total 7 marks)

9. (a) A substitution reaction occurs when 2-bromopropane reacts with aqueous sodium hydroxide.

(i) Draw the structure of the organic product of this reaction and give its name.

Structure

Name .....

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

Name of mechanism .....

Mechanism

(5)

(b) Under different conditions, 2-bromopropane reacts with sodium hydroxide to produce propene.

(i) Name the mechanism for this reaction.

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(ii) State the role of sodium hydroxide in this reaction.

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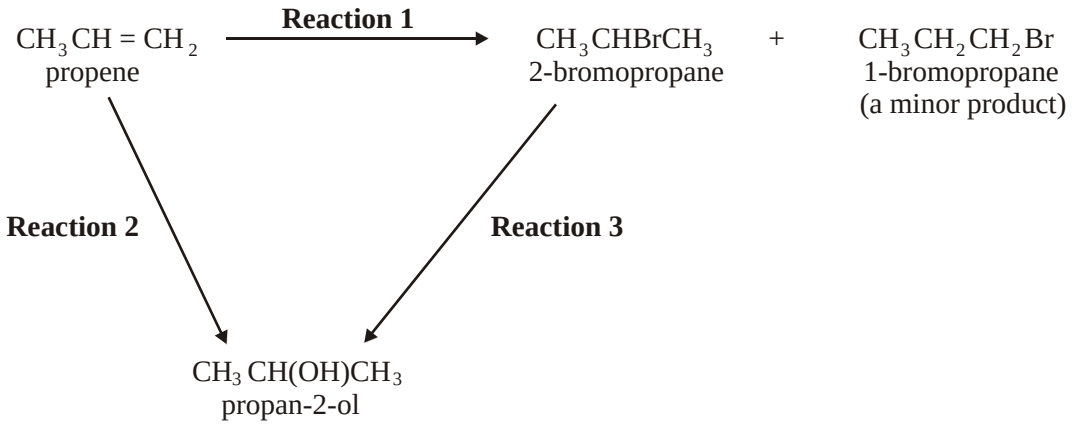
(2)
(Total 7 marks)

10. Consider the following reaction scheme.



(a) Give a suitable reagent and state the essential conditions required for **Reaction 3**.

Reagent ...……..……..…..

Conditions ...……..……..

(2)

(b) The reagent used for **Reaction 3** can also be used to convert 2-bromopropane into propene. State the different conditions needed for this reaction.

.....……

(1)
(Total 3 marks)

11. Compound **X**, $(CH_3)_2CHCN$, can be formed from a haloalkane, C_3H_7Br.

(i) Name compound **X**.

.....

(ii) Give the reagent and conditions necessary to form **X** from C_3H_7Br.

Reagent.....

Conditions.....

(iii) Name and outline the mechanism for this reaction, showing clearly the structure of C_3H_7Br.

Name of mechanism.....

Mechanism

(7)
(Total 7 marks)

12. (a) The equation below shows the reaction of 2-bromopropane with an excess of ammonia.

$$CH_3CHBrCH_3 + 2NH_3 \rightarrow CH_3CH(NH_2)CH_3 + NH_4Br$$

Name and outline the mechanism involved.

Name of mechanism .....

Mechanism

(5)

(b) When 2-bromopropane is heated with ethanolic potassium hydroxide, an elimination reaction occurs. State the role of potassium hydroxide and outline a mechanism for this reaction.

Role of potassium hydroxide .....

Mechanism

(5)
(Total 10 marks)

13. Classify the following reaction.

$C_3H_7Br + KOH \rightarrow C_3H_6 + KBr + H_2O$

.....

(1)
(Total 1 mark)

14. (i) Give the structural formula and name of the organic product of the reaction between $CH_3CH_2CH_2CH_2Br$ and potassium cyanide.

Structural formula.....

Name.....

(ii) Name and outline the mechanism involved in this reaction.

Name.....

Mechanism

(iii) Suggest why $CH_3CH_2CH_2CH_2F$ reacts less rapidly than $CH_3CH_2CH_2CH_2Br$ with potassium cyanide.

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.....

(6)
(Total 6 marks)

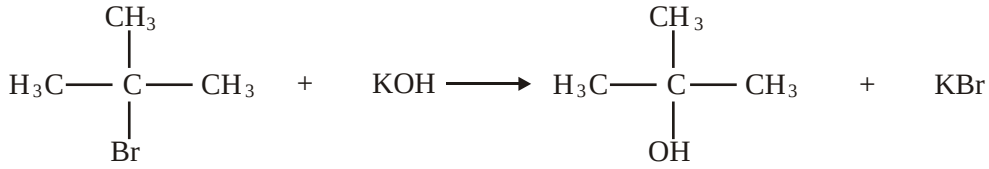
15. (a) Name and outline a mechanism for the reaction of 2-bromo-2-methylpropane with ethanolic potassium hydroxide to form the alkene 2-methylpropene, $(CH_3)_2C=CH_2$

Name of mechanism .....

Mechanism

(4)

(b) When 2-bromo-2-methylpropane reacts with aqueous potassium hydroxide, 2-methylpropan-2-ol is formed as shown by the following equation.



State the role of the hydroxide ions in this reaction.

.....

(1)

(c) Write an equation for the reaction that occurs when $CH_3CH_2CH_2CH_2Br$ reacts with an excess of ammonia. Name the organic product of this reaction.

Equation .....

Name of product .....

(3)

(Total 8 marks)

16. Alkenes can be made in the laboratory from halogenoalkanes by heating them with a suitable reagent. By a similar method, cyclohexene can be prepared from bromocyclohexane.

(i) Suggest the name of a suitable reagent and state an essential condition, other than heat, for this reaction, starting from bromocyclohexane.

Reagent .....

Condition .....

(2)

(ii) Using graphical formulae, write an equation for this reaction.

(2)

(iii) Give the name of this type of reaction.

.....

(1)

(Total 5 marks)

17. (a) (i) Write an equation for the reaction between 1-bromopropane and potassium cyanide.

.....

(1)

(ii) Give the name of the type of mechanism involved in the reaction in (b)(i).

.....

(1)

(b) Give the formula of the attacking species in (b) and state what feature of its structure is responsible for its role.

Formula .....

Structural feature .....

(2)
(Total 4 marks)

18. Consider the following reaction in which an alkene is formed from a haloalkane.

$$CH_3CHBrCH_2CH_3 + KOH \xrightarrow[\text{ethanol solvent}]{\text{heat}} \underset{\text{but}-2-\text{ene}}{CH_3CH=CHCH_3} + KBr + H_2O$$

(a) Name the haloalkane used in this reaction.

.....

(1)

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

Name of mechanism .....

Mechanism

(4)
(Total 5 marks)

19. (a) The reaction of chloromethane with chlorine to form trichloromethane is a free radical substitution involving several propagation steps.

(i) Write an overall equation for this reaction.

.....

(ii) What is meant by the term *propagation step*?

.....

.....

(iii) Write an equation for a propagation step in which chloromethane reacts.

.....

(iv) Write an equation for a propagation step in which trichloromethane is formed.

.....

(4)

(b) Write an equation and outline a mechanism for the reaction of chloromethane with an **excess** of ammonia.

Equation .....

Mechanism

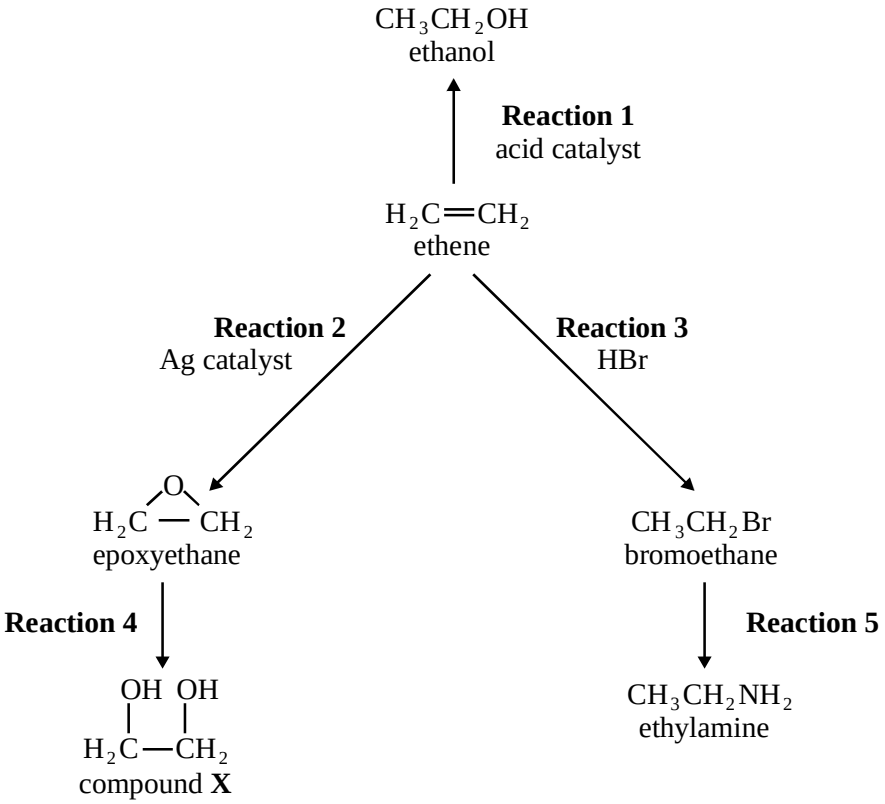
(5)
(Total 9 marks)

20. When a mixture of chlorine with an excess of methane is irradiated with ultraviolet light, a reaction occurs with chloromethane as the main organic product.

Write an equation and a mechanism for the formation of chloromethane.

(5)
(Total 5marks)

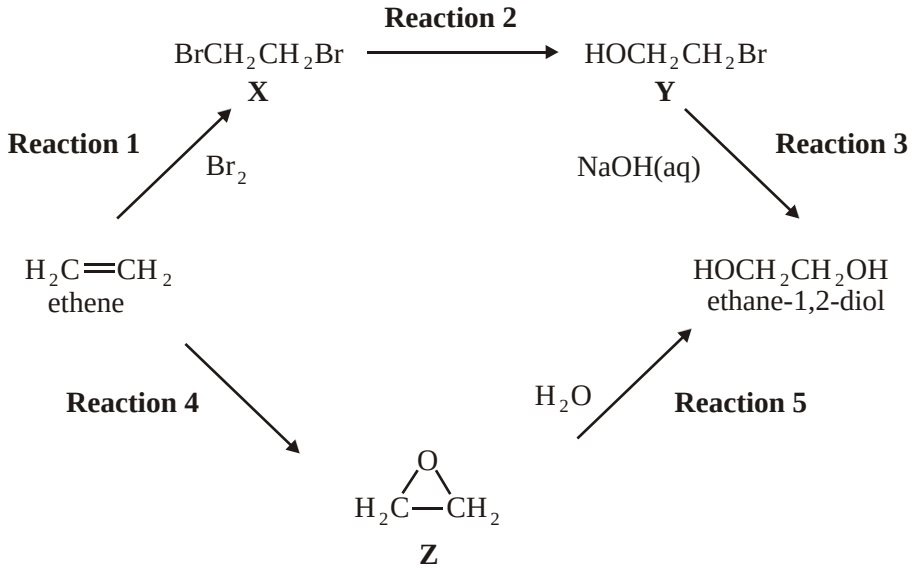
21. Ethene can be converted into a variety of useful products as illustrated below.



(b) Give a reagent for **reaction 5**.

(1)
(Total 1 mark)

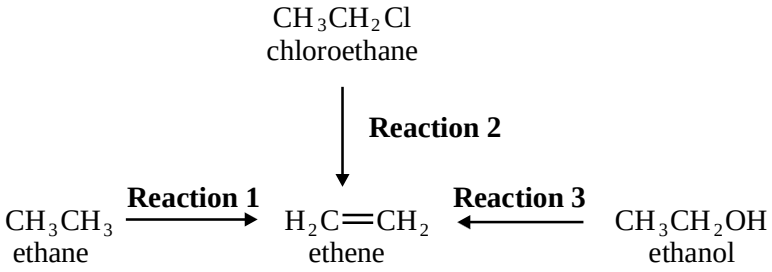
22. Consider the following scheme of reactions for making ethane-1,2-diol from ethene by two different routes.



Name and outline a mechanism for **Reaction 3**. Explain why compound **Y** is susceptible to attack by hydroxide ions.

(4)
(Total 4 marks)

23. Ethene is an important starting point for the manufacture of plastics and pharmaceutical chemicals. Most of the ethene used by industry is produced by the thermal cracking of ethane obtained from North Sea gas (**Reaction 1**). It is also possible to make ethene either from chloroethane (**Reaction 2**) or from ethanol (**Reaction 3**).



(a) Give essential conditions and reagents for **Reaction 2**.

(2)

(b) Name and outline a mechanism for **Reaction 2**. Suggest a reason why chloroethane is **not** chosen by industry as a starting material to make ethene commercially.

(5)
(Total 7 marks)

24. Reaction of 2-bromobutane with potassium hydroxide can produce two types of product depending on the solvent used. In aqueous solution, the formation of an alcohol, **E**, is more likely but in ethanolic solution the formation of alkenes is more likely.

(a) For each type of product, name the type of reaction occurring and state the role of the potassium hydroxide.

(4)

(b) Name alcohol **E** and draw its structural formula. By reference to the structure of the halogenoalkane, explain why the initial step in the mechanism of the reaction producing the alcohol occurs.

(5)
(Total 9 marks)

25. The structural formulae of compounds **A, B, C** and **D,** which are the four structural isomers of molecular formula C_4H_9Cl, are given below.

$CH_3CH_2CH_2CH_2Cl$ $CH_3CH(Cl)CH_2CH_3$ $(CH_3)_2CHCH_2Cl$ $(CH_3)_2C(Cl)CH_3$

A **B** **C** **D**

(i) Give the name of compound **D.**

(1)

(ii) When refluxed with an alcoholic solution of KOH, compound **B** undergoes an elimination reaction. Two structurally isomeric products are formed. Draw the graphical formulae of these two structural isomers.

(2)

(iii) Draw the graphical formula for the product of the reaction between compound **C** and NaOH(aq). Give an outline of the mechanism involved in this reaction.

(4)
(Total 7 marks)

26. In aqueous ethanolic alkali, 2-bromo-2-methylbutane undergoes either substitution or elimination reactions to produce an alcohol or a mixture of two alkenes, respectively. Give the structures and names of these three compounds. Account for the formation of the various products by reference to the mechanisms of the reactions involved.

(14)
(Total 14 marks)