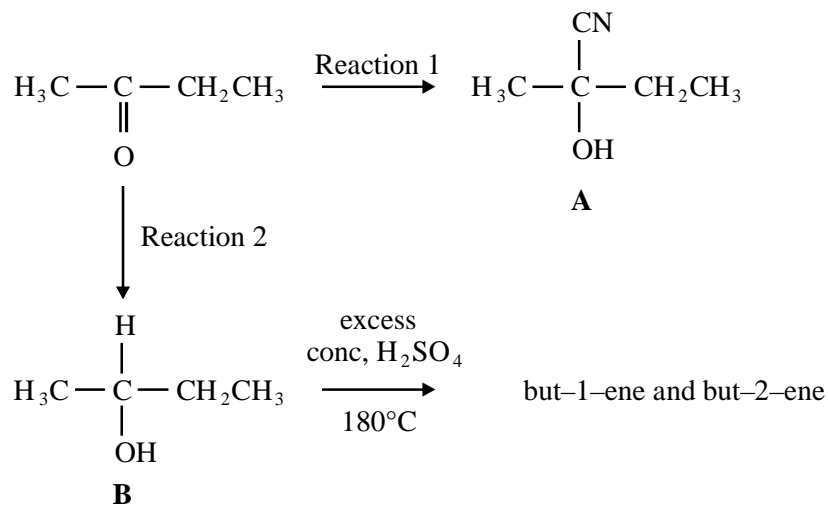


## 10.2 ALCOHOLS EXTRA QUESTIONS

1. Consider the reaction scheme below which starts from butanone.



- (a) When 5.0 g of butanone were used to carry out Reaction 1, the yield was 64% of the theoretical maximum. Calculate the mass of compound **A** formed.

.....

.....

.....

.....

.....

(4)

- (b) Given the table of infra-red absorption data below, describe the two major differences between the infra-red spectra of butanone and of **B**.

Table of infra-red absorption data	
Bond	Wavenumber/cm <sup>-1</sup>
C—H	2850–3300
C—C	750–1100
C=C	1620–1680
C=O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

.....

.....

.....

..... (4)

(c) Draw the structure of the repeating unit in the polymer which can be formed from but-1-ene.

(1)  
(Total 9 marks)

2. Ethanol is produced industrially from ethene. Name the catalyst and state the conditions used in the industrial process and write an equation for the reaction.

*Catalyst*.....

*Conditions*.....

.....

*Equation*.....

(4)  
(Total 4 marks)

3. (a) Write an equation for the complete combustion of butan-2-ol in an excess of oxygen.

..... (1)

(b) But-1-ene and other products can be made by the dehydration of butan-2-ol.

(ii) Explain why but-1-ene does not show geometrical isomerism.

.....

.....

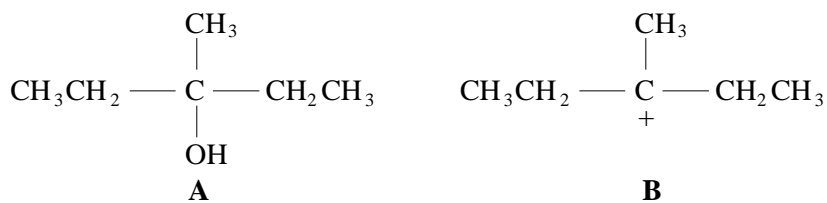
(iii) An alternative dehydration of butan-2-ol produces geometrical isomers. Draw the structure of one of these geometrical isomers and give its full name.

*Structure of geometrical isomer*

*Name*.....

(3)  
(Total 4 marks)

4. Protonation of alcohol **A** and subsequent loss of water, produces the intermediate **B**.



(a) (i) Name alcohol **A**.

.....

(ii) What type of species is intermediate **B**?

.....

(iii) Draw the structures of the two alkenes which can be formed from species **B** by removal of a proton. Label as **C** the alkene which shows geometrical isomerism.

(5)

(b) The intermediate **B** is readily attacked by nucleophiles such as water.

What is the essential feature of a nucleophile?

.....

(1)

(c) (i) State what final colour you would see if alcohol **A** were warmed with acidified potassium dichromate(VI). Explain your answer.

*Colour* .....

*Explanation* .....

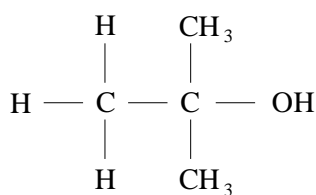
.....

(ii) Draw two structural isomers of alcohol **A** which form branched chain ketones when heated with acidified potassium dichromate(VI), but which could not form alkene **C** on dehydration.

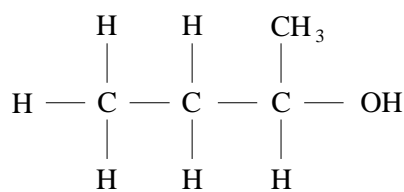
(5)

(Total 11 marks)

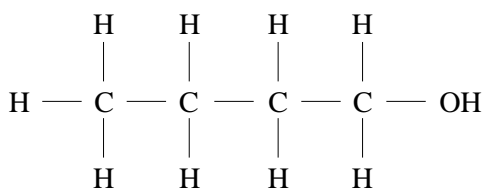
5. There are four structurally isomeric alcohols of molecular formula  $C_4H_{10}O$ . Graphical formulae of these isomers, labelled **A**, **B**, **C** and **D**, are shown below.



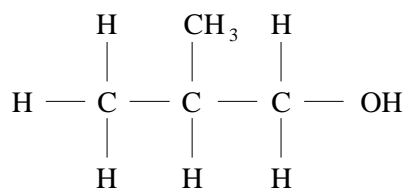
**A**



**B**



**C**



**D**

- (a) Identify the type of alcohol represented by **A** and by **B**.

Type of alcohol represented by **A** .....

Type of alcohol represented by **B** .....

(2)

- (b) Give the name of alcohol **A**.

.....

(1)

- (c) Select one of the alcohols **A**, **B**, **C** or **D** which will, on oxidation, produce an aldehyde.

- (i) Give the structural formula of the aldehyde produced by this reaction.

Alcohol selected .....

Structural formula of aldehyde

(1)

- (ii) State the reagents and conditions required for the aldehyde to be the main product of the oxidation reaction.

Reagents .....

Conditions .....

(3)

(d) All the alcohols **A**, **B**, **C** and **D** may be readily dehydrated.

(i) Explain what is meant by the term *dehydration*.

..... (1)

(ii) State the type of compound formed by dehydration of alcohols.

..... (1)

(iii) Suggest suitable reagent(s) and condition(s) for the dehydration of alcohols.

*Reagent(s)* .....

*Condition(s)* .....

(2)

(iv) Select one of the alcohols **A**, **B**, **C** or **D** which, on dehydration, would give a single product. Draw the structural formula of this product.

*Alcohol selected* .....

*Structural formula of product*

(1)

(v) Select one of the alcohols **A**, **B**, **C** or **D** which, on dehydration, would give two products which are **structurally** isomeric. Draw structural formulae for these two structural isomers and explain why the formation of two structural isomers is possible in this case.

*Alcohol selected* .....

*Structural formula 1*

*Structural formula 2*

*Explanation* .....

.....

.....

(4)

(Total 16 marks)

6. Butan-1-ol can be oxidised by acidified potassium dichromate( VI) using two different methods.

(a) In the first method, butan-1-ol is added dropwise to acidified potassium dichromate( VI) and the product is distilled off immediately.

(i) Using the symbol [O] for the oxidising agent, write an equation for this oxidation of butan-1-ol, showing clearly the structure of the product.  
State what colour change you would observe.

*Equation* .....

*Colour change* .....

(ii) Butan-1-ol and butan-2-ol give different products on oxidation by this first method. By stating a reagent and the observation with each compound, give a simple test to distinguish between these two oxidation products.

*Reagent* .....

*Observation with oxidation product of butan-1-ol*

.....

*Observation with oxidation product of butan-2-ol*

.....

(6)

(b) In a second method, the mixture of butan-1-ol and acidified potassium dichromate( VI) is heated under reflux. Identify the product which is obtained by this reaction.

.....

(1)

(c) Give the structures and names of two branched chain alcohols which are both isomers of butan-1-ol. Only isomer 1 is oxidised when warmed with acidified potassium dichromate(VI).

Structure of isomer 1

Structure of isomer 2

*Name of isomer 1*

*Name of isomer 2*

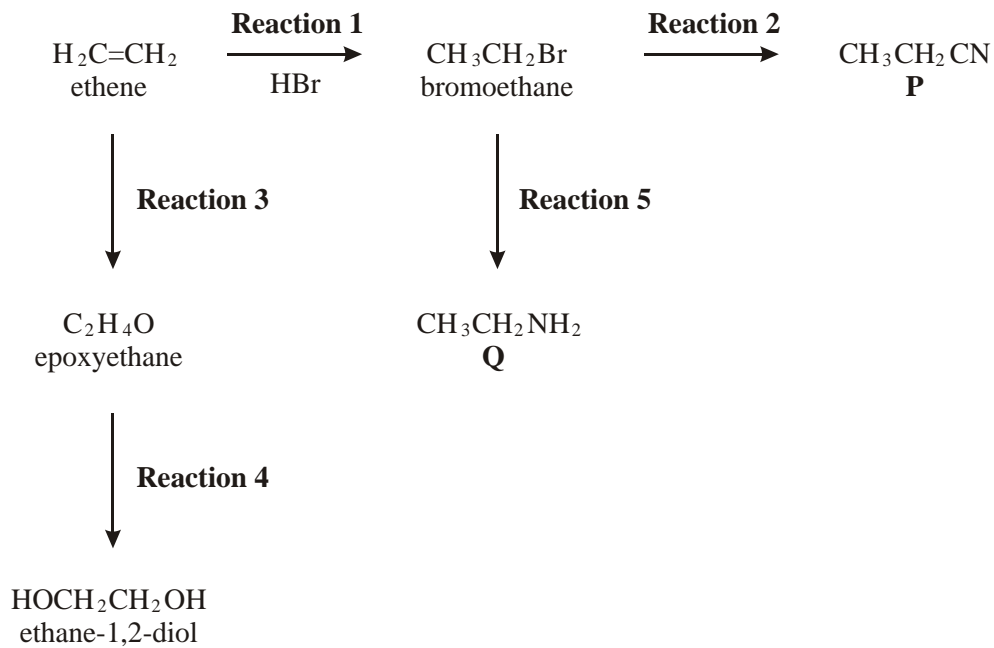
.....

.....

(4)

(Total 11 marks)

7. Consider the following scheme of reactions.



(a) In **Reaction 1**, ethene undergoes electrophilic addition with hydrogen bromide.

(i) State what is meant by the term *electrophile*.

.....  
.....

(ii) Outline a mechanism for this reaction.

(5)

(b) 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* .....

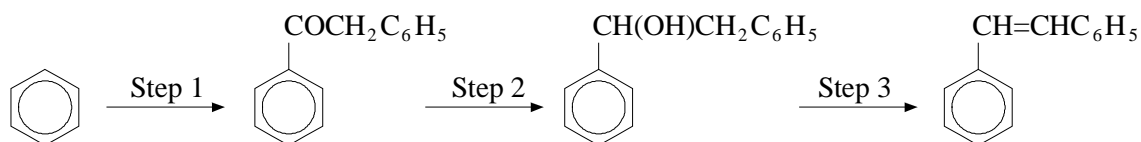
*Name of product Q* .....

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

(8)

(Total 13 marks)

8. Consider the following reaction sequence:



(a) Suggest a suitable reagent for Step 3. Name the mechanism for this reaction.

*Reagents* .....

*Name of mechanism* .....

(2)

(b) Name the type of isomerism shown by the final product, 1,2-diphenylethene, and explain why this compound can exist in two stereoisomeric forms.

*Type of isomerism* .....

*Explanation* .....

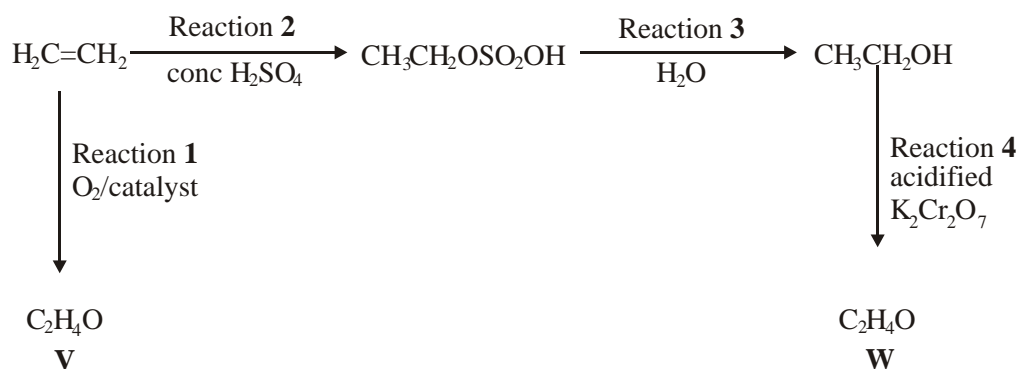
.....

(2)

(Total 4 marks)



9. Consider the following reaction scheme, which leads to the formation of two compounds **V** and **W**.



- (a) Name and outline a mechanism for Reaction 2.

*Name of mechanism* .....

*Mechanism*

(5)

- (b) In Reaction 4, compound **W** is distilled from the reaction mixture.

- (i) Name compound **W** and draw its structure.

*Name* .....

*Structure*

- (ii) Name the type of reaction shown by Reaction 4.

.....

(3)

(Total 8 marks)

10. (a) Ethanol,  $C_2H_5OH$ , can be made from glucose,  $C_6H_{12}O_6$

(i) Write an equation to represent this reaction.

.....

(ii) Give the name of this process for making ethanol.

.....

(2)

(b) Ethanol can be used as a fuel in the internal combustion engine of a motor car.

(i) Write an equation for the complete combustion of ethanol.

.....

(ii) Identify a pollutant produced when ethanol is burned in a limited supply of air.

.....

(iii) Nitrogen monoxide,  $NO$ , is a pollutant gas produced by motor cars. Write an equation to represent a reaction occurring in the catalytic converter which decreases the amount of this pollutant.

.....

(3)

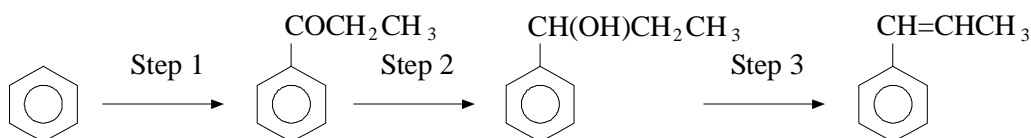
(c) Ethene can be formed by the dehydration of ethanol using concentrated sulphuric acid. Name a mechanism for this reaction.

Name of mechanism .....

(1)

(Total 6 marks)

11. Consider the following reaction sequence:



(a) For step 3, name the type of reaction taking place and suggest a suitable reagent or combination of reagents.

Type of reaction.....

Reagent(s).....

(2)

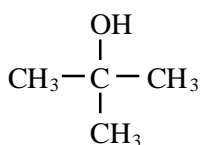
(Total 2 marks)

12. (a) An alcohol containing carbon, hydrogen and oxygen only has 64.9% carbon and 13.5% hydrogen by mass. Using these data, show that the empirical formula of the alcohol is  $C_4H_{10}O$

.....  
 .....  
 .....  
 .....

(3)

- (b) The structural formulae of two of the four possible alcohols of molecular formula  $C_4H_{10}O$  are shown below.



*Isomer 1*



*Isomer 2*

- (i) What type of alcohol is Isomer 1? Suggest a reason why this type of alcohol is not easily oxidised.

*Type of alcohol* .....

*Reason* .....

.....

- (ii) Draw the structural formulae of the two remaining alcohols of molecular formula  $C_4H_{10}O$

*Isomer 3*

*Isomer 4*

(4)

(c) Isomer 2 was oxidised by adding it dropwise to acidified potassium dichromate(VI) solution and immediately distilling off the product. When this product was treated with Fehling's solution, a red precipitate was formed.

(i) State the type of product distilled off during the oxidation by acidified potassium dichromate(VI) solution.

.....

(ii) Write an equation for the oxidation by potassium dichromate(VI), showing clearly the structure of the organic product. Use [O] to represent the oxidising agent.

.....

(iii) Name and draw a structure for the organic product formed by the reaction with Fehling's solution.

Name .....

Structure .....

(5)

(d) State **one** advantage and **one** disadvantage of the production of ethanol by the hydration of ethene compared to the fermentation of glucose.

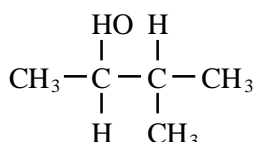
Advantage .....

Disadvantage .....

(2)

(Total 14 marks)

13. In the presence of reagent X, the alcohol shown below undergoes a reaction to form two isomeric alkenes.



(i) Name this alcohol.

.....

(ii) Give the name of the type of reaction involved in the formation of the two alkenes.

.....

(iii) Suggest the identity of reagent X.

.....

(iv) Give the structural formulae of the two isomeric alkenes.

*Alkene 1*

*Alkene 2*

(5)  
(Total 5 marks)

14. Many naturally-occurring organic compounds can be converted into other useful products.

Glucose,  $C_6H_{12}O_6$ , can be fermented to make ethanol, which can then be dehydrated to make the unsaturated compound, ethene.

(i) Write an equation for the fermentation of glucose to form ethanol.

.....

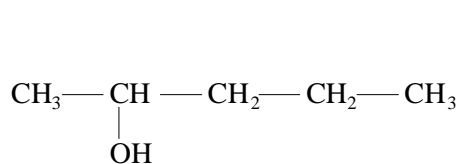
(ii) Identify a catalyst for the dehydration of ethanol to form ethene. Write an equation for this reaction.

*Catalyst* .....

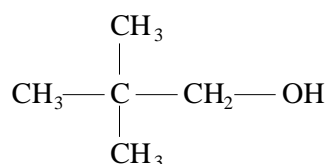
*Equation* .....

(3)  
(Total 3 marks)

15. The structures of two alcohols of formula  $C_5H_{11}OH$  are shown below.



pentan-2-ol



2,2-dimethylpropan-1-ol

(i) A third alcohol of formula  $C_5H_{11}OH$  is tertiary. Draw the graphical formula and give the name of this alcohol.

*Graphical formula*

*Name*.....

(2)

- (ii) Draw the graphical formulae of **two** alkenes formed when pentan-2-ol is heated with concentrated sulphuric acid.

(2)

- (iii) State the type of reaction taking place in (a)(ii).

.....

(1)

- (iv) Explain why the type of reaction taking place in (a)(ii) does not occur when 2,2-dimethylpropan-1-ol is heated with concentrated sulphuric acid.

.....

.....

(1)

**(Total 6 marks)**

- 16.** When 3-bromo-3-methylpentane,  $\text{CH}_3\text{CH}_2\text{CBr}(\text{CH}_3)\text{CH}_2\text{CH}_3$ , is treated with aqueous ethanolic potassium hydroxide, a mixture of 3-methylpentan-3-ol, 3-methylpent-2-ene and an isomeric alkene is formed.

- (a) (i) Name the type of mechanism occurring in the formation of 3-methylpentan-3-ol from 3-bromo-3-methylpentane.

.....

- (ii) Why is it difficult to oxidise 3-methylpentan-3-ol?

.....

(2)

- (b) Name and outline a mechanism for the formation of 3-methylpent-2-ene in the above reaction.

*Name of mechanism* .....

*Mechanism*

(4)

- (c) Give the structure and name of the isomeric alkene formed together with 3-methylpent-2-ene in the above reaction.

*Structure*

*Name* .....

(2)

(Total 8 marks)

17. When 3-bromo-2,3-dimethylpentane,  $(\text{CH}_3)_2\text{CHCBr}(\text{CH}_3)\text{CH}_2\text{CH}_3$ , 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.

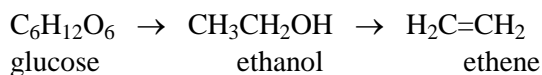
- (iii) Why is it difficult to oxidise this alcohol?

.....

(6)

(Total 6 marks)

18. Glucose can be used as a source of ethanol. Ethanol can be burned as a fuel or can be converted into ethene.



- (a) Name the types of reaction illustrated by the two reactions above.

*Glucose to ethanol* .....

*Ethanol to ethene* .....

(2)

- (b) (i) State what must be added to an aqueous solution of glucose so that ethanol is formed.  
.....
- (ii) Identify a suitable catalyst for the conversion of ethanol into ethene.  
..... (2)
- (c) (i) State the class of alcohols to which ethanol belongs.  
.....
- (ii) Give **one** advantage of using ethanol as a fuel compared with using a petroleum fraction.  
..... (2)
- (d) Most of the ethene used by industry is produced when ethane is heated to 900°C in the absence of air. Write an equation for this reaction.  
..... (1)
- (e) Name the type of polymerisation which occurs when ethene is converted into poly(ethene).  
..... (1)
- (Total 8 marks)**

19. (a) (i) Pentan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ , was oxidised by adding it dropwise to acidified potassium dichromate(VI) and distilling off the organic product immediately. Write an equation for this reaction showing clearly the structural formula of the organic product. You may use [O] to represent the oxidising agent.
- (ii) Pentan-2-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ , was oxidised by heating it under reflux with acidified potassium dichromate(VI). Write an equation for this reaction showing clearly the structural formula of the organic product. You may use [O] to represent the oxidising agent.
- (4)**



- (b) By stating the reagents, conditions and observations, show how you would distinguish between the two oxidation products formed in parts (a)(i) and (a)(ii).

*Reagents*.....

*Conditions*.....

*Observation with the product from part (a) (i)*.....

.....

.....

*Observation with the product from part (a) (ii)*.....

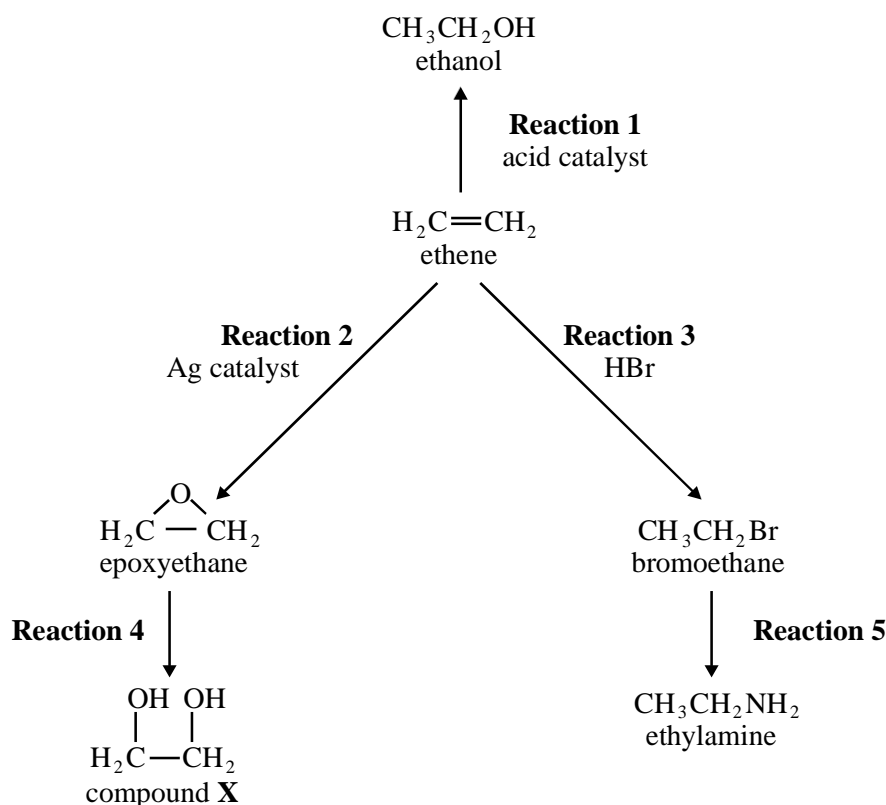
.....

.....

(4)  
(Total 8 marks)

20. Some alcohols can be oxidised to form aldehydes, which can then be oxidised further to form carboxylic acids.  
Some alcohols can be oxidised to form ketones, which resist further oxidation.  
Other alcohols are resistant to oxidation.
- (a) Draw the structures of the **two** straight-chain isomeric alcohols with molecular formula,  $C_4H_{10}O$  (2)
- (b) Draw the structures of the oxidation products obtained when the two alcohols from part (a) are oxidised separately by acidified potassium dichromate(VI). Write equations for any reactions which occur, using [O] to represent the oxidising agent. (6)
- (c) Draw the structure and give the name of the alcohol with molecular formula  $C_4H_{10}O$  which is resistant to oxidation by acidified potassium dichromate(VI). (2)
- (Total 10 marks)**
21. The three compounds  $CH_3CH_2CH_2CH_2OH$ ,  $(CH_3)_3COH$  and  $CH_3CH_2CH_2CHO$  can be distinguished by use of the following reagents:
1. potassium dichromate(VI) acidified with dilute sulphuric acid
  2. Tollens' reagent
- (a) Identify which of these three organic compounds would reduce acidified potassium dichromate(VI). Give the structures of the organic products formed. Write a half-equation for the reduction of dichromate(VI) ions in acidic solution. (6)
- (b) Identify which one of these three organic compounds would reduce Tollens' reagent. Give the structure of the organic product formed. Write a half-equation for the reduction of Tollens' reagent. (3)
- (Total 9 marks)**

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

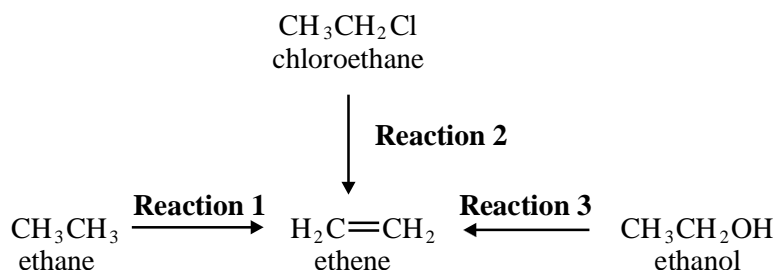


- (a) Give a reagent for each of **Reactions 1** and **5**. (2)
- (b) Outline a mechanism for **Reaction 3**. (4)
- (c) Ethanol can be manufactured from ethene as shown in **Reaction 1** or by the fermentation of sugars. Outline the essential conditions and give an equation for the fermentation reaction. Compare the relative rates and the purity of the product obtained in each case by these two manufacturing processes. (5)
- (Total 11 marks)**

23. Ethanoic acid can be formed from bromoethane in two steps. Give reagents and conditions for each step. Include in your answer the name of the mechanism for the first step and an equation for the second step. (Total 9 marks)

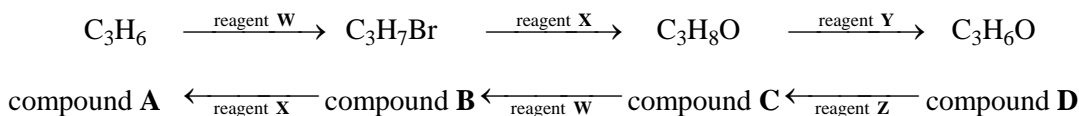
24. (a) When a mixture of chlorine with an excess of methane is irradiated with ultraviolet light, a reaction occurs with chloromethane as the main organic product.
- Write an equation and a mechanism for the formation of chloromethane. (5)
- (b) Ethanol can be produced industrially either by the direct hydration of ethene or by fermentation. State the conditions for each method and compare the two processes by giving two advantages and one disadvantage of direct hydration. (9)
- (Total 14 marks)**

25. 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 each of **Reactions 2** and **3**. (4)
- (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)
- (c) Name a mechanism for **Reaction 3**. Suggest why this route to ethene may become used more commonly in the future as supplies of North Sea gas begin to run out. (2)
- (Total 11 marks)

26. This question is concerned with the six reactions shown in the following scheme. The four compounds involved are represented by their molecular formulae and labelled using the letters **A**, **B**, **C** and **D**.



- (a) State the names of the three homologous series to which compounds **A**, **B** and **C** belong. (3)
- (b) Give the name of the type of reaction occurring in each of the following conversions: (1)
- (i) compound **A** to compound **B**; (1)
- (ii) compound **B** to compound **C**; (1)
- (iii) compound **C** to compound **D**. (1)
- (c) Give the name **or** formula of reagent **X** and state the different conditions under which it would be used in the conversions of compound **B** to compound **C**, and of compound **B** to compound **A**. (3)

- (d) Identify, by name **or** formula, the substances present in reagent **Y** and state an essential condition under which they would be used in the conversion of compound **C** to compound **D**. (3)
- (f) Write an equation for each of the following reactions:
- (i) the conversion of compound **B** to compound **A**; (1)
- (ii) the conversion of compound **B** to compound **C**. (1)
- (g) Outline a possible mechanism for the conversion of compound **B** to compound **C**. (3)
- (Total 17 marks)**