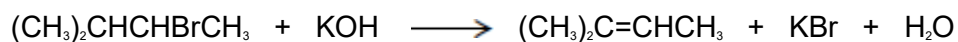


Q1. Haloalkanes are used in the synthesis of other organic compounds.

- (a) Hot concentrated ethanolic potassium hydroxide reacts with 2-bromo-3-methylbutane to form two alkenes that are structural isomers of each other. The major product is 2-methylbut-2-ene.

- (i) Name and outline a mechanism for the conversion of 2-bromo-3-methylbutane into 2-methylbut-2-ene according to the equation.



Name of mechanism

Mechanism

(4)

- (ii) Draw the **displayed formula** for the other isomer that is formed.

(1)

- (iii) State the type of structural isomerism shown by these two alkenes.

.....

(1)

- (b) A small amount of another organic compound, **X**, can be detected in the reaction mixture formed when hot concentrated ethanolic potassium hydroxide reacts with 2-bromo-3-methylbutane.
Compound **X** has the molecular formula $\text{C}_5\text{H}_{12}\text{O}$ and is a secondary alcohol.

(i) Draw the **displayed formula** for **X**. (1)

(ii) Suggest **one** change to the reaction conditions that would increase the yield of **X**.

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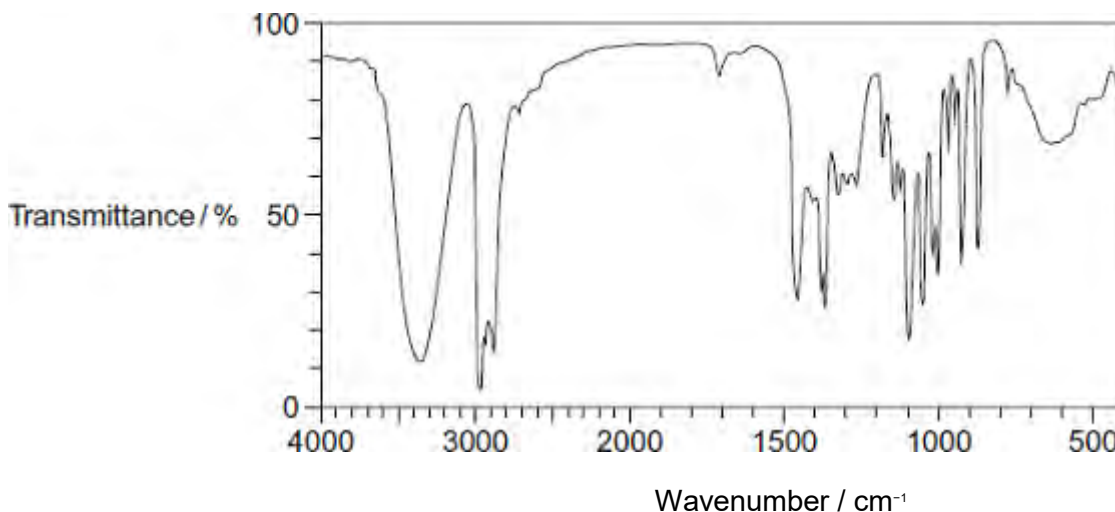
(1)

(iii) State the type of mechanism for the conversion of 2-bromo-3-methylbutane into **X**.

.....

(1)

(iv) Identify **one** feature of this infrared spectrum of a pure sample of **X** that may be used to confirm that **X** is an alcohol.
You may find it helpful to refer to **Table 1** on the Data Sheet.



Feature

.....

(1)

(Total 10 marks)

Q2. Explain how infrared spectroscopy can be used to show that an aldehyde is definitely

pentanal.

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(Total 2 marks)

Q3. The reaction of butane-1,4-diol with butanedioic acid produces the polymer PBS used in biodegradable packaging and disposable cutlery. Butanedioic acid is produced by two different processes.

Process 1

- Aqueous sodium hydroxide reacts with 1,4-dibromobutane to make butane-1,4-diol.
- Butane-1,4-diol is oxidised to butanedioic acid.

Process 2

- Glucose reacts with carbon dioxide in the presence of microorganisms to produce butanedioic acid directly.
- The carbon dioxide used in this process is obtained from a local factory that produces bioethanol.

(a) Deduce **one** safety reason and one environmental reason why **Process 2** is preferred to **Process 1**.

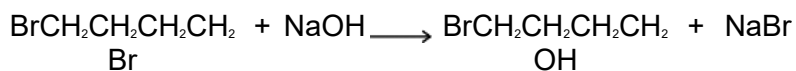
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(2)

- (b) (i) Name and outline a mechanism for the following reaction that occurs in **Process 1**.



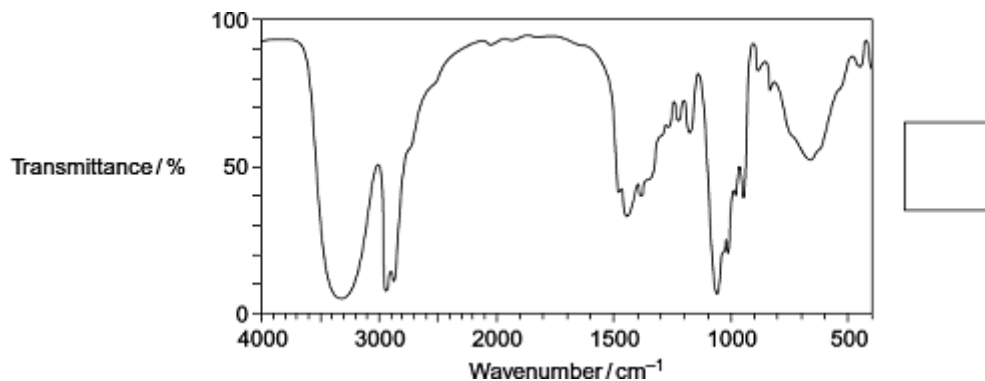
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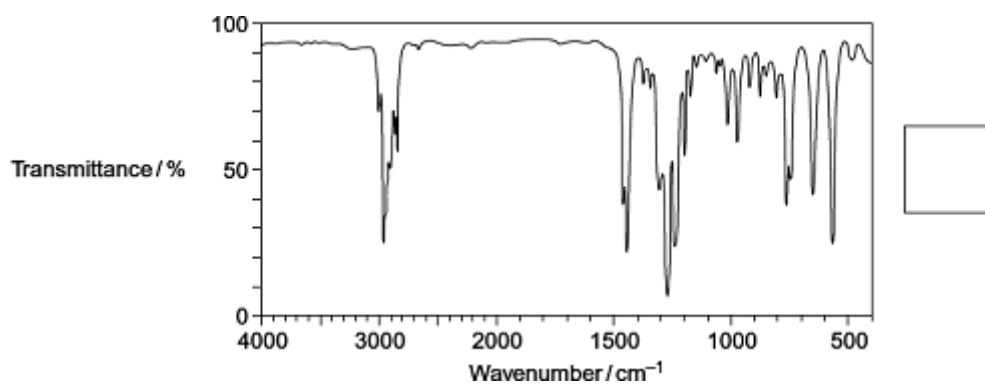
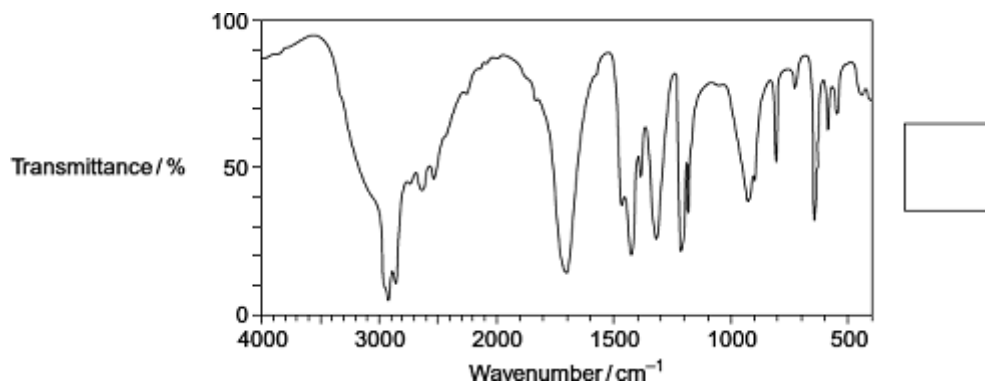
(3)

- (ii) The infrared spectra shown are those of three compounds.

Compound **A** 1,4-dibromobutane
Compound **B** butane-1,4-diol
Compound **C** butanedioic acid

Identify the compound responsible for each spectrum by writing the correct letter, **A**, **B** or **C**, in the box next to each spectrum.
You may find it helpful to refer to **Table 1** on the Data Sheet.





(3)

- (c) In the production of bioethanol, glucose ($C_6H_{12}O_6$) is converted into a dilute aqueous solution of ethanol and carbon dioxide.

Give the name of this process and state **three** essential conditions necessary to produce a good yield of ethanol.

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(Extra space)

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(d) State the class of alcohols to which the diol butane-1,4-diol belongs.

Identify a suitable reagent or combination of reagents for the conversion of butane-1,4-diol into butanedioic acid ($\text{HOOCCH}_2\text{CH}_2\text{COOH}$).

Write an equation for this oxidation reaction using [O] to represent the oxidising agent.

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(Extra space)
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(3)
(Total 15 marks)

Q4. Chloromethanes, such as dichloromethane and trichloromethane, are produced in industry as they have many uses. Trichloromethane has been used in the manufacture of the refrigerant chlorodifluoromethane.

(a) Chlorine can react with dichloromethane (CH_2Cl_2) to form trichloromethane (CHCl_3).

(i) Write an equation for each of the following steps in the mechanism for this reaction.

Initiation step

.....
First propagation step

.....
Second propagation step

.....

(3)

- (ii) Give **one** essential condition for this reaction and name the type of mechanism.

Essential condition

Type of mechanism

(2)

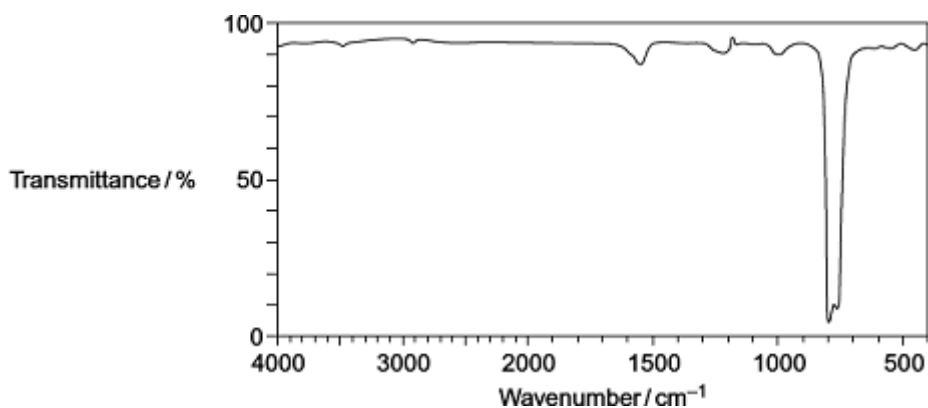
- (b) An organic product, **X**, with $M_r = 154.0$ is obtained when chlorine reacts with trichloromethane.

- (i) Write an equation for the overall reaction of chlorine with trichloromethane to form **X**, by the same mechanism as that outlined in part (a)(i).

.....

(1)

- (ii) The following infrared spectrum was obtained for a sample of **X** produced in this reaction.



Use this infrared spectrum to explain why it is possible to deduce that this sample of **X** contains no trichloromethane.
You may find it helpful to refer to **Table 1** on the Data Sheet.

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(Extra space)
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(2)

- (c) Explain, with the aid of equations and the intermediates that form in the ozone layer, why the European Union has banned the use of chlorodifluoromethane (CHClF_2) as a refrigerant.

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(Extra space)
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.....

(4)

(d) The compound 2,3,3,3-tetrafluoropropene is the refrigerant used in all new car air conditioners.

(i) Draw the displayed formula for 2,3,3,3-tetrafluoropropene.

(1)

(ii) Give **one** reason why 2,3,3,3-tetrafluoropropene is a more **environmentally** acceptable refrigerant than chlorodifluoromethane.

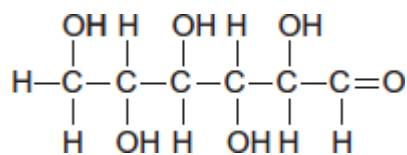
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(1)

(Total 14 marks)

Q5. Glucose is an organic molecule. Glucose can exist in different forms in aqueous solution.

(a) In aqueous solution, some glucose molecules have the following structure.

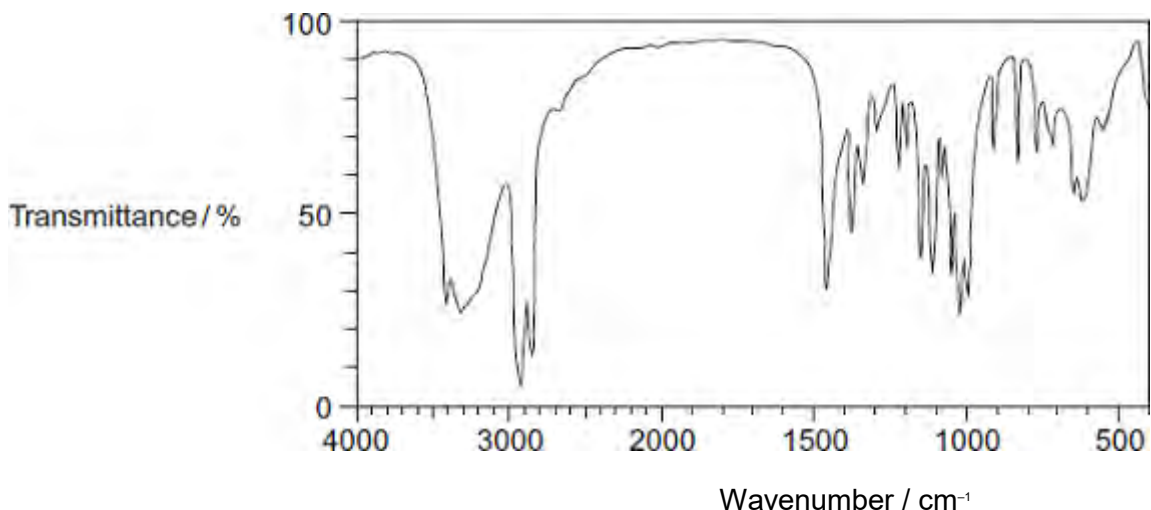


(i) Deduce the empirical formula of glucose.

.....

(1)

(ii) Consider the infrared spectrum of solid glucose.



State why it is possible to suggest that in the solid state very few molecules have the structure shown.

You may find it helpful to refer to **Table 1** on the Data Sheet.

.....

(1)

- (b) In the absence of oxygen, an aqueous solution of glucose can be fermented to produce ethanol for use in alcoholic drinks.

Write an equation for this fermentation reaction.

Give **two** other essential conditions for the production of ethanol in this fermentation.

Equation

.....

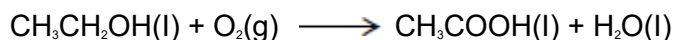
Condition 1

Condition 2

(3)

- (c) Any ethanol present in the breath of a drinker can be detected by using a breathalyser. The ethanol is converted into ethanoic acid. The breathalyser has negative and positive electrodes. A current is measured and displayed in terms of alcohol content.

The overall redox equation is as follows



(i) Draw the displayed formula for ethanoic acid.

(1)

(ii) Deduce a half-equation for the reduction of atmospheric oxygen to water in acidic solution at one electrode of the breathalyser.

.....

(1)

(iii) Deduce a half-equation for the oxidation of ethanol in water to ethanoic acid at the other electrode of the breathalyser.

.....

(1)

(iv) The earliest breathalysers used laboratory chemicals to oxidise the ethanol to ethanoic acid. Detection was by a colour change.

Identify a reagent or combination of reagents that you would use in the laboratory to oxidise ethanol to ethanoic acid.
State the colour **change** that you would expect to see.

Reagent or combination of reagents

Colour change

(2)

(d) The fermentation of glucose from crops is the main method for the production of ethanol. The product is called bioethanol. The European Union has declared that bioethanol is carbon-neutral.

(i) State the meaning of the term *carbon-neutral*.

.....

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.....
(Extra space)

.....

(1)

(ii) Other than carbon-neutrality, state the **main** advantage of the use of glucose from crops as the raw material for the production of ethanol.

.....
.....

(1)

(iii) Give *one* disadvantage of the use of crops for the production of ethanol.

.....
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(1)

(Total 13 marks)