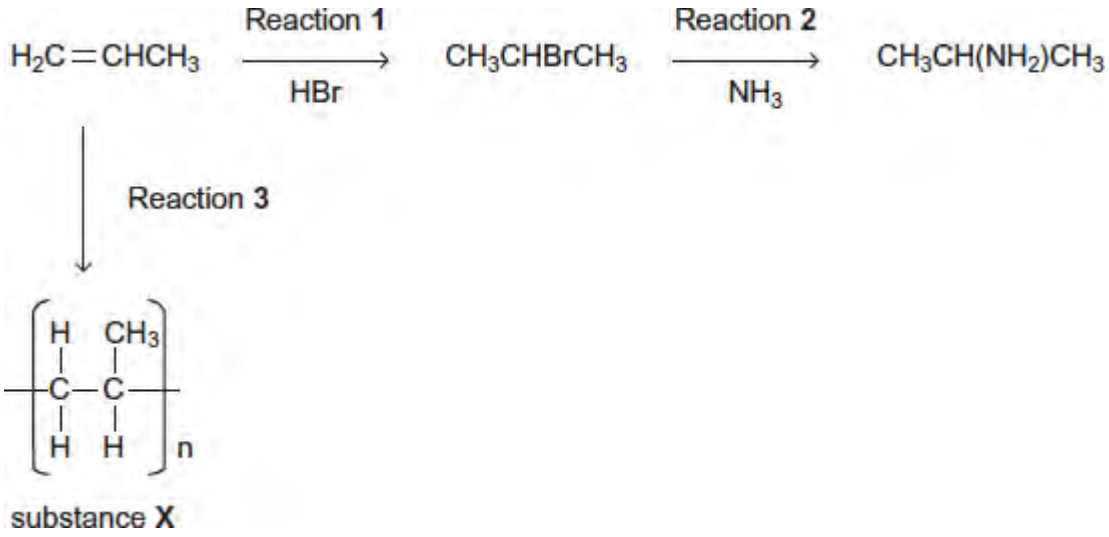
Q1. Consider the following reactions.



substance **X**

(a) Name and outline a mechanism for Reaction **1**.

Name of mechanism

.....

Mechanism

(5)

(b) Name and outline a mechanism for Reaction **2**.

Name of mechanism

.....

Mechanism

(5)

(c) State the type of reaction in Reaction **3**.
Give the name of substance **X**.

.....

.....

.....

(2)

(d) The haloalkane produced in Reaction **1** can be converted back into propene in an elimination reaction using ethanolic potassium hydroxide.

$$CH_3CHBrCH_3 \xrightarrow{KOH} H_2C{=}CHCH_3$$

Outline a mechanism for this conversion.

(3)
(Total 15 marks)

Q2. 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**.

.....

.....

.....

.....

.....

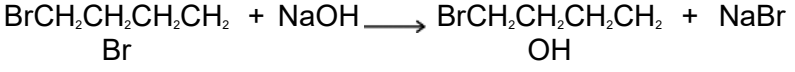
.....

(Extra space) .....

.....

(2)

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



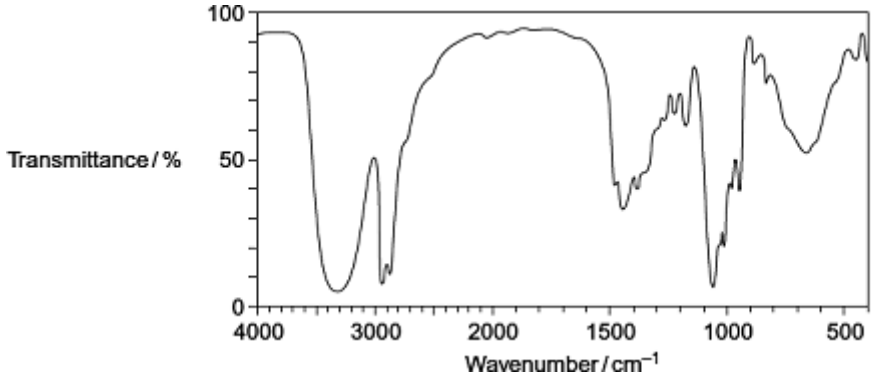
.....

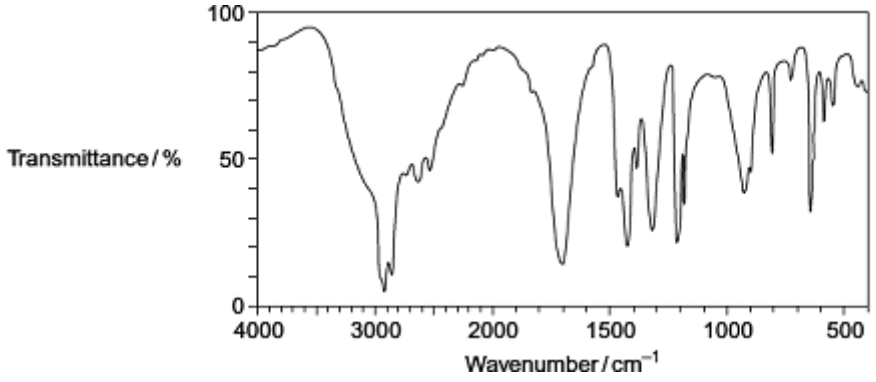
(3)

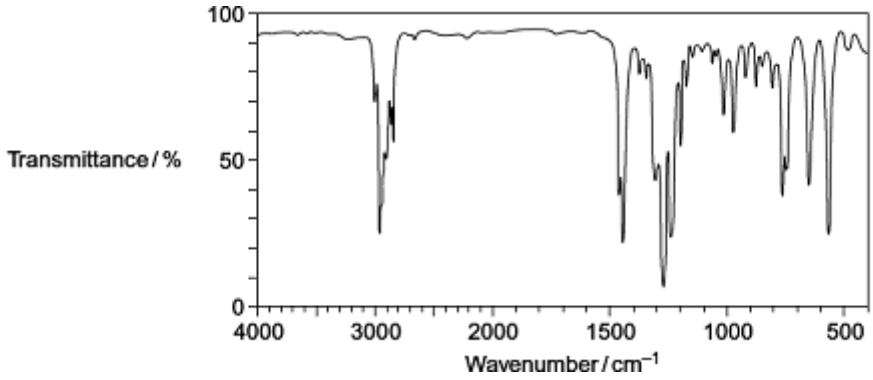
(ii) The infrared spectra shown are those of three compounds.

Compound **A** 1,4-dibromobutaneCompound **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.

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(4)

(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 ($HOOCCH_2CH_2COOH$).

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

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)
(Total 15 marks)

Q3. A student read the following passage on the Internet.

Haloalkanes contain a polar covalent bond. The carbon atom of the polar covalent bond can be attacked by nucleophiles. Nucleophilic attack enables haloalkanes to undergo substitution reactions. A nucleophilic substitution reaction occurs when a haloalkane undergoes hydrolysis; the rate of hydrolysis of the haloalkane is influenced by the carbon–halogen bond enthalpy.

(a) Explain the meaning of each of the following terms in the information given above.

(i) *nucleophile*

.....

.....

.....

(1)

(ii) *substitution,* as applied to nucleophilic substitution in a haloalkane

.....

.....

.....

(1)

(iii) *hydrolysis*

.....

.....

.....

(1)

(iv) *bond enthalpy,* as applied to a carbon–halogen bond.

.....

.....

.....

(1)

(b) Outline a mechanism for the nucleophilic substitution reaction in which 2-bromopropane ($CH_3CHBrCH_3$) reacts with potassium hydroxide to form propan-2-ol.

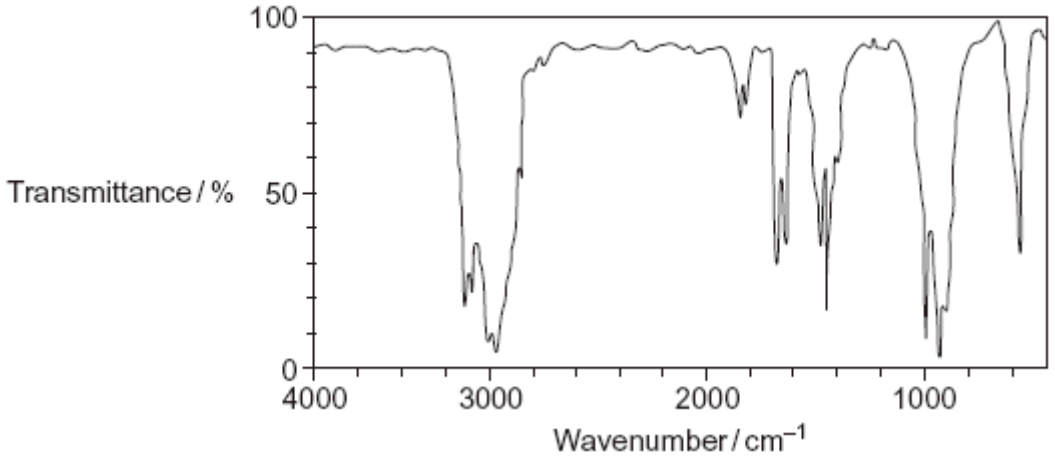
(2)

(c) Haloalkanes also undergo elimination reactions to produce alkenes.

(i) Outline a mechanism for the elimination reaction in which 2-bromopropane reacts with potassium hydroxide to form propene.

(3)

(ii) A student obtained the following infrared spectrum for the product from this elimination reaction.



Use information from the infrared spectrum to state and explain how the student deduced that the product was an alkene.
You may find it helpful to refer to **Table 1** on the Data Sheet.

.....

.....

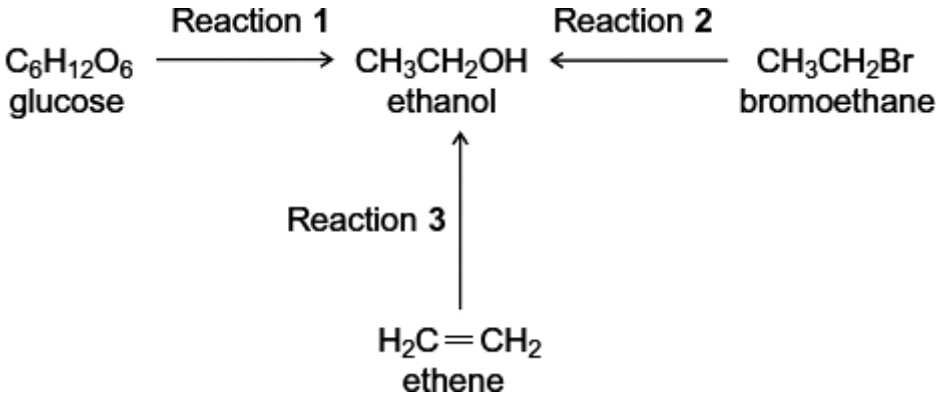
.....

.....

.....

(2)
(Total 11 marks)

Q4. Three different ways of producing ethanol are shown below.



(a) Reaction **1** produces a 15% aqueous solution of ethanol.
It is claimed that the ethanol produced in this way is a carbon-neutral biofuel.

Write an equation for Reaction **1** and name the process.

Write an equation for the complete combustion of ethanol.

Explain why the ethanol produced by this process may **not** be a *carbon-neutral* biofuel.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(5)

(b) Give a reagent and conditions for Reaction **2**.

CH_3CH_2Br —Reaction 2→ CH_3CH_2OH

Name and outline a mechanism for Reaction **2**.

Suggest **one** reason, other than safety, why this method is **not** used in industry to make ethanol.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

.....

.....

.....

(6)

(c) Reaction **3** is used in industry.

$H_2C = CH_2$ $\xrightarrow{\text{Reaction 3}}$ CH_3CH_2OH

Identify a suitable catalyst for Reaction **3**.

Identify the type of reaction.

Give **two** conditions, in addition to the presence of a catalyst, necessary for Reaction **3** to produce a high yield of ethanol.

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

.....

(4)
(Total 15 marks)