1)

(c) Barium metal reacts very quickly with dilute hydrochloric acid, but it reacts more slowly with water.

(c) (i) Write an equation for the reaction of barium with water.

.....

(1 mark)

(c) (ii) A solution containing barium ions can be used to show the presence of sulfate ions in an aqueous solution of sodium sulfate.

Write the **simplest ionic** equation for the reaction that occurs and state what is observed.

Simplest ionic equation

.....

Observation

.....

(2 marks)

(c) (iii) State **one** use of barium sulfate in medicine.
Explain why this use is possible, given that solutions containing barium ions are poisonous.

Use .....

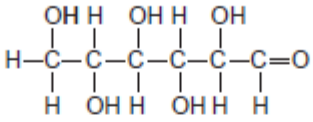
.....

Explanation ..... *(1 mark)*

2)

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.

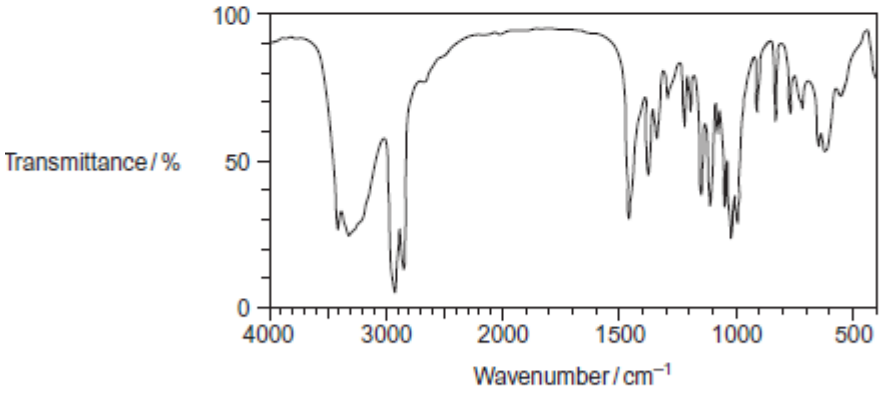


(a) (i) Deduce the empirical formula of glucose.

.....

(1 mark)

(a) (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 mark)

(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 marks)

(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

$$CH_3CH_2OH(l) + O_2(g) \longrightarrow CH_3COOH(l) + H_2O(l)$$

(c) (i) Draw the displayed formula for ethanoic acid.

(1 mark)

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

.....

(1 mark)

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

.....

(1 mark)

(c) (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 marks)

(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.

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

.....

.....

.....

(1 mark)

(d) (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 mark)

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

.....

(1 mark)

3)

The refrigerant R410A, used in air conditioners, is a mixture of two fluoroalkanes, pentafluoroethane and difluoromethane.

(a) (i) The mechanism for the reaction of fluorine with either an alkane or a fluoroalkane is similar to that for the reaction of chlorine with methane.

Name the type of mechanism for the reaction of chlorine with methane.

.....

(1 mark)

(a) (ii) Write equations for the following steps in the mechanism for the reaction of fluorine with fluoromethane (CH_3F) to form difluoromethane (CH_2F_2).

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step leading to the formation of 1,2-difluoroethane.

.....

(4 marks)

(a) (iii) Write an overall equation for the reaction of fluorine with ethane to form pentafluoroethane (CF_3CHF_2) by this mechanism.

.....

(1 mark)

(b) The refrigerant R112A (CCl_3CF_2Cl) has been banned because of concerns about ozone depletion.

Give the IUPAC name for CCl_3CF_2Cl

.....

(1 mark)

(c) Nitrogen monoxide (NO) catalyses the decomposition of ozone into oxygen.

(c) (i) Write the overall equation for this decomposition.

.....

(1 mark)

(c) (ii) Use the overall equation to deduce Step **3** in the following mechanism that shows how nitrogen monoxide catalyses this decomposition.

Step **1** $O_3 \longrightarrow O + O_2$

Step **2** $NO + O_3 \longrightarrow NO_2 + O_2$

Step **3** .....

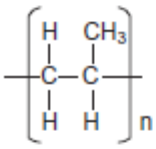
(1 mark)

4)

Consider the following reactions.

$$H_2C{=}CHCH_3 \xrightarrow[HBr]{\text{Reaction 1}} CH_3CHBrCH_3 \xrightarrow[NH_3]{\text{Reaction 2}} CH_3CH(NH_2)CH_3$$

Reaction 3 ↓



substance **X**

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

Name of mechanism .....

Mechanism

(5 marks)

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

Name of mechanism .....

Mechanism

(5 marks)

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

.....

(2 marks)

(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 marks)

5)

Concentrated sulfuric acid reacts with solid potassium iodide as shown in the equation.

$$8KI + 9H_2SO_4 \longrightarrow 4I_2 + 8KHSO_4 + H_2S + 4H_2O$$

Give **two** observations that you would make when this reaction occurs.

In terms of electrons, state what happens to the iodide ions in this reaction.

State the **change** in oxidation state of sulfur that occurs during this formation of H_2S and deduce the half-equation for the conversion of H_2SO_4 into H_2S

.....

(5 marks)

6)

Chlorine is a powerful oxidising agent.

(a) Write the **simplest ionic** equation for the reaction between chlorine and aqueous potassium bromide.

State what is observed when this reaction occurs.

.....

(2 marks)

.....

(b) Write an equation for the reaction between chlorine and cold, dilute, aqueous sodium hydroxide.

Give a major use for the solution that is formed by this reaction.

Give the IUPAC name of the chlorine-containing compound formed in this reaction in which chlorine has an oxidation state of +1.

.....

(3 marks)

(c) Write an equation for the equilibrium reaction that occurs when chlorine gas reacts with cold water.

Give **one** reason why chlorine is used for the treatment of drinking water even though the gas is very toxic.

.....

(2 marks)

(d) State how you could test a sample of water to show that it contains chloride ions.

In your answer, give a reagent, **one** observation and the **simplest ionic** equation for the reaction with the reagent.

.....

(3 marks)

7)

(a) The hydrocarbon but-1-ene (C_4H_8) is a member of the homologous series of alkenes. But-1-ene has structural isomers.

(a) (i) State the meaning of the term *structural isomers*.

.....

(2 marks)

(a) (ii) Give the IUPAC name of the **position** isomer of but-1-ene.

.....

(1 mark)

(a) (iii) Give the IUPAC name of the **chain** isomer of but-1-ene.

.....

(1 mark)

(a) (iv) Draw the displayed formula of a **functional group** isomer of but-1-ene.

(1 mark)

(b) But-1-ene burns in a limited supply of air to produce a solid and water only.

(b) (i) Write an equation for this reaction.

.....

(1 mark)

(b) (ii) State **one** hazard associated with the solid product in part **(b) (i)**.

.....

(1 mark)

(c) One mole of compound **Y** is cracked to produce two moles of ethene, one mole of but-1-ene and one mole of octane (C_8H_{18}) only.

(c) (i) Deduce the molecular formula of **Y**.

.....

(1 mark)

(c) (ii) Other than cracking, give **one** common use of **Y**.

.....

(1 mark)

(d) In cars fitted with catalytic converters, unburned octane reacts with nitrogen monoxide to form carbon dioxide, water and nitrogen only.

(d) (i) Write an equation for this reaction.

.....

(1 mark)

(d) (ii) Identify a catalyst used in a catalytic converter.

.....

(1 mark)