Class Adm No

Candidate Name: _____

H

millennia institute

2024 Preliminary Exams
Pre-University 2

H1 CHEMISTRY **8873/02**

Paper 2 Structured Questions **9 Sep 2024**

2 hours

Candidates answer on the Question paper.

Additional materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so
Write your name, class and admission number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Answer **one** question.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Question		Section A				Section B		Total
	1	2	3	4	5	6	7	
Marks	11	18	16	6	9	20	20	**80**

Section A

Answer **all** the questions in this section in the spaces provided.

1 Silicon compounds are used in the production of glass, ceramics, and refractory materials. Silicon dioxide is a major component of glass and is used in a wide range of applications, including construction, optics, and consumer products.

(a) A sample of silicon contains three isotopes, as shown in Table 1.1.

Table 1.1

Isotope	Percentage abundance / %
^{28}Si	92.23
^{29}Si	4.67
^{30}Si	3.1

(i) Define the term *relative atomic mass of silicon*.

……[1]

(ii) Calculate the relative atomic mass of silicon from this sample, giving your answer in **two** decimal places.

[1]

(b) **(i)** State the full electronic configuration of silicon.

Si : ……[1]

(ii) With reference to the Data Booklet, compare the values of second and third ionisation energies of silicon. Explain why these two energies are different and include an equation representing the third ionisation energy of silicon in your answer.

……

……

……[3]

(c) Describe the reaction, if any, of silicon dioxide with water. Include the approximate pH value of any resulting solution.

……[1]

(d) Silicon dioxide can react with carbon under high temperature to form silicon carbide, SiC. Silicon carbide has a high melting point of 2730 °C. It is very hard and can be used as a semiconductor material.

(i) Suggest the type of structure and bonding of SiC.

Structure : ……

Bonding : …… [1]

(ii) Another method to produce silicon carbide uses silane, SiH_4, and methane gas.

$$SiH_4 + CH_4 \rightarrow SiC + 4H_2$$

Draw the 'dot-and-cross' diagram of silane. State and explain the shape and bond angle around the silicon atom in silane.

……

……

……

……

……[3]

[Total: 11]

2 **(a)** Silver can exist in the form of nanoparticles. The properties of silver nanoparticles make them valuable in a wide range of fields, from healthcare to materials science.

(i) Define the term *nanoparticle*.

……

……[1]

(ii) Suggest why silver nanoparticles are more effective catalysts compared to a single 1 cm^3 block of silver metal.

……

……

……[2]

(iii) Suggest how silver nanoparticles may have an effect on human health.

……

……[1]

(iv) Silver can be synthesised in the form of nanoparticles, while graphene can be synthesised as a nanomaterial.

Describe the structure of graphene and use it to explain why graphene has a high tensile strength.

……

……

……

……[2]

(b) Silver bromide is a sparingly soluble salt that can dissolve in concentrated ammonia. When ammonia is added to silver bromide, a diamminesilver(I) complex ion, $[Ag(NH_3)_2]^+$, is formed.

$$AgBr(s) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq) + Br^-(aq) \quad K_c = 8.5 \times 10^{-6}$$

(i) Write the expression for the equilibrium constant for the above reaction, including its units.

[2]

(ii) In an experiment, solid silver bromide was added to aqueous ammonia. Given that the equilibrium concentration of NH_3 is 0.50 mol dm^{-3}, calculate the equilibrium concentration of $[Ag(NH_3)_2]^+$.

[2]

(iii) Explain the effect of adding excess concentrated ammonia on

I the position of equilibrium

II K_c

I ……..

……....

II ……

……[3]

(iv) Predict the sign for the enthalpy change when one mole of AgBr is dissolved in water. Explain your answer.

……

……[2]

(c) Table 2.1 contains the values of lattice energies of AgBr and MgO.

Table 2.1

Compound	Theoretical value / kJ mol^{-1}	Experimental value / kJ mol^{-1}
AgBr	905	795
MgO	3795	3791

(i) Explain why the lattice energy of MgO is considerably larger in magnitude than AgBr.

……

……[2]

(ii) There is close agreement between the experimental and theoretical values of lattice energy for MgO but not for AgBr. Suggest a reason for this.

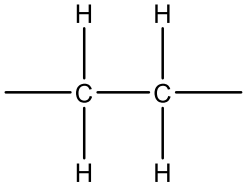
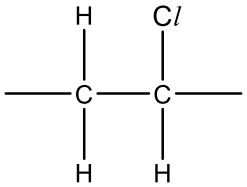
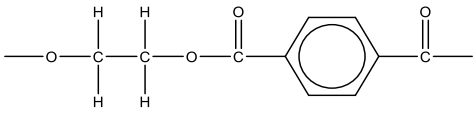
……

……[1]

[Total: 18]

3 Polymers are used in a wide range of applications across industries due to their diverse properties. The properties related to the different polymers are shown in Table 3.1.

Table 3.1

polymer	structure of repeat unit of polymer	chemical reactivity	strength	rigidity
high density poly(ethene) (HDPE)		Low	High	Moderate
Kevlar®	Structure **W**	Very low	Very High	High
poly(chloroethene) (PVC)		Moderate	High	High
poly(ethene) terephthalate (PET)		Moderate	High	Moderate

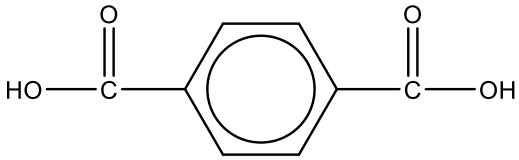
(a) State the type of reaction when PVC reacts with aqueous NaOH and write an equation for the reaction.

Type of reaction: ……

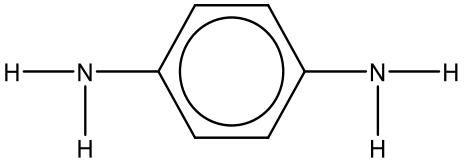
Equation:

[2]

(b) The following structures are the monomer units of Kevlar®.



terephthalic acid



p-phenylenediamine

(i) Explain, in terms of structure and bonding, the differences in melting point between the two monomer units of Kevlar®.

.....

.....

.....

.....

.....[2]

(ii) Draw one repeat unit of Kevlar®, structure **W**.

[1]

(iii) Identify the type of polymerisation in the formation of Kevlar® and provide two reasons to explain your answer.

……

……

……

……[3]

(c) Suggest which polymer can be chosen to make plastic hose. Explain your choice by considering each of the properties listed in the table.

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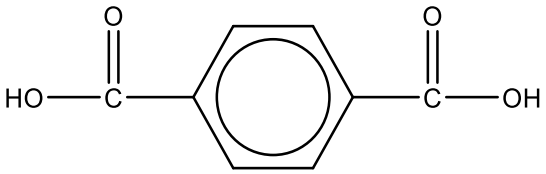
……[4]

(d) **(i)** One of the monomer units of PET is terephthalic acid.

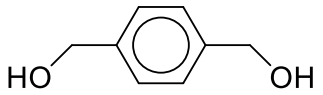


terephthalic acid

Draw the structure of the other monomer.

[1]

(ii) Terephthalic acid can be synthesised from 1,4-benzenedimethanol via oxidation.
Write an equation for the synthesis of terephthalic acid from 1,4-benzenedimethanol.
You may represent the oxidising agent with [O].



1,4-benzenedimethanol

[1]

(iii) In a reaction, the oxidation of 3.8 g of 1,4-benzenedimethanol yielded 3.4 g of terephthalic acid. Determine the percentage yield in this reaction.
[M_r of 1,4-benzenedimethanol = 138; M_r of terephthalic acid = 166]

[2]

[Total: 16]

4 The reaction between hydrogen peroxide and acidified potassium iodide solution can be represented by the following equation.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow I_2 + 2H_2O$$

(a) Identify the species which is being oxidised and the species that is being reduced. Explain your answers in terms of oxidation numbers.

……

……

……[2]

(b) A chemist performs a series of experiments to investigate the effect of changes in concentration on the rate of reaction. The reaction is completed when a deep blue colour solution is obtained. The data obtained for each experiment is given in table 4.1.

Table 4.1

Experiment number	Volume of 0.10 mol dm^3 H_2O_2 / cm^3	Volume of 1.00 mol dm^{-3} KI / cm^3	Volume of 1.00 mol dm^3 HC*l* / cm^3	Volume of water / cm^3	Time for the appearance of deep blue colour / s
1	10.0	15.0	20.0	55.0	20
2	10.0	10.0	20.0	60.0	30
3	40.0	15.0	20.0	35.0	5

(i) State the simple relationship between the time taken for the deep blue colour to appear and the initial rate of reaction.

……

……[1]

(ii) Deduce the order of reaction with respect to $[I^-]$ and $[H_2O_2]$.

[2]

(iii) Hence, write the rate equation.

……[1]

[Total: 6]

5 3-chloropropanoic acid, C*l*CH_2CH_2COOH, is a weak monobasic acid.

(a) **(i)** Define the term *weak acid*.

……[1]

(ii) Given that the pH of a 0.0125 mol dm^{-3} of 3-chloropropanoic acid is 2.38, show that it is a weak acid.

[1]

(b) 3.25 g of 3-chloropropanoic acid is dissolved in water and the volume made up to 250 cm^3 in a volumetric flask. During titration, it was found that 25.0 cm^3 of the acid required 20.00 cm^3 of NaOH(aq) for complete reaction.

(i) Write a balanced equation for the reaction.

……[1]

(ii) Calculate the concentration of NaOH used in the titration.

[2]

(iii) Suggest a suitable indicator for the titration of 3-chloropropanoic acid with sodium hydroxide.

……...[1]

(iv) Before the end-point was reached, there was a mixture of 3-chloropropanoic acid and its salt in the solution. By means of ionic equations, explain how this mixture behaves as a buffer.

……

……

……

……

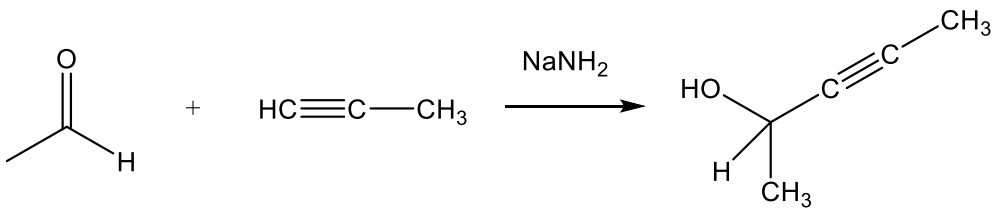
……[3]

[Total: 9]

Section B

Answer **one** question in this section in the spaces provided.

6 **(a)** Propyne is a weak acid. It can react with an aldehyde in the presence of a trace amount of strong base, $NaNH_2$.



ethanal propyne

Fig. 6.1

(i) State the number of σ and π bonds present in propyne.

σ bonds: ..... π bonds: ..... [1]

(ii) The first step of the reaction involves propyne reacting with $NaNH_2$ which produces ammonia as one of the products.

Suggest an equation for the reaction between propyne and $NaNH_2$.

……[1]

(b) Fig 6.2 shows the synthesis of compounds **A** and **B** from the product shown in Fig 6.1.

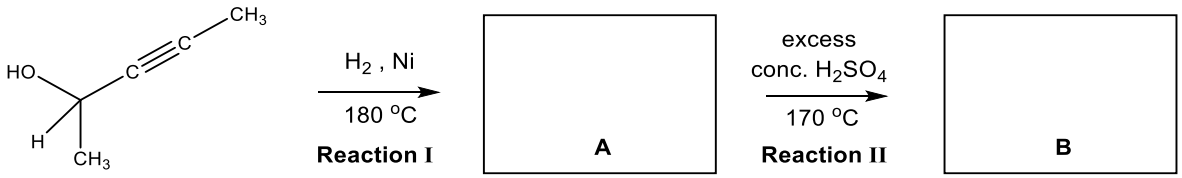


Fig 6.2

(i) Given that the molecular formula of compound **A** is $C_5H_{12}O$, draw the structure of compound **A**.

[1]

(ii) Reaction **II** produces three compounds that are isomers of each other.

Draw all three isomers.

[3]

(iii) 0.70 g of compound **A** is formed from **Reaction I**.

Calculate the volume of hydrogen gas, measured at room temperature and pressure, needed for the reaction.

[2]

(c) **(i)** Define the term *bond energy*.

……[1]

(ii) By using appropriate bond energy values from the Data Booklet, calculate a value for the standard enthalpy change of the reaction in Fig 6.1.

[2]

(iii) The actual $\Delta H_{reaction}$ of the reaction in Fig 6.1 is -136 kJ mol^{-1}. Suggest a reason for the discrepancy between the actual value and that calculated in **c(ii)**.

……

……...……...[1]

(d) **(i)** Draw and label the shape of the **occupied** orbital in valence shell of Na atom.

[1]

(ii) Draw the 'dot-and-cross' diagram of $NaNH_2$.

[1]

(iii) State and explain the trend observed for the ionic radii of Group 1 metals.

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……

……[2]

(e) Describe the reactions, if any, of NaC*l* with water and MgCl_2 with water. State and explain the approximate pH of any solution formed. Write balanced equations for any reactions taking place.

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……[4]

[Total: 20]

7 **(a)** **X** and **Y** are two elements in Period 3 of the Periodic Table.

X is a hard, dark grey solid with a melting point above room temperature. When **X** is heated in oxygen, **X**O_2, with a melting point of 1414 °C, is formed.

Y is a solid that can exist as several different allotropes, most of which contains **Y**$_8$ molecules. **Y** forms a gaseous oxide, **Y**O_3, which dissolves in water to form a solution that reacts with sodium hydroxide.

(i) Deduce the identities of **X** and **Y**.

……[2]

(ii) State and explain the difference in electronegativity of the elements **X** and **Y**.

……

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……[3]

(b) **(i)** Magnesium is also an element in Period 3. Using the energy cycle in Fig 7.1, identify the two enthalpy changes, ΔH_1 and ΔH_2 and calculate the enthalpy change of reaction.

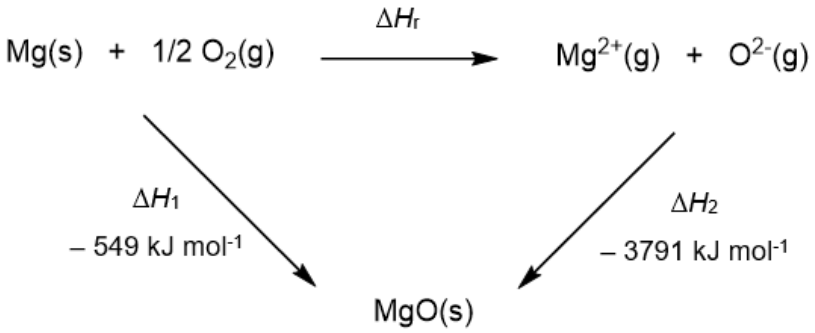

Fig 7.1

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.....[3]

(ii) Draw two simple diagrams to show how a water molecule can be attracted to a magnesium cation, and to an oxide anion. Label each diagram to show the type of interaction involved. Hence, explain why magnesium oxide is soluble in water.

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……[4]

(c) Magnesium plays a critical role in muscle function, particularly in the process of muscle contraction and relaxation. ATPase is one of the enzymes used to increase the rate of hydrolysis of adenosine triphosphate (ATP) into adenosine diphosphate (ADP). This process provides energy needed for muscle contraction.

(i) Explain why ATPase can be described as a *biological catalyst*.

……

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……[2]

(ii) The rate of reaction is increased with the use of ATPase.

Using a labelled Boltzmann distribution diagram, explain why the rate of reaction increases with the use of ATPase.

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……[3]

(iii) At low concentration of ATP, the reaction is first order with respect to [ATP]. However, as the concentration of ATP becomes higher, the active sites of the ATPase becomes fully occupied and the reaction becomes zero order with respect to [ATP].

Using the axes below, sketch a graph showing how the rate of this ATPase catalysed reaction varies with the concentration of ATP.

[2]

(d) Graphene could be used in electrical devices such as transistors as it has good electrical conductivity. Explain why it is a good electrical conductor.

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……[1]

[Total: 20]

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