NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

CHEMISTRY 8873/02
Paper 2 Structured Questions **Tuesday 24 August 2021**
2 hours

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, index number, form class, tutorial class and subject tutor's name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

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

Section A
Answer **all** the questions.

Section B
Answer **one** question.

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.

For Examiner's Use	
Question no.	**Marks**
Section A	
B7	
B8	
TOTAL	**/80**

This document consists of **28** printed pages and **3** blank pages.

Section A

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

1 **(a)** Sulfur reacts with an element **A** to form a compound with empirical formula S$\mathbf{A}_2$. The percentage by mass of **A** in S$\mathbf{A}_2$ is 83.2%.

(i) Assuming the relative atomic mass of **A** to be **y**. Find the number of moles of **A** and S respectively in terms of **y**.

[1]

(ii) Hence, find the value of **y**.

[1]

(iii) Element **A** is from Group 17. Hence, identify Element **A** using your answer in **a(ii)**.

……..[1]

Sulfur has 21 unstable isotopes. Among these isotopes, the one with the longest half-life of 85 days is ^{35}S isotope.

(b) **(i)** Suggest the time taken for ^{35}S to decrease to 6.25% of its initial amount.

[2]

1 **(b)** **(ii)** When an atom of ^{40}Ar collides with a high-speed neutron, ^{35}S and another product is produced. State the identity of this product, including its mass and proton number.

$$^{40}_{18}Ar + {}^{1}_{0}n \longrightarrow {}^{35}_{16}S + \_\_\_\_\_$$

……..……..[1]

(c) Disulfur dichloride, S_2Cl_2, is an important precursor of the extremely toxic chemical warfare agent sulfur mustard. It was widely used during the First World War and the Iran–Iraq conflict.

S_2Cl_2 can be synthesized at 200 °C as shown in the reaction below.

$$CS_2\,(g) + 3\,Cl_2\,(g) \longrightarrow CCl_4\,(g) + S_2Cl_2\,(g)$$

(i) Given the structural formula of disulfur dichloride, S_2Cl_2 is Cl–S–S–Cl.

Draw the 'dot-and-cross' diagram of S_2Cl_2 and state the Cl–S–S bond angle.

Cl–S–S bond angle = …….

[2]

(ii) In terms of structure and bonding, predict the difference in boiling point between CCl_4 and S_2Cl_2.

Compound	M_r	Boiling Point/ °C
CCl_4	154.0	77
S_2Cl_2	135.2	138

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……..……

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……..……..[2]

[Total: 10]

2 In the Haber Process, nitrogen reacts with hydrogen to form ammonia in the presence of iron catalyst. This reaction is reversible and exothermic.

(a) Write a balanced equation for the Haber Process

……...……..……..[1]

(b) A 20 cm^3 vessel containing 0.833 mol of N_2 was connected with another 80 cm^3 vessel containing 3.33 mol of H_2. The reaction mixture was heated at a constant temperature of 500 ^oC. At equilibrium, 0.298 mol of NH_3 was produced.

(i) Write the K_c expression for the Haber Process. State its units.

[2]

(ii) Use the information given, calculate the value of K_c.

[2]

(iii) By using Le Chatelier's Principle, explain why the Haber Process needs to be conduced at an optimal temperature of 500 ^oC.

……

……..……..

……..……..[1]

2 (c) State and explain the effect, if any, on how a change to the following will affect the K_c value.

I: Increase in temperature

……

……

……

……

II: Increase in concentration of N_2

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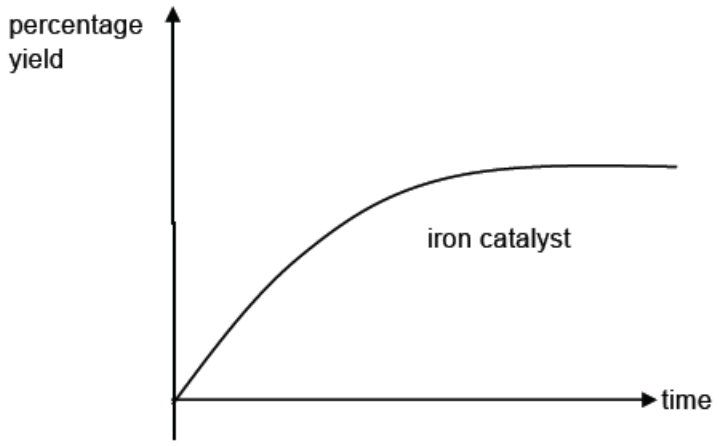
……

……

[3]

(d) (i) The graph below shows how the percentage yield of ammonia varies over time by using iron as the catalyst.



A new catalyst **Z** was introduced and results showed that it can increase the rate of reaction better than that of iron. Sketch on the graph for the new catalyst **Z** on the same axes shown above.

[2]

2 (d) (ii) Explain how iron catalyst can increase the rate of formation of ammonia.

[3]
[Total: 14]

3 (a) Methanoic acid, HCOOH, being a weak acid, is the simplest carboxylic acid and is an important intermediate in chemical synthesis.

The energy content of methanoic acid can be determined by means of calorimetric experiments. These experiments are usually carried out using polystyrene cup in a normal school laboratory. The standard enthalpy change of neutralisation can also be determined.

(i) Define what is meant by the *standard enthalpy change of neutralisation*.

……

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……

…… [1]

(ii) Write a balanced equation for the neutralisation of methanoic acid with potassium hydroxide.

…… [1]

3 (a) (iii) How would you expect the enthalpy change of neutralisation in **(a)(ii)** to compare with the enthalpy change of neutralisation of nitric acid with potassium hydroxide? Explain your answer.

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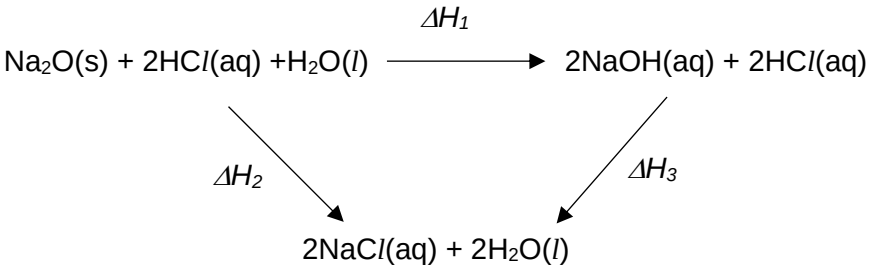
……

…… [1]

(iv) Suggest a suitable indicator for the titration between methanoic acid and potassium hydroxide.

…… [1]

(b) Study the energy cycle and answer the questions that follow.



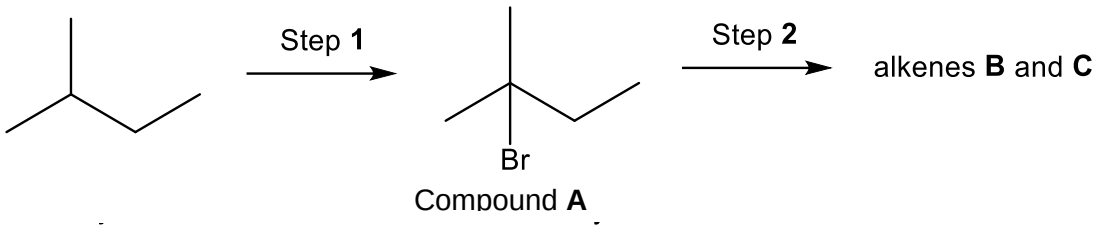
(i) When 7.0 g of $Na_2O(s)$ is dissolved in 200 cm^3 of 1.5 mol dm^{-3} HC*l*(aq), the temperature of the solution increased by 15 °C. Calculate ΔH_2

[3]

(ii) By making use of the energy cycle and your answer to **b(i)**, calculate ΔH_1. Given ethalpy change of neutralisation between NaOH(aq) and HC*l*(aq) is –57.0 kJ mol^{-1}.

[2]
[Total: 9]

4 The following reaction scheme involves a series of reactions involving different organic compounds..



Compound **A**

(a) State the name of compound **A**.

…… [1]

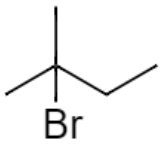
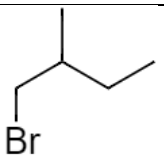
(b) State the reagents and conditions required for Steps **1** and **2**.

Step **1**: ……

Step **2**: ……

[2]

(c) In addition to compound **A** that is formed at the end of Step **1**, compound **D**, which is an isomer of compound **A**, is also produced. Fill in the expected ratio of isomer **D**.

Structure	 Compound **A**	 Compound **D**
Ratio	1	

[1]

(d) By considering the molecular formula, draw the skeletal formula of two more isomers that are constitutional isomers of compound **A** and **D**.

[2]

4 (e) Alkene **B** undergoes an addition reaction with Br_2 in CCl_4 to form 2, 3-dibromo-2-methylbutane. Identify the structure of alkene **B**.

[1]

(f) Suggest a simple chemical test to distinguish between compound **A** and compound **B**.

……

……

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…… [2]

[Total: 9]

5 The water of crystallisation in hydrated barium bromide, $BaBr_2.xH_2O$ is lost when heated.

$$BaBr_2.xH_2O\ (s) \longrightarrow BaBr_2\ (s) + xH_2O\ (g)$$

The varying mass samples of hydrated barium bromide are heated in the experiment. To determine the number of molecules of H_2O in hydrated barium bromide, a graph of the mass of hydrated barium bromide against the mass of anhydrous barium bromide left after heating is plotted.

A student weighed 0.60 g of hydrated barium bromide and transferred it into a crucible. The crucible and the contents were heated until a constant mass has been reached. This mass was then recorded.

The student repeated the experiment using different masses of hydrated barium bromide. For each experiment the student recorded the original mass of the hydrated barium bromide and the mass of anhydrous barium bromide left after heating.

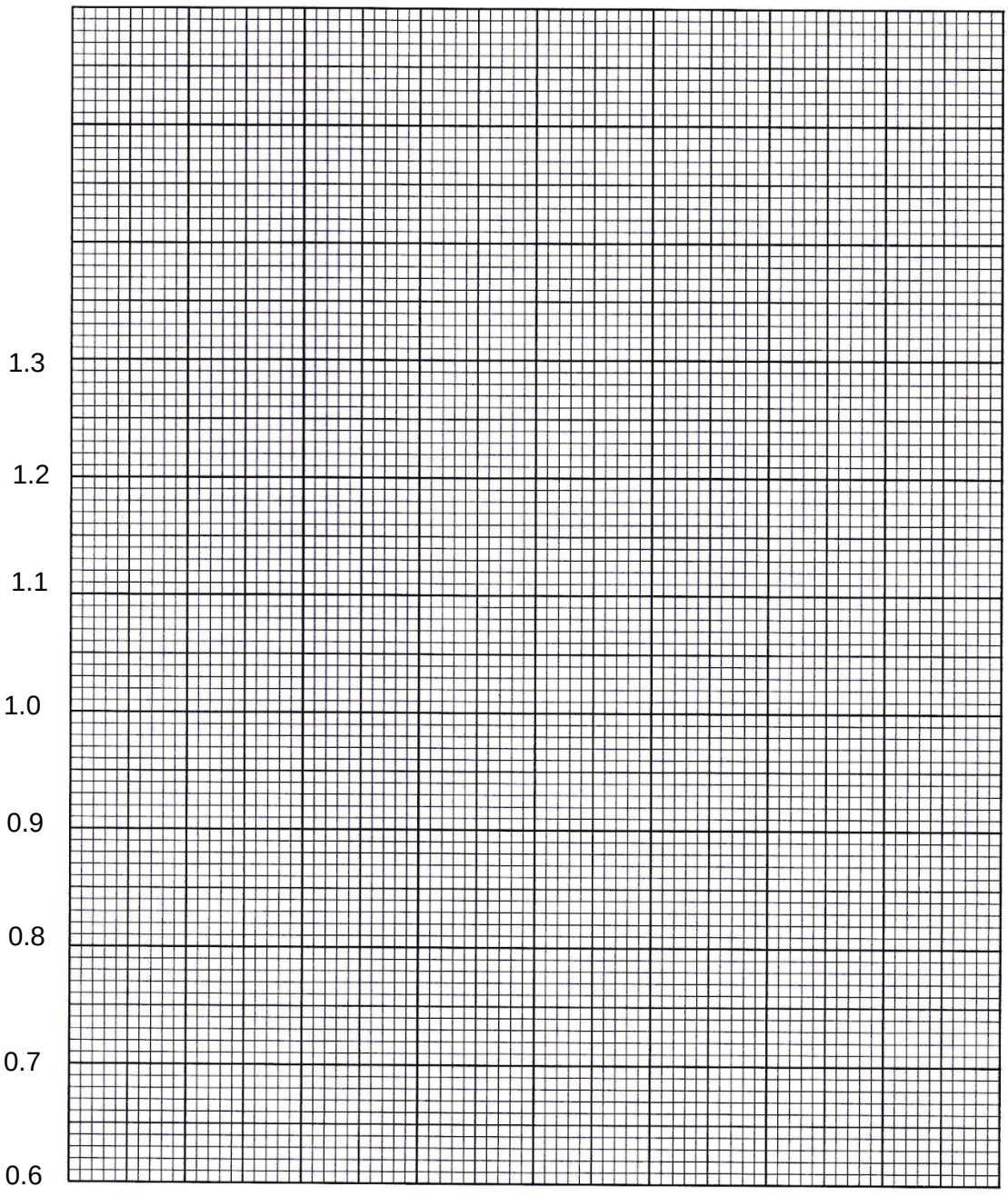
The results are shown below:

Results

Experiment	Mass of $BaBr_2.xH_2O$ / g	Mass of $BaBr_2$ / g
1	0.60	0.58
2	0.70	0.61
3	0.90	0.77
4	1.00	0.86
5	1.30	1.13

5 (a) Plot on the grid below, a graph of the mass of hydrated barium bromide on the y-axis, against the mass of the anhydrous barium bromide on the x-axis.

Label the axes and draw the most appropriate line.



Use the graph to determine the mass of hydrated barium bromide which forms 1.00g of anhydrous barium bromide.

Mass = ……g

[4]

5 (b) Calculate the number of moles of $BaBr_2$ present in 1.00 g of anhydrous barium bromide.

[1]

(c) Using your answer from **(a)** and **(b)**, calculate the M_r of hydrated barium bromide.

[1]

(d) Hence calculate the value of x in $BaBr_2.xH_2O$. Give your answer to the nearest whole number.

[1]

(e) A databook value for the M_r of hydrated barium bromide is 333.1. Calculate the difference between the M_r value obtained from the student's data and the databook value. Express this difference as a percentage of the databook value.

[1]
[Total: 8]

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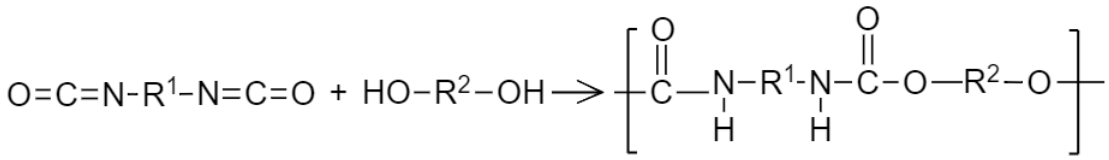
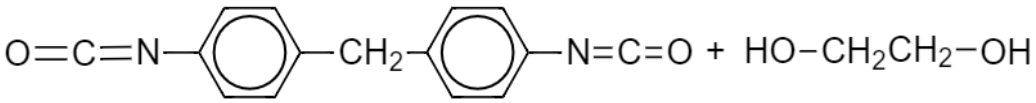
6 (a) Polyurethanes are polymers made by the reaction of a diisocyanate with a diol as shown. R^1 and R^2 are hydrocarbons groups.



a diisocyanate a diol a polyurethane

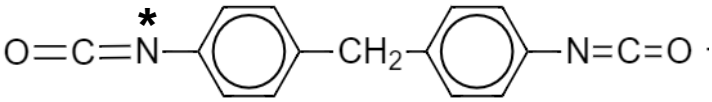
Lycra, an example of polyurethane, is formed from the following compounds.



(i) Draw the repeat unit of Lycra.

[2]

(ii) By considering the number of electron pairs, state the hybridisation on the N atom marked with *. Draw the shape of the hybridised orbital in the space below.



Hybridisation of N: …….

Drawing for the shape of hybridised orbital:

[2]

6 (b) With the aid of a simple well-labelled diagram, explain how thermoplastics differ from thermosets in their bonding between polymer chains.

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…… [3]

(c) Give one example of each of the following types of polymer.

type of polymer	example
wrinkle-free fabric	
water soluble	

[2]
[Total: 9]

Section B

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

7 Selenium and bromine are found in Period 4 of the Periodic Table.

(a) **(i)** Write an equation to represent the third ionization energy of Br.

……..……..……..…… [1]

(ii) Write down the full electronic configuration of Br^{2+} and Se^{2+}.

Br^{2+}: ……..……..……

Se^{2+} : ……..……..……
[2]

(iii) State whether the 3rd ionization energy of bromine is higher or lower than that of selenium. Explain your answer.

……..……..……..…….

……..……..……..

……..……..……..

……..……..……..… [2]

(iv) Suggest with a reason how the first ionisation energy of ^{79}Br is compared to ^{81}Br.

……..……..……..…….

……..……..……..…….

.....…..……..……..…… [1]

7 (b) The oxide of **M** dissolves partially in water to give an alkaline solution, while its chloride readily dissolves in water to give a slightly acidic solution.

1. Identify element **M**.

Element **M** is ……

2. State the pH of the resultant solution when the oxide and chloride of **M** are added to water separately. Write appropriate equations to support your answer.

	equations for reaction with water	pH of resultant solution
oxide of **M**		
chloride of **M**		

[4]

(c) (i) Calculate the pH of a 0.100 mol dm^{-3} solution of H_2SO_4.

[1]

7 (c) (ii) Chromic acid, H_2CrO_4, like sulfuric acid, is a dibasic acid. However, unlike sulfuric acid, chromic acid does not undergo full dissociation in water.

$$H_2CrO_4 \rightleftharpoons HCrO_4^- + H^+$$
$$HCrO_4^- \rightleftharpoons CrO_4^{2-} + H^+$$

Solution **A**, formed by adding equal amounts of $NaHCrO_4$ and Na_2CrO_4, is a *weak acid buffer*. Explain how this buffer can help to maintain a fairly constant pH.

……

……

……

……

……

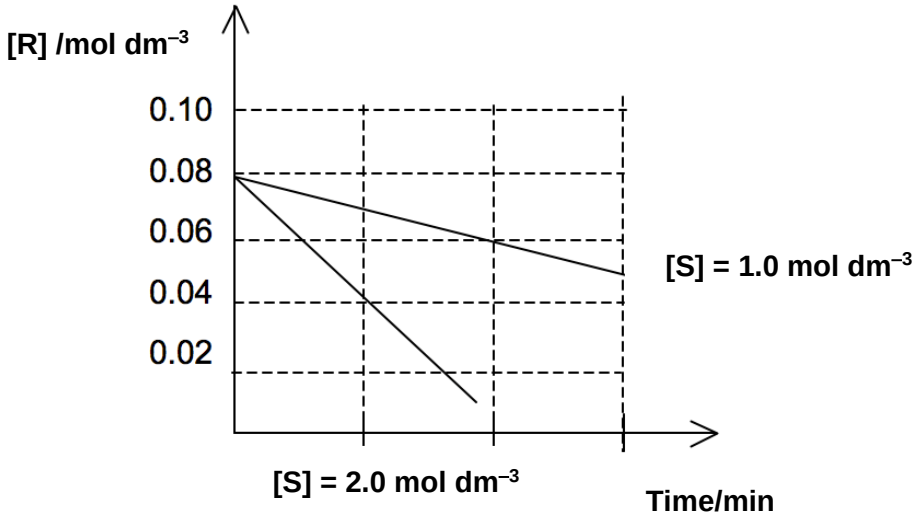
…… [3]

7 (d) Substances ***R*** and ***S*** react according to the following equation:

$$\boldsymbol{R}\,(aq) + 2\boldsymbol{S}\,(aq) \longrightarrow 2\boldsymbol{U}\,(aq) + \boldsymbol{V}\,(aq)$$

To find the rate equation for the above reaction, experiments were performed and the results are shown below.

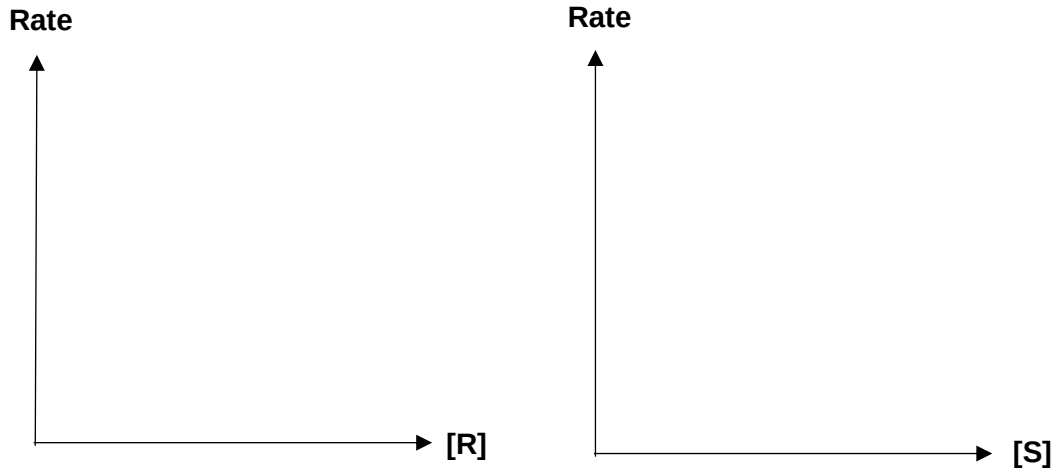
(i) Use the graph below to determine the order of reaction with respect to **R** and **S**. Justify your answer in each case. Hence, write the rate equation.



Rate equation: ……..

[3]

7 (d) (ii) Sketch the rate against concentration for **R** and **S** separately on the graphs below.



[2]

(iii) Calculate the rate constant of the reaction, when the concentration of S is 2.0 mol dm^{-3}.

[1]

[Total: 20]

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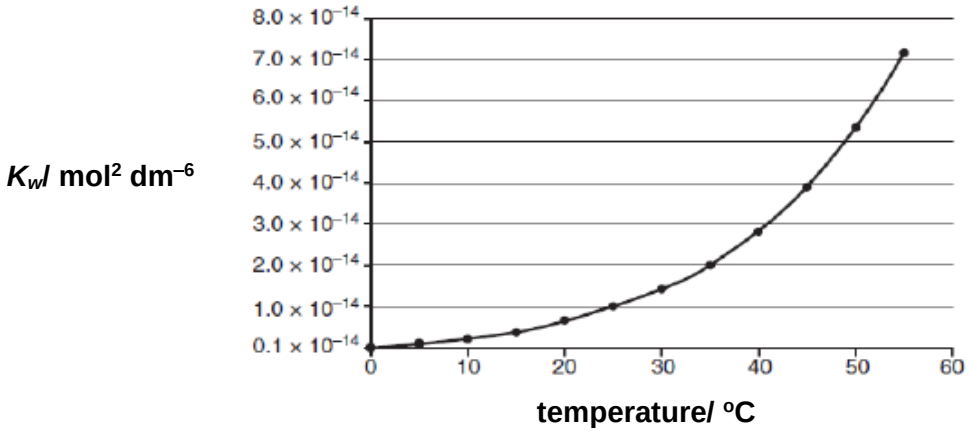
8 (a) The dissociation of water is a reversible reaction.

$$H_2O \rightleftharpoons H^+(aq) + OH^-(aq)$$

The ionic product of water, K_w, measures the extent of dissociation of water. K_w varies with temperature.

The graph below shows how the K_w varies between 0 – 60 °C.



(i) Write an expression for K_w.

…….. [1]

(ii) Calculate the concentration of hydroxide ions in an aqueous solution of hydrochloric acid at pH of 3.5 at 35 °C.

[2]

8 (b) A key reaction in the formation of acid rain and in the industrial production of nitric acid is the reaction between nitrogen monoxide and oxygen.

$$O_2(g) + 2NO(g) \rightarrow 2NO_2(g)$$

An investigation into the kinetics of the reaction between $O_2(g)$ and NO(g) is conducted at 25 ºC. The result is as shown on **Figure A**.

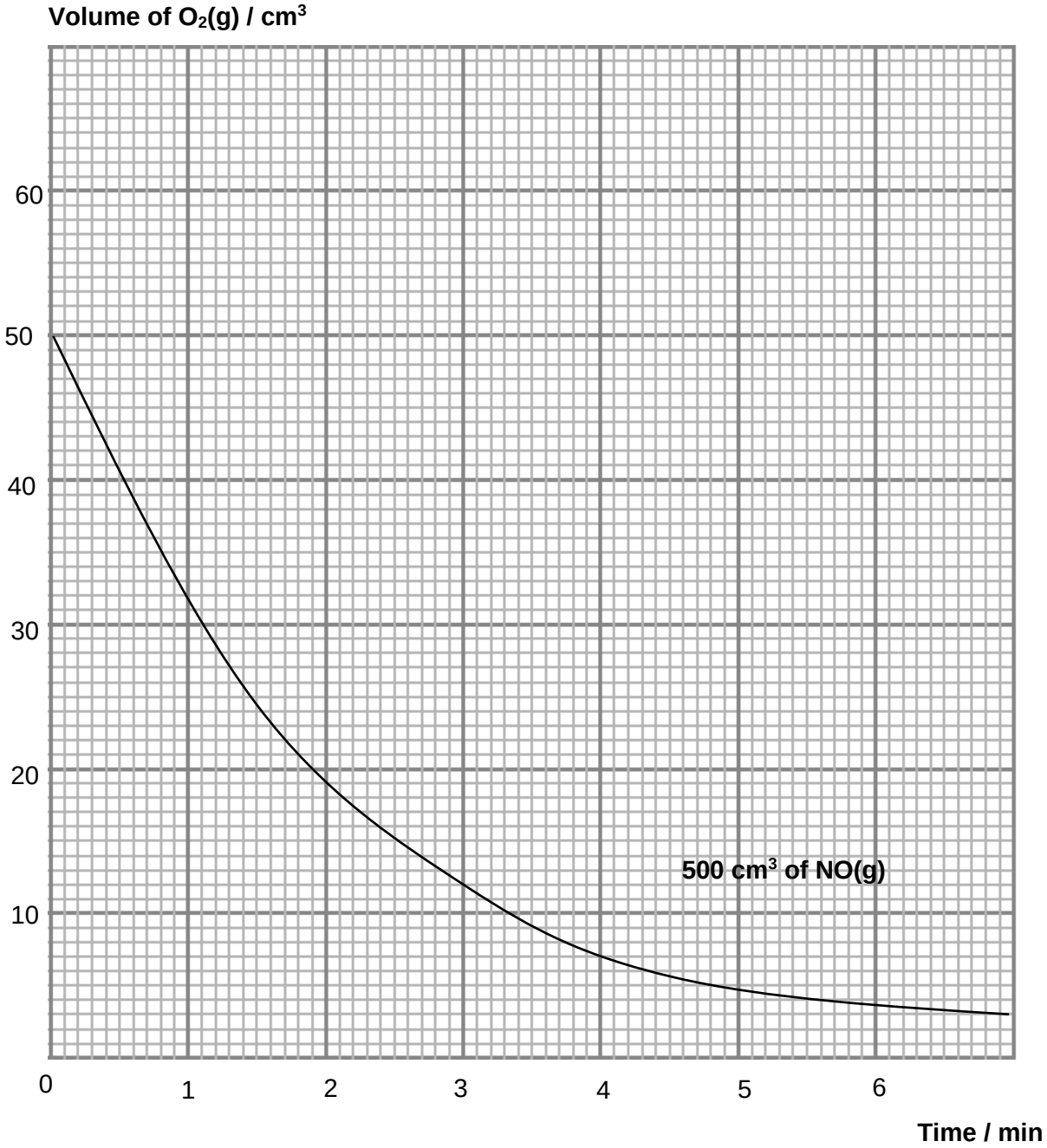


Figure A

8 (b) (i) Using the graph in **A**, deduce the order of the reaction with respect to $O_2(g)$.

[2]

(ii) A series of experiments were performed to investigate the order of reaction with respect to NO. The data collected is shown in **Table B**.

Expt	Initial $[O_2]$/ mol dm^{-3}	Initial [NO]/ mol dm^{-3}	Temperature/ K	Initial rate/ mol $dm^{-3}s^{-1}$
1	0.01	0.013	298	0.0032
2	0.01	0.013	318	0.0135
3	0.01	0.026	298	0.0032

Table B

Determine the order of reaction with respect to NO and write the rate equation for the reaction between NO(g) and $O_2(g)$.

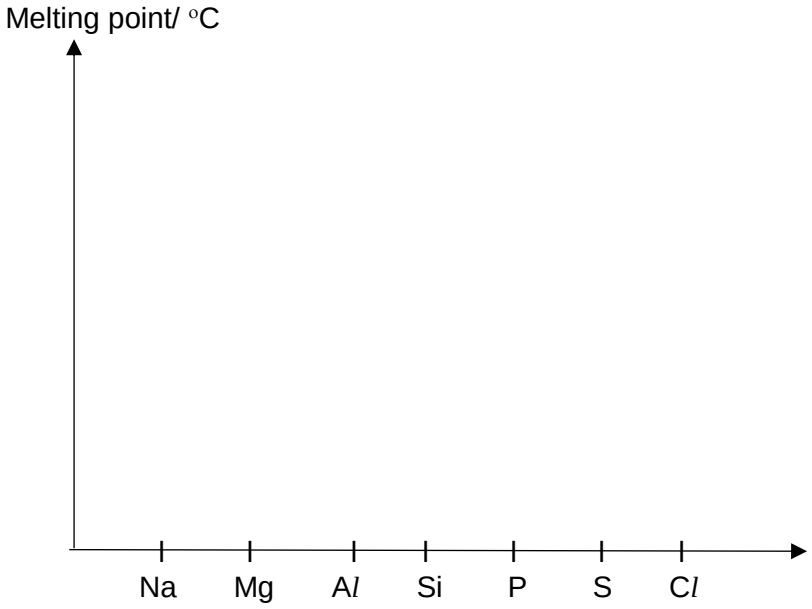
Order of reaction with respect to NO:……..

Rate equation: ……

[2]

(c) Elements of Period 3 show trends in their reactions.

(i) Sketch the melting point trend for Period 3 elements from sodium to chlorine.



[1]

8 (c) (ii) By considering the structure and bonding, explain for the observed melting point of silicon.

……...

……...

……...

……... [1]

(iii) The table below shows the successive ionisation energy values for phosphorus.

	1st	2nd	3rd	4th	5th	6th	7th	8th
IE/ kJ mol^{-1}	1060	1900	2920	4960	6280	21200	25200	30500

Explain how this data shows that phosphorus is a member of Group 15 of the Periodic Table.

……...

……...

……...

……... [1]

(iv) Silicon reacts with calcium to form Ca_2Si. Ca_2Si is thought to contain the Si^{4-} ion. Write out the electronic configuration of Si^{4-}.

Si^{4-} : ……..……... [1]

(v) Compare the difference in size between Si^{4-} and Ca^{2+}.

……...

……...

……...

……...

……...

……... [2]

8 (c) (vi) The elements sodium, aluminium and sulfur react with oxygen to form oxides. Write equations, if any, for the reactions of each of these oxides with water. State the pH of the resultant solution formed.

……...

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……...

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……...

……...

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……...

……... [4]

8 (d) There are three bottles labelled **A**, **B** and **C** in the laboratory. Each bottle contains one of the following reagents: aqueous CI_2, KI solution and KBr solution.

The following tests were carried out and the results were summarised in the table below.

Experiment	Procedure	Observations
1	mixing reagent in bottle **A** with reagent in bottle **B**	mixture remains colourless
2	mixing reagent in bottle **A** with reagent in bottle **C**	mixture turns brown
3	mixing reagent in bottle **B** with reagent in bottle **C**	mixture turns brown

(i) Which bottle contains aqueous CI_2? With the aid of a balanced equation, explain your answer.

……...

……...

……...

……...

……...

……...

……...

……... [2]

(ii) If hexane is also provided, how would you use it to identify the contents of the other two bottles? Include the observations in your answer.

……...

……...

……...

……... [1]

[Total: 20]

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