Established in 1879

# Raffles Girls' School
(SECONDARY)

Name: _____

Class: 4 / _____ Register No: _____

## CHEMISTRY
## RAFFLES PROGRAMME
## YEAR FOUR

### End-of-Year Assessment

**Wednesday** **2 October 2019** **2 hours**

**INSTRUCTIONS TO CANDIDATES**

**This question paper contains two sections.**

**Section A** – Answer **ALL** questions and record your answers as instructed on the OMR answer sheet.

**Section B** – Answer **ALL** questions and write your answers in the spaces provided.

Use only a black or dark blue pen, except for diagrams.

Do not use correction tape or fluid.

Omission of essential working or units, or expressing answers with an incorrect number of significant figures will result in a loss of marks.

School approved calculators are allowed.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is **80**.

The weighting for this paper is **40%**.

| For examiners' use | |
|---|---|
| **Question** | **Marks Obtained** |
| **Section A (20 marks)** | |
| **1-20** | |
| **Section B (60 marks)** | |
| **B1** | **/5** |
| **B2** | **/8** |
| **B3** | **/13** |
| **B4** | **/7** |
| **B5** | **/6** |
| **B6** | **/6** |
| **B7** | **/6** |
| **B8** | **/9** |
| **Units** | |
| **Statements** | |
| **Significant Figures** | |
| **Total** | **80** |

Parents's / Guardian's Name: _____

Signature: _____ Date: _____

## Section A – Multiple Choice Questions [20 marks]

*Four possible answers (**A**, **B**, **C**, and **D**) are given for each question. Choose the most appropriate answer and record your answer in the OMR form provided.*

**1** Which of the following solutions can be used to distinguish sodium hydroxide solution from aqueous ammonia?

**A** copper(II) chloride solution
**B** iron(II) chloride solution
**C** iron(III) chloride solution
**D** zinc sulfate solution

**2** Which of the following reaction which occurs in the blast furnace is an acid-base reaction?

**A** $C + O_2 \rightarrow CO_2$
**B** $CO_2 + C \rightarrow 2CO$
**C** $CaO + SiO_2 \rightarrow CaSiO_3$
**D** $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

**3** A white powder, **B**, turns yellow when heated. When the product cools, it turns back to white. What is **B**?

**A** zinc carbonate
**B** magnesium carbonate
**C** sodium carbonate
**D** calcium carbonate

**4** When crude oil is fractionally distilled, which type of compounds is removed from the top of the fractionating column?

**A** the compounds with the highest relative molecular mass
**B** the compounds with the lowest boiling points
**C** the compounds that are the most viscous
**D** the compounds that are least flammable

**5** Bread can be prepared from a mixture of flour, yeast and sugar. Carbon dioxide produced from the reaction causes the dough to rise.

Which of the following could be the main product from this reaction?

**A** $CH_3COOH$
**B** $CH_3CH_2OH$
**C** $C_6H_{12}O_6$
**D** $H_2O$

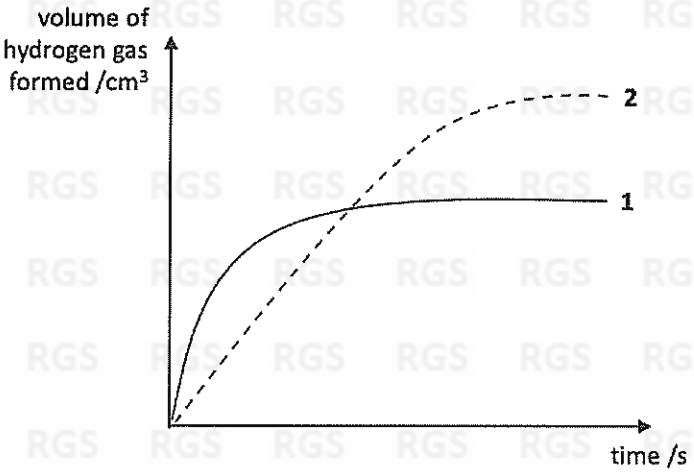
6 **X**, **Y** and **Z** are elements in the same period of the Periodic Table. **X** forms an acidic oxide, **Y** forms a basic oxide and **Z** forms an amphoteric oxide. If **X**, **Y** and **Z** are placed in order of increasing atomic number, which order is correct?

**A** X, Y, Z
**B** X, Z, Y
**C** Y, X, Z
**D** Y, Z, X

7 Which salt is **incorrectly** matched with its method of preparation?

| | salt | method of preparation |
|---|---|---|
| **A** | ammonium nitrate | titrate aqueous ammonia with dilute nitric acid |
| **B** | barium sulfate | mix aqueous barium nitrate and dilute sulfuric acid |
| **C** | iron(II) nitrate | add excess iron(II) oxide with dilute nitric acid |
| **D** | silver chloride | add excess silver carbonate to dilute hydrochloric acid |

8 In the graph, curve **1** was obtained by the reaction between 50.0 $cm^3$ of 1.00 $mol/dm^3$ sulfuric acid and excess zinc granules.

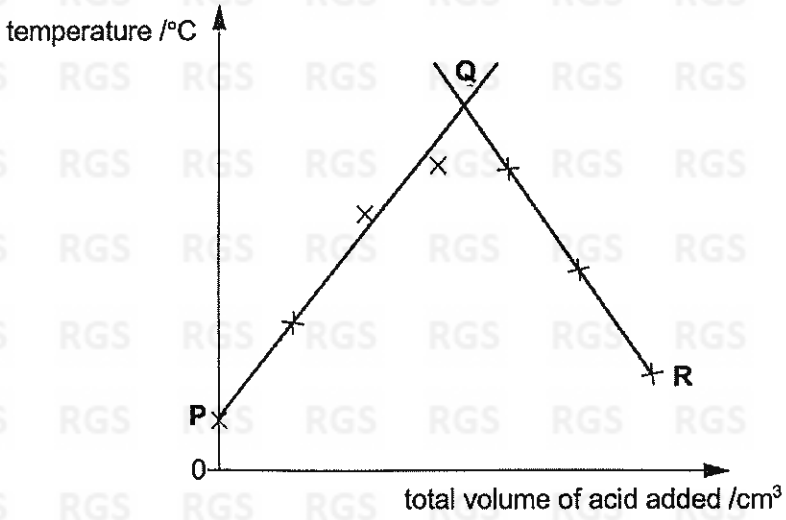



Which change would produce curve **2**?

**A** increase the temperature by 10 °C
**B** add the same mass of zinc powder instead of zinc granules
**C** use 100.0 $cm^3$ of 1.00 $mol/dm^3$ sulfuric acid instead of 50.0 $cm^3$ of 1.00 $mol/dm^3$ sulfuric acid
**D** use 100 $cm^3$ of 0.75 $mol/dm^3$ sulfuric acid instead of 50.0 $cm^3$ of 1.00 $mol/dm^3$ sulfuric acid

**9** Aqueous hydrochloric acid was added from a burette to 25.0 $cm^3$ of 1.50 $mol/dm^3$ aqueous sodium hydroxide. The temperature change was measured each time a portion of the acid was added.

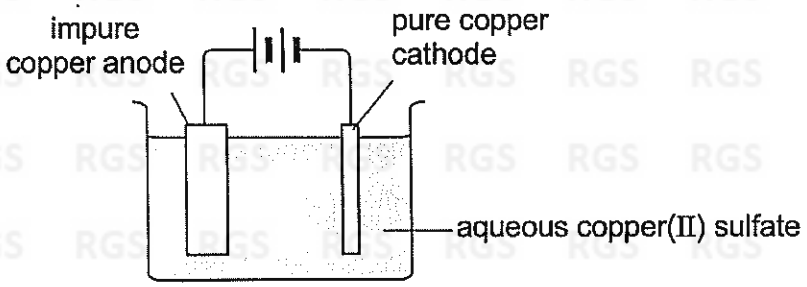
The results of the experiment were plotted on a graph as follows:




Based on the graph, which of the following statements is true?

**A** Neutralisation is complete at **R**.
**B** The sample of alkali has fully reacted at **Q**.
**C** The reaction is exothermic from **P** to **Q**, and becomes endothermic when more acid is added.
**D** The temperature increases from **P** to **Q** because more heat is absorbed in breaking of bonds than in the formation of new bonds.

**10** An impure sample of copper contained a metal below it in the reactivity series. The diagram shows the apparatus used for refining the sample.




The loss in mass of the positive electrode was 45 g and the gain in mass of the negative electrode was 40 g. What was the percentage purity of this sample of copper?

**A** 11.1 %
**B** 12.5 %
**C** 85.0 %
**D** 88.9 %

**11** The table below shows the melting and boiling points of four pure substances. Which substance is the most volatile liquid at room temperature?

| substance | melting point / °C | boiling point / °C |
|---|---|---|
| **A** | -100 | -40 |
| **B** | -6 | 60 |
| **C** | -5 | 220 |
| **D** | 40 | 290 |

**12** A giant molecule is made up of a large amount of carbon, mainly containing isotopes $^{12}C$ and $^{13}C$. It was found that the relative atomic mass of the carbon in the molecule is 12.2.

What is the ratio by mass of $^{12}C$ to $^{13}C$?

**A** 4:1
**B** 1:4
**C** 3:4
**D** 3:1

**13** Carbon dioxide reacts with solutions of carbonate ions according to the following equilibrium.

$$CO_2(g) + H_2O(l) + CO_3^{2-}(aq) \rightleftharpoons 2HCO_3^-(aq)$$

How could the composition of the equilibrium mixture be altered to produce more carbon dioxide gas?

**A** add water
**B** add an acid
**C** add a soluble calcium salt
**D** add an insoluble calcium salt

**14** The labels on three separate bottles of zinc, magnesium and lead powder have dropped off. Which of the following experiments will best enable a student to identify all three bottles of metal?

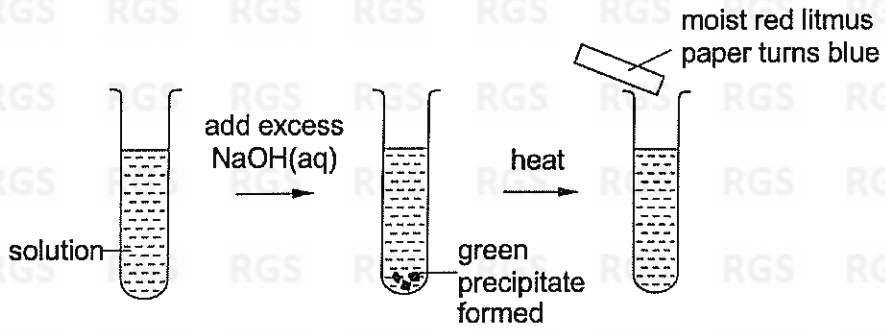
**A** Heat some metal powder with steam.
**B** Place some metal powder in dilute nitric acid.
**C** Place some metal powder in aqueous copper(II) sulfate.
**D** Weigh equal size heap of metal powder.

**15** 60 $cm^3$ of the gaseous oxide of tungsten requires 30 $cm^3$ of oxygen for complete combustion to produce 120 $cm^3$ of the gaseous oxide $WO_2$.

What is the molecular formula of the original oxide?
(All volumes are measured at room temperature and pressure.)

**A** WO
**B** $W_2O$
**C** $W_2O_3$
**D** $W_3O$

**16** A solution was tested as shown.




Which ions are likely to be present in the solution?

**A** $Cu^{2+}$ and $NH_4^+$
**B** $Fe^{2+}$ and $NO_3^-$
**C** $Fe^{3+}$ and $Cl^-$
**D** $NH_4^+$ and $Fe^{2+}$

**17** An aqueous solution of copper(II) sulfate was electrolysed using graphite electrodes for 45 minutes. 30 minutes into the procedure, the mass of the cathode stopped increasing. However, oxygen gas was still evolved at the anode.

Which of the following equations represents the reaction that was taking place at the graphite cathode after 30 minutes?

**A** $C(s) + O_2(g) \rightarrow CO_2(g)$
**B** $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
**C** $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$
**D** $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

**18** Carbon and silicon are both in Group IV of the Periodic Table. Below are statements about oxides of carbon and silicon.

1. At room temperature, $CO_2$ is a gas and $SiO_2$ is a solid.
2. Covalent bonding is weaker in $CO_2$ than in $SiO_2$.
3. $CO_2$ has a simple molecular structure and $SiO_2$ has a giant molecular structure.

Which of the following statements is correct?

**A** Statements 1 and 2 are correct and statement 2 explains statement 1.
**B** Statements 1 and 2 are correct and statement 2 does not explain statement 1.
**C** Statements 1 and 3 are correct and statement 3 explains statement 1.
**D** Statements 1 and 3 are correct but statement 3 does not explain statement 1.

**19** Photographers in the early days used the oxidation of magnesium powder to produce flashes of light in the presence of oxygen from the air. Magnesium reacts according to the equation:

$$2Mg\ (s) + O_2\ (g) \rightarrow 2MgO\ (s) \qquad \Delta H = -2400\ kJ$$

How much energy would be released when 0.12 g of magnesium reacts with excess oxygen?

**A** 1.50 kJ
**B** 3.00 kJ
**C** 6.00 kJ
**D** 12.0 kJ

**20** Many properties of an element and its compounds can be predicted from its position in the Periodic Table. What property **cannot** be predicted in this way?

**A** the number of isotopes
**B** the formula of its oxide
**C** its metallic or non-metallic properties
**D** the number of electrons in its valence shell

**End of Section A**

## Section B (60 Marks)

*Answer **ALL** questions and write your answers in the spaces provided.*

**B1** **(a)** State 4 differences in the chemical or physical properties between transition metals and Group I metals.

.....

.....

.....

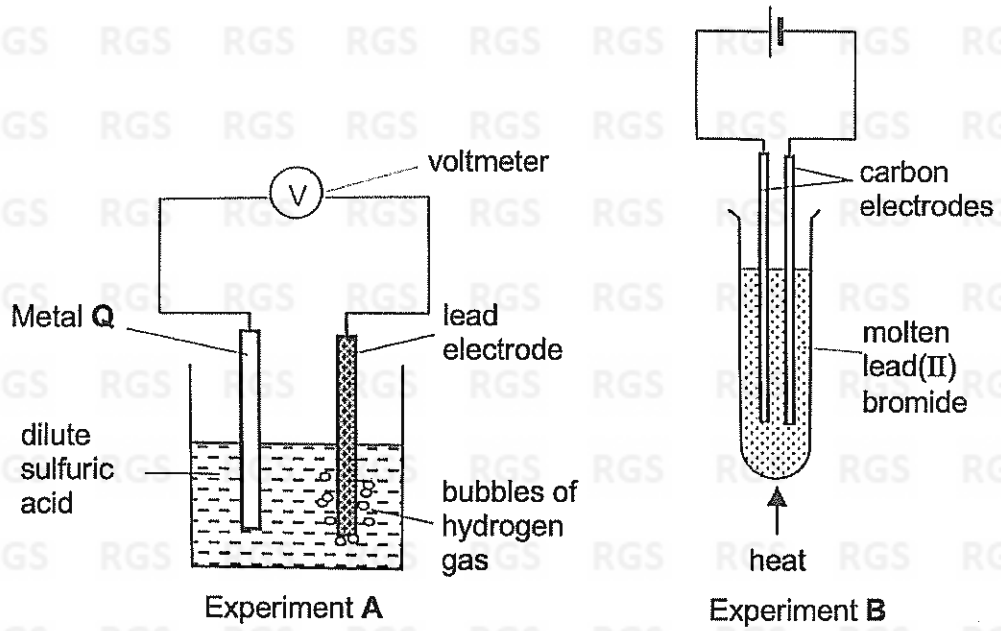
..... [4]

**(b)** Explain why transition metals have good electrical conductivity.

.....

..... [1]

**B2** The diagrams show the set-up of two experiments **A** and **B**. Metal **Q** can be found in Group II of the Periodic Table.




**(a)** One of the above reactions is endothermic. State which reaction is endothermic and explain your answer.

.....

..... [2]

**(b)** **(i)** Write the half equations for the reactions that occur at both electrodes in experiment **A**.

Anode:.....

[2]

Cathode: .....

**(ii)** Using your answers from part **(b)(i)**, state and explain which metal is more reactive in set-up **A**.

.....

..... [2]

**(c)** Given that the battery in experiment **B** is replaced by the set-up in experiment **A**, and 250 $cm^3$ of hydrogen gas was produced at the lead electrode,

**(i)** calculate the number of moles of electrons that was used to produce the hydrogen gas,

[1]

**(ii)** hence, calculate the gain in mass of the cathode in set-up **B**. [1]

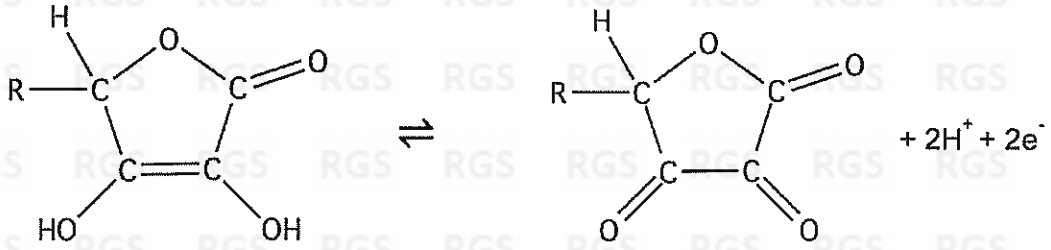
**B3** Antioxidants, such as vitamin C and E are widely used in the industry.

**(a)** Vitamin E, $C_{29}H_{50}O_2$, is often added to fat-containing foods to prevent spoilage. A brand of peanut oil contains 12.9 mg of vitamin E per 20 $cm^3$.

Calculate the concentration in $mol/dm^3$ of vitamin E in cooking oil.

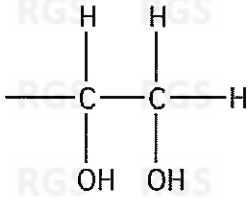
[2]

**(b)** Vitamin C, $C_6H_8O_6$, commonly known as ascorbic acid, can be found in supplements and prevents deficiencies in the immune system. The amount of vitamin C can be determined by the reaction with triiodide ions, $I_3^-$. The products of this reaction are dehydroascorbic acid, $C_6H_6O_6$ and iodide ions, $I^-$. The half equation for the conversion of ascorbic acid to dehydroascorbic acid is shown below.




ascorbic acid dehydroascorbic acid

where R represents




**(i)** Construct the half equation for the conversion of triiodide to iodide ions.

..... [1]

**(ii)** Construct a balanced equation for the reaction of vitamin C with triiodide ions.

..... [1]

**(iii)** State the oxidising agent. Explain your answer, in terms of oxidation state.

.....

..... [2]

**(iv)** Suggest a chemical test to distinguish between ascorbic acid and dehydroascorbic acid.

.....

..... [2]

**(c)** Sodium ascorbate, $C_6H_7O_6Na$, is widely used in oral supplements. It is prepared by reacting ascorbic acid with sodium bicarbonate.

**(i)** Calculate the percentage by mass of sodium in sodium ascorbate.

[1]

**(ii)** The melting point of ascorbic acid is 190 °C. Explain why it is unusually high.

.....

.....

..... [2]

**(iii)** Given that sodium ascorbate is soluble in water, identify its structure and bonding.

.....

.....

..... [2]

**B4** The volume of sulfur dioxide in air can be determined by bubbling a sample of air through sodium hydroxide solution, according to the equation below.

$$SO_2(g) + 2NaOH(aq) \rightarrow Na_2SO_3(aq) + H_2O(l)$$

The concentration of the unreacted sodium hydroxide can be determined by titration against a standard solution of hydrochloric acid.

1000 $dm^3$ of air was bubbled through 200 $cm^3$ of 1.00 $mol/dm^3$ solution of sodium hydroxide. The resulting solution was diluted to 1000 $cm^3$ with distilled water and 25.0 $cm^3$ of this solution was neutralized by 20.0 $cm^3$ of 0.100 $mol/dm^3$ hydrochloric acid.

**(a)** Calculate the total number of moles of unreacted sodium hydroxide.

[2]

**(b)** Calculate the number of moles of sulfur dioxide in 1000 $dm^3$ of air.

[2]

**(c)** Calculate the percentage by volume of sulfur dioxide in the air at room temperature and pressure.

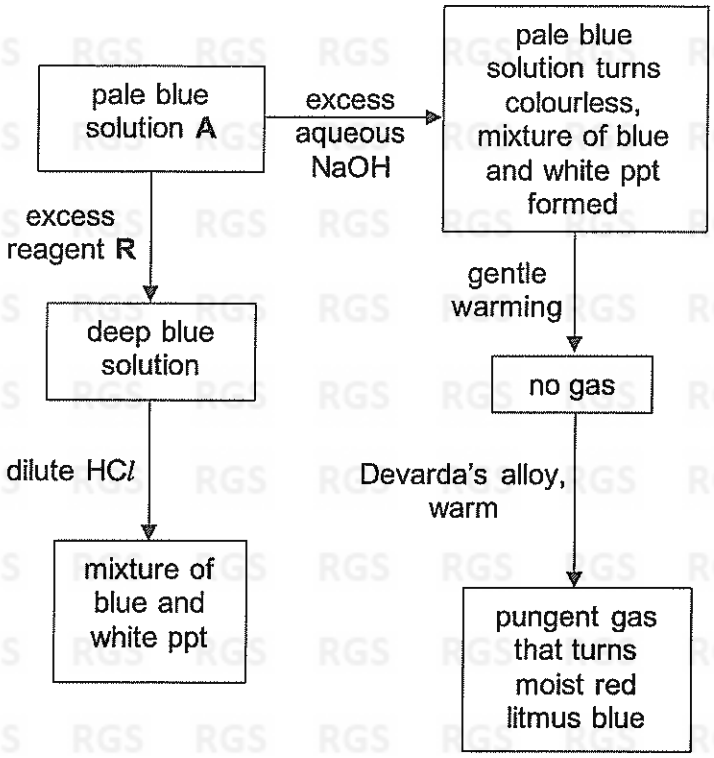
[2]

**(d)** Suggest a key source of error in this experiment.

.....

..... [1]

**B5** An unknown pale blue solution **A** contains three cations and one anion. The following laboratory tests were conducted on **A**.




**(a)** Identify reagent **R.**

..... [1]

**(b)** Name the pungent gas produced.

..... [1]

**(c)** Identify all the ions present in **A**.

..... [4]

**B6** The table below shows the pH values of some acidic compounds with a concentration of 0.500 mol/dm$^3$.

| name | pH |
|---|---|
| sodium dihydrogen phosphate | 3.8 |
| ethanoic acid | 2.5 |
| nitric acid | 0.3 |

**(a)** A toilet cleaning liquid contains the acid salt, sodium dihydrogen phosphate, $NaH_2PO_4$.

**(i)** Explain why sodium dihydrogen phosphate is both an acid and a salt.

.....

.....

..... [2]

**(ii)** Sodium dihydrogen phosphate can be made by reacting sodium hydroxide with phosphoric acid, $H_3PO_4$.

Write a balanced chemical equation for the formation of sodium dihydrogen phosphate.

..... [1]

**(b)** Describe a chemical test to show that nitric acid is a strong acid but ethanoic acid is a weak acid.

State the variables you would keep constant, measurements you would make and results you would expect.

.....

.....

.....

.....

..... [3]

**B7** Gas **S** has a molecular formula of NOC*l*. Upon partial decomposition at room temperature and pressure, it establishes a chemical equilibrium along with the products, nitrogen monoxide gas and chlorine gas.

**(a)** Draw the dot-and-cross diagram of gas **S**.

[2]

**(b)** Calculate the enthalpy change for the decomposition of 1 mol of compound **S**.

| bond | bond energy (kJ/mol) |
|---|---|
| C*l*-C*l* | 240 |
| N-C*l* | 310 |
| N-O | 201 |
| N=O | 607 |
| O-C*l* | 203 |

[2]

**(c)** Predict how the equilibrium will shift if the temperature is decreased. Justify your answer.

.....

.....

..... [2]

## B8 Hydrolysis of halogenoalkanes

Halogenoalkanes can react with aqueous sodium hydroxide upon warming to produce alcohols and the respective hydrogen halides. This is known as a hydrolysis reaction.

For example, $CH_3Br(aq) + NaOH(aq) \rightarrow CH_3OH(aq) + HBr(aq)$

**(a)** A dibromoalkane, **W** (Mr = 188), is warmed with excess aqueous NaOH to produce a diol, **X**, which is an organic compound that contains two hydroxyl functional groups. The diol is then oxidized fully to a dicarboxylic acid, **Y**. Under suitable conditions, **X** and **Y** can react to form polymer, **Z**. Draw the full structural formulae of **W**, **X**, **Y** and one repeating unit of **Z** in the boxes below.

| | |
|---|---|
| **W** | |
| **X** | |
| **Y** | |
| **Z** | |

[4]

**(b) Rate Equation**

The rate equation provides information on how the rate of a reaction depends on the concentration of all the reactants.

Consider the reaction: **xA** + **yB** → products

where **x** and **y** are the stoichiometric coefficients and **A** and **B** are the reactants.

The rate equation can be expressed as:

$$\text{Rate} = k[A]^m[B]^n$$

where **k** is the rate constant,
**m** is the order of reaction with respect to reactant **A**,
**n** is the order of reaction with respect to reactant **B**,
**[ ]** represents the concentration of the reactants.

**Order of reaction**

The way in which the rate of reaction is related to the concentration of each reactant (e.g. **Q**) can be categorized into the following types, governed by different order of reaction.

| type of reaction | order of reaction | characteristic | inference |
|---|---|---|---|
| zero order with respect to **Q** | 0 | rate $\propto [Q]^0$ | If the concentration of **Q** is changed, the rate remains unaffected. |
| first order with respect to **Q** | 1 | rate $\propto [Q]$ | If the concentration of **Q** is doubled, the rate would also double. If the concentration of **Q** is increased by a factor of 4, the rate will also increase by 4 times. |
| second order with respect to **Q** | 2 | rate $\propto [Q]^2$ | If the concentration of **Q** is doubled, the rate would increase by 4 times ($2^2$). If the concentration of **Q** is tripled, the rate would increase by 9 times ($3^2$). |

**Overall Order of a Reaction**

The overall order of a reaction is the sum of the orders of reaction of all the reactants.

For example, if the rate equation for a reaction is

$$\text{Rate} = k[A]^m[B]^n$$

The overall order of the reaction is **(m + n)**.

The results of an investigation into the kinetics of the hydrolysis of bromomethane are given below:

| experiment number | [$CH_3Br$] / mol $dm^{-3}$ | [NaOH] / mol $dm^{-3}$ | initial rate of reaction / mol $dm^{-3}$ $s^{-1}$ |
|---|---|---|---|
| 1 | 0.10 | 0.20 | 0.001 |
| 2 | 0.20 | 0.10 | 0.001 |
| 3 | 0.20 | 0.20 | 0.002 |
| 4 | 0.30 | 0.20 | 0.003 |

**(i)** State the relationship between the concentration of bromomethane and the initial rate of reaction.

Experiments ..... and ..... show that

.....

..... [1]

**(ii)** Hence, find the order of reaction with respect to bromomethane.

order of the reaction with respect to bromomethane = ..... [1]

**(iii)** Given that the order of reaction with respect to aqueous sodium hydroxide is 1, state the overall order of the reaction.

Overall order of the reaction = ..... [1]

**(iv)** Write an overall rate equation for the reaction.

Rate = ..... [1]

**(v)** Determine the value for the rate constant, **k**, in your rate equation in part **(b)(iv)**.

Value for rate constant, k = ..... $mol^{-1}dm^3s^{-1}$ [1]

**End of Paper**

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# The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | 0 |
| | | | | | | | 1 H hydrogen 1 | | | | | | | | | | 2 He helium 4 |
| 3 Li lithium 7 | 4 Be beryllium 9 | | | | | | | | | | | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | | | | | | | | | | | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 |
| 19 K potassium 39 | 20 Ca calcium 40 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium - | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 57 – 71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89 – 103 actinoids | 104 Rf Rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | | 114 Fl flerovium – | | 116 Lv livermorium – | | |

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lanthanoids | 57 La lanthanum 139 | 58 Ce cerium 140 | 59 Pr praseodymium 141 | 60 Nd neodymium 144 | 61 Pm promethium – | 62 Sm samarium 150 | 63 Eu europium 152 | 64 Gd gadolinium 157 | 65 Tb terbium 159 | 66 Dy dysprosium 163 | 67 Ho holmium 165 | 68 Er erbium 167 | 69 Tm thulium 169 | 70 Yb ytterbium 173 | 71 Lu lutetium 175 |
| actinoids | 89 Ac actinium – | 90 Th thorium 232 | 91 Pa protactinium 231 | 92 U uranium 238 | 93 Np neptunium – | 94 Pu plutonium – | 95 Am americium – | 96 Cm curium – | 97 Bk berkelium – | 98 Cf californium – | 99 Es einsteinium – | 100 Fm fermium – | 101 Md mendelevium – | 102 No nobelium – | 103 Lr lawrencium – |

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).