SWISS COTTAGE SECONDARY SCHOOL

SECONDARY 4 CHEMISTRY 6092 PRELIMINARY EXAMINATION 2024

PAPER 3

MARK SCHEME

Question	Skill	MS	Mark	Total
1(a)	**PDO**	all temperature readings recorded to 0.5 °C	**1**	
		temperature changes correctly calculated (to 1 d.p.) ~~and ‘+’ sign is included~~	**1**	
	MMO	full set of data + correct trend (rise in temperature decreases with deceasing volume of **P** used)	**1**	**[4]**
		temperature rise for first reading is greater than 10 °C	**1**	
1(b)	**PDO**	correct axis labels and units	**1**	
		appropriate scale + size of plotted area covers at least 50% of the graph paper	**1**	
		all points correctly plotted	**1**	**[4]**
		correct line of best fit, allow ecf from wrongly plotted points accept both straight line and curved line as long as the line is the best fit anomalous points must be circled	**1**	
1(c)	**ACE**	rise in temperature decreases as the volume of **P** decreases / rise in temperature increases as the volume of **P** increases	**1**	**[2]**
		greater volume of **P** used means greater number of moles of acid to react with the magnesium, leading to more energy given off	**1**	
1(d)	**ACE**	volume of P = $\frac{0.0065}{1.000}$ = 6.5 cm^3	**1**	
		correct calculation and unit		**[2]**
		temperature change correctly read with unit and shown clearly on the graph	**1**	
1(e)	**ACE**	**Answer 1** His prediction was **correct**.		
		As the amount of magnesium ribbon that reacted with the acid doubled, the amount of energy produced would also be doubled. Thus, the rise in temperature also doubled.	**1**	
		The prediction is only correct if it is assumed that the acid is not used up in the reaction. / there is no heat loss to the surroundings. / the pieces of magnesium ribbon have exactly the same length.	**1**	**[2]**

		Answer 2 His prediction was **not correct**. Although the amount of magnesium ribbon added to the acid doubled, there may not be sufficient acid to react completely with the magnesium. / the acid could be the limiting reagent. / the magnesium ribbons could be added in excess. Thus, amount of energy produced may not be doubled. Thus, the rise in temperature may not be doubled. He assumed that there is excess acid present to react completely with the magnesium ribbons. / the acid is not used up in the reaction. / magnesium ribbons reacted completely with the acid. R: the pieces of magnesium ribbon have exactly the same length.	**1** **1**	
1(f)	**MMO ACE**	any two observations with relevant explanation *observation:* Effervescence is seen. / Bubbles are seen. *explanation:* The reaction produces hydrogen gas. *observation:* Magnesium dissolves to form a colourless solution. *explanation:* Soluble magnesium chloride is formed.	**1** **1** **1** **1**	**max [4]**
1(g)	**ACE**	*error:* A measuring cylinder was used to measure the volumes of **P** and water. This was not accurate / precise as it can only measure up to 0.1 cm^3. *improvement:* A burette should be used instead to measure the volumes. A burette can measure up to 0.05 cm^3. *error:* The temperature of the solution was measured using a laboratory thermometer which was not accurate / precise. It can only measure up to 0.5 °C. *improvement:* A temperature sensor and data logger should be used instead. It can give temperature readings up to 0.01 °C. *error:* Each experiment (Experiments 1 to 5) was done only once. Hence, the temperature readings taken were not reliable. *improvement:* Each experiment (Experiments 1 to 5) should be repeated twice. The average temperature change can then be calculated for greater reliability. *error:* The measuring cylinder was washed after each use. As it still contained a very small amount of water, the actual volume of the acid used would be lower than it should be. *improvement:* Use a dry measuring cylinder for each experiment.	**1** **1** **1** **1** **1** **1** **1** **1**	**max [2]**
				Total: 20

2(a)(i)	**PDO** **MMO**	Results table: • Correct headings (initial burette reading, final burette reading and volume of **R** added) and units • Initial reading is plausible e.g. not 50.00 cm^3 • Correct calculations to get volume R • All burette readings recorded to nearest 0.05 cm^3 Titration Results: Supervisor's reading = 21.00 cm^3 • Accuracy: If average titre is within 0.20 cm^3 of Supervisor's average value scores 2 marks If Average titre is within 0.30 cm^3 of Supervisor's average value scores 1 mark • Concordance: At least two titre values are within 0.20 cm^3 Allow ecf from calculation error	**1** **1** **2** **1**	**[5]**
2(a)(ii)	**MMO**	Average volume of **R** in 2 d.p. (titres used should be identified by a tick in the table or in a calculation) Unit must be correct.	**1**	**[1]**
2(b)(i)	**ACE**	no. of mol of aqueous sodium thiosulfate = 0.0500 x (average volume of **R**/1000)	**1**	**[1]**
2(b)(ii)	**ACE**	no. of moles iodine = $\frac{1}{2}$ x no. of moles of aqueous sodium thiosulfate	**1**	**[1]**
2(b)(iii)	**ACE**	no. of mol of chlorate(I) ions in 25.0 cm^3 solution **Q** = no. of moles of iodine	**1**	**[1]**
2(b)(iv)	**ACE** **PDO**	no. of mol of chlorate(I) ions in 1000 cm^3 of solution **Q** = no. of moles of chlorate(I) ions in 25.0 cm^3 of solution **Q** x $\frac{1000}{25}$ no. of mol of chlorate(I) ions in 100 cm^3 commercial bleach = no. of mol of chlorate(I) ions in 1000 cm^3 of solution **Q** concentration of chlorate(I) ions in commercial bleach = no. of mol of chlorate(I) ions in 100 cm^3 commercial bleach x $\frac{1000}{100}$ Statement to describe calculation is insisted, because calculation involves 2 steps. Students must describe clearly which concentration they are calculating. appropriate significant figures (3 s.f.) in final answers in **(b)(i) – (iv)** appropriate units in final answer in **(b)(iv)** mol/dm^3 'mol' not insisted for **(b)(i) – (iii)**	**1** **1** **1** **1**	**[4]**

2(c)(i)	**MMO**	Colourless solution turned yellowish-brown. / brown. / yellow. / dark brown. Effervescence was seen. The gas relighted a glowing splint. The gas is oxygen.	**1** **1**	**[2]**
2(c)(ii)	**ACE**	Solution **T** contains an oxidising agent. Awarded only if correct observation (yellowish-brown / brown solution) is recorded in **2(c)(i)**.	**1**	**[1]**
3	**P**	**Answer 1** [2]: (P) Procedure - include apparatus and measurements taken • *measurement of mass using electronic balance before and after heating* • *heat, cool and measure mass of residue until constant mass is achieved* • Measure the mass of each metal carbonate using an electronic balance. • Heat each carbonate strongly. Cool the residue and measure the mass using an electronic balance. • Continue heating, cooling and measuring the mass of the residue until constant mass is achieved. [2]: (T) Treatment of results of this experiment • *calculation of the no. of moles of metal carbonate and metal oxide correctly described* • *ratio of no. of moles of metal carbonate to no. of moles of metal oxide correctly described* • *show clearly how the relative atomic masses of **X** and **Y** can be compared* Let, mass of $\mathbf{X}CO_3 = m_x$ mass of $\mathbf{Y}CO_3 = m_y$ After heating, the residue left behind is metal oxide. Let, mass of residue $\mathbf{X}O = m_{x'}$ mass of residue $\mathbf{Y}O = m_{y'}$ 1 mole of metal carbonate produces 1 mole of metal oxide. Let, A_r of X = x A_r of Y = y $\frac{m_x}{x + 12 + 3(16)} = \frac{m_{x'}}{x + 16}$ Thus, the value of x is determined. $\frac{m_y}{y + 12 + 3(16)} = \frac{m_{y'}}{y + 16}$	**1** **1** **1** **1**	**[4]**

Thus, the value of y is determined.

Comparison of the calculated values of x and y will tell us which metal has a higher relative atomic mass.

Alternative calculation

Let, mass of $\mathbf{X}CO_3 = m_x$
mass of $\mathbf{Y}CO_3 = m_y$

After heating, the residue left behind is metal oxide.

Let, mass of residue $\mathbf{X}O = m_{x'}$
mass of residue $\mathbf{Y}O = m_{y'}$

1 mole of metal carbonate produces 1 mole of metal oxide.

Let, A_r of X = x
A_r of Y = y

Mass of carbon dioxide produced from $\mathbf{X}CO_3 = m_x - m_{x'}$
No. of mol of carbon dioxide produced from $\mathbf{X}CO_3 = \frac{\text{mass of } CO_2}{44}$

No. of mol of $\mathbf{X}CO_3 = \frac{\text{mass of } \mathbf{X}CO_3}{x + 12 + 3(16)}$

Since no. of mol of $\mathbf{X}CO_3$ = no. of mol of CO_2,

$$\frac{\text{mass of } CO_2}{44} = \frac{\text{mass of } \mathbf{X}CO_3}{x + 12 + 3(16)}$$

$$\frac{\text{mass of } CO_2}{\text{mass of } \mathbf{X}CO_3} = \frac{44}{x + 12 + 3(16)}$$

Thus,

$$\%\text{ decrease in mass} = \frac{44}{A_r \text{ of metal} + 60} \times 100\%$$

Thus, the metal with a higher relative atomic mass will produce a lower percentage decrease in mass due to heating where,

$$\%\text{ decrease in mass} = \frac{\text{mass of carbonate} - \text{mass of oxide}}{\text{mass of carbonate}} \times 100\%$$

Answer 2
[2]: (P) Procedure - include apparatus and measurement taken
- *measure <u>equal</u> mass of each carbonate using electronic balance* **1**
- *heat solid and measure volume of gas produced until constant volume is achieved* **1**

- Measure equal mass of each metal carbonate using an electronic balance.

		• Heat each carbonate strongly. Collect and measure the total volume of carbon dioxide gas produced using a gas syringe. • Continue heating until constant volume is achieved.		
		[2]: (T) Treatment of results of this experiment • *Relate lower volume of carbon dioxide to the lesser number of moles of carbon dioxide produced.* • *Relate the lesser number of moles of carbon dioxide produced to lesser number of moles of metal carbonate used in the reaction.*	1	
		• *Metal with higher relative atomic mass forms metal carbonate with higher molar mass.* • *For the same mass of metal carbonate, the number of moles of metal carbonate is lower if the metal has a higher relative atomic mass.* • *Thus, metal with higher relative atomic mass can be determined by the lower volume of carbon dioxide produced.*	1	
		Compare the volume of carbon dioxide gas produced. A lower volume of carbon dioxide means that there is a lower number of moles of carbon dioxide produced. This means that the number of moles of metal carbonate used is lower. However, the same mass of metal carbonate was used. For the same mass of metal carbonate, the metal with a higher relative atomic mass will result in a higher molar mass of metal carbonate and hence, a lower number of moles of metal carbonate. no. of mol of metal carbonate = $\frac{\text{mass}}{\text{molar mass}}$ Thus, the metal carbonate that produces a lower volume of carbon dioxide contains the metal with a greater relative atomic mass.		
		Answer 3 [2]: (P) Procedure - include apparatus and measurement taken • *measure equal mass of each carbonate using electronic balance* • *heat solid and measure volume of gas produced within a specific time / measure time taken to collect a specific volume of gas*	1 1	
		Measure equal mass of each metal carbonate using an electronic balance. Heat each carbonate strongly. Collect and measure the volume of carbon dioxide gas produced using a gas syringe. Record volume of gas collected after 2 minutes. OR		

		Measure equal mass of each metal carbonate using an electronic balance. Heat each carbonate strongly. Collect and measure the volume of carbon dioxide gas produced using a gas syringe. Record the time taken to collect 10 cm^3 of the gas. [2]: (T) Treatment of results of this experiment • *Describe clearly the relationship between A_r of metal and the thermal stability of metal carbonate on going down Group 2.* • *Describe clearly the relationship between the thermal stability of metal carbonate and the volume of gas produced over a specific time / the time taken to produce a specific volume of gas.* Going down Group 2, A_r of metal increases, reactivity of the metal increases and the thermal stability of metal carbonate increases. The more stable the metal carbonate, the more difficult it is to decompose the metal carbonate by heat. The metal carbonate that contains the metal with higher A_r will produce less carbon dioxide over a specific time / takes a longer time to produce a specific volume of carbon dioxide.	**1** **1**	