

CHEMISTRY 3A - MARKING SCHEME

FORM SIX

1. The volume of the pipette used was 25 cm³

Table of results.

FILLING TABLE = 01 MARK.
ACCURACY = 01 MARK
DECIMAL PLACES = 01 MARK.

Burette Reading (cm ³)	Pilot	1	2	3
Final reading (cm ³)	25.00	24.90	25.10	25.00
Initial reading (cm ³)	0.00	0.00	0.00	0.00
Volume Used (cm ³)	25.00	24.90	25.10	25.00

$$\begin{aligned} \text{Average Volume} &= \left(\frac{V_1 + V_2 + V_3}{3} \right) \text{cm}^3 \quad 00\frac{1}{2} \text{ mark} \\ &= \left(\frac{24.90 + 25.10 + 25.00}{3} \right) \text{cm}^3 \quad 00\frac{1}{2} \text{ mark} \end{aligned}$$

$$\text{Average volume used} = 25.00 \text{cm}^3 \quad 00\frac{3}{2} \text{ mark.}$$

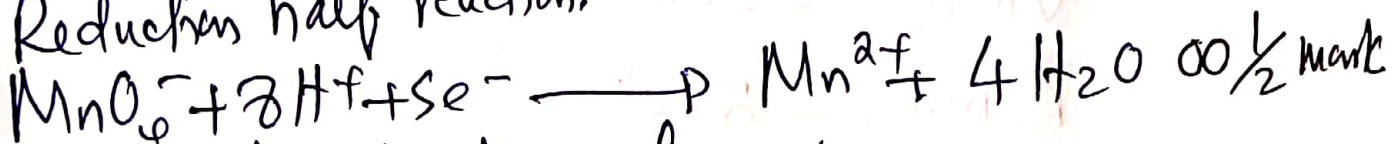
SUMMARY

25.00 cm³ of solution F₁ required 25.00 cm³ of solution F₂ for complete reaction. 1 mark, @ 00 $\frac{1}{2}$ mark

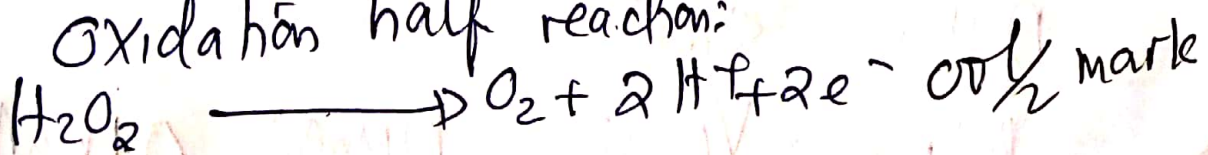
Problems

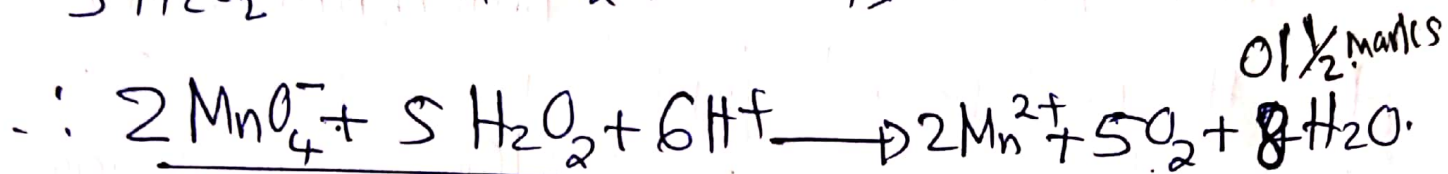
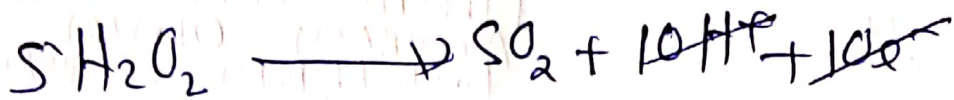
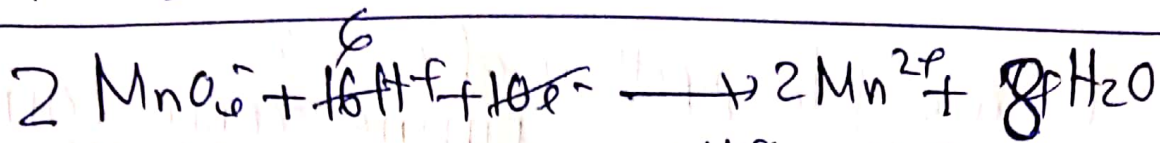
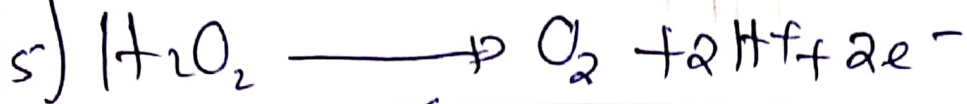
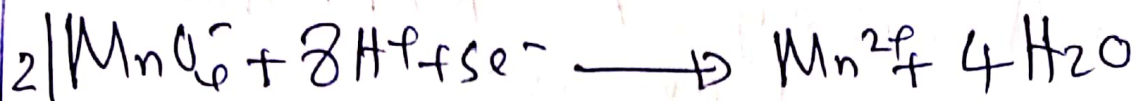
(a) Overall ionic reaction:

Reduction half reaction:



Oxidation half reaction:





(b) $[\text{H}_2\text{O}_2]$ in mol/dm^3 .

$$\text{Molarity of } \text{KMnO}_4 = \frac{\text{Concentration in g/L}}{\text{Molar mass (g/mol)}} \quad \text{0 1 mark.}$$

$$= \frac{3.16 \text{ g/dm}^3}{158 \text{ g/mol}}$$

$$\text{Molarity of } \text{KMnO}_4 = 0.02 \text{ mol/dm}^3 \quad \text{0 1 mark.}$$

$$\therefore \text{M MnO}_4^- = 0.02 \text{ M}$$

$$V \text{ MnO}_4^- = 25 \text{ cm}^3$$

$$M \text{ H}_2\text{O}_2 = ?$$

$$V \text{ H}_2\text{O}_2 = 25 \text{ cm}^3$$

$$n \text{ MnO}_4^- = 2 \text{ mol}$$

$$n \text{ H}_2\text{O}_2 = 5 \text{ mol}$$

$$\text{From } \frac{M \text{ MnO}_4^- \times V \text{ MnO}_4^-}{M \text{ H}_2\text{O}_2 \times V \text{ H}_2\text{O}_2} = \frac{n \text{ MnO}_4^-}{n \text{ H}_2\text{O}_2} \quad \text{0 1 mark.}$$

$$M_{H_2O_2} = \frac{M_{MnO_4^-} \times V_{MnO_4^-} \times N_{H_2O_2}}{V_{H_2O_2} \times N_{MnO_4^-}}$$

$$= \frac{0.02M \times 25cm^3 \times 5mol}{25cm^3 \times 2mol} \quad 01 \text{ mark}$$

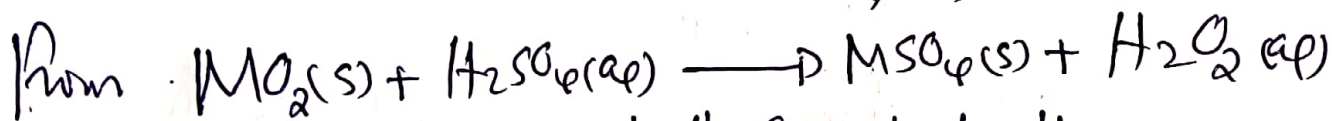
$$M_{H_2O_2} = 0.05M$$

\therefore Molarity of $H_2O_2 = 0.05 \frac{mol}{dm^3}$. 02 marks.

(c) Atomic mass of metal M.

First determine total molar mass of MO_2 .

from Molarity = $\frac{\text{Concentration } (g/dm^3)}{\text{Molar mass } (g/mol)}$ 00 1/2 mark



mole ratio of MO_2 to $H_2O_2 = 1:1$, Hence

$$[MO_2] = [H_2O_2]$$

$\therefore [MO_2] = 0.05 \frac{mol}{dm^3}$. 00 1/2 mark

Where - Concentration in g/L of MO_2 is $8.45g/dm^3$.

- Molarity of MO_2 is $0.05 \frac{mol}{dm^3}$.

$$\text{Molar mass } (g/mol) = \frac{\text{Concentration in } g/dm^3}{\text{Molarity in } mol/dm^3}$$

$$= \frac{8.45g/L}{0.05 mol/dm^3} \quad 01 \text{ mark}$$

Molar mass of $MO_2 = 169 \frac{g}{mol}$ 00 1/2 mark.

But $MO_2 = 169$ $00\frac{1}{2}$ mark

$$M + 16 \times 2 = 169$$

$$M + 32 = 169$$

$$M = 169 - 32$$

$$M = 137$$

\therefore Atomic mass of metal M in the metal peroxide is
137. 01 mark.

(d) The suggested identity of the metal M was
Barium metal. 02 mark.

Table of Results.

Salt	Volume of water (cm ³)	mass of salt (g)	Initial temperature T ₁ (°C)	Final temperature T ₂ (°C)	ΔT = T ₂ - T ₁ (°C)	Mr of the salt
A ₂	50	4	27	34	+7	160
A ₃	50	6	27	26	-1	250

(a) For A₂ (CuSO₄) Table filling 0.6 mark, (a) 0.5 mark.

$$\Delta H = -m c \Delta T \text{ but from } \rho = \frac{m}{V}, m = \rho \times V$$

$$\therefore \Delta H = -\rho V c \Delta T \text{ where } 0.5 \text{ mark}$$

$$\rho_{H_2O} = \rho_{soln} = 1 \text{ g/cm}^3$$

$$V = 50 \text{ cm}^3$$

$$c = 4.2 \text{ J g}^{-1} \text{ K}^{-1}$$

$$\Delta T = +7^\circ\text{C} = 7 \text{ K}$$

$$\Delta H = -1 \frac{\text{g}}{\text{cm}^3} \times 50 \text{ cm}^3 \times 4.2 \text{ J g}^{-1} \text{ K}^{-1} \times 7 \text{ K}$$

$$\Delta H = -1470 \text{ J} \text{ 0.1 mark}$$

$$\Delta H_{\text{molar enthalpy of solution}} = \frac{\Delta H}{n_{A_2}} \text{ 0.5 mark}$$

$$\text{But } n_{A_2} = \frac{m}{M_r}$$

$$n_{A_2} = \frac{4 \text{ g}}{160 \text{ g/mol}}$$

$$n_{A_2} = 0.025 \text{ mol. } 0.5 \text{ mark}$$

$$\text{molar enthalpy of CuSO}_4(\text{aq}) = \frac{-1470 \text{ J}}{0.025 \text{ mol}} = -58800 \text{ J/mol}$$

$$\therefore \text{molar enthalpy of solution of A}_2 \text{ (CuSO}_4\text{)} = \underline{-58800 \text{ J/mol or } -58.8 \text{ kJ/mol. } 0.5 \text{ mark}}$$

for $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (A_3).

$$\Delta H = -\rho V C \Delta T, \text{ where } \rho = 1 \text{ g/cm}^3.$$

00½ mark.

$$V = 50 \text{ cm}^3.$$
$$C = 4.2 \text{ J g}^{-1} \text{ K}^{-1}.$$
$$\Delta T = -1^\circ\text{C} = -1 \text{ K}.$$

$$\Delta H = -1 \frac{\text{g}}{\text{cm}^3} \times 50 \text{ cm}^3 \times 4.2 \text{ J g}^{-1} \text{ K}^{-1} \times -1 \text{ K}$$

$$\Delta H = 210 \text{ J. 01 mark}$$

$$\text{Molar enthalpy of } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \text{ solution} = \frac{\Delta H}{n_{A_3}} \text{ 00½ mark}$$

$$\text{But } n_{A_3}(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = \frac{m}{M_r}$$
$$= \frac{6 \text{ g}}{250 \text{ g/mol}}$$

$$n_{A_3}(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 0.024 \text{ mol. 00½ mark}$$

$$\text{Molar enthalpy of } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} = \frac{210 \text{ J}}{0.024 \text{ mol}} = 8750 \text{ J/mol}$$

$$\therefore \text{Molar enthalpy of } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \text{ solution} = 8750 \text{ J/mol}$$

or 8.75 kJ/mol . 00½ mark.

(b) The molar heat of reaction for CuSO_4 was lower than expected value (-66.10 kJ/mol) due to the fact that some heat was lost during hydration of $\text{Cu} \longrightarrow \text{Cu}^{2+}$.

The molar heat of reaction for $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ was lower than expected ($+11.30 \text{ kJ/mol}$), b/c CuSO_4 was already hydrated to Cu^{2+} , the only heat change was that

00 0½ marks

due to the process of dissolving the solute in water.

$$\begin{aligned} (c) \text{ Enthalpy of hydration of anhydrous } \text{CuSO}_4 &= \Delta H_{\text{f}}(\text{anhydrous}) - \frac{\Delta H_{\text{f}}(\text{hydrate})}{\text{molar mass}} \\ &= -58.8 \frac{\text{kJ}}{\text{mol}} - 81.75 \frac{\text{kJ}}{\text{mol}} \end{aligned}$$

$$\text{Enthalpy of hydration of anhydrous } \text{CuSO}_4 = -67.55 \frac{\text{kJ}}{\text{mol}} \quad \underline{\underline{0.1 \text{ mark}}}$$

S/N	EXPERIMENTS	OBSERVATIONS	INFERENCE
1.	<p>A spatulaful of sample K was put into a boiling test tube and added with water and the mixture was boiled for about 1 minute and filtered to obtain the residue and clear solution. The resulting clear solution was divided into two portions</p> <p>(i) To the first portion, sodium hydroxide solution was added till in excess.</p>	<p>Reddish brown precipitates formed Insoluble in excess</p>	<p>Fe^{3+} may be present</p>
	<p>(ii) To the second portion dil. HNO_3 was added followed by $AgNO_3$.</p>	<p>White precipitates soluble in dilute ammonia solution were formed</p>	<p>Cl^- confirmed</p>
2.	<p>To a little quantity of the residue obtained in step 1 above, dilute HCl was added.</p>	<p>Efferescence of a colourless gas which turned lime water milky occurred</p>	<p>CO_3^{2-} confirmed maybe present.</p>
3.	<p>The resulted solution in step 2) above was diluted with distilled water and the solution was divided into two portions as follows:</p> <p>(i) To the first portion dil. $NaOH$ was added.</p>	<p>White precipitates soluble in excess of $NaOH$ forming colourless solution formed.</p>	<p>Ca^{2+} Sr^{2+} Ba^{2+} Sb^{3+} Bi^{3+} and Mg^{2+} maybe present</p>

S/N	EXPERIMENT	OBSERVATION	INFERENCES
3	(ii) To the second portion, dilute ammonia solution was added	White precipitates soluble in excess ammonia solution formed	Zn^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} may be present.
	(iii) To the third portion, excess ammonia solution was added followed by ammonium oxalate	White precipitates were formed	Ca^{2+} confirmed
4	To the clear solution obtained in step 1, few drops of potassium hexacyanoferrate (II) (potassium ferrocyanide) were added	Dark blue precipitates observed	Fe^{3+} confirmed

Conclusion

The two cations in Sample K are Fe^{3+} and Ca^{2+} and the anions are Cl^- and CO_3^{2-} 4 marks

ⓐ 1 mark:

Experiments ⓐ 00½ mark; ~~but~~ ^{except} Experiment 4 = 01 mark.

Observation ⓐ 00½ marks.

Inferences ⓐ 00½ marks.