CHEMISTRY 3A - MARKING SCHEME
FORM SIX

1\. The volume of the pipette used was $25 cm^3$

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

$$\text{Average Volume} = \left(\frac{V_1+V_2+V_3}{3}\right) cm^3 \quad 00\tfrac{1}{2} \text{ mark}$$

$$= \left(\frac{24.90+25.10+25.00}{3}\right) cm^3 \quad 01\tfrac{1}{2} \text{ mark}$$

Average volume Used = $25.00 cm^3$ $00\frac{1}{2}$ mark.

SUMMARY

$25.00 cm^3$ of solution F1 required $25.00 cm^3$ of solution F2 for complete reaction. 1 mark, @ $00\frac{1}{2}$ mark

Problems

(a) Overall ionic reaction:

Reduction half reaction:

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ $00\frac{1}{2}$ mark

Oxidation half reaction:

$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$ $00\frac{1}{2}$ mark

$2|\ MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

$5|\ H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$

$2MnO_4^- + \overset{6}{\cancel{16}}H^+ + \cancel{10e^-} \longrightarrow 2Mn^{2+} + 8H_2O$

$5H_2O_2 \longrightarrow 5O_2 + \cancel{10H^+} + \cancel{10e^-}$

01½ marks

$\therefore\ 2MnO_4^- + 5H_2O_2 + 6H^+ \longrightarrow 2Mn^{2+} + 5O_2 + 8H_2O.$

(b) $[H_2O_2]$ in mol/dm^3.

Molarity of $KMnO_4$ = $\frac{\text{Concentration in } g/L}{\text{Molar mass } (g/mol)}$. 01 mark.

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

Molarity of $KMnO_4$ = $0,02\, mol/dm^3$. 01 mark

$\therefore\ M_{MnO_4^-} = 0,02M$

$V_{MnO_4^-} = 25cm^3.$

$M_{H_2O_2} = ?$

$V_{H_2O_2} = 25\, cm^3$

$n_{MnO_4^-} = 2\, mol$

$n_{H_2O_2} = 5\, mol.$

From $\frac{M_{MnO_4^-} \times V_{MnO_4^-}}{M_{H_2O_2} \times V_{H_2O_2}} = \frac{n_{MnO_4^-}}{n_{H_2O_2}}$. 01 mark.

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

$$= \frac{0{,}02M \times 25cm^3 \times 5mol}{25cm^3 \times 2mol}$$ 01 marks.

$M_{H_2O_2} = 0{,}05M$

∴ Molarity of $H_2O_2 = 0{,}05 \; mol/dm^3$. 02 marks.

(c) Atomic mass of metal M.

- First determine total molar mass of MO_2.

from Molarity = $\frac{\text{concentration } (g/dm^3)}{\text{molar mass } (g/mol)}$ 00½ mark.

From $MO_{2(s)} + H_2SO_{4(aq)} \longrightarrow MSO_{4(s)} + H_2O_{2(aq)}$

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

∴ $[MO_2] = 0.05 \; mol/dm^3$. 00½ mark.

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

- Molarity of MO_2 is $0.05 \; mol/dm^3$.

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

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

Molar mass of $MO_2 = 169 \; g/mol$ 00½ mark.

But $MO_2 = 169$ 00½. mark

$M + 16 \times 2 = 169$

$M + 32 = 169$

$M = 169 - 32$

$M = 137$

∴ 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 <cm³>	mass of salt <g>	Initial temperature T_1 (°C)	Final temperature T_2 (°C)	$\Delta T = T_2 - T_1$ (°C)	Mr of the salts
A_2	50	4	27	34	+7	160
A_3	50	6	27	26	−1	250

(a) For A_2 < $CuSO_4$ > Table filling 06 mark, @ 00½ mark.

$\Delta H = -mc\Delta T$ but from $\rho = M/V$, $m = \rho \times V$

ie $\Delta H = -\rho V C \Delta T$ where
00½ mark.

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

$V = 50 cm^3$.

$C = 4.2 Jg^{-1}K^{-1}$.

$\Delta T = +7°C = 7K$.

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

$\Delta H = -1470 J/\cancel{mol}$ 01 mark.

~~ΔH~~ molar enthalpy of solution $= \frac{\Delta H}{n_{A_2}}$. 00½ mark.

But $n_{A_2} = \frac{m}{mr}$

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

$n_{A_2} = 0.025 mol$. 00½ mark.

molar enthalpy of $CuSO_4(aq) = \frac{-1470J}{0.025mol} = -58800 J/mol$.

∴ Molar enthalpy of solution of A_2 < $CuSO_4$ > $= -58800 J/mol$ or $-58.8 KJ/mol$. 00½ mark.

for $CuSO_4 \cdot 5H_2O$ (A3).

$\Delta H = -\rho V C \Delta T$ where $\rho = 1 g/cm^3$.
00½ mark. $V = 50 cm^3$.
$c = 4.2 J g^{-1} K^{-1}$.
$\Delta T = -1°C = -1K$.

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

$\Delta H = 210 J$. 01 mark.

Molar enthalpy of $CuSO_4 \cdot 5H_2O$ solution $= \frac{\Delta H}{n_{A_3}}$. 00½ mark.

But $n_{A_3} (CuSO_4 \cdot 5H_2O) = \frac{m}{mr}$

$= \frac{6g}{250 g/mol}$

$n_{A_3} (CuSO_4 \cdot 5H_2O) = 0.024 mol$. 00½ mark.

Molar enthalpy of $CuSO_4 \cdot 5H_2O = \frac{210 J}{0.024 mol} = 8750 J/mol$.

∴ Molar enthalpy of $CuSO_4 \cdot 5H_2O$ solution $= 8750 J/mol$ 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 $Cu \longrightarrow Cu^{2+}$.

- The molar heat of reaction for $CuSO_4 \cdot 5H_2O$ was lower than expected ($+11.30 kJ/mol$), b'se $CuSO_4$ was already hydrated to Cu^{2+} the only heat change was that ~~00~~ 01½ marks due to the process of dissolving the solute in water.

(c) Enthalpy of hydration of anhydrous $CuSO_4$ = ΔH of anhydrous salt − ΔH of hydrated salt 00 ½ mark;

$= -58.8\ kJ/mol - 8.75\ kJ/mol$.

Enthalpy of hydration of anhydrous $CuSO_4$ = $-67.55\ kJ/mol$. 01 mark

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S/N	EXPERIMENTS	OBSERVATIONS	INFERENCES
1.	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. ~~Divide~~ The resulting clear solution was divided into two portions		
	(i) To the first portion, sodium hydroxide solution was added till in excess.	Reddish brown precipitates formed Insoluble in excess	Fe^{3+} may be present
	(ii) To the second portion dil HNO_3 was added followed by $AgNO_3$.	White precipitates soluble in dilute ammonia solution were formed	Cl^- confirmed
2.	To a little quantity of the residue obtained in step 1 above, dilute HCl was added.	Effervescence of a colourless gas which turned Lime water milky occured	CO_3^{2-} confirmed ~~may be present~~.
3.	The resulted solution in step 2) above was diluted with distilled water and the solution was divided into two portions as follows:		
	(i) To the first ~~op~~ portion dil NaOH was added.	White precipitates soluble in excess of NaOH forming colourless solution formed.	Ca^{2+} Sr^{2+} Ba^{2+} Sb^{3+} Bi^{3+} and Mg^{2+} may be present

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 $\underline{Fe^{3+}}$ and $\underline{Ca^{2+}}$ and the Anions are $\underline{Cl^-}$ and $\underline{CO_3^{2-}}$ 4 marks

@ 1 mark:

Experiments @ 00½ mark, ~~but~~ except experiment 4 = 01 mark.

Observation @ 00½ marks.

Inferences @ 00½ marks.