

**CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)  
NORTHERN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)**



**FORM SIX PRE-NATIONAL EXAMINATIONS 2023**

132/3B

**CHEMISTRY 3B**

**MARKING SCHEME**

**Question 1**

The volume of the burette used was 50 cm<sup>3</sup>

The volume of the pipette used was 20 cm<sup>3</sup>

Complete table of results

Titration number	Pilot	1	2	3
Final reading(cm <sup>3</sup> )	20.50	20.00	20.10	20.00
Initial reading(cm <sup>3</sup> )	0.00	0.00	0.00	0.00
Titre value(cm <sup>3</sup> )	20.50	20.00	20.10	20.00

$$\text{Average titre volume} = \frac{20+20.1+20}{3} = 20 \text{ cm}^3$$

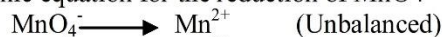
Average titre volume is 20 cm<sup>3</sup>

Summary

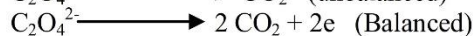
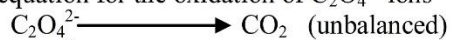
20 cm<sup>3</sup> of RR required 20 cm<sup>3</sup> of SS in the presence of TT for complete reaction

Questions

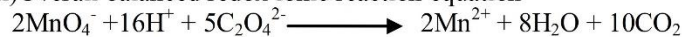
(a)(i) Half ionic equation for the reduction of MnO<sub>4</sub><sup>-</sup>



(ii) Half ionic equation for the oxidation of C<sub>2</sub>O<sub>4</sub><sup>2-</sup> ions



(iii) Overall balanced redox ionic reaction equation



**Question(b)**

The end point was pink because oxalate ions (C<sub>2</sub>O<sub>4</sub><sup>2-</sup>) reduced permanganate ions (MnO<sub>4</sub><sup>-</sup>) to Mn<sup>2+</sup>

**Question (c)**

(i) Molarity of RR

Given; 0.7g of potassium permanganate  $\longrightarrow$  0.25 dm<sup>3</sup> of water

X?  $\longrightarrow$  1 dm<sup>3</sup>

$$X = \frac{1 \times 0.7}{0.25} \text{ g/L}$$

$$= 2.8 \text{ g/L}$$

Then concentration of KMnO<sub>4</sub> is 2.8 g/L

$$\text{Molarity} = \frac{\text{Concentration}}{\text{Molar mass}}$$

$$\text{Molarity} = \frac{39+54.9+16 \times 4}{2.8}$$

$$= 0.017 \approx 0.02 \text{M}$$

Hence molarity of  $\text{KMnO}_4$  is  $0.02 \text{mol/L}$

(ii) Molarity of SS

By using  $M_A V_A$  formula

$$\frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B}$$

Let SS to be A and RR to be B

Make subject for unknown

$$M_A = \frac{M_B V_B n_A}{n_B V_A}$$

Where;  $M_B = 0.02$

$$V_B = 20 \text{ cm}^3$$

$$V_A = 20 \text{ cm}^3$$

$$n_A = 5 \text{ and } n_B = 2$$

Substitute the values;

$$M_A = \frac{0.02 \times 20 \times 5}{2 \times 20} \text{M}$$

$$= 0.05 \text{M}$$

**Hence molarity of SS is  $0.05 \text{mol/L}$**

(iii) Concentration of oxalic acid in g/L

Recall: Concentration = Molarity x Molar mass

$$= 0.05 \times (2 + 12 \times 2 + 16 \times 4)$$

$$= 4.5 \text{g/L}$$

**Hence concentration of oxalic acid is  $4.5 \text{g/L}$**

(iv) Value of X in the compound  $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$

$$\text{From; Molarity of oxalic acid} = \frac{\text{Concentration of impure}}{\text{Molar mass of impure}}$$

$$\text{Molar mass of impure} = \frac{\text{Concentration of impure}}{\text{Molarity}}$$

But concentration of impure =  $3.15 \text{g}/0.5 \text{L}$  or  $6.3 \text{g}/\text{dm}^3$

Molarity =  $0.05 \text{M}$

Substitute the value;

$$\text{Molar mass of impure} = \left( \frac{6.3}{0.05} \right) \text{g/mol}$$

$$= 126 \text{g/mol}$$

Then,  $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O} = 126$

$$2 + 12 \times 2 + 16 \times 4 + 18x = 126$$

$$90 + 18x = 126$$

$$X = 2$$

Hence the value of x in the compound  $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$  is 2

(iv) SS compound is  $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$

Molar mass of SS =  $2 + 12 \times 2 + 16 \times 4 + 2 \times 18 = 126 \text{g/mol}$

**Hence the molar mass of compound  $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$  is  $126 \text{g/mol}$**

**NOTE:**

In redox titrations, sulphuric acid used to provide acidic medium for the reaction to occur and neither HCl nor  $\text{HNO}_3$ , This is because

HCl acid in aqueous medium provides  $\text{Cl}^-$  ion which is strong reducing agent, this can interfere redox reaction.

$\text{HNO}_3$  acid is strong oxidizing agent then bring undesired reaction.

## Question 2

Experimental results

Experiment (salt)	Initial temperature	Final temperature	Temperature change
D	24	20	-4
E	24	26	+2

(03 marks)

(a) The heat change for each experiment.

For salt D

$$\Delta H = -(CPV\Delta T)$$

(00 $\frac{1}{2}$  marks)

$$\text{But } C = 4.18 \text{ J g}^{-1} \text{ k}^{-1}$$

$$P = 1.0 \text{ g/cm}^3$$

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

$$\Delta T = -4.0 \text{ k}$$

$$\Delta H = -(4.18 \text{ J g}^{-1} \text{ k}^{-1} \times 1 \text{ g/cm}^3 \times 50 \text{ cm}^3 \times -4 \text{ k})$$

(00 $\frac{1}{2}$  marks)

$$\Delta H = 836 \text{ J}$$

(00 $\frac{1}{2}$  marks)

$\therefore$  The heat change is

836 J For salt E

$$\Delta H = -(CPV\Delta T)$$

(00 $\frac{1}{2}$  marks)

$$\text{But } C = 4.18 \text{ J g}^{-1} \text{ k}^{-1}$$

$$P = 1.0 \text{ g/cm}^3$$

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

$$\Delta T = +2 \text{ k}$$

$$\Delta H = -(4.18 \text{ J g}^{-1} \text{ k}^{-1} \times 1 \text{ g/cm}^3 \times 50 \text{ cm}^3 \times 2 \text{ k})$$

$$\Delta H = -418 \text{ J}$$

(00 $\frac{1}{2}$  marks)

∴ The heat change is -418J (00 $\frac{1}{2}$  marks)

(b) The molar heat change in each experiment.

$$\begin{aligned} \text{The molar heat change} &= \frac{\text{Heat change}}{\text{number of mole}} \\ = & \end{aligned}$$

For D

$$\begin{aligned} \text{The heat change} &= 836\text{J} \\ \text{Number of moles} &= \frac{\text{mass given (m)}}{\text{molar mass (mr)}} \quad (00\frac{1}{2} \text{ marks}) \end{aligned}$$

$$\text{Number of moles} = \frac{4\text{g}}{286\text{g/mole}}$$

$$\text{Number of moles} = 0.0196\text{moles} \quad (00\frac{1}{2} \text{ marks})$$

$$\begin{aligned} \text{Then molar heat change} &= \frac{\text{Heat change}}{\text{number of moles}} \quad (00\frac{1}{2} \text{ marks}) \\ &= \frac{836\text{J}}{0.0196\text{moles}} \end{aligned}$$

The molar heat change of solution for salt D is = 42653.06J/mole (0.5 marks)

For E

$$\begin{aligned} \text{The heat change} &= -418\text{J} \\ \text{Number of moles} &= \frac{\text{mass given (m)}}{\text{molar mass (mr)}} \quad (00\frac{1}{2} \text{ marks}) \end{aligned}$$

$$\text{Number of moles} = \frac{2\text{g}}{106\text{g/mole}}$$

$$\text{Number of moles} = 0.0189\text{moles} \quad (00\frac{1}{2} \text{ marks})$$

$$\begin{aligned} \text{The molar heat change} &= \frac{\text{Heat change}}{\text{number of moles}} \quad (00\frac{1}{2} \text{ marks}) \\ = & \end{aligned}$$

$$\frac{-418}{0.0189 \text{ mole}} = -22154 \text{ J/mole}$$

1 (00<sub>2</sub> marks)

∴ The molar heat change of solution for salt E is  $-22154 \text{ J/mole}$   
(00<sup>1</sup> marks)

(c) The molar heat of hydration of each experiment  
Hydration energy

= Heat change for hydrated salt + Heat change for anhydrous salt

$$\Delta H_{\text{solution}} = \Delta H_{\text{hydrated}} + \Delta H_{\text{anhydrous}}$$

1 (00<sub>2</sub> marks)

$$= (42.653 - 22.154) \text{ kJ/mole}$$

$$= 20.499 \text{ kJ/mole}$$

(00<sup>1</sup> marks)

∴ The molar heat of hydration is  $20.499 \text{ kJ/mole}$

(00<sup>1</sup> marks) (d) The molar heat change for salt D (hydrated one) the heat was absorbed by the

salt and only small amount of energy were required to dissolve one mole of

salt thus the change was endothermic while the molar heat change for salt E (Anhydrous one) the heat was given out on dissolving it since on dissolving the lattice must be destroyed and hence negative lattice, thus it is exothermic process.

(02<sup>1</sup> marks)

### Question 3

Table of results

S/N	Experiment	Inferences
1	A gas give dense white fumes with ammonia evolved. White sublimate on cooler part of tube A gas which decolourise acidified $\text{KMnO}_4$ evolved. Black residues remained  (00½ marks)	$\text{Cl}^-$ may be present. $\text{NH}_4^+$ may be present. $\text{SO}_4^{2-}$ may be present. (00½ marks)
2	Colourless gas which turn blue litmus red and form dense fumes with ammonia. Blue crystals turns white  (00½ marks)	$\text{Cl}^-$ may be present. $\text{SO}_4^{2-}$ of hydrated $\text{Cu}^{2+}$ may be present (00½ marks)
3	The sample is soluble in water. (00½ marks)	$\text{SO}_4^{2-}$ may be present except of $\text{Ba}^{2+}$ , $\text{Ca}^{2+}$ , $\text{Pb}^{2+}$ and $\text{Sr}^{2+}$ . $\text{Cl}^-$ may be present except of $\text{Ag}^+$ and $\text{Pb}^{2+}$ (00½ marks)
	(i) Black precipitates formed (00½ marks)	$\text{Cu}^{2+}$ present (00½ marks)
	(ii) White precipitates formed which are insoluble in dilute HCl	$\text{SO}_4^{2-}$ present and confirmed
	(iii) No brown ring formed (00½ marks)	$\text{NO}_3^{-2}$ absent (00½ marks)
4	Blue green gas imparted on flame (00½ marks)	$\text{Cu}^{2+}$ may be present (00½ marks).
5	Colourless gas which turns moist red litmus paper blue and form white fumes with con. HCl evolved  (00½ marks)	$\text{NH}_4^+$ present and confirmed (00½ marks)
6	White precipitates formed (00½ marks)	$\text{Cl}^-$ present and confirmed. (00½ marks)

- (a) The cations in sample M are  $\text{Cu}^{2+}$  and  $\text{NH}_4^+$ . (02 marks)
- (b) The anions in sample M are  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ . (02 marks)
- (c) The molecular formula of salts mixed to form sample M are  $\text{NH}_4\text{Cl}$  and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (02 marks)