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^3
The volume of the pipette used was 20 cm^3
Complete table of results

Titration number	Pilot	1	2	3
Final reading(cm^3)	20.50	20.00	20.10	20.00
Initial reading(cm^3)	0.00	0.00	0.00	0.00
Titre volue(cm^3)	20.50	20.00	20.10	20.00

Average titre volume$=\frac{20+20.1+20}{3}$
$=20\ cm^3$
Average titre volume is 20 cm^3
Summary
20 cm3 of RR required 20 cm3 of SS in the presence of TT for complete reaction

Questions
(a)(i) Half ionic equation for the reduction of MnO4-

$MnO_4^- \longrightarrow Mn^{2+}$ (Unbalanced)

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

(ii)Half ionic equation for the oxidation of $C_2O_4^{2-}$ ions

$C_2O_4^{2-} \longrightarrow CO_2$ (unbalanced)

$C_2O_4^{2-} \longrightarrow 2\ CO_2 + 2e$ (Balanced)

(iii)Overall balanced redox ionic reaction equation

$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

Question(b)
The end point was pink because oxalate ions ($C_2O_4^{2-}$) reduced permanganate ions (MnO_4^-) to Mn^{2+}

Question (c)
(i)Molarity of RR

Given; 0.7g of potassium permanganate $\longrightarrow$ 0.25 dm^3 of water

X? $\longrightarrow$ 1 dm3

$X=\frac{1x0.7}{0.25})g/L$

$=2.8g/L$

Then concentration of KMnO4 is 2.8 g/L

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

$$\text{Molarity}=\frac{2.8}{39+54.9+16x4}$$

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

Hence molarity of $KMnO_4$ is 0.02mol/L

(ii)Molarity of SS

By using M_AV_A formula

$$\frac{M_AV_A}{n_A}=\frac{M_BV_B}{n_B}$$

Let SS to be A and RR to be B

Make subject for unknown

$$M_A=\frac{M_BV_Bn_A}{n_BV_A}$$

Where; M_B=0.02

V_B=20 cm3

V_A=20 cm3

n_A=5 and n_B=2

Substitute the values;

$$MA=\frac{0..02x20x5}{2x20})M$$

=0.05M

Hence molarity of SS is 0.05mol/L

(iii)Concentration of oxalic acid in g/L

Recall: Concentration=Molarity x Molar mass

= 0.05 x (2+12x2+16x4)

=4.5g/L

Hence concentration of oxalic acid is 4.5 g/L

(iv)Value of X in the compound $H_2C_2O_4.xH_2O$

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

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

But concentration of impure=3.15g/0.5 L or 6.3 g/dm^3

Molarity=0.05M

Substitute the value;

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

==126g/mol

Then, $H_2C_2O_4.xH_2O$=126

2+12x2+16x4+18x=126

90+18X=126

X=2

Hence the value of x in the compound $H_2C_2O_4.xH_2O$ is 2

(iv) SS compound is $H_2C_2O_4.xH_2O$

Molar mass of SS= 2+12x12x2+16x4+2x18=126g/mol

Hence the molar mass of compound $H_2C_2O_4.xH_2O$ is 126g/mol

NOTE:

In redox titrations, sulphuric acid used to provide acidic medium for the reaction to occur and neither HCl nor HNO_3, This is because

HCl acid in aqueous medium provides Cl- ion which is strong reducing agent , this can interfere redox reaction.

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

$$\Delta H = -(CPV\Delta T) \qquad (00\tfrac{1}{2} \text{ marks})$$

But $C = 4.18Jg^{-1}k^{-}$
$P = 1.0g/cm^3$
$V = 50cm^3$
$\Delta T = -4.0k$

$$\Delta H = -(4.18Jg^{-1}k^{-} \times 1g/cm^3 \times 50cm^3 \times -4k) \qquad (00\tfrac{1}{2} \text{ marks})$$

$$\Delta H = 836J \qquad (00\tfrac{1}{2} \text{ marks})$$

∴ The heat change is
836J For salt E

$$\Delta H = -(CPV\Delta T) \qquad (00\tfrac{1}{2} \text{ marks})$$

But $C = 4.18Jg^{-1}k^{-}$
$P = 1.0g/cm^3$
$V = 50cm^3$
$\Delta T = +2k$

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

$$\Delta H = -418J \qquad (00\tfrac{1}{2} \text{ marks})$$

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

(b) The molar heat change in each experiment.

The molar heat change = $\frac{\text{Heat change}}{\text{number of mole}}$

For D

The heat change = 836J

Number of moles = $\frac{\text{mass given (m)}}{\text{molar mass (mr)}}$ (00$\frac{1}{2}$ marks)

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

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

Then molar heat change = $\frac{\text{Heat change}}{\text{number of moles}}$ (00$\frac{1}{2}$ marks)

= $\frac{836\text{J}}{0.0196\text{moles}}$

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

For E

The heat change = −418J

Number of moles = $\frac{\text{mass given (m)}}{\text{molar mass (mr)}}$ (00$\frac{1}{2}$ marks)

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

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

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

$$= \frac{-418J}{\frac{0.018}{9}moles}$$

$= -22154J/mole$ $(00\frac{1}{2}$ marks)

∴ The molar heat change of solution for salt E is $-22154J/mole$ $(00\frac{1}{2}$ marks)

(c) The molar heat of hydration of each experiment

Hydration energy

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

$\Delta H_{solution} = \Delta H_{hydrated} + \Delta H_{anhydrous}$ $(00\frac{1}{2}$ marks)

$= (42.653 - 22.154)kJ/mole$

$= 20.499kJ/mole$ $(00\frac{1}{2}$ marks)

∴ The molar heat of hydration is $20.499kJ/mole$ $(00\frac{1}{2}$ 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. $(02\frac{1}{2}$ marks)

Question 3

Table os results

S/N	Experiment	Inferences
1	A gas give dense white fumes with ammonia evolved. White sublimate on cooker apart of tube A gas which decolourise acidified $KMnO_4$ evolved. Black residues remained **(00$\frac{1}{2}$ marks)**	Cl^- may be present. NH_4^+ may be present. SO_4^{2-} may be present. **(00$\frac{1}{2}$ marks)**
2	Colourless gas which turn blue litmus red and form dense fumes with ammonia. Blue crystals turns white **(00$\frac{1}{2}$ marks)**	Cl^- may be present. SO_4^{2-} of hydrated Cu^{2+} may be present **(00$\frac{1}{2}$ marks)**
3	The sample is soluble in water. **(00$\frac{1}{2}$ marks)**	SO_4^{2-} may be present except of Ba^{2+}, Ca^{2+}, Pb^{2+} and Sr^{2+}.Cl^- may be present except of Ag^+ and Pb^{2+} **(00$\frac{1}{2}$ marks)**
	(i)Black precipitates formed **(00$\frac{1}{2}$ marks)**	Cu^{2+} present **(00$\frac{1}{2}$ marks)**
	(ii) White precipitates formed which are insoluble in dilute HCl	SO_4^{2-} present and confirmed
	(iii) No brown ring formed **(00$\frac{1}{2}$ marks)**	NO_3^{-2} absent **(00$\frac{1}{2}$ marks)**
4	Blue green gas imparted on frame **(00$\frac{1}{2}$ marks)**	Cu^{2+} may be present **(00$\frac{1}{2}$ marks).**
5	Colourless gas which turns moist red litmus paper blue and form white fumes with con. HCl evolved **(00$\frac{1}{2}$ marks)**	NH_4^+ present and confirmed **(00$\frac{1}{2}$ marks)**
6	White precipitates formed **(00$\frac{1}{2}$ marks)**	Cl^- present and confirmed. **(00$\frac{1}{2}$ marks)**

(a) The cations in sample M are Cu^{2-} and NH_4^+ . **(02 marks)**

(b) The anions in sample M are Cl^- and SO_4^{2-} . **(02 marks)**

(c) The molecular formula of salts mixed to form sample M are NH_4Cl and $CuSO_4.5H_2O$ **(02 marks)**