THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3B **CHEMISTRY 3B**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2020**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:

K: 0.25 dm^3 solution of 0.79 g $KMnO_4$

L: 0.5 dm^3 solution of 13.90 g $FeSO_4 \cdot XH_2O$

M: Dilute sulfuric acid

Summary:

Volume of pipette = 25 cm^3

25 cm^3 of L required 23.30 cm^3 of K

Questions

(a)(i) Half reactions:

Oxidation: Fe^{2+} -----> $Fe^{3+} + e^-$

Reduction: $MnO_4^- + 8H^+ + 5e^-$ -----> $Mn^{2+} + 4H_2O$

(ii) Overall balanced ionic equation:

$MnO_4^- + 5Fe^{2+} + 8H^+$ -----> $Mn^{2+} + 5Fe^{3+} + 4H_2O$

(iii) Oxidant: MnO_4^-

Reductant: Fe^{2+}

(b) Why an indicator is not used

No indicator is needed because $KMnO_4$ is self-indicating (purple fades to colourless when reduced to Mn^{2+})

(c) Why sulfuric acid is used instead of HCl or HNO_3

Sulfuric acid does not react with $KMnO_4$. HCl and HNO_3 would interfere as they can be oxidized or decompose

(d) Calculate:

(i) Concentration of L in g/dm^3

13.90 g in 0.5 dm^3 → 13.90 ÷ 0.5 = 27.80 g/dm^3

(ii) Concentration of K in g/dm^3

0.79 g in 0.25 dm^3 → 0.79 ÷ 0.25 = 3.16 g/dm^3

(iii) Molarity of K

Molar mass of $KMnO_4$ = 158 g/mol

Moles = 0.79 ÷ 158 = 0.005 mol

Molarity = 0.005 ÷ 0.25 = 0.02 mol/dm^3

(iv) Molarity of $FeSO_4$

From reaction: 1 mol MnO_4^- reacts with 5 mol Fe^{2+}

Moles of $KMnO_4$ = 0.02 × 23.30 ÷ 1000 = 0.000466 mol

Moles of Fe^{2+} = 5 × 0.000466 = 0.00233 mol

Molarity in 25 cm^3 = 0.00233

In 1 dm^3: 0.00233 × 1000 ÷ 25 = 0.0932 mol/dm^3

(v) Concentration of $FeSO_4$ in g/dm^3

Molar mass of $FeSO_4$ = 152 g/mol

Concentration = 0.0932 × 152 = 14.1664 g/dm^3

(e) Find value of X in $FeSO_4 \cdot XH_2O$

Moles = 13.90 ÷ molar mass = 13.90 ÷ (152 + 18X)

This is in 0.5 dm^3, so multiply by 2 to get molarity:

0.0932 = (13.90 ÷ (152 + 18X)) × 2

0.0466 = 13.90 ÷ (152 + 18X)

152 + 18X = 13.90 ÷ 0.0466 = 298.28

18X = 298.28 - 152 = 146.28

X = 8.13 ≈ 8

Value of X = 8

2. You are provided with:

H1: 0.05 M sodium thiosulphate

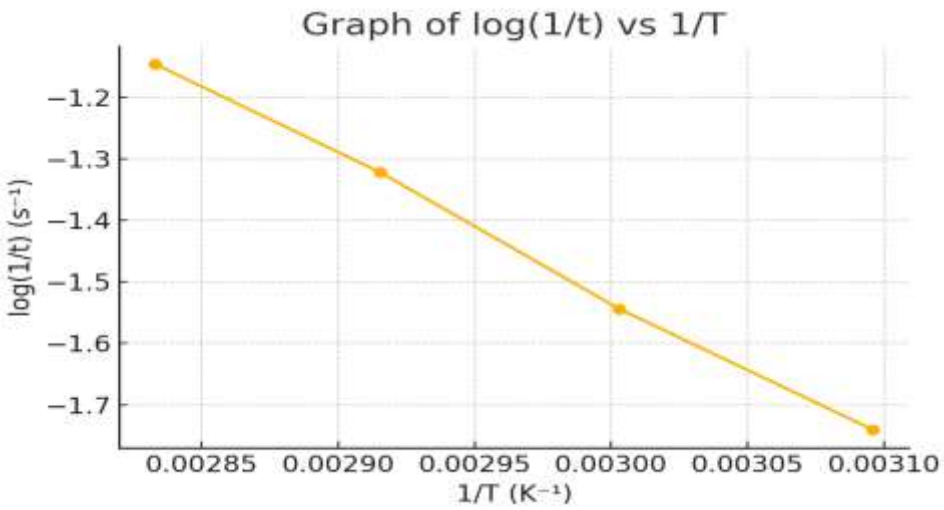
H2: 0.1 M nitric acid

Table 1: Experimental Data

Temperature (°C)	T (K)	t (s)	1/T (K^{-1})	Log10 t
50	323	55	0.00310	1.740
60	333	35	0.00300	1.544
70	343	21	0.00292	1.322
80	353	14	0.00283	1.146

(a) Plot a graph of log10 (1/t) against 1/T

1/t = 1 ÷ time → take log10 of 1/t and plot against 1/T



(b) Determine slope from graph

Use linear regression on (1/T, log10(1/t)) values

(c) Use equation K = Ae^(-Ea/RT), determine Ea

To calculate the activation energy (Ea) clearly from the graph of log(1/t) against 1/T, we use the Arrhenius equation in logarithmic form:

$\log(1/t) = -Ea / (2.303 \times R) \times (1/T) + \log A$

This matches the equation of a straight line:

$y = mx + c$

Where slope $m = -Ea / (2.303 \times R)$

From the graph:

Slope = -2285.69

R = 8.314 J/mol·K

3. You are provided with a sample P containing two cations and one anion. Carry out the experiments described in Table 2. Record carefully your observations and make appropriate inferences. Finally, identify the cations and anion present in the sample P.

Table 2: Table of results

S/n	Experiment	Observations	Inferences
(a)	Appearance of the sample P	White crystalline solid	Presence of a simple ionic salt
(b)	Heat sample P strongly in a dry test tube	Brown gas evolved (smell of NO_2)	Presence of nitrate ion (NO_3^-)
(c)(i)	Add dilute hydrochloric acid to the first portion followed by barium chloride solution	White precipitate forms	Presence of SO_4^{2-}
(c)(ii)	Add lead acetate to the second portion	Yellow precipitate forms	Confirms presence of chromate or lead cation (Pb^{2+}) if unknown
(c)(iii)	To the third portion, add ammonia solution till in excess	Deep blue solution forms	Presence of Cu^{2+}
(c)(iv)	To the fourth portion, add sodium hydroxide solution till in excess	White precipitate forms, dissolves in excess	Presence of Zn^{2+}
(d)	Perform confirmatory tests for the cations	Deep blue with NH_3 confirms Cu^{2+}, amphoteric ppt confirms Zn^{2+}	Confirms Cu^{2+} and Zn^{2+}

Conclusion:

The two cations in the sample P are Cu^{2+} and Zn^{2+}; the anion is NO_3^-.

Now apply the formula:

Ea = -slope × 2.303 × R

Ea = -(-2285.69) × 2.303 × 8.314

Ea = 2285.69 × 2.303 × 8.314

Ea = 2285.69 × 19.147

Ea = 43764.43 J/mol

Ea = 43764.43 ÷ 1000 = 43.76 kJ/mol

So, the activation energy of the reaction is 43.76 kJ/mol.