**THE UNITED REPUBLIC OF TANZANIA**

**NATIONAL EXAMINATIONS COUNCIL**

**ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION**

**132/3A** **CHEMISTRY 3A**

(For Both School and Private Candidates)

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

**Instructions**

1. This paper consists of THREE questions.
2. Answer all questions.







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1. You are provided with the following:

C1: Sodium oxalate, $Na_2C_2O_4$ solution: 3.35 g in 0.5 $dm^3$

C2: Potassium permanganate ($KMnO_4$) solution

C3: Hydrated iron(II) ammonium sulfate, $FeSO_4(NH_4)_2SO_4 \cdot XH_2O$: 33.3 g in 1.0 $dm^3$

C4: Dilute sulfuric acid

Thermometer

Summary:

10 $cm^3$ of solution C1 required 22.50 $cm^3$ of solution C2

10 $cm^3$ of solution C3 required 25.00 $cm^3$ of solution C2

Questions

(a) Calculate the:

(i) Molarity of potassium permanganate

Molar mass of $Na_2C_2O_4$ = 134 g/mol

Moles of $Na_2C_2O_4$ = 3.35 ÷ 134 = 0.025 mol in 0.5 $dm^3$

Molarity of C1 = 0.025 ÷ 0.5 = 0.05 mol/$dm^3$

Reaction:

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

From stoichiometry:

5 mol $C_2O_4^{2-}$ reacts with 2 mol $KMnO_4$

Moles of $C_2O_4^{2-}$ in 10 $cm^3$ = 0.05 × 10 ÷ 1000 = 0.0005 mol

Moles of $KMnO_4$ = (2/5) × 0.0005 = 0.0002 mol

Volume of $KMnO_4$ = 22.50 $cm^3$ = 0.0225 $dm^3$

Molarity = 0.0002 ÷ 0.0225 = 0.00889 mol/$dm^3$

(ii) Concentration of potassium permanganate in g/$dm^3$

Molar mass of $KMnO_4$ = 158 g/mol

Concentration = 0.00889 × 158 = 1.4056 g/$dm^3$

(iii) Molarity of iron(II) salt

Reaction:

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

1 mol $KMnO_4$ reacts with 5 mol $Fe^{2+}$

Moles of $KMnO_4$ = 0.00889 × 25 ÷ 1000 = 0.000222 mol

Moles of $Fe^{2+}$ = 0.000222 × 5 = 0.00111 mol

In 10 $cm^3$ = 0.01 $dm^3$

Molarity = 0.00111 ÷ 0.01 = 0.111 mol/$dm^3$

(iv) Concentration of anhydrous iron(II) salt in g/$dm^3$

Molar mass of $FeSO_4(NH_4)_2SO_4 \cdot XH_2O$ = 284 + 18X

Mass = 33.3 g in 1.0 $dm^3$

Moles = 0.111 mol

Concentration = 0.111 × (284 + 18X)

We'll solve X in part (b)

(b) Find the value of X in the formula $FeSO_4(NH_4)_2SO_4 \cdot XH_2O$

Molar mass = 33.3 ÷ 0.111 = 300

300 - 284 = 16

X = 16 ÷ 18 ≈ 0.89 ≈ 1

So, X = 1

Molar mass = 284 + 18 = 302 g/mol

Concentration = 0.111 × 302 = 33.522 g/dm$^3$

2. You are provided with the following:

T1: 0.02 M $KMnO_4$

T2: 0.05 M oxalic acid in 0.5 M $H_2SO_4$

Thermometer and stopwatch

(a) Write half ionic equations for the reaction.

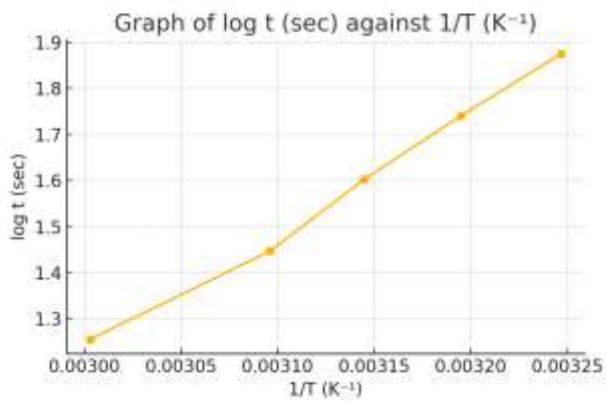
Oxidation:

$C_2O_4^{2-}$ -----> $2CO_2 + 2e^-$

Reduction:

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

(b) Plot a graph of log t (sec) against 1/T (K$^{-1}$)




(c) Use the graph to determine the activation energy of the reaction

To solve question 2(c) and determine the activation energy (Ea), we use the Arrhenius equation in its linear form:

log t = (Ea / 2.303R) × (1/T) + constant

From the plotted graph of log t versus 1/T, we obtain the slope of the line:

slope = -Ea / (2.303 × R)

Where:

R = 8.314 J/mol·K

Slope (from graph) = -10.328

Now plug into the equation:

Ea = -slope × 2.303 × R

Ea = -(-10.328) × 2.303 × 8.314

Ea = 10.328 × 2.303 × 8.314

Ea = 49539.08 J/mol

Convert to kJ/mol:

Ea = 49539.08 ÷ 1000 = 49.5 kJ/mol

So, the activation energy of the reaction is 49.5 kJ/mol.

3.

Table 1: Experimental Table

| S/n | Experiments | Observations | Inferences |
|---|---|---|---|
| (a)(i) | Add sodium hydroxide in excess to the first portion of clear solution | White gelatinous precipitate forms, insoluble in excess | Presence of $Al^{3+}$ |
| (a)(ii) | Add dilute $HNO_3$ and $AgNO_3$ to the second portion | White precipitate forms | Presence of $Cl^-$ |
| (b) | Add hydrochloric acid to the residue from (a) | Effervescence observed, gas with pungent smell released | Presence of $CO_3^{2-}$ |
| (c)(i) | Add NaOH to the first portion of the solution from (b) | Pale green precipitate forms, insoluble in excess | Presence of $Fe^{2+}$ |
| (c)(ii) | Add dilute ammonia to second portion of solution from (b) | Pale green precipitate forms | Confirms $Fe^{2+}$ |
| (d) | Perform confirmatory test for each ion | White ppt with $AgNO_3$ confirms $Cl^-$, brown ppt with $K_3[Fe(CN)_6]$ confirms $Fe^{2+}$ | Confirm presence of $Cl^-$ and $Fe^{2+}$ |

Conclusion:

The two cations in the sample U are $Al^{3+}$ and $Fe^{2+}$; the anions are $Cl^-$ and $CO_3^{2-}$.