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: 2023**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:
J: A solution made by dissolving 1.58 g of $KMnO_4$ in a distilled water to form 0.5 dm^3 of an aqueous solution;
K: A solution made by dissolving 7.91 g of $Na_2S_2O_3 \cdot XH_2O$ in a distilled water to form 0.25 dm^3 of an aqueous solution;
L: A solution of 10% KI;
M: A starch solution;
N: A dilute H_2SO_4 solution.
Theory
A quantitative reaction between potassium permanganate, $KMnO_4$ and potassium iodide, KI can be represented by the reaction:
$MnO_4^-(aq) + I^-(aq) \text{ -----> } Mn^{2+}(aq) + I_2(aq)$
The liberated iodine, I_2, is titrated against sodium thiosulphate, $Na_2S_2O_3$. The reaction taking place during this titration can be represented as:
$I_2(aq) + 2S_2O_3^{2-} \text{ -----> } S_4O_6^{2-} + 2I^-$

Questions
(i) The volume of the pipette used was _____.
The volume of the pipette used was 25 cm^3.

(ii) _____ cm^3 of J liberated iodine that required _____ cm^3 of K for complete reaction.
Suppose volume of K used was 22.50 cm^3 on average.

(a) State the function of M in this experiment.
The function of M (starch) is to act as an indicator. It forms a blue-black complex with iodine, making it easy to detect the endpoint of the titration when the blue-black colour disappears.

(b) State the main purpose of adding L into the conical flask containing an acidified J.
The purpose of adding L (potassium iodide) is to react with MnO_4^- from $KMnO_4$ to liberate iodine (I_2), which is then titrated.

(c) Why is it advisable to add M just close to the end point in this experiment?
It is advisable to add M close to the end point because starch forms a stable complex with iodine. If added too early, it may reduce sensitivity or delay the endpoint detection due to the stability of the starch-iodine complex.

(d) Write an overall balanced reaction equation for the whole experiment.
$MnO_4^- + 8H^+ + 5I^- + 10S_2O_3^{2-} \text{ -----> } Mn^{2+} + 5I^- + 5S_4O_6^{2-} + 4H_2O$

(e) Calculate the:
(i) concentration of $KMnO_4$ in g/dm^3
1.58 g in 0.5 dm^3 means:

= 1.58 / 0.5 = 3.16 g/dm³

(ii) molarity of $KMnO_4$
Molar mass of $KMnO_4$ = 158 g/mol
Moles = 1.58 / 158 = 0.01 mol
In 0.5 dm³, Molarity = 0.01 / 0.5 = 0.02 mol/dm³

(iii) concentration of $Na_2S_2O_3 \cdot XH_2O$ in g/dm³
7.91 g in 0.25 dm³
= 7.91 / 0.25 = 31.64 g/dm³

(iv) molarity of $Na_2S_2O_3$
Molar mass of $Na_2S_2O_3$ = 158 g/mol
Assume no water of crystallization yet:
Moles = 7.91 / 158 = 0.0501 mol
In 0.25 dm³: Molarity = 0.0501 / 0.25 = 0.2004 mol/dm³

(v) concentration of $Na_2S_2O_3$ in g/dm³
= Molarity × Molar mass
= 0.2004 × 158 = 31.86 g/dm³

(f) Find the value of X in $Na_2S_2O_3 \cdot XH_2O$
Molar mass from solution = 7.91 / 0.0501 = 157.9 g/mol
Let molar mass = 158 + (18 × X) = 157.9
157.9 - 158 = 18X
X = 5

2. You are provided with the following:
A: A solution of 0.02 M potassium permanganate;
C: A solution of 0.05 M oxalic acid in 0.5 M sulphuric acid;
A thermometer (0°–100 °C);
Stop watch/clock.

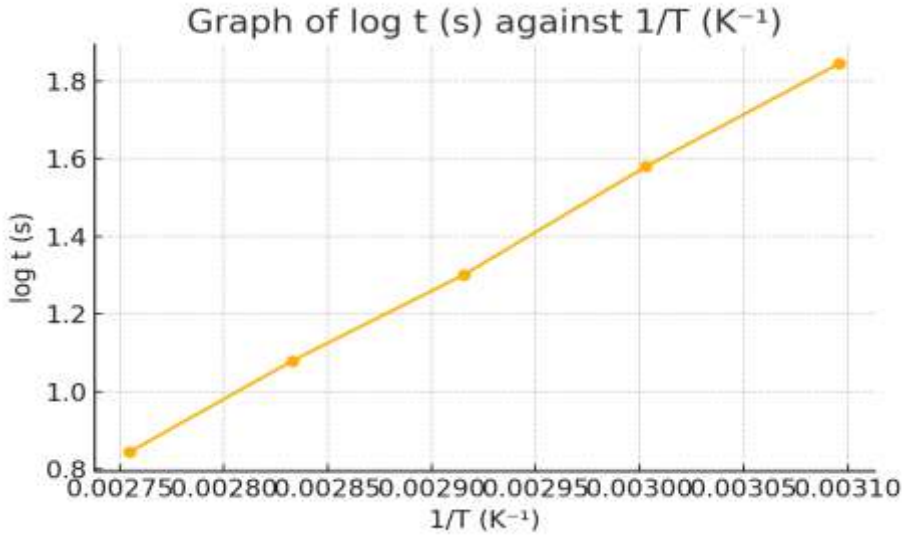
Theory
In acidic medium, oxalic acid is oxidized by potassium permanganate. Completion of the reaction is indicated by the disappearance of the purple colour of permanganate ions:
$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 6H^+(aq) \text{ -----> } 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$
Questions

(a) Write ionic redox half equations for this experiment.
$C_2O_4^{2-} \text{ -----> } 2CO_2 + 2e^-$
$MnO_4^- + 8H^+ + 5e^- \text{ -----> } Mn^{2+} + 4H_2O$

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

Temperature (°C)	Temperature (K)	Time (t) sec	1/T (K^{-1})	log t (s)
50	323	70	0.003096	1.8451
60	333	38	0.003003	1.5798
70	343	20	0.002916	1.3010
80	353	12	0.002832	1.0792
90	363	7	0.002755	0.8451

Use this table to plot the graph with 1/T on x-axis and log t on y-axis.



(c) Calculate the activation energy (Ea) of the reaction for the experiment.

From the slope of graph:

Slope = -Ea / (2.303 × R)

Use two points: (0.003096, 1.8451) and (0.002755, 0.8451)

Slope = (0.8451 - 1.8451) / (0.002755 - 0.003096) = -1.0000 / -0.000341 = 2932.55

Ea = 2.303 × 8.314 × 2932.55 = 56196 J/mol = 56.2 kJ/mol

3. Sample B contains two cations and one anion. Perform the experiments given in Table 2 and record the observations and inferences.

Table 2: Experimental Table

S/n	Experiment	Observations	Inferences
(a)	Observe sample B.	Yellow crystalline solid	Possible presence of Pb^{2+}
(b)	Heat a small portion in dry test tube.	Brown gas evolved	Presence of nitrate ion (NO_3^-)
(c)	Add conc. H_2SO_4 to small portion	Effervescence observed	NO_2 gas evolved confirms NO_3^-
(d)	Perform flame test	Blue-green flame	Presence of Cu^{2+}
(e)	Add NaOH solution	Blue precipitate	Cu^{2+} present
(f)	Add HNO_3 then $AgNO_3$ then NH_3	White ppt soluble in excess NH_3	Confirms presence of Cl^-
(g)(i)	Add H_2S gas in HCl, filter, add acetic acid and lead acetate to filtrate	Yellow precipitate forms	Confirm Pb^{2+}
(g)(ii)	Dissolve residue in aqua regia and add excess NH_3	Deep blue solution	Confirms Cu^{2+}

Questions

(i) Write the molecular formula for the sample.
The molecular formula is $Pb(NO_3)_2 \cdot CuCl_2$

(ii) What are the cations and anion in the sample?
Cations: Cu^{2+} and Pb^{2+}
Anion: Cl^- and NO_3^-