THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/23B **CHEMISTRY 3B**

(ACTUAL PRACTICAL B)

(For Both School and Private Candidates)

Time : 3:30 Hours **ANSWERS** **Year : 2022**

Instructions

1. This paper consists of three questions, answer all questions
2. All writing should be in **blue** or **black** ink.
3. Communication devices and any unauthorised materials are **not** allowed in the examination room.
4. Write your **Examination Number** on every page of your answer booklet(s).

1. You are provided with the following:

AA: A solution of sodium oxalate, $Na_2C_2O_4$ made by dissolving 3.35 g of the salt in a 0.5 dm^3 solution;

BB: A solution of potassium permanganate, $KMnO_4$;

CC: A solution of hydrated iron(II) ammonium sulphate, $FeSO_4(NH_4)_2SO_4 \cdot XH_2O$, made by dissolving 33.3 g of the salt in distilled water to form 1 dm^3 of an aqueous solution;

DD: Dilute sulphuric acid; Thermometer.

Theory:

Standardization of BB solution is done by titrating it against the standard solution of AA in an acidic medium:

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

The standardized BB is then titrated against CC to determine the number of water molecules of crystallization:

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

Questions:

(a) Calculate the:

(i) molarity of potassium permanganate.

(ii) concentration of potassium permanganate in g dm^{-3}.

(iii) molarity of iron(II) salt.

(iv) concentration of anhydrous iron(II) salt in g dm^{-3}.

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

Solution 1

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

Molarity of AA = 0.025 ÷ 0.5 = 0.05 M.

From the equation: $5C_2O_4^{2-}$ react with $2MnO_4^-$.

Therefore, 1 mole of MnO_4^- reacts with 2.5 moles of oxalate.

Moles of oxalate in 10 cm^3 = 0.05 × 10/1000 = 5.0×10^{-4} mol.

Moles of $MnO4^-$ required = (2/5) × 5.0×10^{-4} = 2.0×10^{-4} mol.

If mean volume of KMnO4 (BB) used is 20 cm^3 = 0.020 dm^3,

Molarity of BB = $2.0 \times 10^{-4} \div 0.020$ = 0.01 M.

(i) Molarity of KMnO4 = 0.01 M.

(ii) Concentration in g dm^{-3} = 0.01 × 158 = 1.58 g dm^{-3}.

For CC:

Moles in 10 cm^3 titrated with 20 cm^3 BB (0.01 M).

Moles of $MnO4^-$ = $0.01 \times 20/1000 = 2.0 \times 10^{-4}$ mol.

From the equation, $1MnO4^-$ reacts with $5Fe^{2+}$.

Moles of Fe^{2+} = $5 \times 2.0 \times 10^{-4} = 1.0 \times 10^{-3}$ mol.

Therefore, molarity of CC = $1.0 \times 10^{-3} \div 0.010$ = 0.10 M.

(iii) Molarity of Fe^{2+} salt = 0.10 M.

(iv) Molar mass of anhydrous FeSO4(NH4)2SO4 = 284 g mol^{-1}.

Concentration in g dm^{-3} = 0.10 × 284 = 28.4 g dm^{-3}.

(b) Given actual concentration (from preparation) = 33.3 g in 1 dm^3.

Moles present = 0.10 mol.

Apparent molar mass = 33.3 ÷ 0.10 = 333 g mol^{-1}.

Extra mass = 333 – 284 = 49 g.

49 ÷ 18 ≈ 2.7 ≈ 3.

So X = 3.

2. You are provided with the following:

JJ: 0.05 M sulphuric acid;

MM: 0.035 M potassium iodide;

KK: 0.035 M sodium thiosulphate;

LL: 0.9 M hydrogen peroxide;

HH: Starch solution; Stop watch.

Theory:

Hydrogen peroxide reacts with iodide ions in the presence of hydrogen ions:

$$H2O2 + 2I^- + 2H^+ \rightarrow I2 + 2H2O$$

The iodine produced reacts immediately with thiosulphate:

$$I2 + 2S2O3^{2-} \rightarrow 2I^- + S4O6^{2-}$$

Once all thiosulphate is consumed, iodine accumulates, and starch detects it with a sudden blue-black colour.

Questions:

(a) On the same axes, plot a graph showing the volume of sodium thiosulphate solution KK against time for each experiment.

(b) Comment on the shapes of your graphs and explain what is expected if you continue adding KK for a longer period of time.

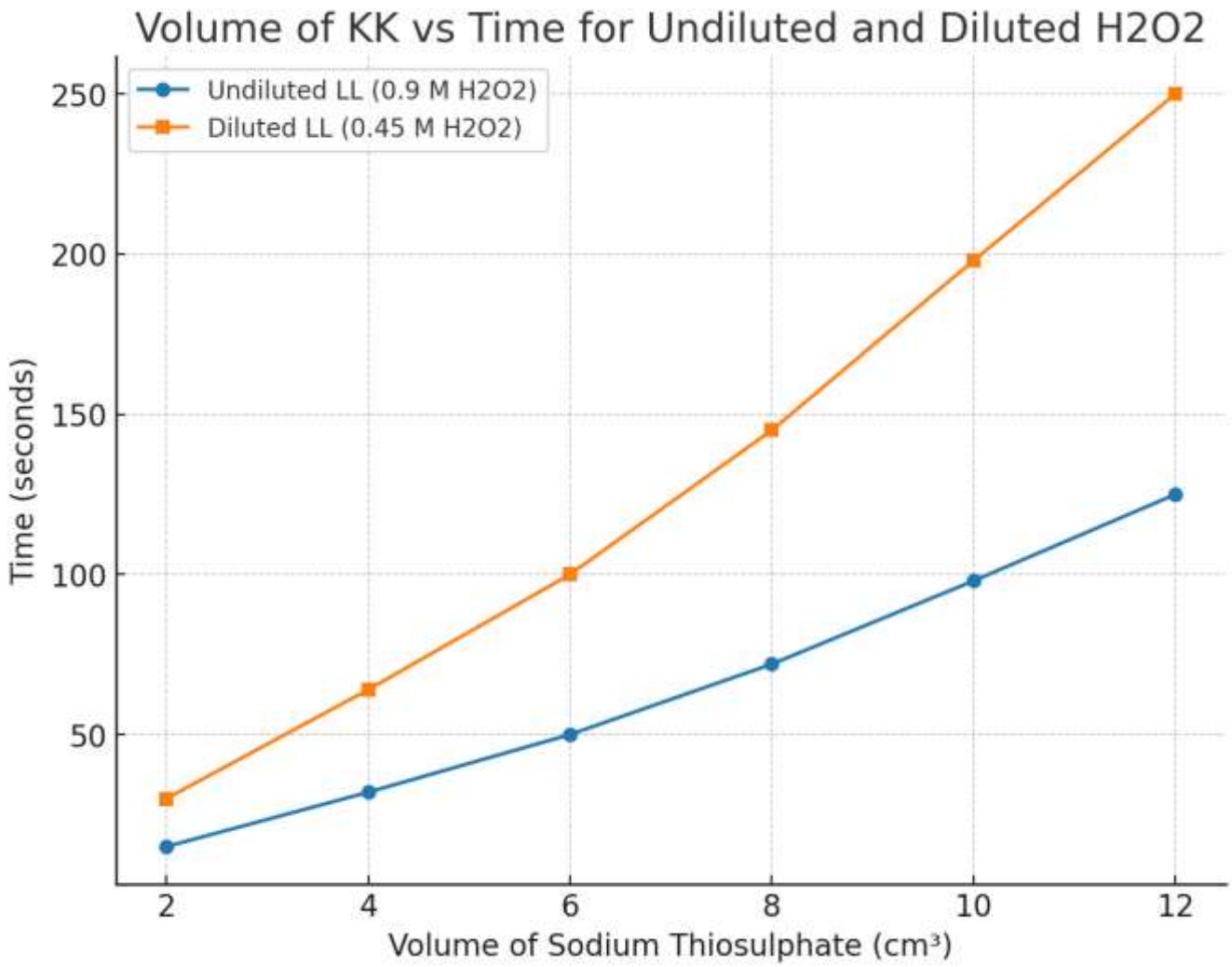
(c) Calculate the slope of each curve and deduce the order of the reaction with respect to hydrogen peroxide.

(d) How is the amount of iodine liberated related to the amount of hydrogen peroxide consumed?

Solution 2

(a) The graphs:

For undiluted LL (0.9 M), the curve shows a faster rise in time intervals as volumes of KK are added. For diluted LL (0.45 M), the curve rises more slowly. Both are curves of KK volume (x-axis) against time (y-axis).



(b) Shape of graphs:

At first, the time intervals are short because the rate of reaction is high with more H2O2 molecules present. As the reaction proceeds, intervals increase since H2O2 is consumed and fewer effective collisions occur. If KK is added for a longer period, the curve would eventually level off (plateau) as all H2O2 is used up and no more iodine is produced.

(c) Slope of curve:

The slope represents Δvolume of KK ÷ Δtime.

For undiluted LL, slope is steeper, meaning faster reaction rate.

For diluted LL, slope is gentler, showing a slower rate.

Since doubling concentration of LL nearly doubles the rate, the reaction is first order with respect to hydrogen peroxide.

(d) Relationship between iodine and H2O2:

From the balanced equation, 1 mole of H2O2 produces 1 mole of I2.

Therefore, the amount of iodine liberated is directly proportional to the amount of H2O2 consumed.

3. Substance T contains two cations and one anion. Use the information given in the experiments column of the Table to complete observations and inferences.

Table 3

S/N	Experiments	Observations	Inferences
(a)	Appearance of the sample	Green crystalline solid	Suggests presence of Fe^{2+} salt (transition metal)
(b)	Heat a small portion of the sample in a dry test tube	Brown gas evolved, residue left	Brown gas is NO_2, confirming nitrate ions
(c)	Add concentrated sulphuric acid to the sample	Brown fumes released	Confirms presence of nitrate (NO_3^-)
(d)	Perform a flame test	Intense yellow flame	Presence of sodium ion (Na^+)
(e)	Add sodium hydroxide solution to a sample solution	Green precipitate forms, turns brown on standing	Green ppt confirms Fe^{2+}, which oxidizes to Fe^{3+}

(f)	Add nitric acid, then silver nitrate, then aqueous ammonia	White ppt soluble in ammonia	Confirms chloride ion (Cl^-)
(g)(i)	Pass H_2S or ammonium sulphide with HCl into solution (filtrate test with $BaCl_2$)	White precipitate	Confirms sulphate ion (SO_4^{2-})
(g)(ii)	Dissolve residue, add aqua regia then excess ammonia	Deep blue solution formed	Confirms presence of Cu^{2+} ions

Final identification:

Cations = Fe^{2+} and Cu^{2+}

Anion = SO_4^{2-}

Molecular formula of sample = $FeSO_4 \cdot CuSO_4$ (double salt).