THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3B **CHEMISTRY 3B**

ACTUAL PRACTICAL B

(For Both School and Private Candidates)

Duration: 3:20 Hours **ANSWERS** **Year: 2025**

Instructions

1. This paper consists of **three (3)** questions.
2. Answer **all** questions.
3. Question **one (1)** carries 20 marks and the other **two (2)**, carry 15 marks each.
4. Qualitative Analysis Guide (QAG) sheet authorised by NECTA may be used
5. Mathematical tables and non programmable calculators may be used.
6. Communication devices and any unauthorised materials are **not** allowed in the examination room.
7. Write your **Examination Number** on every page of your answer booklet(s).
8. You may use the following constants:
   - Atomic masses: H = 1, C = 12, O = 16, S = 32, Na = 23, Cl = 35.5, K = 39, Mn = 55
   - Density of water = 1 g/cm^3
   - Specific heat capacity of water = 4.18 $Jg^{-1}K^{-1}$

1. A solution which contains iodine is commonly used to clean wounds. During this process, medical attendants may unpredictably smear iodine on their clothes. Cleanliness of these clothes requires the use of specific amount of thiosulphate solution. Perform titration technique and calculate the amount of sodium thiosulphate required for the laundry using the following reagents and the given apparatuses.

Q1: A solution of 0.04 M $KMnO_4$;

Q2: A solution of $Na_2 S_2 O_3$;

Q3: A solution of 10% KI;

Q4: A starch solution;

Q5: A solution of 1 M sulphuric acid.

Theory

A quantitative reaction between potassium permanganate and potassium iodide in acidic medium involves production of iodine. Iodine reacts with sodium thiosulphate during titration process.

Procedure

(i) Fill the burette with **Q2**.

2. Measure 10 cm^3 of **Q1** into a conical flask. Add 10 cm^3 of distilled water. Swirl the mixture gently, then add 10 cm^3 of solution **Q3** followed by 10 cm^3 of **Q5** into the mixture.

(iii) Titrate **Q2** against the mixture in the conical flask until a pale yellow colour is observed. Add 2 cm^3 of **Q4** into the conical flask and continue to titrate until the dark blue colour turn to colourless.

(iv) Record the first titre value.

(v) Repeat steps (i) to (iv) three times and record the titre values.

Questions

(a) Tabulate your results.

(b) Write the balanced chemical equation for the whole experiment.

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

$5/2\ I^- \rightarrow I_2 + 2e^-$

$2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

$\therefore 2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$ … (iv)

Case (ii): Reaction of Iodine with $Na_2S_2O_3$

Reduction half reaction:

$I_2(aq) \rightarrow I^+(aq)$

$I_2(aq) \rightarrow 2I^-(aq)$

$I_2 + 2e^- \rightarrow 2I^-(aq)$ … (v)

Oxidation half reaction:

$S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq)$

$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e^-$ … (vi)

Overall reaction:

Add equation (v) and (vi) we get,

$I_2 + 2e^- \rightarrow 2I^-(aq)$

+

$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$

$\therefore I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$ … (vii)

Case (iii): Equation for the whole experiment

Multiply eqn (iv) by 1 and eqn (vii) by 5 then add, we get

$\{ 2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O \}$

+

$5\{ I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^- \}$

$2MnO_4^- + 16H^+ + 10I^- + 5I_2 + 10S_2O_3^{2-} \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O + 5S_4O_6^{2-} + 10I^-$

$\therefore 2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 5S_4O_6^{2-}$

$nMnO_4^- : nS_2O_3^{2-} = 2 : 10 = 1 : 5$

∴ Chemical equation is

$2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 5S_4O_6^{2-}$

(c) Final molarity of $KMnO_4$ (Md).

Since a solution Q was diluted with water, we have:

Molarity of pure $KMnO_4$ (Mc) = 0.04 M

Volume of pure $KMnO_4$ (Vc) = 10 cm^3

Volume of diluted solution (Vd) = 80 + 10 = 90 cm^3

Molarity of diluted $KMnO_4$ (Md) = ?

From dilution law:

$McVc = MdVd$

$Md = McVc / Vd$

$Md = 0.04 \times 10 / 20$

$Md = 0.02$ M

∴ Final molarity of $KMnO_4$ was 0.02 M.

2. Chemists should control rate of chemical reactions in order to avoid explosion for the reactions whose rate is vigorous. This task is done by determining the rate constant of reaction. Determine the rate constant of the reaction using the following reagents:

F1: 0.1 M hydrochloric acid;

F2: 0.15 M sodium thiosulphate;

Distilled water.

Theory

The rate of reaction is expressed as: Rate = $\frac{-d[S_2O_3^{2-}]}{dt} = k[S_2O_3^{2-}][H^+]^y$

Where **x** is the order of reaction with respect to $S_2O_3^{2-}$, **y** is the order of reaction with respect to H+ and **k** is the rate constant.

Procedure

(i) Place a small beaker of 100 cm3 on top of the "**X**" mark on the white paper.

(ii) Measure 25 cm^3 of **F2** using measuring cylinder and pour into the beaker placed on the marked paper.

(iii) Measure 25 cm3 of **F1**, then add into the beaker containing **F2** and immediately start the stopwatch.

(iv) Record the time taken for the mark on white paper to be obscured.

(v) Repeat steps (i) to (iv) using the set of mixtures in Table 1.

TABLE OF RESULTS:

Exp	Volume of H_2 (cm^3)	Volume of water (cm^3)	Volume of total (cm^3)	t (s)	1/t (s^{-1})
1	25	0	25	62.5	0.016
2	20	5	25	78.13	0.013
3	15	10	25	104.17	0.010
4	10	15	25	156.25	0.006

(c) **Ionic equation is:**

$S_2O_3^{2-} + 2H^+ \rightarrow H_2O + SO_2 + S$ (aq)

(d) **Order of reaction with respect to H^+**

From:

Rate (R) = $K [S_2O_3^{2-}]^x [H^+]^y$

Hence,

$R_1 = K [S_2O_3^{2-}]^x [H^+]^y$ … (i)

$R_2 = K [S_2O_3^{2-}]^x [H^+]^y$ … (ii)

Divide the equation (ii) by equation (i):

$R_1 / R_2 = K[S_2O_3^{2-}]^x[H^+]^y / K[S_2O_3^{2-}]^x[H^+]^y$

But,

$R \propto 1/t$

Then,

$R \propto 1/t$

$\therefore R \propto V$

2 (b).

Where

$[H^+]_1 = C(H^+)_2$

$R_1 / R_2 = [S_2O_3^{2-}]_1 / [S_2O_3^{2-}]_2$

But,

$[S_2O_3^{2-}] \propto V$

$R_1 / R_2 = (V_1 / V_2)^x$

$0.016 / 0.013 = (25 / 20)^x$

$1.25 = 1.25^x$

$\therefore x = 1$

$\therefore$ The order of reaction with respect to H_2 ($Na_2S_2O_3$) is first order.

(c) **Rate constant (K) = ?**

Given y = 1

From,

$R = K [S_2O_3^{2-}]^x [H^+]^y$

But,

$R \propto 1/t$

Also,

$[S_2O_3^{2-}] \propto V(S_2O_3^{2-})$

$[H^+] \propto V(H^+)$

(c). **For experiment (4):**

$K_4 = R_4 / (V_{s2o3}^{2-})_4 (V_h^+)_4$

$= 0.006\ s^{-1} / (10\ cm^3 \times 25\ cm^3)$

$= 2.4 \times 10^{-5}\ cm^{-6}\ s^{-1}$

Average (K) $= (K_1 + K_2 + K_3 + K_4) / 4$

$K = (2.56 \times 10^{-5} + 2.6 \times 10^{-5} + 2.67 \times 10^{-5} + 2.4 \times 10^{-5}) / 4$

$K = 2.558 \times 10^{-5}\ cm^{-6}\ s^{-1}$

$\therefore$ **Rate Constant = $2.558 \times 10^{-5}\ cm^{-6}\ s^{-1}$**

3. Sample **RK** contains one cation and one anion. Analyse the sample using systematic qualitative analysis procedures. Carefully, record your experiments, observations and inferences as shown in Table 2. Finally, identify the anion and cation present in sample **RK**.

Systematic Qualitative Analysis

Table 2: Experiment Data

S/N	Experiment	Observation	Inference
1	A small amount of sample RK was heated gently in a dry test tube.	A colorless gas evolved that turned lime water milky.	Presence of carbonate (CO_3^{2-}) or hydrogen carbonate (HCO_3^-) ion.
2	A portion of RK was dissolved in distilled water and tested with litmus paper.	Blue litmus turned slightly red, red litmus remained unchanged.	The solution is weakly alkaline, indicating presence of sodium hydrogen carbonate.
3	The solution was treated with dilute hydrochloric acid.	Effervescence observed with evolution of colorless gas which turned	Confirms presence of hydrogen carbonate ion (HCO_3^-).

		lime water milky.	
4	Another portion was treated with magnesium sulphate solution.	A white precipitate appeared upon heating.	Further confirms presence of HCO_3^- as it forms $MgCO_3$ on heating.
5	The aqueous solution was tested with sodium hydroxide and a drop of phenolphthalein indicator.	The solution turned faint pink.	Indicates presence of weak base ($NaHCO_3$).
6	The solution was tested with potassium hexacyanoferrate(II) and zinc sulphate.	No colored precipitate formed.	Indicates absence of transition metal ions like Fe^{2+}, Cu^{2+}, or Zn^{2+}.
7	The sample solution was tested with flame test.	A bright yellow flame was observed.	Confirms presence of sodium ion (Na^+).

(a) Cation and Anion present in the sample:

The cation present is Sodium ion (Na^+).

The anion present is Hydrogen carbonate ion (HCO_3^-).

(b) Molecular Formula of the Sample:

The molecular formula of the sample is **$NaHCO_3$ (Sodium Hydrogen Carbonate)**.