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: 2016**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:

KK: 0.02 M potassium permanganate

LL: Impure 1.7 g of hydrogen peroxide in 1 dm^3 of aqueous solution

SS: 1 M sulphuric acid

Theory

The reaction between potassium permanganate and hydrogen peroxide in acidic medium is a redox reaction. In this reaction, the MnO_4^- ions act as an oxidizing agent while H_2O_2 acts as a reducing agent.

Procedure

(i) Pipette 25 cm^3 or 20 cm^3 of LL into a conical flask.

(ii) Add 25 cm^3 or 20 cm^3 of solution SS into the conical flask in (i).

(iii) Titrate the mixture against solution KK until a permanent pink colour just appears in the conical flask.

(iv) Record the titre volume and repeat titration to obtain 3 readings.

(v) Record the volume of the pipette used.

Questions

(a) Write half and overall ionic equations of the reaction between potassium permanganate and hydrogen peroxide.

Half equation for reduction:

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

Half equation for oxidation:

$H_2O_2 \text{-----> } O_2 + 2H^+ + 2e^-$

Overall ionic equation:

$2MnO_4^- + 5H_2O_2 + 6H^+ \text{-----> } 2Mn^{2+} + 5O_2 + 8H_2O$

(b) Calculate the percentage purity of hydrogen peroxide.

Step 1: Calculate number of moles of $KMnO_4$

If average titre = 23.50 cm^3 of KK

Volume in dm^3 = 23.50 ÷ 1000 = 0.0235 dm^3

Molarity of KK = 0.02 mol/dm^3

Moles of $KMnO_4$ = $0.02 \times 0.0235 = 4.7 \times 10^{-4}$ mol

Step 2: From the balanced equation

$2MnO_4^-$ react with $5H_2O_2$

Therefore, 4.7×10^{-4} mol MnO_4^- corresponds to

$(5/2) \times 4.7 \times 10^{-4} = 1.175 \times 10^{-3}$ mol of H_2O_2

Step 3: Find mass of H_2O_2

Molar mass of H_2O_2 = 34 g/mol

Mass = $1.175 \times 10^{-3} \times 34 = 0.03995$ g

Step 4: Find % purity

Given that 1.7 g was present in 1 dm^3 solution,

% purity = (0.03995 ÷ 1.7) × 100 = 2.35 %

2. You are provided with the following:

U: A solution of 0.02 M $KMnO_4$

V: A solution of 0.05 M oxalic acid in 0.5 M H_2SO_4

Thermometer and stopwatch

Theory

In acidic medium, oxalic acid is oxidized by $KMnO_4$. Completion of the reaction is indicated by the disappearance of the purple colour of the permanganate ion.

Procedure

(i) Put about 250 cm^3 of water into a 300 cm^3 beaker; heat the beaker. This is your water bath.

(ii) Measure 10 cm^3 of solution U and 10 cm^3 of solution V and put them into separate test tubes.

(iii) Put thermometer into a test tube containing solution U and heat the test tube in a water bath, allow the content to warm to 50°C.

(iv) Pour hot solution U into the test tube containing solution V; immediately start a stopwatch and record the time taken for the purple colour to disappear.

(v) Repeat the experiment at the temperatures 60°C, 70°C and 80°C.

(vi) Record your results in a tabular form.

Questions

(a) Write half ionic equations for the reaction.

Half reaction for MnO_4^-:

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

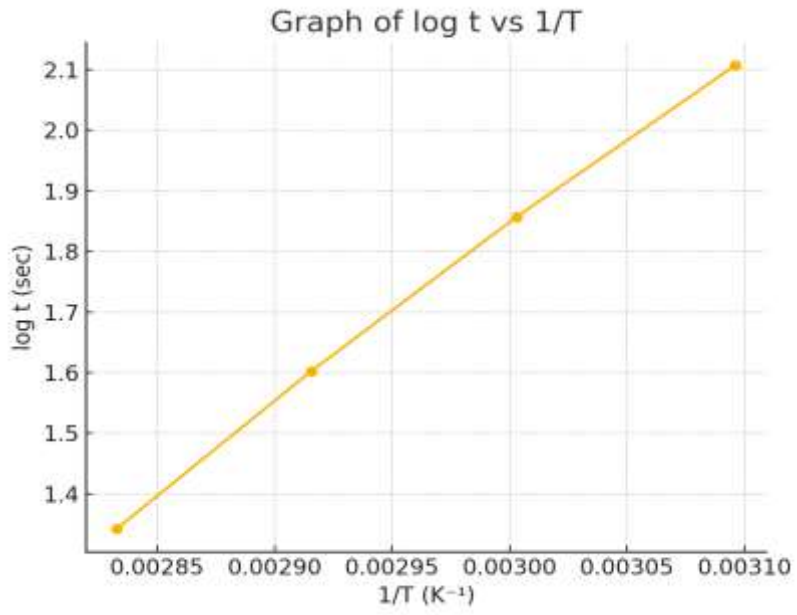
Half reaction for oxalate:

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

Overall equation:

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

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



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

From the Arrhenius equation:

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

The slope = Ea / 2.303R

Slope from graph = 2.48

R = 8.314 J/mol·K

Ea = slope × 2.303 × R

Ea = 2.48 × 2.303 × 8.314 = 47.41 kJ/mol

Therefore, activation energy = 47.41 kJ/mol

3. Sample G contains ONE cation and anion. Use the information given in the experiment column in Table 2 to complete the observations and inferences and hence identify the cation and anion.

Table 2:

S/n	Experiment	Observations	Inferences	
1	Make a solution of G in water and divide into six portions	Colourless solution formed	G is a soluble salt	
2	To the first portion add few drops of NaOH then excess	White precipitate formed	insoluble in excess	Presence of Ca^{2+}
3	To second portion add few drops of nitric acid	boil and then add ammonia solution until alkaline	No visible change	Absence of transition metal cations
4	To the third portion	add few drops of ammonia solution then excess	No precipitate formed	Confirms Ca^{2+} ion
5	Perform confirmatory test	Brick red flame	Confirms calcium ion	
6	To the fourth portion	add lead ethanoate	White precipitate formed	Presence of sulphate (SO_4^{2-})
7	To the fifth portion	add barium chloride	White precipitate formed	Confirms SO_4^{2-}
8	Perform confirmatory test for deductions	Same results	Confirmed presence of Ca^{2+} and SO_4^{2-}	

Conclusion:

(a) The cation in sample G is calcium (Ca^{2+})

The anion is sulphate (SO_4^{2-})

(b) Reaction with NaOH:

$Ca^{2+}(aq) + 2OH^-(aq)$ -----> $Ca(OH)_2(s)$

Observation: White precipitate formed, insoluble in excess NaOH

This confirms the presence of calcium ions.