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: 2009**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

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Prepared by: Maria Marco for TETEA

1. You are provided with the following:

MM: A solution made by dissolving 3.25 g of impure potassium dichromate ($K_2Cr_2O_7$) in 500 cm^3 of distilled water

NN: A solution made by dissolving 12.40 g of sodium thiosulphate pentahydrate ($Na_2S_2O_3 \cdot 5H_2O$) in 500 cm^3 of distilled water

PP: 10% potassium iodide (KI) solution

Also provided: starch indicator and 1M sulphuric acid

Procedure

(i) Pipette 25.00 cm^3 of MM into a clean titration flask

(ii) Add to it 25.00 cm^3 of sulphuric acid

(iii) Add to it 25.00 cm^3 of PP

The liberated iodine reacts with thiosulphate according to the reaction:

$Cr_2O_7^{2-} + 6I^- + 14H^+ \text{-----> } 2Cr^{3+} + 3I_2 + 7H_2O$

$I_2 + 2S_2O_3^{2-} \text{-----> } S_4O_6^{2-} + 2I^-$

(iv) Titrate the iodine against NN using starch as indicator

(v) Repeat for consistent values

Summary

25.00 cm^3 of MM liberated sufficient iodine required to oxidize 23.60 cm^3 of NN

Questions

(a) Write balanced redox equations:

(i) $Cr_2O_7^{2-} + 6I^- + 14H^+ \text{-----> } 2Cr^{3+} + 3I_2 + 7H_2O$

(ii) $I_2 + 2S_2O_3^{2-} \text{-----> } S_4O_6^{2-} + 2I^-$

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(b) Calculate the molarity of potassium dichromate ($K_2Cr_2O_7$) in MM

Volume of NN used = 23.60 cm^3 = 0.02360 dm^3

Mass of $Na_2S_2O_3 \cdot 5H_2O$ = 12.40 g

Molar mass = 248 g/mol

Moles in 500 cm^3 = 12.40 ÷ 248 = 0.05 mol

Molarity = 0.05 ÷ 0.5 = 0.1 mol/dm^3

Moles of thiosulphate in 23.60 cm^3 = 0.1 × 0.02360 = 0.00236 mol

From the second equation, 1 mol I_2 reacts with 2 mol $S_2O_3^{2-}$

Moles of I_2 = 0.00236 ÷ 2 = 0.00118 mol

From the first equation, 1 mol $Cr_2O_7^{2-}$ liberates 3 mol I_2

Moles of $Cr_2O_7^{2-}$ = 0.00118 ÷ 3 = 0.000393 mol

Molarity = 0.000393 ÷ 0.025 = 0.01572 mol/dm^3

(c) Calculate the concentration of $K_2Cr_2O_7$ in g/dm^3

Molar mass of $K_2Cr_2O_7$ = 294 g/mol

Concentration in g/dm^3 = 0.01572 × 294 = 4.621 g/dm^3

(d) Calculate the percentage impurity of the chromate salt

Actual mass used = 3.25 g in 500 cm^3 → scaled to 6.50 g in 1 dm^3

Mass of pure $K_2Cr_2O_7$ = 4.621 g

Percentage purity = (4.621 ÷ 6.50) × 100 = 71.09%

Percentage impurity = 100 − 71.09 = 28.91%

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2. You are provided with the following:

MN: A solution of 0.5 M sodium thiosulphate

PQ: A solution of 0.1 M nitric acid

A stopwatch

A thermometer (0–100 °C)

Theory

A white precipitate of amorphous sulphur can be obtained by the reaction:

$3S_2O_3^{2-} + 2H^+ \text{-----> } 3SO_4^{2-} + 3S\downarrow + H_2O$

This sulphur causes the solution to turn opaque. The rate of the reaction is measured by the time it takes for the solution to obscure a marked letter beneath the beaker.

Procedure

(i) Draw letter X on paper and place a small beaker on it

(ii) Place 200 cm^3 of water into a 250 cm^3 beaker as water bath

(iii) Pipette 10.0 cm^3 of MN and 10.0 cm^3 of PQ into separate boiling tubes

(iv) Warm to required temperature in the bath (e.g., 50 °C)

(v) Pour both into small beaker on letter X and start stopwatch

(vi) Record time (in seconds) taken for letter X to disappear

(vii) Repeat at 60 °C, 70 °C and 80 °C

Results table (example)

Temperature (°C)	T (K)	Time (sec)	1/T (K^{-1})	log(1/t)
50	323	120	0.00310	-2.079
60	333	75	0.00300	-1.875
70	343	45	0.00292	-1.653

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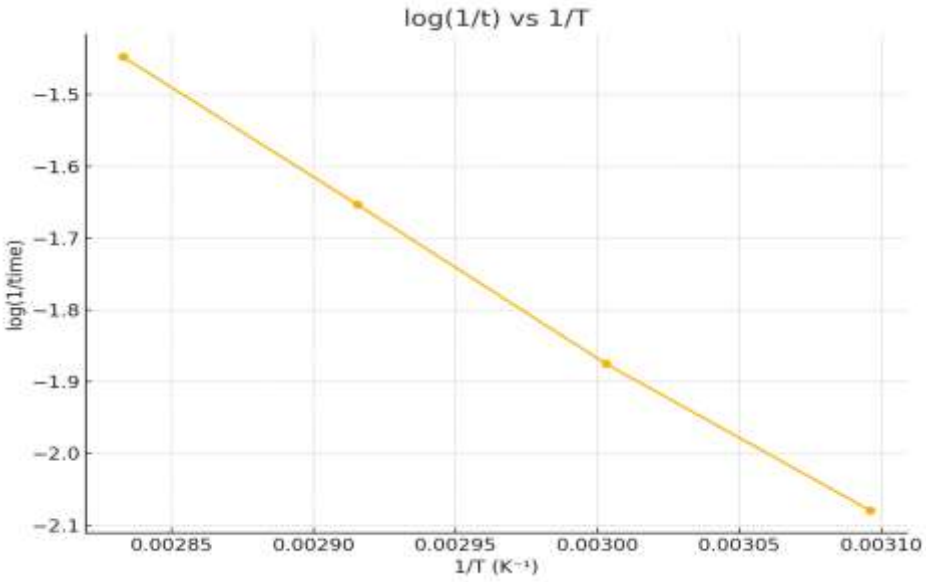
| 80 | 353 | 28 | 0.00283 | -1.447 |

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



(b) The slope of the graph log(1/t) vs 1/T is approximately −2410.88.

This slope was obtained from linear regression using the temperature and time data provided.

(c)Using the equation K = Ae^(-Ea/RT), and the linear form log(1/t) = log A − Ea/(2.303RT):

Activation energy (Ea) = −slope × 2.303 × R

= −(−2410.88) × 2.303 × 8.314

= 46209.90 J/mol

= 46.21 kJ/mol

Pre-exponential factor (A) = 10^intercept

= 2.42×10^5 s^{-1}

Therefore,

Activation energy Ea = 46.21 kJ/mol

Frequency factor A = 2.42×10^5 s^{-1}

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3. You are provided with:

V = 0.5 g of succinic acid

W = 0.2 M sodium hydroxide

Distilled water

Diethyl ether

Phenolphthalein indicator (P.O.P)

Procedure

(i) Fill burette with W

(ii) Measure 50 cm^3 distilled water into separating funnel

(iii) Add 30 cm^3 ether

(iv) Add 0.5 g of succinic acid

(v) Shake vigorously and allow layers to separate

(vi) Tap off aqueous layer, pipette 25 cm^3 into flask

Add P.O.P and titrate with W until pink appears

(a) Volume of NaOH used = 20.0 cm^3

(b) Balanced equation:

$HOOC–CH_2CH_2–COOH + 2NaOH \text{ -----> } NaOOC–CH_2CH_2–COONa + 2H_2O$

(c)(i) Molarity of acid in aqueous layer:

Moles NaOH = $0.2 \times 20 \div 1000 = 0.004$ mol

Moles of acid = $0.004 \div 2 = 0.002$ mol

Volume = 25 cm^3 = 0.025 dm^3

Molarity = $0.002 \div 0.025 = 0.08$ mol/dm^3

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(ii) Mass of acid in 25 cm^3 = 0.002 × 118 = 0.236 g

So in 50 cm^3:

Concentration = 0.236 × 2 = 0.472 g in 50 cm^3

g/dm^3 = 0.472 × 1000 ÷ 50 = 9.44 g/dm^3

(iii) Ether layer has 0.5 − 0.236 = 0.264 g

Volume = 30 cm^3

Concentration = 0.264 × 1000 ÷ 30 = 8.80 g/dm^3

(iv) Partition coefficient

K = concentration in water ÷ concentration in ether = 9.44 ÷ 8.80 = 1.07

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