

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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1. You are provided with the following:

MM: A solution made by dissolving 3.25 g of impure potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) in 500 cm^3 of distilled water

NN: A solution made by dissolving 12.40 g of sodium thiosulphate pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) in 500 cm^3 of distilled water

PP: 10% potassium iodide (KI) solution

Also provided: starch indicator and 1M sulphuric acid

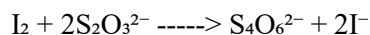
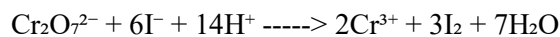
Procedure

(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:



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

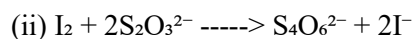
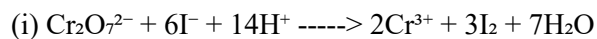
(v) Repeat for consistent values

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:



(b) Calculate the molarity of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) in MM

$$\text{Volume of NN used} = 23.60 \text{ cm}^3 = 0.02360 \text{ dm}^3$$

$$\text{Mass of } \text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} = 12.40 \text{ g}$$

$$\text{Molar mass} = 248 \text{ g/mol}$$

$$\text{Moles in } 500 \text{ cm}^3 = 12.40 \div 248 = 0.05 \text{ mol}$$

$$\text{Molarity} = 0.05 \div 0.5 = 0.1 \text{ mol/dm}^3$$

$$\text{Moles of thiosulphate in } 23.60 \text{ cm}^3 = 0.1 \times 0.02360 = 0.00236 \text{ mol}$$

From the second equation, 1 mol I_2 reacts with 2 mol $\text{S}_2\text{O}_3^{2-}$

$$\text{Moles of } \text{I}_2 = 0.00236 \div 2 = 0.00118 \text{ mol}$$

From the first equation, 1 mol $\text{Cr}_2\text{O}_7^{2-}$ liberates 3 mol I_2

$$\text{Moles of } \text{Cr}_2\text{O}_7^{2-} = 0.00118 \div 3 = 0.000393 \text{ mol}$$

$$\text{Molarity} = 0.000393 \div 0.025 = 0.01572 \text{ mol/dm}^3$$

(c) Calculate the concentration of $\text{K}_2\text{Cr}_2\text{O}_7$ in g/dm^3

$$\text{Molar mass of } \text{K}_2\text{Cr}_2\text{O}_7 = 294 \text{ g/mol}$$

$$\text{Concentration in } \text{g/dm}^3 = 0.01572 \times 294 = 4.621 \text{ g/dm}^3$$

(d) Calculate the percentage impurity of the chromate salt

$$\text{Actual mass used} = 3.25 \text{ g in } 500 \text{ cm}^3 \rightarrow \text{scaled to } 6.50 \text{ g in } 1 \text{ dm}^3$$

$$\text{Mass of pure } \text{K}_2\text{Cr}_2\text{O}_7 = 4.621 \text{ g}$$

$$\text{Percentage purity} = (4.621 \div 6.50) \times 100 = 71.09\%$$

$$\text{Percentage impurity} = 100 - 71.09 = 28.91\%$$

2. You are provided with the following:

MN: A solution of 0.5 M sodium thiosulphate

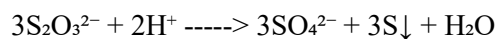
PQ: A solution of 0.1 M nitric acid

A stopwatch

A thermometer (0–100 °C)

Theory

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



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 cm³ of water into a 250 cm³ beaker as water bath
- (iii) Pipette 10.0 cm³ of MN and 10.0 cm³ 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)
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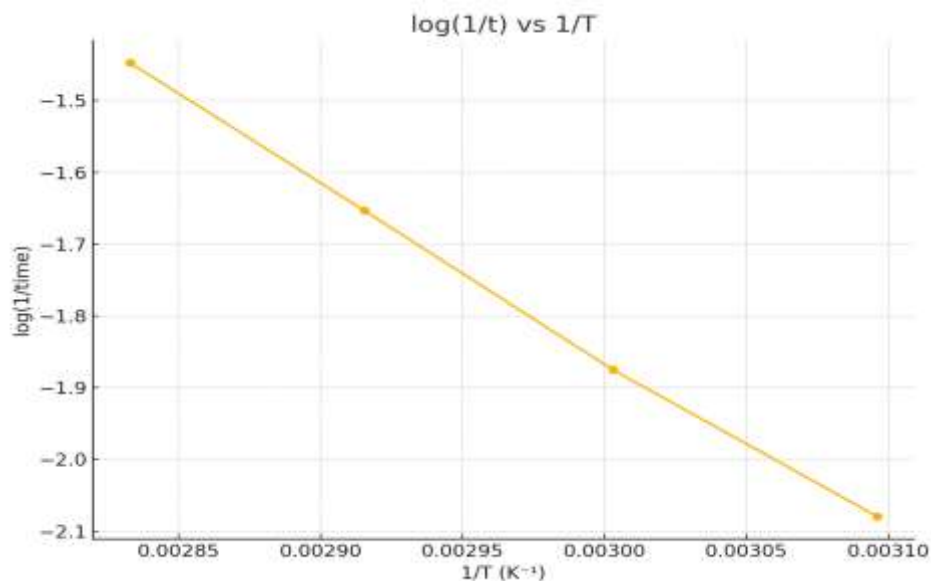
50	323	120	0.00310	-2.079
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60	333	75	0.00300	-1.875
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70	343	45	0.00292	-1.653
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| 80 | 353 | 28 | 0.00283 | -1.447 |

(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 $K = Ae^{(-E_a/RT)}$, and the linear form $\log(1/t) = \log A - E_a/(2.303RT)$:

Activation energy (E_a) = $-\text{slope} \times 2.303 \times R$

$$= -(-2410.88) \times 2.303 \times 8.314$$

$$= 46209.90 \text{ J/mol}$$

$$= 46.21 \text{ kJ/mol}$$

Pre-exponential factor (A) = $10^{\text{intercept}}$

$$= 2.42 \times 10^5 \text{ s}^{-1}$$

Therefore,

Activation energy $E_a = 46.21 \text{ kJ/mol}$

Frequency factor $A = 2.42 \times 10^5 \text{ s}^{-1}$

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 cm³ distilled water into separating funnel

(iii) Add 30 cm³ ether

(iv) Add 0.5 g of succinic acid

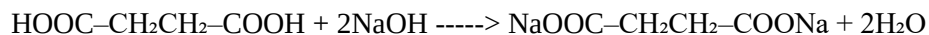
(v) Shake vigorously and allow layers to separate

(vi) Tap off aqueous layer, pipette 25 cm³ into flask

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

(a) Volume of NaOH used = 20.0 cm³

(b) Balanced equation:



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

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

$$\text{Moles of acid} = 0.004 \div 2 = 0.002 \text{ mol}$$

$$\text{Volume} = 25 \text{ cm}^3 = 0.025 \text{ dm}^3$$

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

(ii) Mass of acid in 25 cm³ = $0.002 \times 118 = 0.236$ g

So in 50 cm³:

Concentration = $0.236 \times 2 = 0.472$ g in 50 cm³

g/dm³ = $0.472 \times 1000 \div 50 = 9.44$ g/dm³

(iii) Ether layer has $0.5 - 0.236 = 0.264$ g

Volume = 30 cm³

Concentration = $0.264 \times 1000 \div 30 = 8.80$ g/dm³

(iv) Partition coefficient

K = concentration in water $\div$ concentration in ether = $9.44 \div 8.80 = 1.07$