

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: 2008

Instructions

1. This paper consists of THREE questions.
2. Answer all questions.

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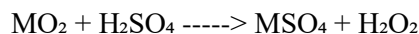
1. You are provided with the following:

F₁: An acidified solution of hydrogen peroxide obtained by reacting 8.45 g of a metal peroxide MO₂ with dilute H₂SO₄ and making the final solution up to 1 dm³

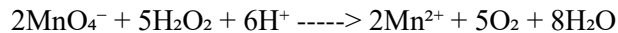
F₂: A solution of potassium permanganate (KMnO₄) prepared by dissolving 3.16 g of the salt in 1 dm³ of distilled water

Theory

The metal peroxide reacts with dilute sulphuric acid to form hydrogen peroxide:



Hydrogen peroxide reacts with KMnO₄ in acidic conditions according to the reaction:



Procedure

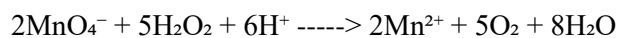
- (i) Pipette 25.0 cm³ of F₁ into a clean titration flask
- (ii) Add dilute sulphuric acid to acidify
- (iii) Titrate with F₂ until a faint pink colour persists
- (iv) Repeat for concordant titres

Summary

25.0 cm³ of solution F₁ required 22.50 cm³ of solution F₂ for complete reaction

Questions

- (a) Write the overall ionic equation for the redox reaction



- (b) Calculate the concentration of hydrogen peroxide in mol/dm³

Given directly:

Concentration of $\text{H}_2\text{O}_2 = 0.1536 \text{ mol/dm}^3$

(c) Calculate the atomic mass of metal M in MO_2

From the equation:

1 mol of MO_2 produces 1 mol of H_2O_2

So, moles of MO_2 in $1 \text{ dm}^3 = 0.1536 \text{ mol}$

Mass of $\text{MO}_2 = 8.45 \text{ g}$

Molar mass of $\text{MO}_2 = 8.45 \div 0.1536 = 55.03 \text{ g/mol}$

$\text{MO}_2 = M + 2 \times 16 = M + 32$

Therefore, $M = 55.03 - 32 = 23.03$

(d) Identity of metal M

The atomic mass of M is approximately 23. The metal M is sodium.

2. You are provided with the following:

AB: 2.0 M NaOH solution

CD: 2.0 M HCl solution

EF: 2.0 M CH_3COOH solution

Thermometer, Plastic beaker (calorimeter), Measuring cylinder

Theory

The enthalpy change for a neutralization reaction can be measured by mixing known volumes of acid and base and recording the temperature change. The enthalpy change is calculated by:

$$q = -\rho \times V \times c \times \Delta t$$

where:

ρ = density of solution = 1 g/cm³

V = total volume of solution in cm³

c = specific heat capacity = 4.2 Jg⁻¹K⁻¹

Δt = temperature change in °C

Assume the following temperature readings:

Experiment	Initial Temperature (°C)	Final Temperature (°C)	Temperature Change (°C)	Total Volume (cm ³)
1	25.0	32.4	7.4	200
2	25.0	31.0	6.0	200

(a) Calculate the heat change

(i) First experiment (NaOH + HCl)

$$\begin{aligned} q &= -\rho \times V \times c \times \Delta t \\ &= -1 \times 200 \times 4.2 \times 7.4 \\ &= -6216 \text{ J} = -6.216 \text{ kJ} \end{aligned}$$

(ii) Second experiment (NaOH + CH₃COOH)

$$\begin{aligned} q &= -1 \times 200 \times 4.2 \times 6.0 \\ &= -5040 \text{ J} = -5.040 \text{ kJ} \end{aligned}$$

(b) Calculate the molar enthalpy of neutralization

Volume of NaOH used = 100 cm³ = 0.1 dm³

Molarity = 2.0 mol/dm³

Moles of NaOH = $2.0 \times 0.1 = 0.2$ mol

(i) NaOH + HCl

Molar enthalpy = heat change \div moles

= $-6.216 \div 0.2 = -31.08$ kJ/mol

(ii) NaOH + CH₃COOH

Molar enthalpy = $-5.040 \div 0.2 = -25.20$ kJ/mol

(c) Comparison

The molar enthalpy of neutralization in the first experiment (NaOH + HCl) is more exothermic than in the second experiment (NaOH + CH₃COOH).

This is because HCl is a strong acid and ionizes completely, while CH₃COOH is a weak acid and partially ionizes, absorbing part of the heat during ionization. Hence, less heat is released in the second reaction.

3. You are provided with the following:

L₁: 0.10 M sodium hydroxide

L₂: Solution containing an unknown concentration of succinic acid

L₃: Ethoxyethane

Also provided: Distilled water, Phenolphthalein indicator (POP)

Theory

Succinic acid dissolves in both water and ethoxyethane and distributes at constant temperature in a fixed ratio between the two solvents.

Procedure 1

(i) Pipette 25.0 cm³ of L₂ into a conical flask and add 2–3 drops of POP

- (ii) Fill the burette with L₁
- (iii) Titrate L₂ against L₁ until colour changes

Suppose:

Volume of L₁ used = 20.5 cm³

Volume of pipette used = 25.0 cm³

(a) Results

(i) Volume of pipette used = 25.0 cm³

(ii) Volume of L₁ used = 20.5 cm³

(iii) Room temperature = 25 °C

(b) Procedure 2

(i) Measure 75.0 cm³ of L₃ and mix with 75.0 cm³ of distilled water in separating funnel

(ii) Add 7.5 cm³ of L₂, shake and allow to stand

(iii) Separate layers, pipette 25.0 cm³ of aqueous layer

(iv) Titrate this aliquot against L₁

Suppose:

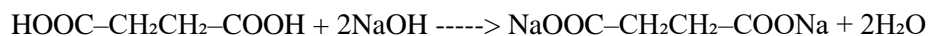
Volume of L₁ used = 7.0 cm³

(b) Results

(i) Volume of aqueous layer taken = 25.0 cm³

(ii) Volume of L₁ used = 7.0 cm³

(c) Balanced chemical equation:



(d) Calculate:

(i) Initial concentration of L₂ in water

$$\text{Volume of } L_1 = 20.5 \text{ cm}^3 = 0.0205 \text{ dm}^3$$

$$\text{Concentration} = 0.10 \text{ M}$$

$$\text{Moles of NaOH} = 0.10 \times 0.0205 = 0.00205 \text{ mol}$$

Succinic acid is dibasic, so:

$$\text{Moles of acid} = 0.00205 \div 2 = 0.001025 \text{ mol}$$

$$\text{Volume of acid} = 25.0 \text{ cm}^3 = 0.025 \text{ dm}^3$$

$$\text{Concentration} = 0.001025 \div 0.025 = 0.0410 \text{ mol/dm}^3$$

(ii) Final concentration of L_2 in aqueous layer

$$\text{Volume of } L_1 = 7.0 \text{ cm}^3 = 0.0070 \text{ dm}^3$$

$$\text{Moles of NaOH} = 0.10 \times 0.0070 = 0.0007 \text{ mol}$$

$$\text{Moles of acid} = 0.0007 \div 2 = 0.00035 \text{ mol}$$

$$\text{Volume} = 25.0 \text{ cm}^3 = 0.025 \text{ dm}^3$$

$$\text{Concentration} = 0.00035 \div 0.025 = 0.0140 \text{ mol/dm}^3$$

(e) Concentration in organic layer

$$\text{Initial moles} = 0.001025$$

$$\text{Final in aqueous} = 0.00035$$

$$\text{In organic} = 0.001025 - 0.00035 = 0.000675 \text{ mol}$$

$$\text{Total volume of ethoxyethane} = 75.0 \text{ cm}^3 = 0.075 \text{ dm}^3$$

$$\text{Concentration} = 0.000675 \div 0.075 = 0.0090 \text{ mol/dm}^3$$

(f) Partition coefficient = conc. in water \div conc. in ether

$$= 0.0140 \div 0.0090 = 1.56$$