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.

1. You are provided with the following:

F_1: An acidified solution of hydrogen peroxide obtained by reacting 8.45 g of a metal peroxide MO_2 with dilute H_2SO_4 and making the final solution up to 1 dm^3

F_2: A solution of potassium permanganate ($KMnO_4$) prepared by dissolving 3.16 g of the salt in 1 dm^3 of distilled water

Theory

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

$MO_2 + H_2SO_4 \text{ -----> } MSO_4 + H_2O_2$

Hydrogen peroxide reacts with $KMnO_4$ in acidic conditions according to the reaction:

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

Procedure

(i) Pipette 25.0 cm^3 of F_1 into a clean titration flask

(ii) Add dilute sulphuric acid to acidify

(iii) Titrate with F_2 until a faint pink colour persists

(iv) Repeat for concordant titres

Summary

25.0 cm^3 of solution F_1 required 22.50 cm^3 of solution F_2 for complete reaction

Questions

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

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

(b) Calculate the concentration of hydrogen peroxide in mol/dm^3

Given directly:

Concentration of H_2O_2 = 0.1536 mol/dm³

(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 dm³ = 0.1536 mol

Mass of MO_2 = 8.45 g

Molar mass of MO_2 = 8.45 ÷ 0.1536 = 55.03 g/mol

MO_2 = M + 2×16 = 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 $Jg^{-1}K^{-1}$

Δt = temperature change in °C

Assume the following temperature readings:

Experiment	Initial Temperature (°C)	Final Temperature (°C)	Temperature Change (°C)	Total Volume (cm³)
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)

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

$= -1 \times 200 \times 4.2 \times 7.4$

= -6216 J = -6.216 kJ

(ii) Second experiment (NaOH + CH_3COOH)

$q = -1 \times 200 \times 4.2 \times 6.0$

= -5040 J = -5.040 kJ

(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 × 0.1 = 0.2 mol

(i) NaOH + HCl

Molar enthalpy = heat change ÷ moles

= -6.216 ÷ 0.2 = -31.08 kJ/mol

(ii) NaOH + CH_3COOH

Molar enthalpy = -5.040 ÷ 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 + CH_3COOH).

This is because HCl is a strong acid and ionizes completely, while CH_3COOH 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:

L_1: 0.10 M sodium hydroxide

L_2: Solution containing an unknown concentration of succinic acid

L_3: 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 cm^3 of L_2 into a conical flask and add 2–3 drops of POP

(ii) Fill the burette with L_1

(iii) Titrate L_2 against L_1 until colour changes

Suppose:

Volume of L_1 used = 20.5 cm^3

Volume of pipette used = 25.0 cm^3

(a) Results

(i) Volume of pipette used = 25.0 cm^3

(ii) Volume of L_1 used = 20.5 cm^3

(iii) Room temperature = 25 °C

(b) Procedure 2

(i) Measure 75.0 cm^3 of L_3 and mix with 75.0 cm^3 of distilled water in separating funnel

(ii) Add 7.5 cm^3 of L_2, shake and allow to stand

(iii) Separate layers, pipette 25.0 cm^3 of aqueous layer

(iv) Titrate this aliquot against L_1

Suppose:

Volume of L_1 used = 7.0 cm^3

(b) Results

(i) Volume of aqueous layer taken = 25.0 cm^3

(ii) Volume of L_1 used = 7.0 cm^3

(c) Balanced chemical equation:

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

(d) Calculate:

(i) Initial concentration of L_2 in water

Volume of L_1 = 20.5 cm^3 = 0.0205 dm^3

Concentration = 0.10 M

Moles of NaOH = 0.10 × 0.0205 = 0.00205 mol

Succinic acid is dibasic, so:

Moles of acid = 0.00205 ÷ 2 = 0.001025 mol

Volume of acid = 25.0 cm^3 = 0.025 dm^3

Concentration = 0.001025 ÷ 0.025 = 0.0410 mol/dm^3

(ii) Final concentration of L_2 in aqueous layer

Volume of L_1 = 7.0 cm^3 = 0.0070 dm^3

Moles of NaOH = 0.10 × 0.0070 = 0.0007 mol

Moles of acid = 0.0007 ÷ 2 = 0.00035 mol

Volume = 25.0 cm^3 = 0.025 dm^3

Concentration = 0.00035 ÷ 0.025 = 0.0140 mol/dm^3

(e) Concentration in organic layer

Initial moles = 0.001025

Final in aqueous = 0.00035

In organic = 0.001025 − 0.00035 = 0.000675 mol

Total volume of ethoxyethane = 75.0 cm^3 = 0.075 dm^3

Concentration = 0.000675 ÷ 0.075 = 0.0090 mol/dm^3

(f) Partition coefficient = conc. in water ÷ conc. in ether

= 0.0140 ÷ 0.0090 = 1.56