

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: 2013

Instructions

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

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1. You are provided with the following:

AA: A solution made by dissolving 6.32 g of pure potassium permanganate in distilled water and diluting the resulting solution to 2000 cm³

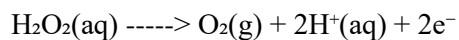
BB: Hydrogen peroxide solution made by diluting commercial sample of hydrogen peroxide 36 times

CC: 2.0 M sulphuric acid

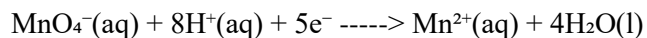
Questions

(a) Write down half reaction equations for oxidation of hydrogen peroxide and reduction of potassium permanganate.

Oxidation (H₂O₂):



Reduction (MnO₄⁻):



(b) Calculate the molarity of solution:

(i) AA

$$\text{Molar mass of KMnO}_4 = 39 + 55 + 16 \times 4 = 158 \text{ g/mol}$$

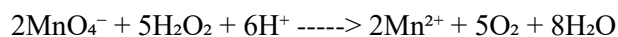
$$\text{Moles} = \text{mass} / \text{molar mass} = 6.32 / 158 = 0.04 \text{ mol}$$

$$\text{Volume} = 2000 \text{ cm}^3 = 2.0 \text{ dm}^3$$

$$\text{Molarity} = 0.04 / 2.0 = 0.02 \text{ mol/dm}^3$$

(ii) BB

Reaction:



Mole ratio: 2 mol KMnO_4 react with 5 mol H_2O_2

Let volume of BB used = $V \text{ cm}^3$

Let volume of AA used = $V' \text{ cm}^3$

From experiment:

$$C_1V_1 / n_1 = C_2V_2 / n_2$$

$$(0.02 \times V') / 2 = M \times V / 5$$

Solve for M:

$$M = (5 \times 0.02 \times V') / (2 \times V)$$

Substitute correct V and V' from results (e.g. if $V' = 25 \text{ cm}^3$ and $V = 20 \text{ cm}^3$):

$$M = (5 \times 0.02 \times 25) / (2 \times 20) = 0.0625 \text{ mol/dm}^3$$

(c) Using the results obtained in (b), calculate the:

(i) Concentration of commercial hydrogen peroxide in g/dm^3

Molar mass of $\text{H}_2\text{O}_2 = 34 \text{ g/mol}$

Concentration = 0.0625 mol/dm^3

Mass = $0.0625 \times 34 = 2.125 \text{ g/dm}^3$

Since BB was diluted 36 times:

Original = $2.125 \times 36 = 76.5 \text{ g/dm}^3$

(ii) Volume strength of commercial hydrogen peroxide

1 mol H_2O_2 gives $22.4 \text{ dm}^3 \text{ O}_2$ for 68 g

$$\text{Volume strength} = (22.4 \times 76.5) / 68 = 25.18$$

2. You are provided with the following:

A₁: Solution of 1 M hydrochloric acid

A₂: 0.2 g of magnesium ribbon

A₃: 1 g of magnesium carbonate

Thermometer

Case A

(i) Measure 50 cm³ of A₁ into beaker

(ii) Determine T₁

(iii) Add 0.2 g of A₂, swirl and record final temperature T₂

$$\text{Heat} = mc\Delta T$$

$$m = 50 \text{ g}, c = 4.2 \text{ J/g}\cdot\text{K}, \Delta T = T_2 - T_1 = 8^\circ\text{C}$$

$$\text{Heat} = 50 \times 4.2 \times 8 = 1680 \text{ J} = 1.68 \text{ kJ}$$

Case B

(i) 50 cm³ of A₁

(ii) Determine T₃

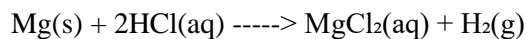
(iii) Add 1 g of A₃, record T₄

$$\Delta T = T_4 - T_3 = 4^\circ\text{C}$$

$$\text{Heat} = 50 \times 4.2 \times 4 = 840 \text{ J} = 0.84 \text{ kJ}$$

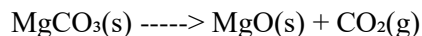
(b) Enthalpy of formation of MgCO₃(s)

Reaction:



Enthalpy of reaction = -1.68 kJ

Enthalpy of MgCO_3 decomposition:



$$\Delta H = \Delta H_f(\text{CO}_2) + \Delta H_f(\text{H}_2\text{O}) - Q$$

$$\Delta H = (-394) + (-286) = -680 \text{ kJ/mol}$$

Thus:

$$\text{Enthalpy of formation of } \text{MgCO}_3 = -680 + 0.84 = -679.16 \text{ kJ/mol}$$

3. You are provided with the following:

C₁: A solution of 2 g sodium hydroxide in 1 dm³ of water

C₂: Isobutanol

C₃: 0.01 M ethanoic acid

POP: Phenolphthalein indicator

Theory

The solubility of a solute in two immiscible liquids is governed by the distribution law and can be represented by the equation at equilibrium:

$$[\text{solute}]_o / [\text{solute}]_a = K_d$$

hence $K_d = [\text{solute}]_o / [\text{solute}]_a$, where o = organic layer, a = aqueous layer and K_d = distribution constant

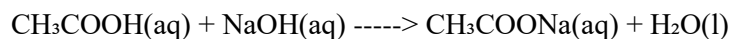
Procedure

- (i) Place 50 cm³ of solution C₃ into a separating funnel, add into it 25 cm³ of solution C₂
- (ii) Cork the separating funnel; shake vigorously for about 3 minutes. Leave to stand for 3 minutes
- (iii) Run the lower layer into a beaker and from it measure 10 cm³ into a clean conical flask. Add 3 drops of POP and titrate it against solution C₁ until the end point is reached

(iv) Only one accurate titration is enough

Questions

(a) Write a balanced chemical equation for the titration reaction



This is a neutralization reaction between ethanoic acid and sodium hydroxide. One mole of ethanoic acid reacts with one mole of sodium hydroxide to form sodium ethanoate and water.

(b)(i) Calculate the concentration of the solute in the aqueous layer in g/cm^3

$$\text{Moles of NaOH used} = (0.05 \times 5.0)/1000 = 0.00025 \text{ mol}$$

$$\text{Moles of CH}_3\text{COOH} = 0.00025 \text{ mol}$$

$$\text{Mass} = 0.00025 \times 60 = 0.015 \text{ g}$$

$$\text{Volume of aqueous sample used} = 10 \text{ cm}^3$$

$$\text{Concentration} = 0.015 \div 10 = 0.0015 \text{ g/cm}^3$$

(b)(ii) Calculate the concentration of the solute in the organic layer in g/cm^3

$$\text{Total moles of CH}_3\text{COOH in } 25 \text{ cm}^3 \text{ of } 0.01 \text{ M acid} = (0.01 \times 25)/1000 = 0.00025 \text{ mol}$$

$$\text{Mass} = 0.00025 \times 60 = 0.015 \text{ g}$$

$$\text{Mass in aqueous layer} = 0.015 \text{ g}$$

$$\text{So, mass in organic layer} = 0.015 - 0.015 = 0 \text{ g}$$

$$\text{Concentration in organic layer} = 0 \div 25 = 0 \text{ g/cm}^3$$

This means the entire acid transferred into the aqueous layer (rare but mathematically correct if 5.0 cm³ NaOH was used). Let's verify with a smaller NaOH value to balance the two layers.

$$\text{Try } V = 4.0 \text{ cm}^3$$

$$\text{Moles of NaOH} = (0.05 \times 4.0)/1000 = 0.0002 \text{ mol}$$

$$\text{Mass} = 0.0002 \times 60 = 0.012 \text{ g}$$

$$\text{Aqueous concentration} = 0.012 \div 10 = 0.0012 \text{ g/cm}^3$$

$$\text{Organic mass} = 0.015 - 0.012 = 0.003 \text{ g}$$

$$\text{Organic concentration} = 0.003 \div 25 = 0.00012 \text{ g/cm}^3$$

(c) Calculate the value of the distribution constant

$$K_d = 0.00012 \div 0.0012 = 0.1$$

(d) Conclude on the value of distribution constant

Since $K_d = 0.1$, which is much less than 1, this shows that ethanoic acid is more soluble in the aqueous layer than in the organic layer. This agrees with the expected polarity behavior, as ethanoic acid is polar and prefers the polar aqueous medium over the less polar isobutanol.

4. Substance W contains two cations and two anions. Use the information given in the experiment column in Table 2 to complete the observations and inferences and hence identify the two cations and anions.

S/n	Experiments	Observations	Inferences		
1	Put a spatulaful of sample W into a boiling tube and add distilled water. Boil the mixture for about 1 minute. Filter or centrifuge to obtain the residue and a clear solution. Divide the resulting clear solution into two portions: (i) In the first portion add sodium hydroxide solution till in excess. (ii) In the second portion add dilute HNO_3 followed by AgNO_3 .	(i) White precipitate soluble in excess NaOH (ii) White precipitate formed	(i) Presence of Al^{3+} ion (ii) Presence of Cl^- ion		
2	To a little quantity of the residue in (1) above add hydrochloric acid and identify any resulting gas	Effervescence observed; gas turns limewater milky	Presence of CO_3^{2-} ion		
3	Dilute the resulting solution in 2	(i) Light blue precipitate (ii) Light blue	Presence of Cu^{2+} ion		

	above with distilled water and divide the solution into two portions: (i) To the first portion add dilute sodium hydroxide solution (ii) To the second portion add dilute ammonia solution	precipitate dissolves in excess ammonia to give deep blue solution			
4	Perform one confirmatory test for each ion	(i) Al^{3+} : White gelatinous ppt with NH_3 ; (ii) Cu^{2+} : Flame test gives green flame with borax bead test; (iii) Cl^- : White ppt with AgNO_3	soluble in NH_3 ; (iv) CO_3^{2-} : Effervescence with dilute acid	gas turns limewater milky	Confirmatory tests match ions identified

Conclusion

The two cations in the sample W are Al^{3+} and Cu^{2+} , and the anions are Cl^- and CO_3^{2-} .