

Uganda Martyrs University

UNIVERSITY EXAMINATIONS

FACULTY OF SCIENCE

DEPARTMENT OF NATURAL SCIENCE

END OF SEMESTER FINAL ASSESMENT

SEMESTER 2, 2022/2023

COURSE: **BACHELOR OF SCIENCE WITH EDUCATION**
YEAR: **1, 2 & 3**
EXAM: **MATHEMATICAL CHEMISTRY**
CODE: **CHE 1202**
SEMESTER: **II**
DATE: **MAY 18, 2023**
TIME: **2:00-5:00PM**
DURATION: **3 HOURS**

INSTRUCTIONS:

This paper has five questions. Attempt only four Questions.

Write on both sides of the answer sheets but begin each question on a fresh page.

Do not write anywhere on the question paper.

Use a graph paper where applicable.

1. (a) Discuss how the concept of BODMAS can be used to determine
- Molecular mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, ($\text{Cu} = 64$, $\text{S} = 32$, $\text{O} = 16$, $\text{H} = 1$) [5 mks]
 - The value of the left hand side of the expression below. Suppose 1 mole of argon occupies $2.5 \times 10^{-3} \text{ m}^3$ at $1.0 \times 10^5 \text{ Pa}$. Given that a is $0.16 \text{ Pa m}^6 \text{ mol}^{-2}$ and b is $4.0 \times 10^{-5} \text{ m}^3 \text{ mol}^{-1}$. [6 mks]

$$\left[P + \left(\frac{n^2 a}{V^2} \right) \right] (V - nb) = nRT$$

- A chemist prepares a solution containing $1/50$ mole of propanol in 1000ml of water. Use the principle of multiplying fractions to determine the moles in a 250ml aliquot of this solution? [5 mks]
- In the esterification reaction, 32g of ethanol react with 60g of ethanoic acid to form 74g of ester.

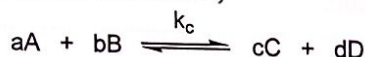
$$\text{CH}_3\text{OH} + \text{CH}_3\text{COOH} \longrightarrow \text{CH}_3\text{COOCH}_3 + \text{H}_2\text{O}$$
 - Determine the fractional yield [5 mks]
 - Determine the percentage yield [4 mks]
- In an experiment, the pressure of a gas is monitored as the temperature is changed, while the volume and amount of gas remain constant and the following relationship was established:

$$p = 0.034T$$

- Identify the variables and coefficients in the equation [3 mks]
 - What is p a function of? [2 mks]
 - Given T is 320, what is the value of p ? [3 mks]
- (b) Use the laws of indices to make a the subject in the equation below
- $$v = u + at$$
- (c) make K_c the subject in the equation below [5 mks]
[6 mks]

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - 2.303 \frac{RT}{nF} \log K_c$$

- (d) Find the units of the molar gas constant R using the ideal gas equation where p is measured in $\text{kg m}^{-1} \text{s}^{-2}$, V in m^3 , n in mol and T in K [6 mks]
- $$pV = nRT$$
3. (a) For the hypothetical reaction below,



- Write the expression for K_c [3 mks]
 - Find the simplified logarithm expression of K_c [4 mks]
 - Make d the subject in the expression [5 mks]
- (b) (i) Rearrange the pH expression below to make $[\text{H}^+]$ the subject [3 mks]
- $$\text{pH} = -\log[\text{H}^+]$$
- (ii) Rearrange the Arrhenius equation and make T the subject [5 mks]

$$k = A \exp \left(-\frac{E_a}{RT} \right)$$

- (c) A molecule of N_2 has a mass of $4.6 \times 10^{-26} \text{ kg}$ and is at a temperature of 293 K. The nitrogen's velocity is given in the equation:

$$E_k = \frac{1}{2} mv^2$$

$$E_k = \frac{1}{2} k_b T$$

What is the velocity, given k_b is 1.4×10^{-23} ? [5 mks]

4. 2.5 g of calcium carbonate are placed in globe of capacity 850 cm^3 . The globe is evacuated and heated to a temperature of 80°C at which the gases evolved exerted a pressure of 26660 Nm^{-2} .

(a) Write the equation for the reaction [2 mks]

(b) State the stoichiometric ratios of the products obtained [2 mks]

(c) Calculate

(i) v/w ratio of carbon dioxide in the compound [5 mks]

(ii) percentage composition of calcium carbonate decomposed [8 mks]

- (d) In the water-gas shift reaction, a sample containing 0.632 M CO_2 and 0.570 M H_2 is allowed to equilibrate at 700 K . At this temperature, $K_c = 0.106$.

(i) Write the equation for the reaction [2 mks]

(ii) Write the quadratic expression [2 mks]

(iii) What is the composition of the reaction mixture at equilibrium? [4 mks]

5. (a) The hydrolysis of ethylethanoate to ethanoic acid follows first order kinetics with respect to ethylethanoate ie



i) derive the integral equation for the rate of the above reaction [10 mks]

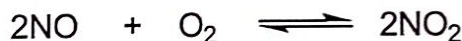
ii) show that the half-life $t_{1/2}$ from the integral equation is given by [5 mks]

$$t_{1/2} = \frac{\ln 2}{k}$$

iii) If 50% of ethylethanoate is hydrolysed in 80 minutes, at the same conditions, how long will it take for 30% of the ethylethanoate to be hydrolysed?

[5 mks]

(b) The reaction,



Is at equilibrium at 25°C with the equilibrium constant K_c being 375. The equilibrium $[\text{O}_2]$ is 0.0148 moles in 0.755 litres . What is the ratio of $[\text{NO}]$ to $[\text{NO}_2]$ in the equilibrium mixture? [5 mks]

---End---