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
   (i) Molecular mass of $CuSO_4.5H_2O$, (Cu =64, S=32, O=16, H=1) [5 mks]
   (ii) The value of the left hand side of the expression below. Suppose 1 mole of argon occupies $2.5x10^{-3}$ m^3 at $1.0x10^5$ Pa. Given that a is 0.16 Pa m^6 mol^{-2} and b is $4.0x10^{-5}$ m^3 mol^{-1}. [6 mks]

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

   (b) 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]
   (c) In the esterification reaction, 32g of ethanol react with 60g of ethanoic acid to form 74g of ester.

$$CH_3OH + CH_3COOH \longrightarrow CH_3COOCH_3 + H_2O$$

   (i) Determine the fractional yield [5 mks]
   (ii) Determine the percentage yield [4 mks]

2. (a) 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:

$$p = 0.034T$$

   (i) Identify the variables and coefficients in the equation [3 mks]
   (ii) What is p a function of? [2 mks]
   (iii) 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

$$v = u + at$$

   [5 mks]
   (c) make K_c the subject in the equation below [6 mks]

$$E_{cell} = E^o_{cell} - 2.303\frac{RT}{nF}\log K_c$$

   (d) Find the units of the molar gas constant R using the ideal gas equation where p is measured in kg $m^{-1}s^{-2}$, V in m^3, n in mol and T in K [6 mks]

$$pV = nRT$$

3. (a) For the hypothetical reaction below,

$$aA + bB \underset{}{\overset{k_c}{\rightleftharpoons}} cC + dD$$

   (i) Write the expression for K_c [3 mks]
   (ii) Find the simplified logarithm expression of K_c [4 mks]
   (iii) Make d the subject in the expression [5 mks]
   (b) (i) Rearrange the pH expression below to make $[H^+]$ the subject [3 mks]

$$pH = -\log[H^+]$$

   (ii) Rearrange the Arrhenius equation and make T the subject [5 mks]

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

   (c) A molecule of N_2 has a mass of $4.6x10^{-26}$ 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°Cat 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, $Kc = 0.106$.
      (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

$$CH_3COOC_2H_5 + H_2O \rightleftharpoons CH_3COOH + CH_3CH_2OH$$

   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]

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

   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,

$$2NO + O_2 \rightleftharpoons 2NO_2$$

Is at equilibrium at 25°C with the equilibrium constant Kc being 375. The equilibrium $[O_2]$ is 0.0148 moles in 0.755 litres. What is the ratio of [NO] to $[NO_2]$ in the equilibrium mixture? [5 mks]

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