SO

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

SPECIAL/SUPPLEMENTARY EXAMINATIONS
2021/2022 ACADEMIC YEAR
FIRST YEAR FIRST SEMESTER EXAMINATIONS
FOR THE DEGREE
OF
BSc (CHEMISTRY) AND BSc (INDUSTRIAL CHEMISTRY)

COURSE CODE: **SCH 170**

COURSE TITLE: **MATHEMATICS FOR CHEMISTS**

DATE: *Thursday 28/07/2022* **TIME:** *8.00 – 10.00 AM*

INSTRUCTIONS TO CANDIDATES

Answer all the Questions

TIME: 2 Hours

QUESTION ONE [20 MARKS]

a) Pressure can be expressed in various units as shown in the table below

Unit	Value
Atmosphere (Atm)	1 atm
Pascal	1 atm = 1.01325×10^5 Pa
Millimeter of mercury	1 atm = 760 mmHg
Torr	1 atm = 760 torr

The lowest pressure ever recorded at sea level was 25.69 mmHg. Express this pressure in: [3 Marks]

(i) Atmospheres
(ii) kPa
(iii) Torr

b) Below is the van der Waals equation which relates the pressure **P**, the volume **V** and the absolute temperature **T** of an amount **n** of a gas.

$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ Where a and b are constants

Make '**a**' the subject of this equation. [3 marks]

c) Combustion of a 1.000 g sample of an organic compound known to contain carbon, hydrogen and oxygen, produces2.360 g of CO_2 and 0.640 g H_2O. (C = 12, H = 1, O = 16)

(i) Calculate the mass of Carbon in the CO_2 produced. [1 Mark]
(ii) Calculate the mass hydrogen in the H_2O produced. [1 Mark]
(iii) Calculate the mass of oxygen in 1.000 g sample of the organic compound. [1 Mark]
(iv) Hence determine the empirical formula of the organic compound [2 Marks]

d) The overall equation for the extraction of aluminium is as follows.

$2Al_2O_3 \rightarrow 4Al + 3O_2$

(i) Calculate how many tonnes of aluminium can be obtained from 2040 tonnes of aluminium oxide. (Al = 27, O = 16) [3 marks]
(ii) Calculate the volume of oxygen in m^3 that could be formed from 2040 tonnes of aluminium oxide. The volume of 1 mol of gas at room temperature and pressure is 0.024 m^3. [3 marks]

e) Find the value and the units of the molar gas constant R using the ideal gas equation,

$PV = nRT$

Given p = 4.0×10^5 kg m^{-1} s^{-2}, V= 3.75×10^{-3} m^3, n = 0.1mole and T = 2°8C. [3 marks]

QUESTION TWO [18 MARKS]

a) Use LCM, even numbers or otherwise to balance the following equation

$FeS_{2\,(s)} + O_{2\,(g)} \rightarrow Fe_2O_{3(s)} + SO_{2\,(g)}$ [2 Marks]

b) A solution contains $\frac{1}{35}$ mole of NaOH in 1000ml of water. How many moles of NaOH are there in a 250ml aliquot of this solution? [2 Marks]

c) The pH of a solution is given by the equation $pH = -log_{10}[H^+]$

(i) Rearrange the equation to get an expression for determining $[H^+]$ [2 Marks]

(ii) Determine the concentration of hydrochloric acid whose pH = - 0.4786 [1 Marks]

(iii) 0.1 moles of a weak acid with a dissociation constant $K_a = 1.8 \times 10^{-4}$ is dissolved in water to form a solution. The K_a relates the concentration of the H^+ ions, $[H^+]$, and the amount of acid dissolved, N, by the equation:

$$K_a = \frac{[H^+]^2}{N - [H^+]}$$

(I) Determine the value of $[H^+]$ in the solution [4 Marks]

(II) Hence calculate the pH of the solution [2 Marks]

d) Rate constants for the first-order decomposition is given by the equation:

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

The equation below shows decomposition of acetone dicarboxylic acid

$$\underset{\text{Acetonedicarboxylic acid}}{CO(CH_2COOH)_2\,(aq)} \rightarrow \underset{\text{Acetone}}{CO(CH_3)_2\,(aq)} + 2\,CO_2\,(g),$$

The rate constants for this decomposition are $k = 4.75 \times 10^{-4}\ s^{-1}$ at 293 K and $k = 1.63 \times 10^{-3}$ at 303 K. Calculate the activation energy, E_a, for this reaction? ($R = 0.08206$ L Atm mol^{-1}. K^{-1}

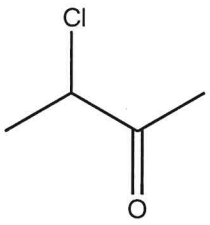
[5 Marks]

QUESTION THREE [17 MARKS]

a) Make θ the subject of the equation below [3 Marks]

$$\frac{\theta^2}{(1-\theta)^2} = K[A]$$

b) Without considering, the hydrogen atoms, determine the atom connectivity matrix of benzene shown below: Explain how you arrive at you answer. [6 Marks]



a) Data from adsorption of xenon gas on a sample of a porous solid gave the following equations, in which V_O is the volume (in cm^3) of the gas required to cover the surface of the solid completely and K is a constant.

$$\frac{1}{V_0K} + \frac{1.31}{V_0} = 0.91176 - - - - - - - - (equestion\ 1)$$

$$\frac{1}{V_0K} + \frac{4.17}{V_0} = 2.373 - - - - - - - - - - (equation\ 2)$$

Compute the values of V_0 and K [8 Marks]

QUESTION FOUR [15 MARKS]

a) Braggs equation which is very useful in analysis of crystals is written as:

$\lambda = \frac{2d}{n} \sin\theta$.

Where: d = separation between successive layers in a crystal,

λ = the wavelength of the X-rays

n = an integer n

Θ = angle through which the X-rays are scattered

Determine the rate of change of λ with Θ [3 Marks]

c) The electrode potential of a copper electrode $E_{Cu^{2+},Cu}$, immersed a solution of Cu^{2+} ions, at a given temperature, T, can be determined using the Nernst equation below.

$$E_{Cu^{2+},Cu} = E^{\theta}{}_{Cu^{2+},Cu} + \frac{RT}{nF} \ln[\frac{a(Cu^{2+})}{a(Cu)}]$$

Where;

$E^{\theta}{}_{Cu^{2+},Cu}$ is the standard electrode potential of a copper; $a(Cu^{2+})$ and $a(Cu)$ are the activities of copper (II) ions and the copper electrode, respectively, in the solution; **n** are the number of moles of the ions in solution; while R and F are constants.

(i) Identify the variables in this equation and indicate whether the variable is independent or dependent. [6 Marks]

d) The electrode potential of copper at 298K was determined to be 0.300 V. Given that the standard electrode potential of copper is 0.34V and assuming the activity copper through the experiment was 1, calculate the value of $a(Cu^{2+})$. [Take R = 8.314 $JK^{-1}mol^{-1}$; F = 9.648 x 10^4 $Cmol^{-1}$; n = 1 mol; and 1volt = $1JC^{-1}$) [6 Marks]