MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR BACHELOR OF SCIENCE (ELECTRIC AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 102: CHEMISTRY FOR ENGINEERS II

DATE: 10/8/2021 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.

Required data

- Gas constant, R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 1 atm = 760 mmHg = 101325 Nm^{-2}

Section A - Compulsory.

QUESTION ONE (30 MARKS)

a) Calculate the vapour pressure of a solution containing 5.85 g benzene (MW = 78) and 2.3 g of toluene (MW = 92) at 323K, if the vapour pressures of the pure components at this temperature are 3.6 x 10^4 Nm^{-2} and 1.12 x 10^4 Nm^{-2}, respectively. (4 marks)

b) The rate of diffusion of O_2 is 0.6litres /sec. Given that the vapour density of gas X is 14 calculate the rate of diffusion for gas X (3 marks)

c) i) States the Boyles's law? (1 mark)

ii) 500.0 liters of a gas in a flexible-walled container are prepared at 700.0 mmHg and

200.0 °C. The gas is placed into a tank under high pressure. When the tank cools to

20.0 °C, the pressure of the gas is 30.0 atm. What is the volume of the gas?

(3 marks)

iii) A sample of 0.5 moles of NH_3 gas occupies 0.5 L at 0 °C. Calculate the pressure of the gas (in atm) using the:

I) Ideal gas equation (2 marks)

II) Van der Waals equation given a = 6.58 L^2 atm mol^{-2} and b = 0.056 L mol^{-2}

(3 marks)

d) i) State Dalton's Law of partial pressures (1 mark)

ii) 100 cm^3 of oxygen gas at 1.75 atm and 200 cm^3 of nitrogen gas at 0.6 atm are passed into a 500 cm^3 vessel. Compute the total pressure of the gas mixture in the vessel at the same temperature (4 marks)

e) i) State the Equilibrium law? (1 mark)

ii) Given the reversible equation: $N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g))}$ ΔH = -5508 J. Explain the

iii) Effect of the following changes on the position of the equilibrium (4 marks)

(a) decrease in pressure (b) Increase in temperature

(c) Removing ammonia (d) Addition of Hydrogen

iv) Given equation (i) $N_{2\,(g)} + ½\,O_{2\,(g)} \leftrightarrow N_2O_{\,(g)}$ Whose **K** is 2.0×10^{-2} and equation (ii) $N_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2NO_{\,(g)}$ whose **K** is 3.0×10^{-2}.

Compute the **K** for the reaction $2N_2O_{(g)} + O_{2\,(g)} \leftrightarrow 4NO_{\,(g)}$ (4 marks)

Section B: Answer any two questions

QUESTION (20 MARKS)

a) Define the following terms;

i) Galvanic cells

ii) Oxidation number

iii) Spontaneous Reaction (3 marks)

b) Given the following electrochemical cell: $Ag/Ag^+(0.5\ M)\ //\ Li^+(1.5\ M)/Li$ and the following cell potentials

$Li^+_{(aq)} + e^- \rightarrow Li$ $\quad E^o = -3.045\ V$

$Ag^+_{(aq)} + e^- \rightarrow Ag$ $\quad E^o = -0.799\ V$

i) Write the half reactions at the anode, cathode and the overall reaction (3 marks)

ii) Determine the e.m.f of the cell at 25 °C. (4 marks)

iii) Draw a schematic diagram of the cell using separate beakers for each half cell. Label the anode, cathode and the other components of the cell. Indicate the flow of the electrons (5 marks)

c) i) Write the balanced net ionic equation for the reaction

$Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$ (3 marks)

ii) Identify the oxidizing and the reducing agent in the above reaction (2 marks)

QUESTION THREE (20 MARKS)

a) Define the following terms;

i) Rate laws

ii) Zero order reaction

iii) Rate of reaction (3 marks)

b) Camphor is composed of 78.90% C and 10.51% O. The remainder is H. What is its empirical formula? (3 marks)

c) Briefly explain three factors that influence the rate of a chemical reaction (3 marks)

d) Define half-life ($t_{1/2}$) and show that for a 1st order rate reaction, the half life ($t_{1/2}$) is independent of initial concentration. (5 marks)

e) The reaction $2NOCl_{(g)} \rightarrow 2NO_{(g)} + Cl_{2(g)}$ is a second order reaction with respect to NOCl. K=0.81M-1s-1at 20°C. If the concentration of NOCl is 7.5 x 10^{-3}M, how much NOCl will be left after a reaction time of 10 minutes? Determine the half-life of this reaction (6 marks)

QUESTION FOUR (20 MARKS)

a) i) What is an ideal solution? (1 mark)

ii) Briefly describe the properties of an ideal solution. (2 marks)

b) What is the pH of 0.25M ammonia solution (NH_3) given that Kb=1.8 x10^{-5} (4 marks)

c) A chemist isolated a bacterial gene fragment and dissolved a 17.6 mg sample of the material in enough water to make 31.5 mL of solution. The osmotic pressure of the solution was 0.340 torr at 25.0 °C. Calculate the molar mass of the gene fragment. (4 marks)

d) i) What is a buffer solution? (1 mark)

ii) Derive the Henderson-Hasselbalch equation for a weak acid (CH_3COOH) (4 marks)

e) Sketch the following graphs:

i) Pressure against volume based on Boyle's law (2 marks)

ii) Volume against temperature based on Charles's law (2 marks)

QUESTION FIVE (20 MARKS)

a) i) State Raoult's Law (1 mark)

ii) Calculate vapour pressure of water over a solution made by dissolving 225 g of glucose in 575 g of water at 35 °C. (At 35 °C, P_{H2O} = 42.2 mmHg, MW of glucose is 180.2 g/mol and H_2O is 18.02 g/mol) (4 marks)

b) i) Define colligative properties (1 mark)

ii) List three examples of colligative properties. (3 marks)

c) Given an equation below for an ideal gas

$$P = \frac{mN\bar{u}^2}{3V}$$

show that the kinetic energy E_k for one mole of a gas is dependent on temperature (3 marks)

d) Suppose that in the reaction $PBr_{5\,(g)} \leftrightarrow PBr_{3\,(g)} + Br_{2\,(g)}$, the fraction of PBr_5 that dissociate to reach equilibrium is ***Y*** and the total gas pressure at equilibrium is **P**. Show that

$$K_p = \frac{Y^2P}{1 - Y^2}$$

(5 marks)

e) Given that K_{sp} for AgBr is 2.8×10^{-10} mol^2l^{-2} at 25 °C. Calculate the solubility of AgBr in 1 litre of water. (3 marks)