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 EDUCATION (SPECIAL EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (BIOLOGY)

BACHELOR OF SCIENCE (MATHEMATICS)

SCH 101: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: 9/8/2021 **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) i) States the Boyle's law (1 mark)

ii) The volume of a sample of ideal gas held at a fixed temperature is 2.25 L under a pressure of 8.46 atm. What is the volume of the gas if its expands at constant temperature until the pressure is 1.75 atm? (3 marks)

iii) By how much should the temperature be raised if 1.1 L of an ideal gas at 0.4775 atm and 12.2 °C undergoes a change in volume and pressure to 5.3 L and 1.22 atm. (3 marks)

(b) Calculate the approximate molar mass of an ideal gas whose density is 33.3 g/L at 30^{o}C and 780 torr. (3 marks)

(c) i) State the Dalton's Law of partial pressures. (1 mark)

ii) A mixture consist of 0.495 g of gas A whose molecular weight is 66 g and 0.182g of gas B of molecular weight 45.5 g if the total pressure of the two gases is 760.2 mmHg. Calculate the partial pressures of gas A and B. (4 marks)

(d) Compare the pressure predicted for 0.8 *litres* of 0.25 moles of CO_2 gas at 0 ^{o}C (in atm) using the:

i) Ideal gas equation (2 marks)

ii) Van der Waals equation given a = 6.581 L^2 atm mol^{-2} and b = 0.056 L mol^{-2} (3 marks)

(e) (i) Write an expression for the relationship between K_p and K_c (1 mark)

(ii) The K_C for the equilibrium reaction $2SO_{3\,(g)} \leftrightarrow 2SO_{2\,(g)} + O_{2\,(g)}$ is 1.45×10^{-4} at 227 ^{o}C. Calculate the K_p for the reaction and the partial pressure of SO_3 if the partial pressure of SO_2 is 0.928 atm and that of O_2 is 0.432 atm. (4 marks)

(f) i) State the *Le-Chatelier's* Principle (1 mark)

ii) Given the reversible equation: $2SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2SO_{3\,(g).}$ $\Delta H = 5508$ J. Explain the effect of the following changes on the position of the equilibrium. (4 marks)

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

(c) Addition of a catalyst (d) Addition of oxygen

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Discuss briefly what is a buffer solution (2 marks)

b) Derive the Henderson–Hasselbalch equation for (CH_3COOH), a weak acid. (4 marks)

c) What are colligative properties and what do they depend on? (4 marks)

d) State the following:

(i) Raoult's Law (1 mark)

(ii) Henry's Law (1 mark)

e) Calculate the vapour pressure of a solution containing 23.4 g benzene (MW=78) and 9.2g Toluene (MW=92) at 50 ^oC, if the vapour pressure of pure components at this temperature is 3.6 x 10^4 Nm^{-2} and 1.12 x10^4 Nm^{-2}, respectively. (4 marks)

f) A measured amount of Argon escaped through a tiny hole in 77.3 s. A similar amount of unknown gas escapes 20.3 s slower than Argon under the same conditions. Calculate the molar mass of the unknown gas given the molar gas for argon is 39.95$gmol^{-1}$ (4 marks)

QUESTION THREE (20 MARKS)

a) Differentiate between a first order and a second order reaction. (2 marks)

b) Given that for a first order equation

$$\text{Rate} = \frac{d[A]}{dt} = K[A]$$

Show that

$$[A] = [A]_o e^{-kt}$$

(5 marks)

c) 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)

d) From equation

$P = \frac{mN\overline{u}^2}{3V}$, for an ideal gas, show that the kinetic energy E_k for one mole of a gas is given by $E_k = \frac{3}{2}RT$ (3 marks)

e) Suppose that in the reaction $PCl_{5\,(g)} \leftrightarrow PCl_{3\,(g)} + Cl_{2\,(g)}$, the fraction of PCl_5 that dissociate to reach equilibrium is ***X*** and the total gas pressure at equilibrium is **P**. Show that

$$K_p = \frac{X^2P}{1 - X^2}$$ (5 marks)

QUESTION FOUR (20 MARKS)

a) Differentiate between voltaic cells and electrolytic cells (2 marks)

b) Given the following electrochemical cell: Zn (s) | Zn^{2+} (1 M) || Cu^{2+} (1 M) | Cu (s)

and the following cell potentials

$Cu^{2+} + 2\ e^- \rightarrow Cu$ $\quad E^\circ = 0.337$

$Zn \rightarrow Zn^{2+} + 2\ e^-$ $\quad E^0 = -0.763$

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) Is the cell spontaneous? (1 mark)

iv) 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) What is an ideal solution (1 mark)

(ii) List two properties of an ideal solution consisting of component A and B (2 marks)

d) What are the oxidation states of nitrogen and phosphorous in ammonium

dihydrogenphosphate $NH_4H_2PO_4$ (2 marks)

QUESTION FIVE (20 MARKS)

a) Given the reaction below:

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)

b) Isoprene is a liquid compound that can be polymerized to form synthetic rubber. It is composed of 88.17 % C and 11.83 % H. Its molar mass is 68.11 g/mol. Determine its empirical and molecular formula's? (5 marks)

c) Explain why when equal amounts of 0.150M NaOH and HCl are mixed the pH is 7, but when HCl is replaced with HOCl the solution is basic (5 marks)

d) The pH of 0.10M HClO which dissociates in water as shown below is 4.23, what is the K_a of HClO? (5 marks)

$HClO_{(aq)} \leftrightarrow H^+_{(aq)} + ClO^-_{(aq).}$