MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES
FIRST YEAR FIRST SEMESTER SUPPLEMENTRARY EXAMINATION FOR THE DEGREE OF
BACHELOR OF EDUCATION (SPECIAL EDUCATION)
BACHELOR OF EDUCATION (SCIENCE)
BACHELOR OF SCIENCE (BIOLOGY)
BACHELOR OF SCIENCE (MATHEMATICS)
BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SCH 101: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: 27/9/2019 **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.

Q1. a) i) States the Charles'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)

ii) A sample of 100 moles of NH_3 gas occupies 5 L at 100 °C. Calculate the pressure of the gas (in atm) using the:

I) Ideal gas equation (2 marks)

II) Van der Waals equation given a = 2.35 L^2 atm mol^{-2} and b = 0.0398 L mol^{-2} (3 marks)

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

ii) 150 cm^3 of oxygen gas at 1.5 atm and 175 cm^3 of nitrogen gas at 0.5 atm are passed into a 600 cm^3 vessel. Compute the total pressure of the gas mixture at the same temperature (4 marks)

c) i) State the Le Chatelier's Principle (1 mark)

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

iii) For the equilibrium $2SO_{3(g)} \leftrightarrow 2SO_{2(g)} + O_{2(g).}$ The K_c value is 4.07 x 10^{-3} mol $litre^{-1}$ at 1000 K. Compute the K_p for the reaction at the same temperature (4 marks)

d) It takes nitrogen gas 4 minutes to diffuse through an orifice. Calculate the time taken by methane (CH_4) gas to diffuse through the same orifice (3 marks)

e) A mixture of 0.005 moles of H_2 and 0.01 moles of I_2 are placed in a 5 L container at 500 °C and allowed to come to equilibrium. Analysis of the equilibrium shows that the concentration of HI is 1.87 x 10^{-3} M. Calculate K_c at 500 °C for the reaction. The stoichiometric equation of the reaction is $H_{2(g)} + I_{2(g).} \leftrightarrow 2HI_{(g)}$ (4 marks)

Section B: Answer any two questions

2. a) Define the following terms;

   i) Redox reaction

   ii) Oxidation number

   iii) Spontaneous Reaction (3 marks)

   b) Given the following electrochemical cell: $Sn/Sn^{2+}(0.5\ M)$ // $Cu^{2+}(1.5\ M)/Cu$ and the following cell potentials

   $Cu^{2+}{}_{(aq)} + 2e^- \rightarrow Cu \qquad E^o = +0.337\ V$

   $Sn^{2+}{}_{(aq)} + 2e^- \rightarrow Sn \qquad E^o = -0.136\ V$

   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)

3. a) Define the following terms;

   i) Zero order reaction

   ii) Rate of reaction

   iii) Rate constant (3 marks)

   b) Camphor is composed of 78.90% C and 10.59% H. The remainder is O. 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 1^{st} order rate reaction, the half life ($t_{1/2}$) is independent of initial concentration. (5 marks)

e) The following data was obtained for the decomposition of a certain compound A.

Time (min)	[A] (M)
0	0.36
15	0.30
30	0.25
48	0.19
75	0.13

i) Determine if the above data support a first order reaction. (4 marks)

ii) Calculate the rate constant for the reaction. (2 marks)

4. 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, MM 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) State three examples of colligative properties. (3 marks)

c) From equation

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

d) 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)

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

5. a) i) Define an ideal solution (1 mark)

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

b) Calculate the vapour pressure of a solution containing 11.7 g benzene (MW = 78) and 4.6 g methylbenzene (MW = 92) at 50 °C, if the vapour pressures of the pure components at this temperature are 3.6×10^4 Nm^{-2} and 1.12×10^4 Nm^{-2}, respectively. (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 (4 marks)

iii) Determine the change in H^+ ions and pH when 1 mL HCl is added to one litre of pure water (4 marks)