MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

BACHELOR OF SCIENCE (TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY)

BACHELOR OF SCIENCE IN FOOD NUTRITION AND DIETETICS

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (BIOLOGY)

SCH 101/HFN 141: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: **TIME:**

INSTRUCTIONS:

i) The paper consists of **TWO** sections, section **A** and section **B**.
ii) Section **A** is **compulsory** (30 marks).
iii) Answer any **two** questions from section **B** (each 20 marks).
iv) Scientific calculators may be used.

Given that, $$P = \frac{nRT}{v - nb} - \frac{an^2}{v^2}$$

SECTION A (COMPULSORY)
QUESTION ONE (30 MARKS)

a) Convert the following values to the units indicated in brackets (5 marks)
   i) 360 °C to (K)
   ii) 1350 torr to (atm.)
   iii) 0.35 Molar of H_2SO_4 to (g/L)
   iv) 0.05 cm^3 to Litres
   v) 17 L to dm^3

b) Define the following terms as used in chemistry: (7 marks)
   i) Mole
   ii) Diffusion
   iii) Auto ionization
   iv) pH
   v) Conjugate acid
   vi) A base
   vii) Common ion effect

c) Differentiate between a real gas and an ideal gas. (2 marks)

d) Calculate the pH of a 10.5 M solution of sodium hydroxide (3 marks)

e) The volume of an ideal gas collected at 87.0 ^{0}C and atmospheric pressure of 1.2 atmospheres is 240 ml. Calculate the moles of the gas in the vessel.(R = 0.0821atm.L/mole.K, O = 16.0) (3 marks)

f) Determine the pressure exerted on the walls of a container by 18litres containing 11.5 moles of CO_2 at 25 °C if it behaves like a real gas at this temperature. (4 marks)
Given that for CO_2, a = 3.59 $atm.mol^{-2}$ and b = 0.0427 $Lmol^{-1}$, R = 0.0821 $L.atm.mol^{-2}K^{-1}$

g) Calculate each of the following quantities: (6 Mks)
(Given that Na = 23.0, O = 16.0, C = 12.0, H = 1.0, K = 39.0, N = 14.0, L = 6.023x 10^{23})
i) Grams of solute in 300.0 ml of 0.45 M sodium ethanoate, CH_3COONa

ii) Molarity of a 2.45 litre solution containing 3.32 g potassium hydroxide, KOH.

iii) Moles of solute in 10.5 L of 2.5 M magnesium cyanide

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

a) Given the following reaction, state and explain what happens to the position of equilibrium when

$$N_2(g) + O_2(g) \rightleftharpoons 2NO\ (g)\ \Delta H = +181\ kJmol^{-1}$$

i) Temperature is raised (2 marks)

ii) Pressure is raised (2 marks)

iii) A catalyst is added (2 marks)

b) i) Calculate the equilibrium constant, Kc for the following reaction. (3 marks)

$PCl_3\ (g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ at 450 °C

Given that $[PCl_3] = 0.20$ M, $[Cl_2] = 0.125$ M and $[PCl_5] = 0.60$ M

(ii) State and explain the direction favoured by the equilibrium in the reaction in b (i). (1 mark)

(iii) Calculate the Kp value for this reaction (2 marks)

c) If 2 moles of hydrogen and 1 mole of iodine are mixed together in a $1dm^3$ vessel at 440 ^oC. How many moles of HI, H_2 and I_2 will be present at equilibrium?

Given that Kp = 0.02 and that the reaction proceeds as, $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ (5 marks)

d) 25 cm^3 of carbon (II) oxide, (CO), diffuses across a porous plate in 25 seconds. How long will it take 75 cm^3 of carbon (IV) oxide, (CO_2) to diffuse across the same plate under the same conditions of temperature and pressure. (C = 12.01, O = 16.0) (3 marks)

QUESTION THREE (20 MARKS)

a) (i) Starting from the ideal gas equation, $PV = nRT$ where n is the number of moles, Show that $M = \frac{\ell RT}{P}$ where M is the formula mass of the gas, R is the gas constant, T is the absolute temperature, P is pressure and ℓ is the density of the gas. (5 marks)

(ii) Calculate the density (g/L) of carbon (IV) oxide at r.t.p (3 marks)

(C = 12.01, O = 16.00, R = 0.0821 $atm.L.mol^{-1}K^{-1}$)

(iii) Determine the number of Carbon (IV) oxide molecules per liter (3 marks)

(Avogadros number, L = 6.023×10^{23} particles)

b) (i) State the Dalton's law of partial pressures. (1 mark)

(ii) Two gases A and B having relative molecular masses of 32 and 71 respectively are enclosed in a vessel. Their masses in the vessel are 0.5g and 0.3g respectively and the total pressure of the mixture is 760 mmHg. Calculate the partial pressures of the two gases. (5 marks)

c) 120 cm^3 of hydrogen chloride gas effuses through an apperture in 80 seconds. How long would it take 90 cm^3 of carbon (IV) oxide gas to effuse through the same pot under the same conditions (H =1.008, Cl = 35.5, C = 12.01, O =16.0) (3 marks)

QUESTION FOUR (20 MARKS)

a) Define the following terms as used in ionic equilibria of aqueous systems (4 marks)

i) Buffer solution

ii) Dynamic equilibrium

iii) Solubility

iv) Supersaturated solution

b) Given the boiling point of ethanol, C_2H_5OH as 78.5 °C. Determine the boiling point of a solution of 34 g vanillin (Vanillin molar mass = 152.14 g/mole) in 500.0 g ethanol. Given that K_b of ethanol is 1.22 °C/m) (4 marks)

c) Determine the hydrogen ion concentration in a solution with a pH of 2.0 (2 marks)

d) (i) Outline the procedure of preparing a buffer solution. (5 marks)

(ii) A bakery chef requires a carbonate buffer of pH 10.00 to study the effects of bread acidification. What mass of sodium carbonate must be added to 1.5 litres of 0.20 M (baking powder) $NaHCO_3$ to make the buffer? Given that Ka of $HCO_3^{1-} = 4.7 \times 10^{-11}$. (5 marks)

QUESTION FIVE (20 MARKS)

a) State the Henry's law of solubility of gases in liquids. (1 mark)

b) In a normal person, the partial pressure of O_2 gas dissolved in the plasma is 80 atm. at 37°C. Determine the solubility of O_2 in the plasma under these conditions given that the Henry's constant for O_2 in plasma = 3×10^{-2} mol/L.atm at 37 °C. (3 marks)

c) Calculate the vapour pressure of a solution of 11.0 g glycerol ($C_3H_8O_3$) in 250.0 g of water at 25.0 °C. At this temperature, the vapour pressure of pure water is 23.76 torr. (Assume the ideal behavior) (Given that H = 1.008, O = 16.00, C = 12.01) (5 marks)

d) Using a phase diagram, describe the water boiling point elevation and freezing point depression as a result of vapour pressure variation. (7 marks)

e) Calculate the freezing point of a solution when 500 g of the antifreeze ethylene glycol ($C_2H_6O_2$) is added to a car radiator, containing 2250 g water. (4 marks)

a. (Given that H = 1.008, C = 12.01, O = 16.00 and K_b = 1.86 °C/molal)