MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (BIOLOGY)

SCH 101/HFN 141: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: 28/1/2022 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

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

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Define the following terms as used in chemistry: (8 marks)

i. Mole
ii. Buffer solution
iii. Dynamic equilibrium
iv. Heterogenous reaction
v. Solubility
vi. Supersaturated solution
vii. Colligative properties
viii. Boiling point elevation

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

c) Determine the pressure exerted on the walls of a container by 18 litres containing 11.5 moles of CO_2 at 25 °C if it behaves like a real gas at this temperature. (3 marks)
(Given that for CO_2, a = 3.59 atm.L^2mol^{-2} and b = 0.0427 L.mol^{-1}, R = 0.0821L.atm.$mol^{-1}K^{-1}$)

d) The volume of an ideal gas collected at 47.0^0C and atmospheric pressure of 1.2 atmospheres is 180 ml. Calculate, the moles of the gas in the vessel. (3 marks)
(R = 0.0821 L.atm.$mol^{-1}K^{-1}$, O = 16.0)

e) Convert the following values to the units indicated in brackets (4 marks)
   i. 300 °C to (K)
   ii. 109 torr to (atm.)
   iii. 0.01 Molar of HCl to (g/L)
   iv. 0.05 cm^3 to (Litres)

f) Calculate each of the following quantities: (10 marks)
   i. Grams of solute in 170.8 ml of 0.045 M calcium ethanoate
   ii. Molarity of a 5 litre solution containing 3.32 g potassium iodide
   iii. Moles of solute in 3.011 L of 0.850 M sodium cyanide
   iv. Volume in litres of 2.88 M Potassium hydroxide that contains 8.96 g solute
   v. Number of Chloride ions in 5.2 L of 2.3M Copper (II) chloride as per the equation;
   $CuCl_2$ (aq) → Cu^{2+} (aq) + 2 Cl^{1-} (aq)

(Ca = 40.0, O = 16.0, C = 12.0, H = 1.0, K = 39.0, I = 127.0, N = 14.0, Cu = 63.5, Cl = 35.5, Avogadros number, L = 6.023x 10^{23})

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (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 x 10^{23} particles)

Commented [DN1]: Confirm the values for a and b and also the units. I am seeing from literature a is given in L^2.atm.mol^{-2}

Also confirm the units for R. I am seeing it should be L.atm.$mol^{-1}K^{-1}$

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

ii. Two gases A and B having relative molecular masses of 17 and 28 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 250 mmHg. Calculate the partial pressures of the two gases. (5 marks)

c) $120cm^3$ of hydrogen chloride gas effuses through an aperture in 80 seconds. Calculate the time it would take $90cm^3$ 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 THREE (20 MARKS)

a) i. State Le Chatelier's principle. (1 mark)

ii. Given the following reaction, state and explain what happens to the position of equilibrium when

$N_2(g) + 3F_2(g) \rightleftharpoons 2NF_3(g)$ $\Delta H = -98kJmol^{-1}$

I. Temperature is raised (2 marks)

II. Pressure is raised (2 marks)

III. A catalyst is added (1 mark)

b) i) Calculate the equilibrium constant, Kc for the following reaction and state the direction favoured by the equilibrium. (3 marks)

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at 450°C

Given that $[SO_2]$ =1.2 M, $[O_2]$ = 0.88 M and $[SO_3]$ =2.92 M

ii. Calculate the Kp value for this reaction (3 marks)

c) If 2 moles of Hydrogen and 1 mole of Iodine are mixed together in a $1dm^3$ vessel at 440ºC, determine the moles of HI, H_2 and I_2 will be present at equilibrium? (5 marks)

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

d) The solubility product of sodium sulphate at 20°C is 6.0×10^{-9} Mol^3 dm^{-9}. Calculate its solubility in grams per Litre at this temperature? (3 marks)

(O = 16.00, Na = 23.00, S = 32.07)

QUESTION FOUR (20 MARKS)

a) Define the following terms as used in ionic equilibria of aqueous systems (5 marks)

i. Auto ionization

ii. pH

iii. Conjugate base

iv. An acid

v. Common ion effect

b) Calculate the pH of a 0.005 M solution of sodium hydroxide (3 marks)

c) Determine the hydrogen ion concentration in a solution with a pH of 6.55 (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. Calculate the mass of sodium carbonate that must be added to 1.5 litres of 0.20M $NaHCO_3$ (baking powder) 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 soft drink plant, the partial pressure of CO_2 gas inside a bottle of Cola is adjusted to 4 atm. at 25°C. Calculate the solubility of CO_2 under these conditions? Given that the Henry's constant for CO_2 in water = 3×10^{-2} mol/L.atm at 25°C. (2 marks)

c) Using Raoult's law, calculate the vapour pressure lowering when 10.0 mL glycerol ($C_3H_8O_3$) is added to 500 mL water at 50°C. At this temperature, the vapour pressure of pure water is 92.5 torr and its density is 0.988 g/ml. The density of glycerol is 1.26g/mL. (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) 1.0 kg of the antifreeze ethylene glycol ($C_2H_6O_2$) is added to a car radiator containing 4450 g water. Calculate the freezing point of the solution given that H = 1.008, C = 12.01, O = 16.00 and K_b = 1.86 °C/molal). (5 marks)