MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF EDUCATION (SCIENCE)
BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)
BACHELOR OF SCIENCE (TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY)
BACHELOR OF SCIENCE (MATHEMATICS)
BACHELOR OF SCIENCE IN FOOD NUTRITION AND DIETETICS

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.

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Convert the following values to the units indicated into brackets

i) 400K to **(°C)** (1 mark)

ii) 0.991 atm to **(torr)** (1 mark)

iii) 15 Molar of Nitric (V) acid to **(g/L)**; (1½ mks)

iv) 30.05 cm^3 to **(Litres)** (1 mk)

v) 45 g of Anhydrous Cobalt (II) chloride to **(moles)**; (1½ mks)

vi) 2.0077×10^{23} molecules of Fluorine gas to **(grams)**; (1½ mks)

b) Write the ionic equation for the reaction between solid Calcium carbonate with dilute Hydrochloric acid. (1½ mks)

c) Define the following terms as used in chemistry: (6 marks)

i) Supersaturated solution

ii) pH

iii) Conjugate acid

iv) A real gas

v) Mole

vi) Diffusion

d) Differentiate between a base and an acid according to Arrhenius theory. (2 marks)

e) Calculate the pH of a 0.15 M solution of sodium hydroxide (2 marks)

f) The volume of an ideal gas collected at 87.0^0C and atmospheric pressure of 1.2 atmospheres is 240ml. Calculate the moles of the gas in the vessel.

(R = 0.0821 atm.L/mole.K) (3 marks)

g) Calculate each of the following quantities: (8 marks)

i) Grams of solute in 300.0 ml of 0.45M Sodium ethanoate, CH_3COONa

ii) Molarity of a 2.45 litre solution containing 32.5g sodium chloride, NaCl.

iii) Moles of solute in 1.5 L of 2.5 M Magnesium nitrate

iv) Volume in litres of 27.5 M Sodium hydroxide that contains 120.0g solute

Molar mass of NaOH = 40 g/mole

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

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \quad \Delta H = -111 \text{ kJmol}^{-1}$$

i) Temperature is raised (2 marks)

ii) Pressure is raised (2 marks)

iii) Addition of Cl_2 gas to the system (2 marks)

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

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \text{at } 600°C$$

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

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

c) The Formation of Nitrogen (II) oxide gas is usually through a series of reactions as shown in the following equations (i) and (ii)

$$N_2O(g) \rightleftharpoons N_2(g) + \tfrac{1}{2} O_2(g) \quad K = 3.71 \times 10^{17} \ldots\ldots \text{(i)}$$

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \quad K = 4.70 \times 10^{-31} \ldots\ldots \text{(ii)}$$

The overall chemical equation for the formation of Nitrogen (II) oxide gas, NO may be arrived by combining Equation (i) and (ii) to obtain;

$$2N_2O(g) + O_2(g) \rightleftharpoons 4NO$$

Determine the equilibrium constant, K for the overall equation by manipulating the equilibrium constants of equation (i) and (ii). (5 marks)

d) 150 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. (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 $M = \dfrac{\ell RT}{P}$ 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 ammonia gas at s.t.p (3 marks)

($R = 0.0821$ atm.L.mol^{-1}K^{-1})

(iii) Determine the number of ammonia molecules per liter (3 marks)

(Avogadros number, $L = 6.023 \times 10^{23}$ particles)

(b) A 1.98L vessel contains 215g of dry ice. After standing at 26^0C, the CO_2(s) changes to CO_2(g). ($R = 0.08206$ atm.L/mole.K, the Van der Waals constants for CO_2 are $a = 3.59$ atm. L^2/mole, $b = 0.0427$ L/mole)

Calculate the pressure on the vessel using the

(i) Ideal gas equation (3 marks)

(ii) Van der Waals equation (4 marks)

(iii) Explain the difference in the values obtained in (i) and (ii) above. (2 marks)

QUESTION FOUR (20 MARKS)

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

i) Buffer solution

ii) Dynamic equilibrium

iii) Homogenous reaction

iv) Solubility

v) Absolute zero temperature

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. (4 marks)

b) (i) Calculate the pOH of a 0.005 M solution of potassium hydroxide (2½ marks)

(ii)Determine the hydrogen ion concentration in a solution with a pH of 2.0 (2½ marks)

c) 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 0.20M? (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. Given that the Henry's constant for O_2 in plasma = 3×10^{-2} mol/L.atm at 37°C, calculate the solubility of O_2 in the plasma under these conditions (3 marks)

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

(d) Using a phase diagram, describe the water boiling point elevation and freezing point depression as a result of vapour pressure variation. (6 marks)

(e) 500g of the antifreeze ethylene glycol ($C_2H_6O_2$) is added to a car radiator, containing 2250g water. Calculate the resultant freezing point of the solution. (5 marks)

(Given that K_b = 1.86 °C/molal)