UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

FIRST YEAR second SEMESTER
Special/supplementary EXAMINATIONS

FOR THE DEGREE OF BAB, BAE AND BEE

COURSE CODE: SCH 121*

COURSE TITLE: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: 15/8/2023   **TIME:** 2:00-4:00PM
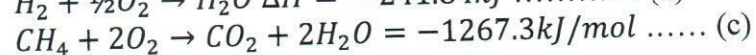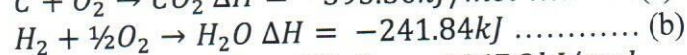

INSTRUCTIONS TO CANDIDATES:

TIME: 2 Hours

ANSWER **QUESTION ONE** AND **ANY TWO** OF THE REMAINING

THIS PAPER CONTAINS FOUR PRINTED PAGES

QUESTION ONE (30MARKS)

(a)State the following laws   (3 marks)

   i.   Boyle's law

   ii.   Charles law

   iii. Avogadro's law

(b) Gases are divided into ideal and real gases. State the two conditions under which real gases tend to obey ideal gas laws   (2 marks)

(c) A sample of a gas weighing $0.0286 \times 10^{-3} Kg$ occupies a volume of $0.05 \times 10^{-3} m^3$ at a pressure of 1atm and temperature of 25°C. Find the molar mass of the gas. R=8.314J/mol/K   (3 marks)

(d) (i) State the law of mass action   (1 mark)

(ii) The equilibrium constant k_c for the reaction $H_2 + I_2 \rightarrow 2HI$ is 60 at 450°C. Calculate the number of moles of HI in equilibrium with 2 moles of Hydrogen and 0.3 moles of iodine at 450°C   (2 marks)

(e) i) Define Degree of dissociation   (2 mark)

(ii) State the four factors that determine the degree of dissociation   (4 marks)

(f) Using the information given in equations *a,b* and *c* below, calculate the enthalpy of the following equation   (3 Marks)

$$C + 2H_2 \rightarrow CH_4 \ ?? \ kJ/mol$$

$C + O_2 \rightarrow CO_2 \ \Delta H = -393.50 kJ/mol \ \dots\dots \ (a)$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \ \Delta H = -241.84 kJ \ \dots\dots \ (b)$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O = -1267.3 kJ/mol \ \dots \ (c)$

(g) State three differences between metallic and electrolytic conductors   (3 marks)

(h) Can you store silver nitrate solutions in a copper pot? Explain $((Cu^{2+} + 2e \rightleftharpoons Cu \ (+.034v), \ Ag^+ + e \rightleftharpoons Ag \ (+0.8V))$ (2marks)

(i) When a current was passed through $CuSO_4$ solution for 10 minutes, 0.293g of copper was deposited at the cathode. Calculate the amount of current passed (1F = 96487 C mol⁻¹, Cu=64)   (2 marks)

(j) (i) In chromatography what is retention factor (Rf)   (1 mark)

(ii) If a compound travels 2.1 cm and the solvent front travels 2.8 cm determine the retention factor   (2 mark)

QUESTION TWO (20 MARKS)

(i) The boiling point of a pure liquid is 353.23 K. If we add 2.70 g of a non-volatile solute in 90 g of liquid, the boiling point of the solution rises to 354.11 K. What will be the molar mass of non-volatile solute? Take the value of K_b of liquid to be 2.53 K kg mol⁻¹.   (5 marks)

(ii) Distinguish between ebullioscopic constant and cryoscopic constant   (3 marks)

(iii) A scientist has a 5.0 M solution of hydrochloric acid (HCl) and his new experiment requires 150.0 mL of 2.0 M HCl. How much water and how much 5.0 M HCl should the scientist use to make 150.0 mL of 2.0 M HCl?   (3 Marks)

(iv) A major textile dye manufacture developed a new yellow dye. The dye has a percent composition of 75.95%C, 17.72%N and 6.33%H by mass with molar mass of about 258g/mol. Determine the molecular formula of the of the dye **(3 marks)**

                C   N   H

(v) (a) Define electrolysis **(2 marks)**

(b) State the two types of electrochemical cells **(2 marks)**

(c) Use the following electrode potentials to answer the question that follows

$Al^{3+}_{aq} + 3e \rightarrow Al_s$ $-1.66V$

$Fe^{2+}_{aq} + 2e \rightarrow Fe$ $-0.44V$

Calculate the emf of Al/Fe cell **(2 marks)**

QUESTION THREE (20 MARKS)

(a) Using the ideal gas equation $PV = nRT$ Derive and state the significance of gas constant R **(5 marks)**

(b) Balance the following chemical equations **(4 marks)**

    ✓ $Ag_{(s)} + H_2S_{(g)} + O_{2(g)} \rightarrow Ag_2S_{(s)} + H_2O_{(l)}$

    ✓ $Cu_{(s)} + HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)} + NO_{(g)}$

    ✓ $(NH_4)_2Cr_2O_{7(s)} \rightarrow Cr_2O_{3(s)} + N_{2(g)} + H_2O_{(g)}$

    ✓ $Ca_3(PO_4)_{2(aq)} + H_3PO_{4(aq)} \rightarrow Ca(H_2PO_4)_{2(aq)}$

(c) In a titration of sulfuric acid against sodium hydroxide, 32.20 mL of 0.250 M NaOH is required to neutralize 26.60 mL of H₂SO4. Calculate the molarity of the sulfuric acid **(3 marks)**

(d) A given mass of a gas occupies a volume of 250ml at 21°C and a pressure of 1.4 atm. At what pressure would the volume be 300ml when the temperature rises to 49°C **(3marks)**

(e) At total pressure of 2 atm and $678K$, the equilibrium constant K_p for the reaction

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

is 1.64×10^{-4}. Calculate K_c **(5 marks)**

QUESTION FOUR (20 MARKS)

(a) i) From the ideal gas equation is $pv = nRT$ and the modifications that need to be done for it to hold for real gases deduce Vander Waal equation of state. **(5marks)**

(b) Three moles of sulphur dioxide gas are confined in 5 litres vessel at 298 K. calculate the pressure in atm exerted by sulphur dioxide

(i) Assuming ideal gas behaviour ($R = 0.08205 Latmmol^{-1}K^{-1}$) **(2 marks)**

(ii) Assuming sulphur dioxide gas behaves as real gas ($a = 0.6780 litreatmmol^{-2}, b = 0.0564 litremol^{-1}$ **(2marks)**

(c) (i) Define colligative property **(2 mark)**

(ii) The vapour pressure of pure benzene is 0.850 bars at room temperature. On addition of 0.6 g of non-volatile solute in 39 g of benzene solution, the vapour pressure of benzene reduces to 0.845 bars. What is the molar mass of the non-volatile solute? **(3 marks)**

(d) (i) State Lechateliers principle **(2 marks)**

ii) Briefly explain the effect of the following on equilibrium

a) Pressure **(2 marks)**

b) Catalyst **(2 marks**

QUESTION FIVE (20 MARKS)

(i) Define the term pH (2 marks)

(ii) Calculate the pH value of a solution containing $1.0 \times 10^{-3} M \ of \ NaOH$ (5 marks)

(iii) (a) What is a buffer solution (2 marks)

(b) Calculate the PH of a buffer solution containing 0.2M CH_3COOH and 0.02M Sodium acetate. $(K_a = 1.85 \times 10^{-5})$ (4 marks)

(iv) Define bases using the following concepts

(a) Arrhenius concept (2 mark)

b) Lewis concepts (2 mark)

(v) The solubility product of silver chromate (Ag_2CrO_4) is 9.0×10^{-12}. Calculate the solubility of silver chromate (3 marks)