NATIONAL OPEN UNVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
OCTOBER/NOVEMBER 2019_2 EXAMINATION

COURSE CODE: CHM 301
COURSE TITLE: PHYSICAL CHEMISTRY III
CREDIT: 3 UNIT
TIME ALLOWED: 3 HOURS
INSTRUCTION: Answer question 1 and any other four questions.

(Take the values for F= 96,500 coulombs, k= 1.38066 x $10^{-23;}$R= 0.0821 L atmmol^{-1}K^{-1}=8.314JK^{-1}mol^{-1}=62.396mmHgLK^{-1}mol^{-1} =1.987calK^{-1}mol^{-1}; $\boldsymbol{\pi}$= 3.142; and use when required)

QUESTION 1 (22 MARKS)

(a) Given an isothermal irreversible process, derive an expression for total work done when a gas in a cylinder expand from V_1 to V_2 against a constant external pressure. **(7marks)**

(b) List the colligative properties and write the corresponding equations and define the terms. **(4 marks)**

(c) Analysis of an organic compound, gave the following percentage composition. C= 30.5 %, H=1.7% and Br =67.8%. [C=12; H=1; Br=80]. Calculate the emperical formular of W **(2 marks)**

(d) A solution made by dissolving 4.0g of sample W in 50.0g of benzene freezes at 3.74^{o}C. The freezing point of pure benzene is 5.48^{o}C. [K_f of benzene =5.12 deg molality^{1}]

Calculate

(i) The molality of the solution **(2 ½ marks)**
(ii) The number of moles of W **(2 marks)**
(iii) Molar mass of W **(2 marks)**
(iv) Molecular formula of W **(2 ½ marks)**

QUESTION 2 (12 MARKS)

(a) The equilibrium constant for the reaction

$$H_2\,(g) + S\,(s) \rightleftharpoons H_2S\,(g)$$

is 18.5 at 925 K and 9.25 at 1000 K respectively. Calculate

(i) the standard enthalpy of the reaction **(3 marks)**

(ii) Δ_rG^o at 925 K **(3 marks)**

(iii) Δ_rS^o at 925 K **(3 marks)**

(b) Calculate the entropy change when 2.0 mol of a perfect gas A and 3.0 mol of a perfect gas B mix spontaneously. **(3 marks)**

QUESTION 3 (12 MARKS)

(a) State the third law of thermodynamics **(2 marks)**

(b) $Hg_2Cl_2(s) + H_2\,(1atm) \rightleftharpoons 2Hg(l) + 2H^+\,(a=1) + 2Cl^-\,(a=1)$ is $E^0_{298.15} = +0.2676$ volt and $(\frac{\partial \epsilon}{\partial T})$ at constant pressure is -3.09×10^{-4} volt/deg. where T is the Celsius temperature. Given that 2 moles of electrons are involved in the cell reaction, calculate ΔG^0, ΔH^0, ΔS^0 for the cell at 25°C. **(6 marks)**

(c) Giving your reasons, state the conditions in which the reactions will occur spontaneously

i) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ (The reaction is exothermic) **(2 marks)**

ii) $O_2(g) \rightarrow 2O(g)$ (The reaction is endothermic) **(2 marks)**

QUESTION 4 (12 MARKS)

(a)Differentiate between a state and path function. **(2 marks)**

(b) A diatomic gas assumed ideal, initially at 23.7 L 0.9 bar and 308K expands to 38.2 L. calculate:

a. Number of moles present **(1 marks)**

b. work done

i. Isothermally and reversibly **(2 marks)**

ii. Under isobaric conditions **(2 marks)**

iii. Adiabatically **(5 marks)**

QUESTION 5 (12 MARKS)

(a) (i) State the Carnot theorem **(3 marks)**

(ii) What are the features used by carnot to analyse the functioning of an engine ***(5 marks)***

(b) Define the term Entropy **(2 marks)**

(c) Calculate the change of entropy when $3.6 \times 10^4\ J$ of heat is transferred reversibly and isothermally to a system at 600 K. **(2 marks)**

QUESTION 6 (12 MARKS)

(a) Define the following terms as applied to chemical thermodynamics

(i) Internal energy (ii) heat (iii) work **(3 marks)**

(b) Methane gas, CH_4 originally at 800℃, undergoes a reversible adiabatic expansion that doubles its volume. Assuming the gas is ideal calculate the following

(i) The final temperature. **(2 marks)**

(ii) The maximum work done for 0.5 moles of the gas **(1 marks)**

(c) The vapour pressure of propanol (C_3H_8O) is 375 torr at 38.8 ^oC, but fell to 372.1 torr when 8.69 g of an involatile organic compound Y is dissolved in 50 g of the propanol.

Calculate

(i) The mole fraction of solute and solvent **(2 marks)**

(ii) the number of moles of compound Y **(1 ½ marks)**

(iii) The molar mass of compound Y **(1 marks)**

(d) Calculate the change in the chemical potential of a perfect gas when it expands isothermally at a temperature of 20.0°C so that its volume doubles. **(1½ marks)**