NATIONAL OPEN UNVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
APRIL/MAY, 2019 EXAMINATIONS

CHM 301-PHYSICAL CHEMISTRY III (3 UNITS)

INSTRUCTION: Answer question 1 and any other 4 questions.

Time allowed 2 ½ Hours

R= 0.0821 L atmmol^{-1}K^{-1}=8.314JK^{-1}mol^{-1}=62.396mmHgLK^{-1}mol^{-1} =1.987calK^{-1}mol^{-1}; k= 1.38066 x 10^{-23}; π= 3.142; F= 96,500 coulombs

QUESTION 1

(a) Define the following terms as applied to chemical thermodynamics
(i) Internal energy (ii) heat (iii) work *(6 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. *(4 marks)*

(ii) The maximum work done for 0.5 moles of the gas *(2 marks)*

(c) The vapour pressure of propanol (C_3H_8O) is 375 torr at 38.8 ^oC, but droped 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 *(4 marks)*
(ii) The molar mass of compound Y *(2 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. *(4 marks)*

QUESTION 2

(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 *(2 marks)*

b. work done

i. Isothermally and reversibly *(2 marks)*

ii. Under isobaric conditions *(2 marks)*

iii. Adiabatically *(4 marks)*

QUESTION 3

(a) What are the features used by Carnot to analyze the functioning of an engine *(5 marks)*

(b) Define the term entropy *(3 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. *(4 marks)*

QUESTION 4

(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) $\Delta_r G^o$ 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. *(6 marks)*

QUESTION 5

(a) State the third law of thermodynamics *(3 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) *(3 marks)*

ii) $O_2(g) \rightarrow 2O(g)$ (The reaction is endothermic) *(3 marks)*

QUESTION 6

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

(b) An organic compound W on analysis, 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)*

(c) 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. [Kf of benzene =5.12 deg molality^{-1}]

Calculate

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