



NATIONAL OPEN UNIVERSITY 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, $k = 1.38066 \times 10^{-23}$; $R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1} = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$; $1 \text{ cal} = 4.184 \text{ J}$; $1 \text{ mmHg} = 133.322 \text{ Pa}$; $1 \text{ mol} = 6.022 \times 10^{23}$; $\pi = 3.142$; and use when required)

QUESTION 1 (22 MARKS)

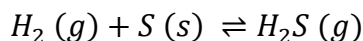
- (a) Given an isothermal irreversible process, derive an expression for total work done when a gas in a cylinder expand from V_1 to V_2 against a constant external pressure. **(7marks)**
- (b) List the colligative properties and write the corresponding equations and define the terms. **(4 marks)**
- (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 empirical formula of W **(2 marks)**
- (d) A solution made by dissolving 4.0g of sample W in 50.0g of benzene freezes at 3.74°C . The freezing point of pure benzene is 5.48°C . [K_f of benzene = $5.12 \text{ deg molality}^{-1}$]

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



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

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

(ii) $\Delta_r G^\circ$ at 925 K **(3 marks)**

(iii) $\Delta_r S^\circ$ 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 $E_{298.15}^0 = +0.2676$ volt and $\left(\frac{\partial \epsilon}{\partial T}\right)$ 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, CH₄ originally at 800°C, 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 (C₃H₈O) is 375 torr at 38.8 °C, 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**)