



**NATIONAL OPEN UNIVERSITY OF NIGERIA**  
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA  
**FACULTY OF SCIENCES**  
**DEPARTMENT OF PURE & APPLIED SCIENCES**  
**2021\_2 EXAMINATION**<sup>45678</sup>

**COURSE CODE: CHM 301**

**CREDIT: 3 Units**

**COURSE TITLE: PHYSICAL CHEMISTRY III**

**TIME ALLOWED: 3 Hours**

**INSTRUCTION: Answer Question ONE (1) and any other Four (4) Questions**

Q1a) Derive Kirchhoff's equation. (6Marks)

b) Explain bond enthalpy and state its application (3Marks)

c) State the three applications of Clausius-Clapeyron equation (6Marks)

d) Explain phase diagram of water system (7Marks)

2a) 1.00 Mol. of a monoatomic gas initially at  $3.00 \times 10^2$  K and occupying  $2.00 \times 10^{-3}$  m<sup>3</sup> is heated to  $3.25 \times 10^2$  K and the final volume is  $4.00 \times 10^{-3}$  m<sup>3</sup>. Assuming ideal behaviour, calculate the entropy change for the process. (4Marks)

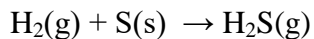
b) Derive an equation for entropy of mixing for mole fraction of gases (8Marks)

3a) What is the total volume of the solution, when 3.80 mol of water is mixed with 0.500 Mol. of ethanol? The partial molar volumes of water and ethanol at this composition are  $1.80 \times 10^5$  M<sup>3</sup> mol<sup>-1</sup> and  $5.34 \times 10^{-5}$  M<sup>3</sup> Mol<sup>-1</sup>, respectively. (5Marks)

b) Derive an expression for determining the fugacity of a gas at any pressure. (4Marks)

c) The  $\gamma$  factor in the above derivation is known as what. Give the general ideal gas equation. (3Marks)

4a) The equilibrium constant for the reaction



is 18.5 at 925 K and 925 at 1000 K, respectively. Calculate the standard enthalpy of the reaction. Also calculate  $\Delta_r G^\circ$  and  $\Delta_r S^\circ$  at 925 K. (4Marks)

b) Discuss osmotic pressure as one of the colligative properties (6Marks)

c) What are two allotropic form of sulphur and which one exist at low temperature. (2Marks)

5a) Derive an expression for isothermal reversible process and state the conditions of W (3Marks)

b) An ideal gas initially at  $3.00 \times 10^2$  K and  $3.00 \times 10^5$  Pa pressure occupies  $0.831 \text{ m}^3$  space. What is the minimum amount of work required to compress the gas isothermally and reversibly so that the final pressure is  $6.00 \times 10^6$  Pa?

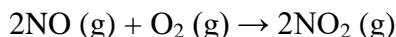
$$p_1 = 3.00 \times 10^5 \text{ Pa}; \quad p_2 = 6.00 \times 10^6 \text{ Pa}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}; \quad T = 3.00 \times 10^2 \text{ K} \quad (5\text{Marks})$$

c) Briefly discuss the entropy change of a system undergoing isothermal Irreversible Expansion and Reversible Compression (5Marks)

6a) Derive a Helmholtz equation to show that the change in Helmholtz; free energy is equal to the amount of reversible work done on the system. (5Marks)

b) For the reaction,



Calculate  $\Delta G$  at  $7.00 \times 10^2$  K. The entropy and enthalpy changes at  $7.00 \times 10^2$  K are respectively,  $-1.45 \times 10^2 \text{ J Mol}^{-1} \text{ K}^{-1}$  and  $-1.13 \times 10^2 \text{ kJ Mol}^{-1}$ . (4Marks)

c) Derive this relation:  $(\frac{\partial A}{\partial T})_V = -S$  at constant volume (3Marks)