NATIONAL OPEN UNIVERSITY OF NIGERIA PLOT 91, CADASTRAL ZONE,
NNAMDI AZIKIWE EXPRESSWAY, JABI – ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF CHEMISTRY
2023_1 EXAMINATIONS

COURSE CODE: CHM 301
COURSE TITLE: PHYSICAL CHEMISTRY III
COURSE UNIT: 3
INSTRUCTION: Answer question one (1) and any other three questions
**Time: 3 hours**

QUESTION 1

1.   (a) Define system and explain two types of system each with respect to the following

(i) Phases (ii) Exchange of matter and energy between the system and the surroundings.

(10 marks)

(b) (i) Define thermal equilibrium.   **(2 marks)**

(ii) State the Zeroth law of thermodynamics.   **(2 marks)**

(c) Define bond enthalpy and state the significance of bond enthalpy of molecules. **(5**

marks)

(d) Consider the following equation:

$2SO_2 + O_2 \longrightarrow 2SO_3$

2.0 moles of SO_2 and 1.0 mole of O_2 were allowed to react in a vessel. At equilibrium,
1.8 moles of SO_3 had formed and the pressure in the flask was 2 atm.
(i)   Write the expression for Kp for the reaction between SO_2 and O_2.
(ii)   Calculate the mole fractions of SO_2, O_2 and SO_3 at equilibrium.   **(4 marks)**

(e) Define fugacity of a real gas.   **(2 marks)**

QUESTION 2

2. (a) Define the following terms: **(9 marks)**

   (i) Isothermal process (ii) Adiabatic process (iii) Cyclic process

(b) In the reaction below, the chlorine atom is in the middle of the ClO_2 molecule. Taking the chlorine-oxygen bond energy as 278 kJ mol^{-1}, and other values given, calculate enthalpy change of the reaction ΔH^o (O=O = 496, Cl-Cl = 244 kJ mol^{-1}).

$$2ClO_2(g) \rightarrow Cl_2(g) + 2O_2(g)$$
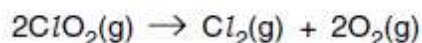
(6 marks)

QUESTION 3

3. (a) 1.2×10^2 mol of an ideal gas at 310 K temperature and 5.8×10^6 Pa pressure occupies 0.032 m^3 space initially. Calculate the work done on the gas and the heat absorbed by the gas if it undergoes expansion under the following conditions such that the final volume and pressure are 0.735 m^3 and 2.4×10^5 Pa: (i) isothermal reversible conditions (ii) isothermal irreversible conditions. **(9 marks)**

(b) Mention four (4) characteristics of the functioning of an engine based on Carnot theory.

(6 marks)

QUESTION 4

4. (a) State Carnot theory. **(4 marks)**

(b) Define efficiency of Carnot engine. **(3 marks)**

(c) Draw the diagram for Carnot cycle and mention 4 operations that describes the Carnot cycle. **(8 marks)**

QUESTION 5

5. (a) Mention three (3) applications of the Clausius-Clapeyron equation. **(6 marks)**

(b) Calculate the vapour pressure of water at 298 K. Molar enthalpy of vaporization of water at its normal boiling point is 4.10×10^4 J mol^{-1} (standard pressure is 1×10^5 Pa). **(9 marks)**

QUESTION 6

6. (a) Define colligative properties of non-volatile solutes and list four (4) of these properties.

(9 marks)

(b) Calculate the molecular mass of 8 g non-volatile organic compound, dissolved in 55 g of pure water at 25°C, which depresses the vapour pressure of the water from 3.20 x 10^3 to 3.14 x 10^3 Nm^{-2}. **(6 marks)**