



NATIONAL OPEN UNIVERSITY 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

$R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1} = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 62.396 \text{ mmHg L K}^{-1} \text{ mol}^{-1} = 1.987 \text{ cal K}^{-1} \text{ mol}^{-1}$; $k = 1.38066 \times 10^{-23}$; $\pi = 3.142$; $F = 96,500 \text{ coulombs}$

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°C , 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 ($\text{C}_3\text{H}_8\text{O}$) is 375 torr at 38.8°C , but dropped 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

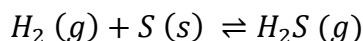
- i. Isothermally and reversibly (2 marks)
- ii. Under isobaric conditions (2 marks)
- iii. Adiabatically (4 marks)

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 $3.6 \times 10^4 \text{ J}$ of heat is transferred reversibly and isothermally to a system at 600 K. (4 marks)

QUESTION 4

- (a) The equilibrium constant for the reaction



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)
- (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) $\text{Hg}_2\text{Cl}_2(\text{s}) + \text{H}_2 (1\text{atm}) \rightleftharpoons 2\text{Hg}(\text{l}) + 2\text{H}^+ (\text{a}=1) + 2\text{Cl}^- (\text{a}=1)$ is $E^\circ_{298.15} = +0.2676$ volt and $\left(\frac{\partial E}{\partial T}\right)$ 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° , ΔH° , ΔS° for the cell at 25°C. (6 marks)
- (c) Giving your reasons, state the conditions in which the reactions will occur spontaneously
 - i) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ (The reaction is exothermic) (3 marks)
 - ii) $\text{O}_2(\text{g}) \rightarrow 2\text{O}(\text{g})$ (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 empirical formula of W (2 marks)
- (c) 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. [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) |