



NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
JANUARY 2018 EXAMINATION QUESTIONS

CHM301: PHYSICAL CHEMISTRY III
CREDIT: 3 UNIT

TIME: 3 HOURS

INSTRUCTION: ANSWER QUESTION ONE & ANY OTHER FOUR QUESTIONS.

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

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 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 (4 marks)
(ii) the number of moles of compound Y (3 marks)
(iii) 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. (4 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 (5 marks)

QUESTION 3

(a) (i) State the Carnot theorem (3 marks)

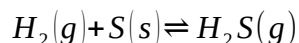
(ii) What are the features used by Carnot to analyse the functioning of an engine (5 marks)

(b) Define the term Entropy (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)

(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. (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 $\left(\frac{dE}{dT}\right)_P$ 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. [K_f of benzene =5.12 deg molality⁻¹]

Calculate

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|-------|------------------------------|-----------|
| (i) | The molality of the solution | (2 marks) |
| (ii) | The number of moles of W | (2 marks) |
| (iii) | Molar mass of W | (2 marks) |
| (iv) | Molecular formula of W | (3 marks) |