NATIONAL OPEN UNIVERSITY OF NIGERIA PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI – ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF CHEMISTRY
2025_2 EXAMINATIONS

COURSE CODE: CHM 405
COURSE TITLE: CHEMICAL THERMODYNAMICS
COURSE UNIT: 2
INSTRUCTION: Answer question one (1) and any other two questions
Time: Two (2) Hours

QUESTION 1

1. (a) Describe the following briefly with one (1) example each
(i) Ion-induced dipole forces **(3 marks)** (ii) ion-dipole forces **(3 marks)**
1. (b) (i) Define the term 'Thermodynamic processes' **(2 marks)**

(ii) Chemical potential - particle number is one of the three (3) groups of thermodynamic processes, mention and define the other two types. **(6 marks)**
1. (c) Calculate the freezing point of water when 0.025 mol of glucose was dissolved in 850 g of water, (K_f =1.858^{o}Ckgmol^{-1}, C= 12, H=1.0, O =16.0gmol^{-1}) **(7 marks)**
1. (d) Mention three (3) important thermodynamic functions that are very essential in assessing the free energy of a given system **(3 marks)**
1. (e) Highlight the three (3) major ensembles in statistical thermodynamics and give the condition for each **(6 marks)**

QUESTION 2

2. (a) Define reversible and irreversible processes in thermodynamics **(4 marks)**
2. (b) The Table below shows the lattice enthalpy of silver halides obtained from Born-Haber cycle and ionic model methods

Compound	**Born-Haber**	**Ionic model**	**% Difference**
AgCl	918	864	5.9
AgBr	905	830	8.3

(i) Explain why there is a difference between the Lattice energies obtained from the two methods. **(2 marks)**
(ii) Why is the Lattice enthalpy of AgCl greater than AgBr? **(2 marks)**

2. (c) (i) Draw the Born–Haber cycle for the formation of calcium sulphide (CaS). The enthalpy enthalpy changes for the steps are given in the table below **(4 marks)**

Enthalpy changes	Values (kJ` mol^{-1})
$\Delta H^o_{formation} CaS$(s)	–482
$\Delta H^o_{atomisation}$Ca(s)	+178
$\Delta H^o_{atomisation}$S(s)	+279
ΔH^o_{IE1}Ca(g)	+590
ΔH^o_{IE2} Ca^+ (g)	+1145
$\Delta H^o_{elecron\ affinity1}$ S(g)	–200
$\Delta H^o_{Lattice}$ CaS(s)	-3013

(ii) Calculate the second electron affinity of sulphur $\Delta H^{o}_{elecron\ affinity2}$ $S^{-1}(g)$ using the data given above. **(5 marks)**

2.(d) Define entropy and state the second law of thermodynamics with respect to entropy change of natural processes **(3 marks)**

QUESTION 3

3. (a) Discuss the thermodynamics of the four operation steps in a cyclic process **(10 marks)**

3. (b) Give one important usefulness of Clausius-Clapeyron equation. **(1 mark)**

3. (c) Given an independent variable, x and y and f representing the total differential of a dependent state function such that:

$$df = adx + bdy$$

where a and b are functions of x and y, hence, write the Maxwell equation by applying the principle of reciprocity to these equations:

(i) $dU = TdS - PdV$ **(ii)** $dH = TdS + VdP$

(iii) $dA = -PdV - SdT$ **(iv)** $dG = VdP - SdT$ **(9 marks)**

QUESTION 4

4. (a) Enthalpy is a state function obtained at constant pressure and can be written as H = U + PV ,from this equation and by applying conditions for exact differential, show that

$\left(\frac{\partial H}{\partial S}\right)_P = T$ and $\left(\frac{\partial H}{\partial P}\right)_S = V$. **(9 marks)**

4. (b) Define exothermic lattice energy. **(2 marks)**

4. (c) Define colligative properties and list four (4) of these properties. **(6 marks)**

4. (d) Explain heat of solution. **(3 marks)**

QUESTION 5

5.(a) Define the following (i) adiabatic process **(2 marks)** (ii) isentropic process **(2 marks)**

5. (b) If the volume of 4 mol of an ideal gas change from 250 to 500 cm^3 at 298 K, calculate the work done during the isothermal expansion of the gas. What will be the final pressure of this gas after expansion if its initial pressure was 101325 Pa ? **(10 marks)**

5. (c)When 0.18g of hexane was completely burnt, it raised the temperature of 100g (0.1kg) water from 22 ^{o}C to 47 ^{o}C. Calculate its enthalpy of combustion. **(6 marks)**