A 313

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2005.

Third Semester

Industrial Bio–Technology

IB 235 — CHEMICAL THERMODYNAMICS AND BIO THERMODYNAMICS

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What are the limitations of first law of Thermodynamics?

2. What do you understand by the term internal energy of the system? How is it related to the enthalpy of a system?

3. Calculate the change in entropy accompanying the isothermal expansion of 4 moles of an ideal gas at 300 K until its volume has increased 3 times.

4. What is phase rule? Give its equation.

5. What is COP?

6. Draw TS diagram for a pure fluid.

7. What are the important properties of a Refrigerant?

8. State Lewis–Randall rule.

9. What is the enthalpy of 100 g of formic acid at 50°C and 1 atm relative to 25°C and 1 atm? C_p of formic acid = 0.524 Cal./gm°C.

10. Relate the rate constant K and temperature of a biochemical reaction.

PART B — ($5 \times 16 = 80$ marks)

11. A rigid and insulated tank of 3 m^3 volume is divided into two compartments. One compartment of volume 1 m^3 contains an ideal gas at 0.1 MPa and 300 K while the second compartment of volume 2 m^3 contains the same gas at 1 MPa & 1000 K. If the partition between the two compartments is ruptured, determine the final state (T & P) of the gas. (16)

12. (a) N_2 which was initially at 1 bar & 280 K is compressed to 5 bar & 280 K by two different reversible processes.

(i) Cooling at constant pressure followed by heating at constant volume.

(ii) Heating at constant volume followed by cooling at constant presure.

For each of the above paths determine the conditions at the intermediate state and change in U & H, and Q & W Assume N_2 is ideal gas $C_V = 5R/2$ & $C_p = 7R/2$. where 'R' is 8.314 KJ/Kg mol°K. (16)

Or

(b) (i) Explain the PVT behaviour of the pure fluids using PV diagram and PT diagram. (7)

(ii) Determine the enthalpy and entropy changes of liquid water for a change of state from 1 bar and 298.15 K (25°C) to 1000 bar and 323.15 K (50°C). The following data for water are available : (9)

T(K)	P (bar)	Cp (KJ Kmol^{-1} K^{-1})	V10^{-3} (m^3 Kmol^{-1})	β (K^{-1})
298.15 (25)	1	75.305	18.071	256×10^{-6}
298.15 (25)	1000	....	18.012	366×10^{-6}
323.15 (50)	1	75.314	18.234	458×10^{-6}
323.15 (50)	1000	....	18.174	568×10^{-6}

13. (a) Show that :

(i) $H^R/RT = -T(\int_O^P (\partial Z/\partial T)P(\partial P/P))$ at constant Temperature. (8)

(ii) $S^R/RT = -T(\int_O^P (\partial Z/\partial T)P(\partial P/P) - \int_O^P (Z-1)(\partial P/P))$ at constant Temperature. (8)

Or

(b) (i) Define "Residual properties" and give its significance. (4)

(ii) Explain the qualitative behaviour of vapour–liquid equilibria using P–x–y and T–x–y (12)

14. (a) Consider the system in which the following independent reactions proceed simultaneously :

$CH_4 + H_2O \rightarrow CO + 3H_2 (1)$

$CH_4 + 2H_2O \rightarrow CO + 4H_2 (2)$

Where the numbers (1) and (2) indicate the value of 'j' , the reaction index. If there are present initially 2 mol CH_4 and 3 mol H_2O, determine expressions for the y_i as functions of ε_1 and ε_2.

Where ε_1 and ε_2 are reaction co–ordinates. (16)

Or

(b) Explain in detail about the application of equilibrium criteria to chemical reactions. (16)

15. (a) Binary system acetonitrile (i) nitromethane (ii) conforms closely to Raoult's law. Vapour pressures for the pure species are given by the following Antoine equations :

$\ln P_1^{sat}/kPa = 14.2724 - 2945.47/(T - 49.15)$

$\ln P_2^{sat}/kPa = 14.2043 - 2972.64/(T - 64.15)$.

(1) Prepare a graph showing P vs. x_1 and P vs. y_1 for a temperature of 348.15 K

(2) Prepare a graph showing T vs. x_1 and T vs. y_1 for pressure of 70 KPa. (16)

Or

(b) (i) The need arises in a laboratory for 2000 cm^3 of an antifreeze solution consisting of 30–mol–% methanol in water. What volumes of pure methanol and of pure water at 298.15 K must be mixed to form the 2000 cm^3 of antifreeze, also at 298.15 K? Partial molar volumes for methanol and water. In a 30–mol–% methanol solution and their pure–species molar volumes, both at 298.15 K are :

Methanol (1) : $\bar{V}_1 = 38.632\ cm^3\ mol^{-1}$ $V_1 = 40.727\ cm^3\ mol^{-1}$

Water (2) : $\bar{V}_2 = 17.765\ cm^3\ mol^{-1}$ $V_2 = 18.068\ cm^3\ mol^{-1}$. (8)

(ii) From the equations developed in Part (a), find values for G^E, S^E and H^E for an equimolar solution of benzene (1) /n–hexane (2) at 323.15 K given the following excess–property values for an equimolar solutions at 298.15 K.

$C_P^E = -2.86\ J\ mol^{-1}\ K^{-1}$, $H^E = 897.9\ J\ mol^{-1}$, $G^E = 384.5\ J\ mol^{-1}$. (8)