

Time: 3 Hours

Total Marks: 80

N.B.:

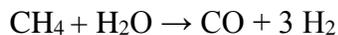
- (i) Question No.1. is compulsory.
- (ii) Attempt any three questions out of remaining five questions.
- (iii) Assume suitable data and justify the same.
- (iv) Figures to the right indicate full marks.

1. (a) Derive a general relation to estimate the heat of a reaction as a function of temperature, if the constant pressure molar heat capacities of the gaseous species are expressed as: 08

$$C_p, \text{ J/mol.k} = a + bT + cT^2 + dT^3 + eT^{-2}$$

- (b) State Raoult's and Henry's law. 06

- (c) A system initially containing 2 mol CH₄ & 3 mol H₂O undergoes the reactions: 06



Develop expressions for the mole fractions of the reacting species as functions of the reaction coordinates for the two reactions.

2. For the acetone(1) /acetonitrile(2) /nitro-methane(3) system, we have the following equations: 20

$$\ln P_1^s = 14.5463 - \frac{2940.46}{t + 237.22}$$

$$\ln P_2^s = 14.2724 - \frac{2945.47}{t + 224.00}$$

$$\ln P_3^s = 14.2043 - \frac{2972.64}{t + 209.00}$$

where temperature is in °C & vapor pressures are in kPa. Assuming that Raoult's law is appropriate to this system, calculate:

i) t & $\{y_i\}$ given that $P = 80$ kPa, $x_1 = 0.30$, $x_2 = 0.45$, $x_3 = 0.25$

ii) t & $\{x_i\}$ given that $P = 90$ kPa, $y_1 = 0.60$, $x_2 = 0.20$, $x_3 = 0.20$

3. (a) What are azeotropes? With proper phase diagrams, distinguish between minimum & maximum boiling azeotropes. 10

- (b) The excess volume(m³/kmol) of a binary liquid mixture is given by 10

$$V^E = 0.1 x_1 x_2 (20x_1 + 10x_2) \text{ at } 298\text{K} \text{ \& } 1 \text{ bar}$$

Determine molar volumes (V_1 , V_2) & total volume of equimolar mixture of components 1 & 2.

$$V_1^0 = 0.12 \text{ m}^3/\text{kmol}$$

$$V_2^0 = 0.15 \text{ m}^3/\text{kmol}$$

4. (a) The NH_3 synthesis reaction: 10
$$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$$

is carried out under different sets of conditions described below. Calculate equilibrium conversion and fraction of nitrogen reacted if initial mixture consists of 1 mol N_2 , 5 mol H_2 and 0.3 mol NH_3 at 800K and 100 bar.
Data:
 $K = 1.1067 \times 10^{-5}$ at 800 K
- (b) Determine the number of degree of freedom in a gaseous system consisting of H_2O , HCl , O_2 & Cl_2 . 10
5. A cold storage plant is required to store 10 tons of fish. The fish is supplied at a temperature of 30°C . Specific heat of fish above freezing point is $0.7 \text{ kcal/kg}^\circ\text{C}$. Specific heat of fish below the freezing point is $0.3 \text{ kcal/kg}^\circ\text{C}$. Freezing point of fish is -4°C . The fish is maintained at -8°C . Latent heat of fish is 56 kcal/kg . If the plant requires 1000 kcal/min of work, find out: 20
i) The capacity of the plant
ii) Time taken to achieve cooling
Assume actual COP = one third of Carnot COP
6. Write short notes on any four:- 20
(i) Standard heat of reaction
(ii) Gibbs Duhem equation
(iii) Van't Hoff equation
(iv) Vapor compression refrigeration
(v) Estimation of critical properties
