

Time: 3 Hours

Total Marks: 80

N.B.:

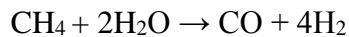
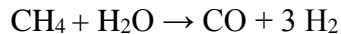
- (i) Question No.1. is compulsory.
- (ii) Attempt any three questions out of remaining five questions.
- (iii) Assume suitable data and justify the same.
- (iv) Figures to the right indicate full marks.

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 CH<sub>4</sub> & 3 mol H<sub>2</sub>O 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(m<sup>3</sup>/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  $\text{NH}_3$  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  $\text{N}_2$ , 5 mol  $\text{H}_2$  and 0.3 mol  $\text{NH}_3$  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  $\text{H}_2\text{O}$ ,  $\text{HCl}$ ,  $\text{O}_2$  &  $\text{Cl}_2$ . 10
5. A cold storage plant is required to store 10 tons of fish. The fish is supplied at a temperature of  $30^\circ\text{C}$ . 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  $-4^\circ\text{C}$ . The fish is maintained at  $-8^\circ\text{C}$ . Latent heat of fish is  $56 \text{ kcal/kg}$ . If the plant requires  $1000 \text{ kcal/min}$  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

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