

Time: 3hour

MaxMarks: 80

N.B. (1) Question No 1 is compulsory**(2) Attempt any three questions out of remaining five questions****(3) Assumption made, if any should be clearly stated****(4) Figures to the right indicate full marks.**

- Q.1 Attempt any Four . 20**
- Explain Lewis Randall rule solution and fugacity
 - Differentiate ideal and non-ideal solution.
 - Describe important properties of refrigerants
 - Describe activity and activity coefficient
 - Following reaction occurs in a mixture consisting of 2 mole methane, 1 mole water, 1 mole carbon monoxide and 4 mole hydrogen initially

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Deduce the expression for mole fraction of various species in terms of extent of reaction
- Q.2 a. Laboratory alcohol containing 96% alcohol and 4% water is to be diluted to a solution containing 56% alcohol and 44% water. All percentages are on weight basis. The partial specific volume are as follows: In 96% alcohol solution, $\bar{V}_w = 0.816 \times 10^{-3} \text{ m}^3/\text{kg}$, $\bar{V}_E = 1.273 \times 10^{-3} \text{ m}^3/\text{kg}$. In 56% alcohol solution, $\bar{V}_w = 0.953 \times 10^{-3} \text{ m}^3/\text{kg}$, $\bar{V}_E = 1.243 \times 10^{-3} \text{ m}^3/\text{kg}$. The density of water may be taken as $0.997 \times 10^3 \text{ kg/m}^3$. Calculate how much water should be added to two liter of laboratory alcohol. 10**
- b. Derive various forms of Gibbs Duhem equation 10**
- Q.3 a. Explain absorption refrigeration 10**
- b. Explain in detail Chemical Potential as a criteria phase equilibrium 10**
- Q.4 a. Explain different consistency test for VLE data 10**
- b. Prove that if Raoult's law is valid for one constituent of a binary solution over the whole concentration range, it must also apply to the other constituent. 10**
- Q.5 a. A gas mixture containing 2 mole of nitrogen, 7 moles hydrogen and 1 mole ammonia initially, is undergoing following reaction 10**
- $$N_2 + 3H_2 \rightarrow 2NH_3$$
- Derive expression for mole fraction of various component in the reaction mixture in terms of extent of reaction
 - Explain how the conversion of limiting reactant is related to extent of reaction
- b. The molar excess free energy for particular system is given by 10**
- $$\frac{G_E}{RT} = Bx_1x_2$$
- Where B is a function of temperature only. Show that for every temperature at which azeotropic exists, the azeotropic composition x_1^{az} and azeotropic pressure P^{az} are related by

$$x_1^{az} = \frac{1}{2} \left[1 + \frac{\ln \left(\frac{P_1^0}{P_2} \right)}{B} \right]$$

- Q.6**
- a. Find degree of freedom in Catalytic oxidation of ammonia containing NH₃, NO₂, NO, H₂O, O₂, N₂ **10**
- b. Saturated ammonia at 226.3Kpa enters a 150mm X 150mm twin cylinder single acting compressor. Volumetric efficiency is 79% and speed is 4 Hz. The head pressure is 1167 kPa. Liquid ammonia at 294K enters the expansion valve. For ideal cycle Calculate: **10**
- Ammonia circulated in kg/min
 - Refrigeration in tons
 - C.O.P

$$C_{pl} = 4.844 \text{ kJ/kg.K}, C_{pv} = 2.7559 \text{ kJ/Kg.K}$$

Properties of ammonia

P _s KPa	T _s K	V _s m ³ /Kg	Enthalpy, kJ/Kg K		Entropy, kJ/Kg K	
			H _l	H _v	ϕ _l	ϕ _v
226.3	258	0.509	112.17	1424.919	0.4564	5.5423
1167	303	0.011	322.57	1468.09	1.2017	4.9809