(3 Hours) [Total Marks : 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 Explain any four **20**

(a) State Raoult's law .Show that it is simplified form of Lewis Randall Rule
(b) Concept of Phase Equilibria
(c) Chemical Potential
(d) Effect of Temperature on equilibrium Constant
(e) Coefficient of Performance and Refrigerator capacity

Q 2 (a) Derive Gibbs Dehum Equation and check whether these equation satisfy the Gibbs-Duhem equation or not **12**

The activity coefficient data for a binary solution at constant T and P are correlated by the relation

$\ln \gamma_1 = x_2^2 (0.5 + 2x_1)$ $\ln \gamma_2 = x_1^2(1.5 - 2x_2)$

(b) Explain Phase rule and Determine the number of degrees of freedom in a gaseous system consisting of H_2O, HCl, O_2 and Cl_2 **08**

Q 3 (a) The following simultaneous reaction take place in a gas mixture **10**

$A+B \rightarrow C + D \quad K_1 = 0.1429$

$A+C \rightarrow D + E \quad K_2 = 2$

Calculate the equilibrium composition at 1 bar if an equimolar mixture of A and B is fed to a reactor to produce D. Assume that the reaction mixture behaves like an ideal gas

(b) Explain vapour absorption refrigeration system with principle. **10**

Q 4 (a) The volume of a solution prepared from MgSO4 and 1 kg of water varies with molality (moles solute per kg of solvent) according to the expression **10**

$V = 1.00121 \times 10^{-3} + 34.09 \times 10^{-6} (m-0.070)^2$

Where m is the molality of the solution in mol/kg and V is the volume in m3. Calculate the partial molar volume of the salt and solvent when m = 0.05 mol/kg

(b) Define excess property and Property change of Mixing and show that the property change of mixing and excess properties are identical. **10**

Q 5 **(a)** At a pressure of 101.3 kPa , ethyl acetate (1) and ethyl alcohol(2) form an azeotrope containing 53.90 mole %ethyl acetate at 345 K **12**

i) Determine the van Laar constants

ii) Determine the composition of the vapour in equilibrium with a liquid of composition 60 mole % alcohol and 40 % acetate and boiling at a temperature of 329.5 K.

Data : The vapour pressure of ethyl acetate and ethyl alcohol **at 345 K** are 84.77 kPa and 78.24 kPa

The vapour pressure of ethyl acetate and ethyl alcohol **at 329.5 K** are 47.98 kPa and 39.72 kPa

(b) What are azeotropes? Explain in brief maximum and minimum boiling Azeotropes. **08**

Q 6 **(a)** A refrigerating unit using Freon -12 as the working fluid operates between 18^0C and 37^0C. The rate of circulation of refrigerant is 2 kg/min and the efficiency of the compressor is 0.85. Using the following data of enthalpy, calculate **10**

i) The capacity of the plant in tons of refrigeration

ii) The power required to run the unit

iii) The COP of the unit

Data : The enthalpies of R-12 liquid at 37^0C is 455 kJ/kg. The enthalpies of R-12 entering and leaving the compressor are 563.15 kJ/kg and 595.4 kJ/kg respectively.

(b) Calculate the Gibbs free energy change and equilibrium constant at 700 K for the ammonia synthesis reaction $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ **10**

The standared heat of formation and standared free energy of ammonia at 298 K are -46100 and -16500 J/mol respectively

C_P^0 Data : $N_2 : 27.27 + 4.93 \times 10^{-3} T$

$H_2 : 27.01 + 3.51 \times 10^{-3} T$

$NH_3 : 29.75 + 25.11 \times 10^{-3} T$
