(3 Hours) Total Marks: 80

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

Q1 Explain **Any Four**

(a) Define equilibrium constant K of a chemical reaction. How is it related to kf & kp **05**

(b) Difference between ideal and non-ideal solution **05**

(c) Explain various properties of refrigerant used in Refrigeration system **05**

(d) What is Excess Properties? Explain **05**

(e) What are azetropes? What is effect of pressure on it? **05**

Q2 (a) The Excess Free energy is given by **10**

$$\frac{G^E}{RT} = -3X_1X_2(0.4\,X_1 + 0.5\,X_2)$$

Find the expressions for $\ln\gamma_1$ and $\ln\gamma_2$

(b) In a laboratory for 2000 cm^3 of an antifreeze solution consisting of A 30 mole % methanol in water. What volumes of pure methanol and of pure water at 25ºC (298.15K) must be mixed to form the 2000 cm^3 of antifreeze also at 25ºC (298.15K)? Partial molar volumes for methanol and water in a 30 mole % methanol solution and their pure species molar volumes both at 25ºC(298.15K) are **10**

Methanol(1) $\bar{V}_1 = 38.632\ cm^3/mole$ $V_1 = 40.727\ cm^3/mole$

Water(2) $\bar{V}_2 = 17.765 cm^3/mole$ $V_2 = 18.068 cm^3/mole$

Q3 (a) n. butyl alcohol and n.butyl acetate form an azeotrope at 760 mmHg pressure and at 116.8^0C and at 79.01 mole percent of n.butyl alcohol. Vapor pressure of n.butyl alcohol and n.butyl acetate are 740.8 and 546.6 mmHg respectively at this temperature calculate **12**

i) Vanlaar constant

ii) Vapor composition if the solution behaves ideally

iii) Azetrope composition at 76.4 0C if the vanLaar constants are undependent of temperature. The vapor pressure of n.butyl alcohol is 137.37 mmHg and for n.butyl acetate is 135.16mmHg.

(b) Prove that if Raoults law is valid for one constituent of a binary solution over the whole concentration , it must also apply to the other constituent. **08**

Q4 (a) The vapour pressure of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equation **12**

$$\ln P_1^s = 14.5463 - \frac{2940.46}{T - 35.93}$$

$$\ln P_2^s = 12.0586 - \frac{2945.47}{T - 49.15}$$

Where T is in K and P is in kPa. Assuming that the solution formed by these are ideal , calculate

i) x_1 and y_1 at 327 K and 65 kPa

ii) T and y_1 at 65kPa and $x_1 = 0.4$

iii) P and y_1 at 327 k and $x_1 = 0.4$

iv)T and x_1 at 65 kPa and $y_1 = 0.4$

v) P and x_1 at 327 K and $y_1 = 0.4$

(b) Explain Phase rule in detail for reacting and non reacting system with examples. **08**

Q5 (a) For the reaction $0.5\ N_2 + 1.5\ N_2 \rightarrow NH_3$ with 0.5 mole of nitrogen and 1.5 mole of hydrogen as the initial amount of reactant and with the assumption that the gaseous mixtures behaves as an ideal gas show that **10**

$$X = 1 - [\ 1 + 1.299\ PK_P]^{-0.5}$$

(b) What is standard heat of reaction and derive an expression for effect of temperature on standard heat of reaction **10**

Q6 (a) R-12 is condensed at 30^0C. It is then throttled to -5^0C. Find the refrigerant flow rate that enters the compressor for 1 T of refrigerant. **12**

T_{sat}	Psat	H_g KJ/Kg	H_f KJ /Kg
-5^0C	0.2619 MPA	31.42	185.243
30^0C	0.7449 MPA	64.539	199.475

It is assumed that compressor discharged is at the saturated vapour conditions. Find work done by compressor and COP.

(b) Show that $\mu i = \left(\frac{\partial G}{\partial n_i}\right)_{T,P,n_j}$ **08**

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