

B.TECH. Degree Examination, December 2020

Fifth Semester

CH18503- Chemical Engineering Thermodynamics-II

(Regulation 2018)

Time: Three hours

Maximum : 80 Marks

Answer **ALL** questions**PART A - (8 X 2 = 16 marks)**

1. Find the fugacity coefficient of component 1 in a binary solution if fugacity is 10 bar and the system pressure is 20 bar
 - a) 0.2
 - b) 0.5
 - c) 0.6
 - d) 0.8
2. During the change of phase of a pure substance
 - a) $dG = 0$
 - b) $dP = 0$
 - c) $dH = 0$
 - d) $dU = 0$
3. For gas and liquid phases in equilibrium, a component in a non-ideal system follows the relation,
 - a) $p_i = x_i P_i^S$
 - b) $f_i^L = f_i^V$
 - c) $p_i = y_i \pi$
 - d) $f_i^L = p_i$
4. Partially miscible systems
 - a. in which the solubility of one liquid in another liquid is seen only under certain conditions are temperature.
 - b. in which the solubility of one liquid in another liquid is seen only under certain conditions are pressure
 - c. in which the solubility of one liquid in another liquid is seen only under certain conditions are density
 - d. in which the solubility of one liquid in another liquid is seen only under certain conditions are partial pressure

5. Give the importance of Gibbs-Duhem's equation.
6. Differentiate between minimum boiling and maximum boiling azeotropes?
7. Discuss the significance of co-existence equation.
8. Express the effect of temperature on equilibrium constant?

PART B - (4 X16 = 64 marks)

09. (a) (i) The expression for volume of a solution formed from MgSO₄ and 1kg of water (8)
is

$$V = (1.00121 \times 10^{-3}) + (34.69 \times 10^{-6})(m - 0.07)^2$$

where m is the molality of the solution. Calculate the partial molar volume of the MgSO₄ and water.

- (ii) At 300K and 1 bar the volumetric data for a liquid mixture of benzene and cyclohexane are represented by (8)

$$V = 101.4 \times 10^{-6} - 15.8 \times 10^{-6} X - 2.64 \times 10^{-6} X^2$$

where X is the mole fraction of the benzene and V has the units of m³/mol. Find the expressions for the partial molar volumes of benzene and cyclohexane.

(OR)

- (b) The enthalpy at 300 K and 1 bar binary liquid mixture is (16)

$$H = 400x_1 + 600x_2 + x_1x_2(20x_1 + 20x_2)$$

Where H is in J/mol. For the stated temperature and pressure determine

- a) Expressions for H₁ and H₂ in terms of x₁.
 - b) Numerical values for the pure component enthalpies H₁ and H₂.
 - c) Numerical values for the partial molar enthalpies at infinite dilution H₁ and H₂.
10. (a) Assuming Raoult's law to be valid for the system Benzene (1) –Ethyl Benzene (2) and (16)
the vapor pressures are given by the Antoine equations.

$$\ln P^s_1 = 13.8858 - \frac{2788.51}{T - 52.41}$$

$$T - 52.41$$

$$\ln P^s_2 = 14.0045 - \frac{3279.47}{T - 60.00}$$

$$T - 60.00$$

Where P is in KPa and T is in K. Construct the following

- (a). The P –x-y diagram at 373 K
- (b). The T– x-y diagram at 101.3 KPa

(OR)

(b) Applying the criteria for phase equilibrium, obtain the Clausius – Clapeyron equation. **(16)**

11. (a) The following data were reported for the vapor - liquid equilibrium for the ethanol water system at 298 K. Test whether the data are thermodynamically consistent or not. **(16)**

x_i	0.122	0.163	0.226	0.320	0.337	0.437	0.440	0.579	0.830
y_i	0.474	0.531	0.562	0.582	0.589	0.620	0.619	0.685	0.849
P KPa	5.57	6.02	6.38	6.76	6.80	7.02	7.04	7.30	7.78

The vapor pressure of ethanol and water are 7.86 and 3.17 KPa.

(OR)

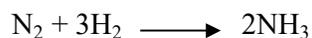
(b) A mixture contains 45% (mol) methanol (A), 30% (mol) ethanol (B) and the rest n-propanol (C). Liquid solution may be assumed to be an ideal and perfect gas law is valid for the vapour phase. Calculate at a total pressure of 101.3 Kpa. **(16)**

- The bubble point and the vapour composition
- The dew point and the liquid composition.

The vapour pressures of the pure liquids are given below

Temperature, K	333	343	353	363
P_A , kPa	81.97	133.29	186.61	266.58
P_B , kPa	49.32	73.31	106.63	166.61
P_C , kPa	39.32	62.65	93.30	133.29

12. (a) In the synthesis of ammonia, stoichiometric amounts of nitrogen and hydrogen are sent to a reactor where the following reaction occurs **(16)**

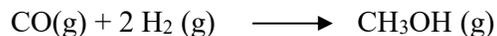


The equilibrium constant for the reaction at 675 K may be taken as 2×10^{-4} .

- Determine the per cent conversion of nitrogen to ammonia at 675 K and 20 bar.
- What would be the conversion at 675 K and 200 bar?

(OR)

- (b) Methanol is produced by the following reaction (16)



The standard heat of formation of CO(g) and CH₃OH (g) at 298 K are (-110,500) J/mol and (-200,700) J/mol respectively. The standard free energies of formation are (-137,200) J/mol and 162,000 J/mol respectively.

- i) Calculate the standard free energy change and determine whether the reaction is feasible at 298K.
- ii) Determine the equilibrium constant at 400K assuming that the heat of reaction is constant.
- iii) Derive an expression for standard free energy of reaction as function of temperature if the specific heats of the components are:

$$C_p : 3.376 R + 0.557 * 10^{-3} RT - 0.031 * 10^5 RT^{-2} \text{ for CO}$$

$$C_p : 3.249 R + 0.422 * 10^{-3} RT + 0.083 * 10^5 RT^{-2} \text{ for H}_2$$

$$C_p : 2.211 R + 12.216 * 10^{-3} RT - 3.450 * 10^{-6} RT^2 \text{ for CH}_3\text{OH}$$