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 is **(8)**

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

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 m^3/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 H_1 and H_2 in terms of x_1.
b) Numerical values for the pure component enthalpies H_1 and H_2.
c) Numerical values for the partial molar enthalpies at infinite dilution H_1 and H_2.

10. (a) Assuming Raoult's law to be valid for the system Benzene (1) –Ethyl Benzene (2) and the vapor pressures are given by the Antoine equations. **(16)**

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

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

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)**

xi	0.122	0.163	0.226	0.320	0.337	0.437	0.440	0.579	0.830
Yi	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)**

a. The bubble point and the vapour composition

b. 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)**

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

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

(a) Determine the per cent conversion of nitrogen to ammonia at 675 K and 20 bar.

(b) What would be the conversion at 675 K and 200 bar?

(OR)

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

$$CO(g) + 2\,H_2\,(g) \longrightarrow CH_3OH\,(g)$$

The standard heat of formation of CO(g) and CH_3OH (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:

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

Cp : $3.249\,R + 0.422 * 10^{-3}\,RT + 0.083 * 10^{5}\,RT^{-2}$ for H_2

Cp : $2.211\,R + 12.216 * 10^{-3}\,RT - 3.450 * 10^{-6}\,RT^{2}$ for CH_3OH