Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V • EXAMINATION – WINTER 2013

Subject Code: 150503 Date: 04-12-2013

Subject Name: Chemical Engineering Thermodynamics-II

Time: 10.30 am - 01.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define Chemical potential and prove that for a multi component system, the chemical potential of each component is the same in all phases. **07**

(b) Define ideal solution. Discuss Henry's law for dilute solutions. **07**

Q.2 **(a)** What is partial molar property ? Derive general form of Gibbs- Duhem equation. **07**

(b) Define fugacity coefficient . Discuss any two methods to evaluate fugacity coefficient. **07**

OR

(b) A container is divided into two compartments. One contains 3 moles of hydrogen at 298 K and 1 bar and the other contains 1 mol of nitrogen at 298 K and 3 bar. Calculate the free energy of mixing when the partition is removed. Assume gases behave ideally. **07**

Q.3 **(a)** Discuss vapor-liquid equilibria for non ideal solutions with neat sketch. **07**

(b) The vapour pressures of acetone(1) and acetonitrile (2) can be evaluated by the following Antoine equations, where P is in kPa and T is in K. **07**

$$\ln P_1^s = 14.5463 - \frac{2940.46}{T - 35.93}, \quad \ln P_2^s = 14.2724 - \frac{2945.47}{T - 49.15}$$

Assuming ideal solutions, calculate

1) x_1 and y_1 at 327 K and 65 kPa 2) P and y_1 at 327 K and x_1= 0.4

OR

Q.3 **(a)** Discuss minimum and maximum boiling azeotropes giving examples for each with neat diagrams. **07**

(b) Calculate the bubble temperature of a binary liquid mixture of benzene (1) and toluene (2) at 760 Torr. The mole fraction of benzene in the liquid is 0.4047. Antoine equations are given below where P is inTorr and T is in ℃. **07**

$$\log 10\, P_1^s = 6.87987 - \frac{1196.76}{T+219.161}, \log 10\, P_2^s = 6.95087 - \frac{1342.310}{T+219.187}$$

Q.4 **(a)** Define activity coefficient. Discuss Margules equation and Wilson equation with their merits and demerits. **07**

(b) The van Laar constants A and B for the system nitro methane (1) and CCl_4 (2) at 45 ℃ are 2.230 and 1.959 respectively. Calculate the activity coefficients of the components in a solution with 30 mol % CCl_4. **07**

OR

Q.4 **(a)** Enlist the methods to test consistency for any VLE data and describe any two in detail. **07**

(b) Binary system acetonitrile(1)/ nitro methane (2) confirms closely to Roult's law. Vapor pressures of pure species are given by the following Antoine equations, where P is in kPa and T is in ℃. Prepare P-x, y diagram at 75 ℃. **07**

$$lnP_1^s = 14.2724 - \frac{2945.47}{T + 224.00}, \quad lnP_2^s = 14.2043 - \frac{2972.64}{T + 209.00}$$

Q.5 **(a)** Discuss effect of temperature and pressure on equilibrium constant. **07**

(b) Methanol is produced according to the following reaction **07**

$$CO_{(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(g)}$$

Estimate the degree of conversion of CO into methanol at 500 K and 5 bar if

1) An equimolar mixture of CO and H_2 is fed to the reactor
2) CO and H_2 the ratio 1: 4 enters the reactor.

Use relation $K_a = K_\phi K_y P^{\Sigma vi}$,

given that $K_a = 4.973 \times 10^{-3}$, $K_\phi = 1$

OR

Q.5 **(a)** Write short note on equilibrium with simultaneous reactions. **07**

(b) For the following reaction prove that $\Delta G° = -RT\ln K$ **07**

$$aA + bB \rightarrow lL + mM$$

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