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.
- Define Chemical potential and prove that for a multi component system, **Q.1** (a) 07 the chemical potential of each component is the same in all phases. 07
 - Define ideal solution. Discuss Henry's law for dilute solutions. **(b)**
- (a) What is partial molar property? Derive general form of Gibbs- Duhem 0.2 07 equation.
 - (b) Define fugacity coefficient. Discuss any two methods to evaluate fugacity 07 coefficient.

OR

(b) A container is divided into two compartments. One contains 3 moles of 07 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.

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

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

 $lnP_1^s = 14.5463 - \frac{2940.46}{T - 35.93}, \quad lnP_2^s = 14.2724 - \frac{2945.47}{T - 49.15}$ 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

- Discuss minimum and maximum boiling azeotropes giving examples for 07 0.3 (a) each with neat diagrams.
 - Calculate the bubble temperature of a binary liquid mixture of benzene (1) 07 **(b)** 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 °C.

$$log10 P_1^s = 6.87987 - \frac{1196.76}{T+219.161}$$
, $log10 P_2^s = 6.95087 - \frac{1342.310}{T+219.187}$

- (a) Define activity coefficient. Discuss Margules equation and Wilson 07 0.4 equation with their merits and demerits.
 - (b) The van Laar constants A and B for the system nitro methane (1) and CCl₄ 07 (2) at 45 °C are 2.230 and 1.959 respectively. Calculate the activity coefficients of the components in a solution with 30 mol % CCl₄

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

(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 °C. Prepare P-x, y diagram at 75 °C.

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

Q.5 Discuss effect of temperature and pressure on equilibrium constant. 07 (a) Methanol is produced according to the following reaction 07 **(b)** $CO_{(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(g)}$ 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 $K_a = K_\varphi \; K_y \; P^{\Sigma \nu i}$, 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 $\Delta G^{\circ} = - RT \ln K$ 07

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