

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 in Torr and T is in °C. **07**

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

- 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 CCl₄ (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. **07**

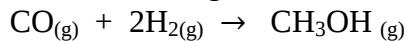
OR

- 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 Roults 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. 07

$$\ln P_1^s = 14.2724 - \frac{2945.47}{T + 224.00}, \quad \ln P_2^s = 14.2043 - \frac{2972.64}{T + 209.00}$$

- Q.5 (a) Discuss effect of temperature and pressure on equilibrium constant. 07
 (b) Methanol is produced according to the following reaction 07



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

- 1) An equimolar mixture of CO and H₂ is fed to the reactor
- 2) CO and H₂ the ratio 1: 4 enters the reactor.

Use relation $K_a = K_\phi K_y P^{\sum v_i}$,

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

