Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V EXAMINATION – WINTER 2015

Subject Code: 150503 **Date:08/12/2015**

Subject Name: Chemical Engineering Thermodynamics – II

Time: 10:30am to 1:00pm **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)** Derive the equation for criteria for phase equilibrium in terms of chemical potential for a mixture of N components and π phases. **07**

(b) Write a brief note on ideal solutions and non-ideal solutions. **07**

Q.2 **(a)** Discuss various methods for checking the consistency of experimental VLE data. **07**

(b) Define activity coefficient. Discuss Margules and Wilson equations with their merits and demerits. **07**

OR

(b) The experimental pressure-volume data for benzene at 675K from a very low pressure to about 75 bar may be approximated by the equation V = 0.0561 (1/P – 0.0046), where V is in m^3/mol and pressure P is in bar. What is fugacity of benzene at 1 bar and 675 K? **07**

Q.3 **(a)** The excess Gibbs energy of a particular ternary liquid mixture is represented by the empirical expression with parameters A_{12}, A_{13}, and A_{23} functions of T and P only: **07**

$$\frac{G^E}{RT} = A_{12}x_1x_2 + A_{13}x_1x_3 + A_{23}x_2x_3$$

i) Determine the implied expressions for ln γ_1, ln γ_2, and ln γ_3.

ii) Determines expressions (or values) for ln γ_1 for the limiting case $x_1 = 0$.

(b) Write a brief note on excess properties. **07**

OR

Q.3 **(a)** At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by **07**

$V = 109.4 \times 10^{-6} - 16.8 \times 10^{-6}\, x - 2.64 \times 10^{-6}\, x^2$, where x is the mole fraction of benzene and V has the units of m^3/mol. Find the expressions for the partial molar volumes of benzene and cyclohexane.

(b) Construct P-x-y diagram for the cyclohexane(1)/benzene(2) system at 40°C. Use the following expressions for the liquid-phase activity coefficients: ln $\gamma_1 = 0.458\, x_2^2$, ln $\gamma_2 = 0.458\, x_1^2$. At 40°C, $p_1^{sat} = 0.243$ atm and $p_2^{sat} = 0.241$ atm. **07**

Q.4 **(a)** Write a short note on phase diagram for completely immiscible systems. **07**

(b) Derive the expression of vapor composition at equilibrium using flash vaporization. **07**

OR

Q.4 **(a)** An equimolar solution of benzene and toluene is totally evaporated at a constant temperature of 363 K. At this temperature, the vapour pressures of benzene & toluene are 135.4 and 54 kPa respectively. What are pressures at the beginning & at the end of the vaporization process? **07**

(b) Calculate the equilibrium constant at 298 K of the reaction **07**

N_2O_4 (g) → $2NO_2$ (g)

Given that the standard free energies of formation at 298 K are 97,540 J/mol for N_2O_4 and 51,310 J/mol for NO_2.

Q.5 **(a)** Develop expressions for the mole fractions of reacting species as functions of the reaction coordinate for: **07**

(i) A system initially containing 2 mol of NH_3 & 5 mol of O_2 and undergoing the reaction $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

(ii) A system initially containing 3 mol of H_2S & 5 mol of O_2 and undergoing the reaction $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

(b) Explain briefly evaluation of equilibrium conversion for heterogeneous reactions. **07**

OR

Q.5 **(a)** Derive the relation between standard free energy change and equilibrium constant from the first principle. **07**

(b) Discuss the effect of pressure and temperature on equilibrium constant for chemical reaction equilibrium. **07**

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