Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER–II EXAMINATION – SUMMER 2015

Subject Code: 2723008 **Date: 26/05/2015**

Subject Name: Advanced Chemical Engineering Thermodynamics

Time: 02:30 PM to 05:00 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)**	Explain the importance of phase equilibrium problem and describe three step applications of thermodynamics to phase equilibrium problem.	**07**
	(b)	Describe the procedure to find out fugacity of a component in a mixture at moderate pressure.	**07**
Q.2	**(a)**	Explain Lewis fugacity rules along with assumptions made in this rule.	**07**
	(b)	At 0 ^{o}C and pressures to 20 bar, the solubility of methane (1) in methanol (2) follows Henryôs law; Henryôs constant is 1022 bar. The vapor pressure of methanol at 0 ^{o}C is 0.0401 bar. Second virial coefficients (cm^3 $mol^{ï\ 1}$) at 0 ^{o}C are B_{11} = ï 53.9, B_{12} = ï 166, and B_{22} = ï 4068. At 0 ^{o}C and 20 bar, what is solubility (mole fraction) of methanol in methane?	**07**
		OR	
	(b)	Discuss the fundamental relations of excess functions.	**07**
Q.3		Describe the procedure to find out activity coefficients from excess functions in binary mixtures. Derive two suffix Margules equations.	**14**
		OR	
Q.3	**(a)**	Discuss Wilson equation used to represent excess Gibbs energy of a binary solution based on molecular consideration.	**07**
	(b)	Total pressure data are available for the entire concentration range of a binary solution at constant temperature. At the composition x_1 = a, the total pressure is maximum. Show that at the composition x_1 = a, this solution has an azeotrope means that the relative volatility at this composition is unity. Assume that the vapor phase is ideal.	**07**
Q.4	**(a)**	Write a note on upper and lower consolute temperatures.	**07**
	(b)	Write a short note on the method of Lagrange's undetermined multipliers for gas-phase reactions.	**07**
		OR	
Q.4	**(a)**	Write a short note on Van Laar and NRTL equations.	**07**

(b) Discuss phase rule and Duhemôs theorem for reacting systems. **07**

Q.5 **(a)** In laboratory investigation, acetylene is catalytically hydrogenated to ethylene at 1120 ^{o}C temperature and 1 bar pressure according to following reactions. **07**

$$C_2H_2 \rightarrow 2C + H_2 \text{ é é } (1)$$

$$2C + 2H_2 \rightarrow C_2H_4 \text{ é . } (2)$$

If the feed is an equimolar mixture of acetylene and hydrogen, what is the composition of the product stream at equilibrium? The equilibrium constant K_1 for reaction (1) is 4 x 10^5 and K_2 for reaction (2) is 2.5 x 10 ï 6 at the reaction temperature. Assume that the reacting mixture behaves as an ideal gases at this elevated temperature.

(b) Derive the relation between equilibrium constant and composition for homogeneous gas phase reaction at low pressure. Also discuss the effect of temperature and pressure on equilibrium constant. **07**

OR

Q.5 **(a)** A feed stock of pure n-butane is cracked at 750 K temperature and 1.2 bar pressure to produce olefins. Only two reactions have favorable equilibrium conversions at these conditions: **07**

$$C_4H_{10} \rightarrow C_2H_4 + C_2H_6 \text{ é é } (1)$$

$$C_4H_{10} \rightarrow C_3H_6 + CH_4 \text{ é é . } (2)$$

If these reactions reach equilibrium, what is the product composition? The equilibrium constant K_1 for reaction (1) is 3.856 and K_2 for reaction (2) is 268.4 at temperature of 750 K.

(b) Carbon black is produced by the following reaction at 700 K temperature and 1 atmosphere pressure. **07**

$$CH_{4\,(g)} \rightarrow C_{(s)} + 2H_{2\,(g)}$$

The thermodynamics equilibrium constant of the reaction at temperature of 700 K is 7.403, calculate equilibrium mole fraction of methane and hydrogen. Assume that the equilibrium mixture behaves as an ideal gas.

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