Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER II (NEW) – • EXAMINATION – SUMMER 2016

Subject Code: 2723008 **Date: 24/05/2016**

Subject Name: Advanced Chemical Engineering Thermodynamics

Time:10:30 am to 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 and distinguish classical, statistical and molecular thermodynamics. **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 vapour phase is ideal. **07**

Q.2 **(a)** Describe procedure to find out fugacity in a mixture according to Van der Waalsôequation of state. **07**

(b) The volume coefficient of expansion of mercury at 0°C is 18 x $10^{ï5}$ $(^oC)^{ï1}$. The coefficient of compressibility K_T is 5.32 x $10^{ï6}$ $(bar)^{ï1}$. If mercury were heated from 0°C to 1 °C in a constant-volume system, what pressure would be developed? **07**

$$K_T = -\frac{1}{v}\left(\frac{\partial v}{\partial p}\right)_T$$

OR

(b) Write a short note on Van Laar, Wilson, NRTL and UNIQUAC equations. **07**

Q.3 **(a)** Explain importance of virial equation of state in calculating fugacities for components in a gaseous mixture. Show how second and third virial coefficient can be found at low pressure. **07**

(b) Discuss various methods to test thermodynamic consistency. **07**

OR

Q.3 **(a)** The second virial coefficient B of a certain gas is given by, $B = b - \frac{a}{T^2}$, where a and b are constants. Compute the change in internal energy for this gas in going, at temperature T, from very low pressure to a pressure π. Use the equation given below. **07**

$$Z = \frac{PV}{RT} = 1 + \frac{BP}{RT}$$

(b) Which are the methods available for estimation of vapour-liquid critical properties T_c, P_c, and V_c? Describe any one method in detail. **07**

Q.4 **(a)** Describe the procedure to find out activity coefficients from excess functions in binary mixtures. Also, Derive two suffix Margules equations. **07**

(b) Write equations to find out fugacity of a pure liquid or solid. Also explain Poynting correction factor. **07**

OR

Q.4 **(a)** Explain partial miscibility with the use of excess functions. Also explain incipient instability and upper and lower consolute temperatures. **07**

(b) Explain criteria of chemical equilibrium in detail with neat sketch. **07**

Q.5 **(a)** Explain Lagrange undetermined multipliers method of multi reaction equilibria. **07**

(b) Acetic acid is esterified in the liquid phase with ethanol at 100 ^{o}C and atmospheric pressure to produce ethyl acetate and water according to the reaction: **07**

$$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \text{ ---------}\rightarrow CH_3COOC_2H_{5(l)} + H_2O_{(l)}$$

If initially there is one mole each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium.

Components	**$\Delta H^0_{f,298}$ (J/mol)**	**$\Delta G^0_{f,298}$ (J/mol)**
$CH_3COOH_{(l)}$	-484500	-389900
$C_2H_5OH_{(l)}$	-277690	-174780
$CH_3COOC_2H_{5(l)}$	-480000	-332200
$H_2O_{(l)}$	-285830	-237130

OR

Q.5 **(a)** State and explain phase rule and Duhemôs theorem for reacting system. **07**

(b) Hydrated sodium carbonate decomposes as follows: **07**

$$Na_2CO_3 \cdot H_2O_{(s)} \text{ ------}\rightarrow Na_2CO_{3(s)} + H_2O_{(g)}$$

The equilibrium pressure of water vapor during this reaction is given by

$$\ln P = 18.3 \text{ ï } (6910/T) \qquad \text{where P is in bar and T is in K}$$

Derive an expression for æG^0 as a function of temperature for the above reaction.

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