Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME SEMESTER II EXAMINATION – SUMMER 2017

Subject Code: 2723008 **Date: 25/05/2017**

Subject Name: Adv. Chem. Engg. 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) A system consist of Six particles has four energy levels with relative energy values of 0, 1, 2, 3. The total energy of the system is 6 and the degeneracy of the four levels is 4 each respectively. Determine the thermodynamic probability for each of the possible distribution assuming Fermi Dirac Statistics. **07**

Q.2 (a) Production methanol proceeds as follows:- **07**

$$C + 2H_2 \text{-------} \rightarrow CH_3OH.$$

The above reaction is carried out at temperature of 390oC and pressure of 300 atm. The value of ratios of activity coefficients (Kv) is 0.434 and the value of free energy change for reaction at 663.2K is + 14,700 cal/gmole. Show that the values of yield of methanol and equilibrium conversion are 21% and 45% respectively.

(b) Describe with the help of appropriate data, equations and relevant graphs, the calculation of equilibrium conversion under adiabatic conditions for a reaction of type A→ B being highly reversible and endothermic in nature. **07**

OR

(b) Starting from first principle, derive an expression for Heat of Reaction for a reaction of type $a \cdot A + b \cdot B \leftrightarrows c \cdot C + d \cdot D$ occurring at any temperature (T) and any pressure (P) under non-ideal conditions. **07**

Q.3 (a) Explain in detail about the Liquid-Liquid Equilibrium with constant pressure solubility diagram? **07**

(b) Explain method for DEWP calculation with the help of block diagram and all supportive equations. **07**

OR

Q.3 (a) Total pressure data are available for the entire concentration range of a binary solution at constant temperature. At the composition X_1 = b, the total pressure is maximum. Show that at the composition X_1 = b, this solution has an azeotrope means that the relative volatility at this composition is unity. Assume that the vapor phase is ideal. **07**

(b) Explain calculations of equilibrium conversion values under isothermal conditions for the following two reactions proceeding simultaneously: **07**

$A \rightarrow B+C$ and $A \rightarrow D+E$.

Derive relevant equations for equilibrium constant (K) as a function of P, n_t & x_e. Also briefly describe stepwise procedure for calculation of values of x_e when both reactions proceed simultaneously.

Q.4 (a) A saturated liquid mixture, containing 45.1% propane, 18.3% iso-butane and 36.6% *n*-butane (by mole), is available at 40.8 bar a and 125.6º C (398.78 K). It is adiabatically flashed at 22 bar a and 93.1ºC (366.25 K). At these conditions, K values are 1.42, 0.86 and 0.72 respectively. Determine the degree of vaporization and composition of vapour and liquid phases. **14**

(b) The volume coefficient of expansion of mercury at 0°C is 18×10^{-5} (ºC)$^{-1}$. The coefficient of compressibility K_T is 5.32×10^{-6} (bar)$^{-1}$. If mercury were heated from 0°C to 1°C in a constant-volume system, what pressure would be developed? $K_T = -\frac{1}{v}\left(\frac{\partial v}{\partial p}\right)_T$

OR

Q.4 (a) The following isomerization reaction occurs in liquid phase: $A \rightarrow B$, where A and B are miscible liquids for which $G^E/RT = 0.1\, x_A\, x_B$ If $\Delta G°_{298}$ = - 1000 J/mol what is the equilibrium composition of mixture at 25° C? How much error is introduced if one assumes that A and B form an ideal solution? **07**

(b) Derive the function for the solution of a P-T Flash calculation problem and explain the block diagram of P-T Flash calculations for multi component mixtures? **07**

Q.5 (a) Explain importance of virial equation of state in calculating fugacity's for components in a gaseous mixture. Show how second and third virial coefficient can be found at low pressure **07**

(b) For the system ethyl ethanoate (1)/ n-heptane (2) at 343.15 K, P_1^{sat}= 79.8 kPa, P_2^{sat} = 40.5 kPa and $G^E / RT = 0.95\, x_1\, x_2$. If the system forms an azeotrope at 343.15 K. Find its conditions. **07**

OR

Q.5 (a) Write equations to find out fugacity of a pure liquid or solid. Also explain Poynting correction factor. **07**

(b) Write a brief note on Wilson and NRTL equation for non-ideal solution **07**

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