Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– V(OLD) EXAMINATION – SUMMER 2019

Subject Code:150503 Date:31/05/2019

Subject Name:Chemical Engineering Thermodynamics - II

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)** Define thermodynamic equilibrium. Explain chemical potential as criteria for phase equilibrium. **07**

(b) Define partial molar property. Derive summability relation and Gibbs/Duhem equation. **07**

Q.2 **(a)** With neat sketch describe phase diagrams for partially miscible systems. **07**

(b) Describe the effect of temperature and pressure on fugacity. **07**

OR

(b) Explain the phenomena of retrograde condensation. **07**

Q.3 **(a)** Explain block diagram for bubble point temperature calculation. **07**

(b) The enthalpy of a binary liquid system of species 1 and 2 at fixed T and P is represented by the equation: **07**

$$H = 400x_1 + 600x_2 + x_1x_2\left(40x_1 + 20x_2\right)$$

Determine the expressions for $\overline{H}_1$ and $\overline{H}_2$ as a function of x_1. Calculate the values of H_1 , H_2 , $\overline{H}_1^{\infty}$ and $\overline{H}_2^{\infty}$

OR

Q.3 **(a)** Define azeotrope. What kind of azeotrope is a system likely to form if it exhibits large positive deviation from Raoult's law? Explain. **07**

(b) For the system methanol and methyl acetate, the following equation provide reasonable correlation for activity coefficient **07**

$$\ln\gamma_1 = Ax_2^2 \qquad \ln\gamma_2 = Ax_1^2$$

$$A = 2.771 - 0.00523T$$

$$\ln P_1^{sat} = 16.591 - \frac{3643.31}{T - 33.424} \quad and \quad \ln P_2^{sat} = 14.253 - \frac{2665.54}{T - 53.424}$$

where T in K and vapor pressures are in kPa. Assuming the validity of modified Raoults law , calculate P and y_i for T = 318.15 K and x_1 = 0.25.

Q.4 **(a)** At 25 ^{0}C the density of a methanol (1) – water (2) solution at x_1 = 0.7779 is 825.959 kg/m^3. Partial molar volume of water in this solution is 15.686 x 10^{-6} m^3/mol. Determine the partial molar volume of methanol in the solution. **07**

(b) Derive phase rule for reacting system. **07**

OR

Q.4 **(a)** Determine the fugacity coefficients for nitrogen and methane in a $N_2(1)/CH_4(2)$ mixture at 200 K and 30 bar, if the mixture contains 40 mol% N_2. **07**

Data given:

Experimental virial coefficient data are as follows:

B_{11} = -35.2 cm^3/ mol, B_{22} = -105 cm^3/ mol, B_{12} = -59.8 cm^3/ mol

(b) List out various methods for evaluation of fugacity coefficient of pure component. Discuss any one in detail. **07**

Q.5 **(a)** Derive the expression relating equilibrium constant (K) with standard Gibbs energy change ($\Delta G°$) at constant temperature and pressure. **07**

(b) For a system in which following reaction occurs, **07**

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

assume there are present initially 2 mol CH4, 1 mol H2O, 1 mol CO and 4 mol H2. Determine expressions for the mole fractions yi as a function of ε.

OR

Q.5 **(a)** Explain the method of Lagrange's undetermined multipliers for gas phase reaction to minimize total Gibbs free energy. **07**

(b) Consider the system in which the following reaction occurs: **07**

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad ....(1)$$

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2 \quad ....(2)$$

If there are present initially 2 mol of CH_4 and 3 mol of H_2O. Determine expressions for the y_i as a functions of the ε_1 and ε_2.

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