

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER- V (New) EXAMINATION – WINTER 2019

Subject Code: 2150503

Date: 04/12/2019

Subject Name: Chemical Engineering Thermodynamics - II

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: (1) Partial molar property (2) Activity coefficient (3) Fugacity. **03**
 - (b) Discuss the excess Gibbs free energy relation with activity coefficient and chemical potential. **04**
 - (c) Determine P-x-y data for chloroform (1) methanol (2) system at 35°C, vapor pressure of chloroform and methanol is 39.54 KPa and 27.95 KPa respectively. Margules parameters are: $A_{12}=0.738$ and $A_{21}=1.868$. **07**

- Q.2**
- (a) Define chemical potential and state its significance. **03**
 - (b) Derive the expression to estimate fraction of initial mixture that is vaporized at equilibrium using flash vaporization calculation. **04**
 - (c) Derive Margules equations for determination of activity coefficients of a binary system from the expression: **07**

$$\frac{G^E}{RT} = (A_{21}x_1 + A_{12}x_2)x_1x_2$$

OR

- (c) Show that for a binary system, Henry's law is valid for component '1' then Lewis Randall rule is valid for component '2'. **07**

- Q.3**
- (a) Write a short note on Bubble point equilibria. **03**
 - (b) Write a short note on 'fugacity of a pure liquid'. **04**
 - (c) A gas mixture of $\text{SO}_{2(g)}$, $\text{O}_{2(g)}$ and inert $\text{A}_{(g)}$ in mole ratio 1: 0.5: 2 enters in a reactor at 30bar and 900K to produce $\text{SO}_{3(g)}$ as:
 $\text{SO}_{2(g)} + 0.5 \text{O}_{2(g)} \rightarrow \text{SO}_{3(g)}$. Determine the degree of conversion at equilibrium and composition of mixture leaving the reactor. Assume the reaction mixture behaves like an ideal gas. $K = 5.973$ and $K_\phi = 1$. **07**

OR

- Q.3**
- (a) Derive summability relation for partial molar properties. **03**
 - (b) Methanol (1)-acetone (2) system is described by the Van Laar activity coefficient model. At 60°C the model parameters are $A_{12} = 0.47$ and $A_{21}=0.78$. Estimate the activity coefficients for a solution containing 15mole% of methanol. **04**
 - (c) Derive equation for establish expression of standard Gibbs free energy change of chemical reaction as a function of thermodynamic equilibrium constant. **07**

- Q.4**
- (a) With neat diagram explain tangent-intercept method to estimate partial molar volume of a binary solution. **03**
 - (b) Discuss van Laar equations applicable in determination of activity coefficient for VLE at low pressure with suitable examples. **04**

- (c) For binary mixture of liquid A and liquid B, activity coefficients are given by $\ln \gamma_1 = 0.6x_2^2$ and $\ln \gamma_2 = 0.6x_1^2$. At $T = 353\text{K}$, vapor pressure of A, $P_A^{\text{sat}} = 119.96\text{KPa}$ and that of B is $P_B^{\text{sat}} = 79.97\text{KPa}$. Does an azeotrope exist at 353K ? If so, determine the azeotropic pressure and composition. **07**

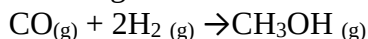
OR

- Q.4 (a)** Derive an expression for partial molar volumes $\bar{V}_1$ and $\bar{V}_2$ using following relationship for the molar volume of the binary liquid mixture of components 1 and 2. **03**

$$V = x_1 V_1 + x_2 V_2 + x_1 x_2 [B + C(x_1 - x_2)]$$

- (b) Explain any two methods for estimation of fugacity of pure gas. **04**

- (c) A gas mixture containing 30 mol% of CO , 50 mol% of H_2 and 20 mol% of inert gas is to be used for synthesis of methanol as: **07**



Gases issued from the catalytic chambers are in chemical equilibrium with respect to the reaction at 30 bar and 625K . Assume that the equilibrium mixture forms an ideal solution, $K = 5 \times 10^{-5}$ and $K_\phi = 1$. What is the percentage conversion of CO ?

- Q.5 (a)** Explain criteria of stability for a single phase binary system. **03**

- (b) Draw neat diagram of idealized osmotic system and derive an equation for osmotic pressure difference. **04**

- (c) Mixtures of n-Heptane (A) and n-Octane (B) are expected to behave as an ideal solution. The total pressure over the system is 101.3KPa . Use vapour pressure data given below and construct **07**

a) T- x_A , y_A diagram b) Equilibrium diagram for A.

T, K	371.4	378	383	388	393	398.6
P_A^{sat} , KPa	101.3	125.3	140	160	180	205.3
P_B^{sat} KPa	44.4	55.6	64.5	74.8	86.6	101.3

OR

- Q.5 (a)** For VLE with suitable example, draw diagram for minimum azeotrope. **03**

- (b) Determine the number of degree of freedom F for each of following: **04**

(1) A system prepared by partial decomposition of CaCO_3 into evacuated space.

(2) A system of two miscible non reacting species which exists as an azeotrope in VLE.

- (c) With proper nomenclature draw three types of constant- pressure liquid-liquid solubility diagram. **07**
