Seat No.: _____ Enrolment No.

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 35^0C, 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: $$\frac{G^E}{RT} = (A_{21}x_1 + A_{12}x_2)x_1x_2$$	**07**
		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 $SO_{2(g)}$ $O_{2(g)}$ and inert $A_{(g)}$ in mole ratio 1: 0.5: 2 enters in a reactor at 30bar and 900K to produce $SO_{3(g)}$ as: $SO_{2(g)}$ + 0.5 $O_{2(g)}$ → $SO_{3(g)}$.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 60^0C 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 co-efficient 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 $\ln\gamma_2= 0.6\ x_1^2$. At T = 353K, vapor pressure of A, P_A^{sat} = 119.96KPa and that of B is P_B^{sat} =79.97KPa.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**

$CO_{(g)} + 2H_{2\ (g)} \rightarrow CH_3OH_{\ (g)}$

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, $K = 5x10^{-5}$ and K_ϕ =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 101.3 KPa. 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**

****