

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE- SEMESTER-IV EXAMINATION – WINTER 2025****Subject Code:3140507****Date:28-11-2025****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.
4. Simple and non-programmable scientific calculators are allowed.

	MARKS
<b>Q.1 (a)</b> Define: (1) Partial molar property, (2) Fugacity coefficient and (3) Activity coefficient.	<b>03</b>
<b>(b)</b> Explain the difference between ideal and non-ideal solution.	<b>04</b>
<b>(c)</b> Define azeotropes and explain minimum boiling and maximum boiling azeotropes with suitable examples and neat diagrams.	<b>07</b>
<b>Q.2 (a)</b> Explain the significance of phase equilibria in chemical engineering.	<b>03</b>
<b>(b)</b> Write short note on flash vaporization.	<b>04</b>
<b>(c)</b> Prove that if Raoult's law is valid for one constituent of a binary solution over the whole concentration range, it must also apply to the other constituent.	<b>07</b>
<b>OR</b>	
<b>(c)</b> Derive general form of Gibbs- Duhem equation.	<b>07</b>
<b>Q.3 (a)</b> Derive summability relation for partial molar properties.	<b>03</b>
<b>(b)</b> Discuss any one group contribution methods to determine Activity coefficients.	<b>04</b>
<b>(c)</b> The compressibility factor for oxygen gas at 20°C is given by expression in terms of pressure as $Z = a + bP + cP^2$ . Where, a, b and c are empirical constants and pressure is in bar. Determine the fugacity of oxygen at 20°C and 100 bar for given values of empirical constants. $a = 1.0, b = 0.75 \times 10^{-3}$ and $c = 0.15 \times 10^{-5}$	<b>07</b>
<b>OR</b>	
<b>Q.3 (a)</b> Define chemical potential and state its significance.	<b>03</b>
<b>(b)</b> Discuss Margules equation with their merits and demerits.	<b>04</b>
<b>(c)</b> Discuss any two methods to evaluate fugacity coefficient.	<b>07</b>
<b>Q.4 (a)</b> Show that for an ideal gas $\left(\frac{\partial \mu_i}{\partial P}\right)_T = \frac{RT}{P}$	<b>03</b>
<b>(b)</b> Discuss about liquid – liquid equilibrium (LLE).	<b>04</b>
<b>(c)</b> The azeotropic mixture of the ethanol-Methyl ethyl ketone has a composition of 52.5 mole% ethanol with boiling point of 250 K at 101.32 kPa. At this temperature the vapour pressure of methyl ethyl ketone is 93.65 kPa and vapour pressure of ethanol is 94.38 kPa. What is the activity	<b>07</b>

coefficient in a solution containing 75% methyl ethyl ketone? (Use Van Laar equation)

**OR**

- Q.4** (a) With neat diagram explain tangent-intercept method to estimate partial molar volume of a binary solution. **03**
- (b) What is gamma-phi formulation of VLE? **04**
- (c) The fugacity of ethanol in a binary liquid mixture with methyl-ethyl-  
ketone at 298 K and 10 bar is given by  $\bar{f}_1 = 25x_1 - 40x_1^2 + 20x_1^3$ , where  
 $\bar{f}_1$  is in bar and  $x_1$  is mole fraction of ethanol in liquid mixture, Determine;  
1. Fugacity of a pure ethanol ( $f_1$ ).  
2. Henry's law constant ( $K_1$ ).  
3. Activity coefficient of ethanol for equimolar binary mixture ( $\gamma_1$ ).
- Q.5** (a) List out various methods for checking the consistency of experimental VLE data. **03**
- (b) Derive the relationship between the mole fraction of the components taking part in the reaction and the extent of the reaction. **04**
- (c) Industrial grade methanol can be produced according to the reaction **07**  
 $CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$   
For this reaction,  $\Delta G_{400}^0 = -1.3484 \text{ kJ}$ . If an equimolar mixture of CO and H<sub>2</sub> is fed to a reactor maintained at 400 K and 10 bar, determine the fraction of CO that is converted into CH<sub>3</sub>OH at equilibrium. Assume that the reaction mixture behaves like an ideal gas.
- OR**
- Q.5** (a) Differentiate activity coefficient model and equation of state. **03**
- (b) Write the effect of temperature on equilibrium constant. **04**
- (c) Establish the relationship between equilibrium constant and standard free energy change. **07**

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