Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV EXAMINATION – SUMMER 2025

Subject Code:3140507 **Date:23-05-2025**

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.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define fugacity, fugacity co efficient, and activity	**03**
	(b)	Derive the equation for determination of fugacity of pure gases using any two methods.	**04**
	(c)	For a system in which the following reaction occurs, $CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 3H_{2(g)}$ Assume there are present initially 2mol of CH_4, 1mol of H_2O, 0.5mol of CO, and 3.5mol of H_2. Determine an expression for the mole fraction yi as function of εe	**07**
Q.2	**(a)**	Write a brief note on Ideal solutions	**03**
	(b)	Define azeotrope and explain maximum boiling azeotrope with a neat diagram.	**04**
	(c)	Estimate activity coefficient of methanol for chloroform (1) / methanol (2) system at 35°C. The vapour pressures of chloroform and methanol at 35°C are 39.54kPa and 27.95kPa respectively, when the mole fraction of methanol in the liquid mixture is 0.4. Margules' parameters are $A_{12} = 0.738$, $A_{21} = 1.868$.	**07**
		OR	
	(c)	The fugacity of component 1 in binary liquid mixture of components 1 and 2 at 298 K and 20 bar is given by $\bar{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$ where $\bar{f}_1$ is in bar and x_1 is the mole fraction of component 1. Determine: (i) The fugacity f_1 of pure component 1 (ii) The fugacity coefficient ϕ_1 (iii) The Henry's law constant K_1 (iv) The activity coefficient Υ_1.	**07**
Q.3	**(a)**	Discuss the criteria of phase equilibrium for a homogeneous closed system.	**03**
	(b)	What is partial molar property? Discuss the physical significance and importance of partial molar property.	**04**
	(c)	The molar volume of a binary solution at 300 K and 1 bar is given by: $V = 500x_1 + 1000x_2 + x_1x_2(50\ x_1 + 40x_2)$ cm^3/mol For the stated temperature and pressure, determine: (i) Expressions for $\bar{V}_1$ and $\bar{V}_2$ in terms of x_1 (ii) Numerical values for the partial molar volumes at infinite dilution $\overline{V_1^\infty}$ and $\overline{V_2^\infty}$	**07**
		OR	

Q.3 **(a)** What is retrograde condensation and explain its application in chemical industry. **03**

(b) State applications and limitations of Wilson and NRTL equation. **04**

(c) The vapour pressures of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equations **07**

$$\ln P_1^S = 14.5463 - \frac{2940.46}{T - 35.93}$$

$$\ln P_2^S = 14.2724 - \frac{2945.47}{T - 49.15}$$

Where T is in K and P is in kPa. Assuming that the solutions formed by these are ideal, calculate x1, and y1 at 327 K and 65 kPa

Q.4 **(a)** Determine the fugacity and fugacity coefficient of steam at 623 K and 1000 kPa using enthalpy and entropy values from steam tables. Assume that steam behaves ideally at 101.3 kPa and 623K, H = 3176 kJ/kg; S = 8.38 kJ/kg K. Data from steam tables: At 1000kPa and 623K, **03**

H = 3159 kJ/kg; S = 7.3 kJ/kg K.

(b) The Henry's law constant for oxygen in water at 298 K is 4.4*10 4bar. Estimate the solubility of oxygen in water at 298 K for a partial pressure of oxygen at 0.25 bar. **04**

(c) Write steps to determine Bubble point temperature using Raoult's Law. **07**

OR

Q.4 **(a)** What do you mean by the 'extent of reaction'? How is it related to the mole fraction of the species in the reaction mixture? **03**

(b) Discuss any one group contribution method to determine activity coefficients **04**

(c) The water-gas-shift reaction is carried out under the different sets of conditions described below. Calculate the fraction of steam reacted in each case. Assume the mixture behaving as an ideal gas. **07**

$$CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + H_{2(g)}$$

(i) The reactants consist of 1mol of water vapour and 1mol of carbon monoxide. The equilibrium constant K= 1 for the reaction at temperature of 1100 K and the pressure of 1 bar.

(ii) Same as (i) except that 3 mol of N2 is included in the reactants.

(iii)The reactants are 2 mol of CO and 1 mol of H2O; other conditions are the same as in (i).

Q.5 **(a)** Describe phase rule for reacting systems **03**

(b) Explain any one method for checking the consistency of experimental VLE data. **04**

(c) Explain how the equilibrium constant for liquid reaction is evaluated. **07**

OR

Q.5 **(a)** Calculate the equilibrium constant at 298K of the reaction **03**

$$N_2O_{4(g)} \rightarrow 2NO_{2(g)}$$

Given that the standard free energies of formation at 298K are 97,540 J/mol for N2O4 and 51,310 J/mol for NO2.

(b) Explain effect of temperature and pressure on equilibrium constant. **04**

(c) Using the fundamental properties relation for single phase reaction, show that $\Delta G0 = -RT \ln K$ **07**

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