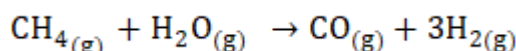


GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-IV EXAMINATION – SUMMER 2025****Subject Code:3140507****Date:23-05-2025****Subject Name: Chemical Engineering Thermodynamics II****Time: 10:30 AM TO 01:00 PM****Total Marks:70****Instructions:**

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, | 07 |



Assume there are present initially 2mol of CH₄, 1mol of H₂O, 0.5mol of CO, and 3.5mol of H₂. Determine an expression for the mole fraction y_i as function of ε

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| 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

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|---|-----------|
| (c) The fugacity of component 1 in binary liquid mixture of components 1 and 2 at 298 K and 20 bar is given by | 07 |
|---|-----------|

$$\bar{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$$

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 γ_1 .

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| 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: | 07 |

$$V = 500x_1 + 1000x_2 + x_1x_2(50x_1 + 40x_2) \text{ cm}^3/\text{mol}$$

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 \bar{V}_1^∞ and \bar{V}_2^∞

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 x_1 , and y_1 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, $H = 3159$ kJ/kg; $S = 7.3$ kJ/kg K. **03**
- (b)** The Henry's law constant for oxygen in water at 298 K is 4.4×10^4 bar. 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**
- $$\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_{2(g)}$$
- (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 N_2 is included in the reactants.
- (iii) The reactants are 2 mol of CO and 1 mol of H_2O ; 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**
- $$\text{N}_2\text{O}_{4(g)} \rightarrow 2\text{NO}_{2(g)}$$
- Given that the standard free energies of formation at 298K are 97,540 J/mol for N_2O_4 and 51,310 J/mol for NO_2 .
- (b)** Explain effect of temperature and pressure on equilibrium constant. **04**
- (c)** Using the fundamental properties relation for single phase reaction, show that $\Delta G^0 = -RT \ln K$ **07**
