

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-IV (NEW) EXAMINATION – WINTER 2023****Subject Code:3140507****Date:31-01-2024****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) Say, whether the following statements are TRUE or FALSE. Give correct statements to the false ones.	03
	<ol style="list-style-type: none"> 1. Real gases behave ideally at low pressures and/or high temperatures. 2. For an ideal gas, the fugacity and pressure are equal 3. For a chemically reacting system at equilibrium at constant temperature and pressure, the Gibbs free energy is maximum 	
	(b) Prove that for a multi component system, chemical potential of each component is the same in all phases.	04
	(c) Molar volume of a binary liquid mixture is given by	07
	$V = 90 * 10^{-3}x_1 + 50 * 10^{-3}x_2 + x_1x_2(6 * 10^{-3}x_1 + 9 * 10^{-3}x_2)$	
	Obtain expressions for \bar{V}_1 and \bar{V}_2 and show that they satisfy Gibbs- Duhem equations.	
Q.2	(a) Distinguish between Raoult's law and Henry's law	03
	(b) Derive the Gibbs-Duhem equation from fundamentals	04
	(c) The azeotrope of the methanol-benzene system has a composition of 44.8 mole percent ethanol with a boiling point of 68.2°C at 760 mmHg. At 68.2°C, the vapor pressure of pure benzene is 517 mmHg and that of ethanol is 506 mmHg. Calculate the Margules constants for the system and determine the activity coefficients for a solution containing 20 mole percent ethanol	07
	OR	
	(c) Discuss Retrograde condensation	07
Q.3	(a) Discuss partial molal properties in brief.	03
	(b) Discuss any two methods for determination of fugacity of pure gases.	04
	(c) Calculate the vapor phase composition of equimolar mixture of Benzene (1) and Toluene (2) mixture in equilibrium with into liquid mixture at one atmosphere and 80°C. Data: At 80°C, $P_1^{\text{sat}} = 760\text{mmHg}$ $P_2^{\text{sat}} = 300\text{mmHg}$	07
	OR	
Q.3	(a) Explain Lewis/Randall rule for ideal solution. Derive equations for fundamental excess property relations.	03
	(b) Estimate the fugacity of iso-butane at 15 atm. and 87°C using the compressibility factor correlation $Z = 1 + (BP/RT)$, given that the second virial coefficient $B = - 4.28 * 10^{-4} \text{ m}^3/\text{mol}$.	04

- (c) Assuming the validity of Raoult's law, Compute for the system of Benzene (1), and Toluene (2) Given $y_1 = 0.30$ and $t = 80^\circ\text{C}$, find x_1 , x_2 and P . **07**
 Data: At 80°C , $P_1^{\text{sat}} = 101.05 \text{ kPa}$, $P_2^{\text{sat}} = 38.83 \text{ kPa}$.

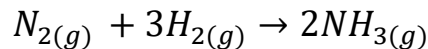
- Q.4** (a) Define azeotrope and explain maximum boiling azeotrope with a neat diagram **03**
 (b) Write steps to determine Dew point temperature using Raoult's Law. **04**
 (c) Mixtures of n-Heptane (A) and n-Octane (B) are expected to behave as an ideal solution. The total pressure over the system is 101.3 kPa Using vapor pressure data given below **07**

T, K	371.4	378	383	388	393	398.6
P_A , kPa	101.3	125.3	140.0	160.0	179.9	205.3
P_B , kPa	44.4	55.6	64.5	74.8	86.6	101.3

Construct: T- x, y diagram

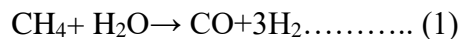
OR

- Q.4** (a) Define equilibrium constant K of a chemical reaction. How is it related to K_f and K_p ? **03**
 (b) Explain Liquid-Liquid Equilibrium with suitable example. **04**
 (c) In the synthesis of ammonia, stoichiometric amounts of nitrogen and hydrogen are sent to a reactor where the following reaction occurs **07**



The equilibrium constant for the reaction at 675K may be taken equal to 2×10^{-4} . Determine the per cent conversion of nitrogen to ammonia at 675 K and 20 bar.

- Q.5** (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) Consider a system in which the following reactions occur: **04**

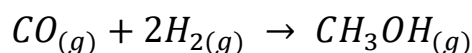


If 3mol CH_4 and 4mol H_2O are initially present, Compute the mole fraction of the product gases for $\varepsilon_1 = 0.5$ and $\varepsilon_2 = 0.5$

- (c) Discuss the effect of temperature, pressure and inerts on equilibrium constant. **07**

OR

- Q.5** (a) Describe phase rule for reacting systems **03**
 (b) How would you predict the feasibility of a chemical reaction from the value of standard free energy change? **04**
 (c) A gaseous mixture of 30% CO , 50% H_2 and rest inert gas is sent to a reaction chamber for methanol synthesis. The following reaction occurs at 635 K and 310 bar. **07**



Assuming that the gas mixture behaves as an ideal solution calculate the percentage conversion of CO given that $K_f = 5 \times 10^{-5}$ and $K_\phi = 0.35$
