Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– IV(NEW) EXAMINATION – SUMMER 2023

Subject Code:3140507 Date:25-07-2023

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.**

Q-1	**A**	Write a short note on fugacities of solids and liquids.	**03**
	B	Define the terms: 1.Acivity 2. Fugacity coefficient 3. Residual property 4. fugacity	**04**
	C	Derive the relation between equilibrium constant and standard free energy change.	**07**
Q-2	**A**	Show the P-x-y, T-x-y and x-y curves for the minimum boiling azeotrope.	**03**
	B	Discuss the flash vaporization calculation for vapor and liquid phase equilibrium.	**04**
	C	State the various methods for determination of fugacity of pure gases. Discuss any two methods in detail.	**07**
		OR	
	C	The two-suffix Margules equation for excess Gibbs free energy is $G^E = Ax_1\,x_2$ Where A is empirical constant. Derive the expression for the activity coefficient.	**07**
Q-3	**A**	Discuss the different conditions under which the Lewis-Randall rule becomes applicable.	**03**
	B	Discuss van Laar equation for activity coefficient.	**04**
	C	Discuss and prove the tangent-intercept method to determine partial molar properties.	**07**
		OR	
Q-3	**A**	Define and explain partial molar property and chemical potential.	**03**
	B	Derive the equation which shows the effect of temperature on chemical potential.	**04**
	C	Derive the various forms of Gibbs Duhem equation.	**07**
Q-4	**A**	Discuss Roult's law and ideal solutions.	**03**
	B	Calculate the standard free energy change at 298 K in the gas-phase alkylation of isobutene with ethylene to form neohexane $C_4H_{10\,(g)} + C_2H_{4\,(g)} \rightarrow C_6H_{14\,(g)}$ The free energies of formation at 298 K are -21000 J/mol, 68460 J/mol and -9950 J/mol for isobutane, ethylene and neohexane respectively.	**04**
	C	Laboratory alcohol containing 96% alcohol and 4% water is to be diluted to a solution containing 56% alcohol and 44% water. All percentages are on weight basis. The partial specific volumes are as follows: In 96% alcohol solution, $\overline{V_w} = 0.816 * 10^{-3}$ m^3/kg, $\overline{V_E} = 1.273 * 10^{-3}$m^3/kg. In 56% alcohol solution, $\overline{V_w} = 0.953 * 10^{-3}$ m^3/kg, $\overline{V_E} = 1.243 * 10^{-3}$m^3/kg. The density of water may be taken as 0.997 * 10^3 kg/m^3, (a) How much water should be added to 2 * 10^{-3} m^3 of the laboratory alcohol? (b) What is the volume of the dilute alcohol obtained?	**07**
		OR	
Q-4	**A**	State phase rule for reacting system. Discuss with example.	**03**
	B	A gas mixture containing 3 mol CO_2, 5 mol H_2 and 1 mol water is undergoing the following reactions	**04**

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$
$$CO_2 + H_2 \rightarrow CO + H_2O$$

Develop expressions for the mole fraction of the species in terms of the extent of reaction.

C Prove that if Raoult's law is valid for constituent of a binary solution over the whole concentration range, it must also apply to the other constituents. **07**

Q-5 **A** Explain and discuss the feasibility of a reaction. **03**

B An equimolar solution of benzene and toluene is totally evaporated at a constant temperature of 363 K. At this temperature, the vapor pressures of benzene and toluene are 135.4 and 54 kPa respectively. What are the pressures at the beginning and at the end of the vaporization process? **04**

C In the synthesis of ammonia, stoichiomeric amounts of nitrogen and hydrogen are sent to reactor where the following reaction occurs **07**

$$N_2 + 3H_2 \rightarrow 2\ NH_3$$

The equilibrium constant for the reaction at 675 K may be taken equal to 0.0002. Determine the % conversion of nitrogen to ammonia at 675 K and 20 bar.

OR

Q-5 **A** Explain boiling point diagram for binary solution. **03**

B Define: 1. Extent of reaction 2. Bubble point 3. Azeotrope 4. Henry's law **04**

C Explain and derive the criteria of chemical reaction equilibrium. **07**