Seat No./Enrollment No.: _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 4 – EXAMINATION – SUMMER 2026

Subject Code: 3140507 **Date: 04/06/2026**

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)**	Differentiate between ideal and non-ideal solutions.	**03**
	(b)	State and explain Duhem-Margules equation.	**04**
	(c)	Find the fugacity coefficient at 1 bar, 5 bar, and 10 bar for a gas that follows the equation of state $PV = RT(1 – 0.00513\ P)$, where P is pressure in bar	**07**
Q.2	**(a)**	Derive the equation for determination of fugacity of pure gases using any two methods.	**03**
	(b)	Explain Lewis/Randall rule for ideal solution.	**04**
	(c)	For a binary solution consider M1 and M2 are properties of component 1 and component 2 in a solution. Derive equations to calculate partial properties of component 1 and component 2 in a solution.	**07**
		OR	
Q.2	**(c)**	At 303 K, the vapour pressures of benzene (A) and toluene (B) are 15.75 kPa and 4.89 kPa respectively. Determine the partial pressures and weight composition of the vapour in equilibrium with a liquid mixture consisting of equal weights of the two component	**07**
Q.3	**(a)**	Write the expression for partial molar properties and explain their significance.	**03**
	(b)	State applications and limitations of Wilson and NRTL equation.	**04**
	(c)	Prove that for a multi component system, chemical potential of each component is the same in all phases.	**07**
		OR	
Q.3	**(a)**	Explain Liquid-Liquid Equilibrium with suitable example.	**03**
	(b)	Define azeotrope and explain maximum and minimum boiling azeotrope with a neat diagram.	**04**
	(c)	Write steps to determine Bubble point temperature using Raoult's Law.	**07**
Q.4	**(a)**	State Henry's law and its importance.	**03**
	(b)	Explain the concept of activity coefficient.	**04**
	(c)	List out different methods to determine thermodynamic consistency of VLE data and explain any one in detail.	**07**
		OR	
Q.4	**(a)**	What is retrograde condensation and write its application in chemical industry.	**03**

(b) List the limitations of Margules equation. **04**

(c) The water–gas shift reaction, **07**
$CO(g) + H2O(g) \rightarrow CO2(g) + H2(g)$
takes place at 373 K. The equilibrium constant KP for this reaction at 537 K = 9.8 x 10^{-4}. The heats of formation at 298 K are: CO = –110,525 J/mol, CO2 = –393,509 J/mol, H2O = –241,818 J/mol. Calculate the equilibrium constant at 1000 K.

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

(b) What is the effect of temperature on equilibrium constant? Using Van't Hoff equation predict the effect of increasing temperature on endothermic and exothermic reactions. **04**

(c) Consider a system in which the following reactions occur: **07**
$CH4 + H2O \rightarrow CO + 3H2$…….. (1)
$CH4 + 2H2O \rightarrow CO2 + 4H2$ …….(2)
If 2mol CH4 and 3mol H2O are initially present, Compute the mole fraction of the product gases for $\varepsilon1 = 0.25$ and $\varepsilon2 = 0.5$

OR

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) Explain partially miscible liquids. **04**

(c) Calculate standard Gibbs free energy change and equilibrium constant at 700 K for the reaction: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ **07**
Given that the standard heat of formation and standard free energy of formation of NH_3 at 298 K to be – 46100 J/mol and – 16500 J/mol respectively. The specific heat (J/mol K) as a function of temperature for nitrogen, hydrogen and ammonia are as given below.

$C_P, N_2 = 27.27 + 4.93 \times 10^{-3} T$

$C_P, H2 = 27.01 + 3.51 \times 10^{-3} T$

$C_P, NH_3 = 29.75 + 25.11 \times 10_{-3} T$

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