Seat No./Enrollment No.: _____

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

Subject Code: BE04005041 **Date: 30/05/2026**

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) State and explain Duhemn Theorem **03**

(b) Define azeotrope and explain maximum and minimum boiling azeotrope with a neat diagram. **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.

Q.2

(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) In the laboratory of mass transfer, will it be possible to prepare $0.12m^3$ of alcohol-water solution by mixing $0.04m^3$ alcohol with $0.08m^3$ pure water? If not possible, Assess the volume which should have been mixed in order to prepare a mixture of the same strength and of the required volume? Density of ethanol and water are $789kg/m^3$ and $997kg/m^3$ respectively. **07**
Data: The partial molar volumes of ethanol and water at the desired compositions are: Ethanol = $53.6*10^{-6}m^3/mol$; Water = $18*10^{-6}m^3/mol$.

OR

(c) Assuming Raoult's law to be valid for the system Benzene (1)–Ethyl benzene (2) and the vapour pressures are given by the Antoine equation: **07**

$\ln P_i^{sat} = \left[A - \left(\frac{B}{T+C}\right)\right]$, where P is in kPa and T is in K.

Q.2

Species, i	A	B	C
1	13.8858	2788.51	-52.41
2	14.0045	3279.47	-60.00

Construct the T-x-y diagram at 101.33 kPa.

Q.3

(a) What is partial molar property? Discuss the physical significance and importance of partial molar property. **03**

(b) Write a brief note on Ideal solutions **04**

(c) 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} m^3/mol **07**

OR

Q.3

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

(b) Write steps to determine Bubble point temperature using Raoult's Law. **04**

(c) The azeotrope of the Ethanol-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**

Q.4

(a) State applications and limitations of Wilson and NRTL equation. **03**

(b) Explain Liquid-Liquid Equilibrium with suitable example. **04**

(c) Assuming the validity of Raoult's law, Compute for the system of Benzene (1), and Toluene (2) Given $y_1 = 0.40$ and t= 80°C, find x_1, x_2 and P. **07**
Data: At= 80°C , P_1^{sat} =101.05 kPa P_2^{sat} =38.83kPa.

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 any one method for checking the consistency of experimental VLE data. **04**

(c) Using the fundamental properties relation for single phase reaction, show that **07**

$\Delta G^0 = - RT \ln K$

(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**

Q.5 **(c)** Consider a system in which the following reactions occur: **07**

$$CH_4 + H_2O \rightarrow CO + 3H_2 \ldots\ldots\ldots (1)$$

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2 \ldots\ldots (2)$$

If 2mol CH_4 and 3mol H_2O are initially present, Compute the mole fraction of the product gases for $\varepsilon_1 = 0.5$ and $\varepsilon_2 = 0.5$

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) The water–gas shift reaction takes place at 373K, **04**

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

The equilibrium constant K_P for this reaction at 537K = 9.8×10^{-4}. The heats of formation at 298K are: CO = –110,525J/mol, CO_2 = –393,509 J/mol, H_2O= –241,818 J/mol. Calculate the equilibrium constant at 1000 K.

(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 4 mol of N_2 is included in the reactants.

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