Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)

ENDSEM EXAMINATIONS, MAY 2023

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS-II [CHE 2251]

REVISED CREDIT SYSTEM

(24/05/2023)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A	The molar enthalpy of a binary solution at constant temperature and pressure is given by the relation $H = 500x_1 + 1000x_2 + (50x_1 + 40x_2)x_1x_2$ where H is in J/mol. Solve the expression for $\overline{H_1}$ in terms of component 1. Determine the numerical value of pure component enthalpy of component 1 and also $\left(\frac{\partial \overline{H_1}}{\partial x_1}\right)_{x_1=0}$	**4**
1B	Examine whether the following equations satisfy Gibbs Duhem equation. $ln\gamma_1 = 14x_1^3 - 20x_1x_2 + 20x_1 + 2x_2 + 126$ $ln\gamma_2 = 70 + x_1 - x_1x_2 + 14x_1^2 + 14x_1^2x_2^2 - 28x_1^2x_2$ (Note: The final answer on both sides of the Gibbs Duhem equation should be in terms of x_1.)	**3**
1C	(a) The concept of ideal gaseous solution is less restrictive than that of an ideal gaseous mixture. Justify the statement. (1) (b) Discuss LeChatelier's principle and demonstrate with respect to exothermic and endothermic reaction (2)	**3**
2A	Evaluate the fugacity of the component at 800 bar from the following data at 273 K. (Use compressibility factor method). <table><tr><td>*P*, bar</td><td>50</td><td>100</td><td>200</td><td>400</td><td>800</td><td>1000</td></tr><tr><td>*Z*</td><td>0.9846</td><td>0.9846</td><td>1.0365</td><td>1.2557</td><td>1.7959</td><td>2.0641</td></tr></table>(a) Using ideal gas behavior Using the compressibility factor method.	**4**

2B	With the help of phase diagram, discuss the effect of varying pressure on constant pressure equilibria.	3
2C	Discuss Henry's law, Raoult's law and Duhem theorem	3

3A n-pentane (1) and n-heptane (2) forms an ideal liquid solution. Determine the composition of the vapour in equilibrium with a liquid containing 34% (mol) pentane and the equilibrium temperature at P=95 kPa.
The Antoine constants are given in the following table. **[3]**

	A	B	C
n-pentane (1)	13.8183	2477.07	40.00
n-heptane (2)	13.8587	2911.32	56.56

3B Discuss the minimum boiling azeotrope, with the help of phase diagrams. **[3]**

3C Starting from the vander Waal's equation of state, determine the values of vander Waal's parameters for a gas mixture containing 70% n-pentane and 30% propane at 500 K and 12 bar and estimate the molar volume occupied by the mixture.

Given the properties of the components **[4]**

	Critical temperature (K)	Critical pressure (bar)
n-pentane	469.8	33.75
Propane	369.9	42.57

4A Vapour liquid equilibrium data for the system methanol (1)- benzene (2) at 313 K are given below. Check the thermodynamic consistency using zero area method. **[4]**

x_1	0	0.141	0.304	0.468	0.552	0.702	0.834	1.00
y_1	0	0.507	0.531	0.543	0.548	0.578	0.641	1.000
P, kPa	24.46	46.52	48.32	48.73	48.78	47.61	46.01	35.12

4B For the 2-propanol (1) – water (2) system which follows Wilson equation of state, the following data are given. $V_1 = 76.92\times 10^{-6}$ m³/mol and $V_2 = 18.07\times 10^{-6}$ m³/mol. The values of $\Lambda_{12} - \Lambda_{11}$ and $\Lambda_{12} - \Lambda_{22}$ are 1833.74 and 5183.26 J/mol respectively.
The vapour pressures are given by **[3]**

$$\ln P_1^S = 16.678 - \frac{3640.20}{T-53.54}$$

$$\ln P_2^S = 16.2887 - \frac{3816.44}{T-46.13}$$ where P is in kPa and T in in K.

Evaluate three sets of P-x-y data at 353.15 K. Also determine the type of azeotrope.

4C A vapour mixture of hydrocarbons containing n-propane 5%, n-butane 30%, n-pentane 40% and n-hexane 25% is available at 350 kPa. It is subjected to isobaric cooling. Estimate the dew point and the composition of the liquid that is formed. Use the K-factor chart. **[3]**