U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E.	**Semester: IV**
Branch: Chemical Engineering	**Duration: 3 hrs.**
Course Code: 19CH4DCTD2	**Max Marks: 100**
Course: Process Engineering Thermodynamics -II	

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	**Marks**
1	a)	Derive Maxwell's equations from fundamental property relations. State its significance.	*CO2*	*PO2*	**8**
	b)	Derive Clausius-Clapeyron equations with assumptions.	*CO2*	*PO2*	**8**
	c)	Determine the increase in entropy of solid magnesium when the temperature is increased from 300 K to 800 K at atmospheric pressure. The heat capacity is given by the following relation $C_P = 26.04 + 5.586 \times 10^{-3}\ T + 28.476 \times 10^{-4}\ T^{-2}$ Where, C_P is in J/mol K and temperature in K.	*CO1*	*PO1*	**4**
		OR			
2	a)	Show that $dU = -\left[P + T\left\{ \frac{\left(\frac{\partial V}{\partial T}\right)_P}{\left(\frac{\partial V}{\partial P}\right)_T} \right\}\right] dV + C_V\, dT$	*CO2*	*PO2*	**12**
	b)	Show that $\left(\frac{\partial C_P}{\partial P}\right)_T = \left(\frac{\partial C_P}{\partial V}\right)_T = 0$	*CO2*	*PO2*	**8**
		UNIT - II			
3	a)	Discuss how estimated fugacity from compressibility factor is, give relevant equation.	*CO3*	*PO2*	**06**
	b)	For isopropanol vapour at 200˚C, $Z = 1\text{-}9.86\text{x}10^{-3}P\ \text{-}11.41\text{x}10^{-5}P^2$. Where P is pressure in bar. Estimate the fugacity coefficient and fugacity at 50 bar and 200˚C.	*CO3*	*PO2*	**08**
	c)	Derive property change of mixing in terms of molar volume.	*CO3*	*PO2*	**06**
		OR			
4	a)	List various forms of Gibb's-Duhem equation and explain the terms.	*CO3*	*PO2*	**06**

<table>
<tr><td></td><td></td><td>b)</td><td>Discuss on any one method to evaluation of partial molar properties.</td><td>CO3</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by
$V = 109.4\,X\,10^{-6} - 16.8\,X\,10^{-6}x - 2.64\,X\,10^{-6}\,x^2$, where x is the mole fraction of benzene and ‘V’ has the units of m^3/mol. Find the expressions for the partial molar volumes of benzene and cyclohexane.</td><td>CO3</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td></td><td>UNIT-III</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>Draw T-x-y and P-x-y diagram for binary VLE mixture and explain.</td><td>CO4</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>From the following vapor pressure data, construct the temperature-composition diagram at 1 atm, for the system benzene-toluene, assuming ideal solution behavior.
<table>
<tr><td rowspan="2">Temperature (^0C)</td><td colspan="2">Vapor pressure (mm Hg)</td></tr>
<tr><td>Benzene</td><td>Toluene</td></tr>
<tr><td>80</td><td>760</td><td>300</td></tr>
<tr><td>92</td><td>1078</td><td>432</td></tr>
<tr><td>100</td><td>1344</td><td>559</td></tr>
<tr><td>110.4</td><td>1748</td><td>760</td></tr>
</table></td><td>CO4</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>Show that the chemical potential of each component is same in all phases, when the phases are in equilibrium.</td><td>CO4</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Determine the composition of the liquid which is in equilibrium with a vapour containing 50 mole% benzene and 50 mole% toluene at 368 K.
Data: The vapour pressure of benzene and toluene at 368 K are 1176.21 Torr and 477.03 Torr respectively.</td><td>CO4</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - IV</td><td></td><td></td><td></td></tr>
<tr><td></td><td>7</td><td>a)</td><td>Define azeotropes and explain minimum boiling and maximum boiling azeotropes with P-x-y and T-x-y diagrams.</td><td>CO6</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>The following data gives the composition versus total pressure for the system chloroform (1)–ethyl alcohol (2) at 328 K:
<table>
<tr><td>Components</td><td>1</td><td>2</td></tr>
<tr><td>x_i</td><td>0.0331</td><td>0.0348</td></tr>
<tr><td>P,kPa</td><td>40.84</td><td>84.88</td></tr>
</table>
Vapor pressures of chloroform and acetone at 328 K are 82.35 and 37.30 kPa, respectively. Estimate the constants in the Margules equation</td><td>CO4</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
</table>

	8	a)	Explain the Redlich-Kister method to check the consistency of the given VLE data.	CO6	PO3	**4**
		b)	Liquids A and B form an azeotrope containing 46.1 mole per cent A at 101.3 kPa and 345 K. At 345 K, the vapor pressure of A is 84.8 kPa and that of B is 78.2 kPa. Calculate the van Laar constants.	CO4	PO3	**8**
		c)	At 318 K and 24.4 kPa, the composition of the system ethanol (1) and toluene (2) at equilibrium is $x1$ = 0.3 and $y1$ = 0.634. The saturation pressures at the given temperature for the pure components are P_1^s = 23.06 kPa and P_2^s =10.05 kPa, respectively. Calculate the liquid-phase activity coefficients.	CO4	PO3	**8**
			UNIT - V			
	9	a)	Derive an equation to relate Gibbs free energy change with chemical reaction equilibrium constant.	CO5	PO3	**10**
		b)	A gas mixture containing 25% CO, 55% H_2 and 20% inert gas is to be used for methanol synthesis. The gases issue from the catalyst chamber in chemical equilibrium with respect to the reaction. $CO (g) + 2H_2 (g) \rightarrow CH_3OH (g)$ at a pressure of 300 bar and temperature of 625 K. Assume that the equilibrium mixture forms an ideal solution and K and $K_{\emptyset}$ are 4.5×10^{-5} and 0.35 respectively. Find the per cent conversion of CO.	CO5	PO3	**10**
			OR			
	10	a)	Derive the relationship between mole fraction of species in multiple reactions and the extent of reactions.	CO5	PO3	**10**
		b)	In the synthesis of ammonia, initial amounts of nitrogen and hydrogen around 2 and 6 moles are sent to a reactor where the following reaction occurs$N_2 + 3H_2 \rightarrow 2NH_3$. The equilibrium constant for the reaction at 875 K may be taken equal to 4×10^{-4}. i. Determine the percent conversion of nitrogen to ammonia at 875 K and 10 bar. ii. What would be the conversion at 875 K and 100 bar and how this change effects the conversion of nitrogen to ammonia?	CO5	PO3	**10**

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