IV SEMESTER B. TECH (CHEMICAL ENGINEERING) END SEMESTER EXAMINATIONS – April/May 2024

SUBJECT: Chemical Engineering Thermodynamic-II [CHE-2251]

(Date:11/05/24 and Time:2:30-5:30 Pm)

Time: 3 Hours **MAX. MARKS: 50**

Instructions to Candidates:

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

S. N.		Question	Marks
1	a	Derive the Gibbs-Duhem equation and summability relations for binary system. What are the major fields of application of the Gibbs-Duhem equation?	03
	b	Explain the following terms: I. Concepts of solution thermodynamics II. Concept of infinite dilution	04
	c	At constant temperature and pressure, the molar density of a binary mixture is given by $\rho=1+X_2$, where X_2 is the mole fraction of component 2. Calculate the partial molar volume at infinite dilution for component 1, $\overline{V_1}$ is given as $\overline{V_1} = V - x_2 \frac{dv}{dx_2}$	03
2	a	Explain the following terms: I. Concept of bubble point pressure II. Concept of dew point pressure.	04
	b	The molar volume of (V), a binary mixture of species 1 and 2 having mole fractions X_1 and X_2, respectively, is given by $V=220X_1-180X_2-X_1X_2(90X_1-50X_2)$. Determine the partial molar volume of species 2 at $X_2= 0.3$.	03
	c	The excess Gibbs free energy for cyclohexene (component 1) and phenol (component 2) is given as: $G^E/RT=-2.1X_1X_2$ X_1 and X_2 are the mole fraction of the components 1 and 2 in the liquid phase. The vapor pressure of components at 417K is $P_1^{sat}=80$ kPA and $P_2^{sat}=50$ kPA. Determine the equilibrium pressure at liquid composition at $X_1=0.5$ if the fugacity coefficient of both components is $\Phi=0.8$	03
3	a	Derive the partial molar properties in a binary system. Also, write the application of partial molar properties in a thermodynamic system.	04
	b	A pure gas obeys the equation of state given by $\frac{PV}{RT} = 1 + \frac{BP}{RT}$	03

		Where, P= pressure, T= Absolut temperature, V=molar volume of gas, R=gas constant, B=parameter independent of T and P. The residual molar Gibbs free energy G^R of the gas is given as, $\frac{G^R}{RT} = \int_o^P (Z-1)\frac{dP}{P}$ The compressibility factor and the integral are evaluated at constant temperature. If the value of $B=1x10^{-4}$ mol^3 mol^{-1}, calculate the residual molar enthalpy of the gas at 1000 kPa and 300 K in J/mol.	
	c	For a gas phase cracking reaction $A \longrightarrow B+C$ at 300 °C. The Gibes free energy of the reaction at this temp is -2750 J/mol. The pressure is one bar. The Gas-phase can be assumed to be ideal. R= 8.314J/mol. K. Determine the fractional conversion of A at equilibrium.	03
4	a	Derive the Maxwell relations in differential forms of Gibes free energy, enthalpy, internal energy and Helmholtz free energy.	03
	b	For water at 300 °C, it has a vapour pressure of 8592.70 Kpa and a fugacity 6738.90 Kpa. Under this condition, one mole of the water liquid phase has a volume 25.28 cm^3 and that in the vapour pressure phase 391.10 cm^3. Calculate the fugacity of the water at 9000 kPa.	04
	c	The partial molar enthalpies of mixing for benzene (component 1) and cyclohexene (component 2) at 300 K and 1 bar are given as: $\Delta\overline{H_1} = 3600x_2^2$ $\Delta\overline{H_2} = 3600x_1^2$ X_1 and X_2 are the mole fractions, when 1 mole of benzene is added to 2 mole of cyclohexene, estimate the enthalpy change.	03
5	a	Describe the following terms: I. Equilibrium constant II. Standard Gibbs free energy III. Criteria for chemical Equilibrium	04
	b	Derive the two suffix Margules equation. Also, write the application of the Margules equation.	03
	c	A binary system at a constant P with species 1 and 2 is described by the two suffix Margules equation: $G^E/RT=3X_1X_2$ G^E is the molar excess Gibbs free energy, R= Gas constant, T= Temp., X_1 and X_2 are the molar Gibbs free energy of the pure species 1 and 2, respectively. At the same temperature, G represents the molar Gibbs free energy of the mixture. Calculate the value of G/RT for a binary mixture with 40 mole% of species 1.	03