P P SAVANI UNIVERSITY

Fifth Semester of B. Tech. Examination

November- 2022

SECH3041 Chemical Engineering Thermodynamics - II

02.12.2022, Friday **Time: 10:00 a.m. To 12:30 p.m.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.

SECTION – I

		[05]	CO	BTL
Q - 1	MCQ/Short Question/Fill in the Blanks			
(i)	For ideal gases, the fugacity is the same as the pressure (TRUE/FALSE)		2	1
(ii)	Define the fugacity coefficient.		2	1
(iii)	Define partial molar property.		4	1
(iv)	The value of change in internal energy for isothermal process = _____ 1 (b) 0 (c) W (d) none of above.		5	2
(v)	Partial molar properties are _____ properties. (Extensive/Intensive).		4	1
Q - 2 (a)	What is the activity? Determine the activity of solid magnesium (MW 24.32) at 300 K and 10 bar if the reference state is 300 k and 1 bar. The density of magnesium at 300 K is $1.745*10^3$ kg/m^3 and is assumed constant over this pressure range. Equation: $\ln a = \frac{V}{RT}(P - P^0)$	[05]	4	3
Q - 2 (b)	Define adiabatic process. Derive the PV relations for the adiabatic process.	[05]	5	1
	OR			
Q - 2 (a)	Discuss PVT behavior of pure fluids.	[05]	1	2
Q - 2 (b)	Define fugacity. The density of gaseous ammonia at 473 K and 50 bar is 24.3 kg/m^3. Estimate its fugacity. Equation: $f = \frac{VP^2}{RT}$	[05]	2	2
Q - 3 (a)	Derive the general forms of the Gibbs-Duhem equation.	[05]	3	4
Q - 3 (b)	State the various methods to estimate the fugacity of pure gases. Discuss anyone in detail.	[05]	2	4
	OR			
Q - 3 (a)	Discuss in the brief tangent-intercept method.	[05]	3	1
Q - 3 (b)	Will it be possible to prepare 0.1 m^3 of the alcohol-water solution by mixing 0.04 m^3 alcohol with 0.06 m^3 pure water? If not possible, what volume should have been mixed in order to prepare a mixture of the same strength and of the required volume? The density of ethanol and water are 789 and 997 kg/m^3 respectively. The partial molar volume of ethanol and water at the desired composition are: Ethanol = $53.6*10^{-6}$ m^3/mol. Water = $18*10^{-6}$ m^3/mol	[05]	4	5
Q - 4	Attempt any one	[05]		
(i)	State Redlich–Kwong equation of state.		5	2

(ii)	Define azeotrope. Explain its significance		3	1

SECTION – II

Q - 1	Write a short note on the property change of mixing.	[05]	3	2
Q - 2 (a)	Discuss any two methods of consistency test of VLE- data with examples and diagrams.	[05]	1	2
Q - 2 (b)	Write a short note on ideal solutions and Raoult's law.	[05]	4	2

OR

Q - 2 (a)	Discuss binary liquid-liquid equilibria with diagram.	[05]	1	2
Q - 2 (b)	Discuss any one consistency test of following for VLE data. (1) using slope of $\ln \gamma$ curves (2) Redlich-kister method.	[05]	1	6
Q - 3 (a)	Define chemical potential. Discuss the effect of temperature on chemical potential.	[05]	3	2
Q - 3 (b)	The following values refer to Wilson parameters for the system acetone (1) – water (2), $a_{12} = 1225.31$ J/mol, $a_{21} = 6051.01$ J/mol, $V_1 = 74.05 \times 10^{-6}$ m³/mol, $V_2 = 18.07 \times 10^{-6}$ m³/mol, $P_1^S = 190.37$ kPa and $P_2^S = 39.87$ kPa Calculate equilibrium pressure and composition of vapor in equilibrium with a liquid of composition $x_1 = 0.43$ at 349 K.	[05]	4	5

$$P_1^S = 190.37\ \text{kPa}, \quad P_2^S = 39.87\ \text{kPa}$$

The parameters in the Wilson equation [Eq. (8.72)] Λ_{12} and Λ_{21} are calculated using Eq. (8.73). Thus,

$$\Lambda_{12} = \frac{V_2}{V_1}\exp\left[-\frac{a_{12}}{RT}\right] = \frac{18.07}{74.05}\exp\left(-\frac{1225.31}{8.314 \times 349}\right) = 0.1600$$

$$\Lambda_{21} = \frac{V_1}{V_2}\exp\left[-\frac{a_{21}}{RT}\right] = \frac{74.05}{18.07}\exp\left(-\frac{6051.01}{8.314 \times 349}\right) = 0.5092$$

OR

Q - 3 (a)	The azeotrope of the ethanol-benzene system has a composition of 44.8% (mol) ethanol with a boiling point of 341.4 K at 101.3 kPa. At this temperature vapor pressure of benzene is 68.9 kPa and the vapor pressure of ethanol is 67.4 kPa. What are the activity coefficients in a solution containing 10% alcohol?	[05]	4	5

$$\gamma_1 = \frac{P}{P_1^S} = \frac{101.3}{68.9} = 1.4702, \quad \gamma_2 = \frac{P}{P_2^S} = \frac{101.3}{67.4} = 1.5030$$

Equation:

$$A = \ln \gamma_1\left(1 + \frac{x_2 \ln \gamma_2}{x_1 \ln \gamma_1}\right)^2 \qquad \ln \gamma_1 = \frac{Ax_2^2}{[(A/B)x_1 + x_2]^2}$$

$$B = \ln \gamma_2\left(1 + \frac{x_1 \ln \gamma_1}{x_2 \ln \gamma_2}\right)^2 \qquad \ln \gamma_2 = \frac{Bx_1^2}{[x_1 + (B/A)\,x_2]^2}$$

Q - 3 (b)	For the cyclohexane (1) – benzene (2) system at 313 K given that at 313 K the vapor pressures are $P_1^S = 24.62$ kPa and $P_2^S = 24.41$ kPa. The liquid phase activity	[05]	5	5

coefficients are given by $\ln \gamma_1 = 0.458x_2^2$, and $\ln \gamma_2 = 0.458x_1^2$
Calculate P and y_1 for $x_1 = 0.2$ and 0.4.

$$\ln \gamma_1 = 0.458 x_2^2, \quad \ln \gamma_2 = 0.458 x_1^2$$

Q - 4 State and explain the significance of Lewis-Randall rule. **[05] 3 1**

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CO : Course Outcome Number BTL : Blooms Taxonomy Level

Level of Bloom's Revised Taxonomy in Assessment

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create