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

Autonomous Institute Affiliated to VTU

September / October 2023 Semester End Main Examinations

Programme: B.E.   **Semester: IV**
Branch: Chemical Engineering   **Duration: 3 hrs.**
Course Code: 22CH4PCTD2   **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.

			UNIT - I	CO	PO	Marks
1	a)		Derive Maxwell relations from the first principles.	*CO1*	*PO1*	**10**
	b)		Prove that $C_p - C_v = \frac{TV\beta^2}{K}$, where β = coefficient of volume expansion and K = isothermal compressibility factor.	*C 2*	*PO2*	**10**
			OR			
2	a)		Derive modified equation for change in internal energy and enthalpy as function of temperature and pressure.	*CO 2*	*PO2*	**10**
	b)		What is the significance of Joule – Thomson coefficient and Joule-Thomson inversion curve? Prove that it is zero for ideal gas.	*CO2*	*PO2*	**10**
			UNIT - II			
3	a)		Elucidate fugacity in solutions. State and derive Lewis-Randall rule from the fundamental concepts. Also state the conditions under which this rule is valid.	*CO4*	*PO3*	**10**
	b)		Calculate the fugacity of gaseous propane at 12 bar and 310 K using the following data. Also compute the fugacity of propane at 310 K and 70 bar given that the vapor pressure of propane at 310K is 13 bar.	*CO2*	*PO2*	**10**
			OR			
4	a)		The excess Gibbs energy of a binary liquid mixture at T and P is given by the following equation. $$\frac{G^E}{RT} = (-2.61x_1 - 1.8x_2)x_1x_2.$$ Find the expressions for $\ln \gamma_1$ and $\ln\gamma_2$ at T and P.	*CO*	*PO2*	**10**

Table within Question 3 b):

P, bar	1.7	3.4	6.8	10.2	11.7	13.6
V, m³/ kg	0.33	0.16	0.07	0.04	0.03	0.02

	b)	Derive Gibb's – Duhem equation, stating all the assumptions.	CO2	PO3	**10**
		UNIT - III			
5	a)	Show that the chemical potential of each component is same in all the phases when the phases are in equilibrium. Give the general criterion of equilibrium in terms of fugacity.	CO4	PO3	**12**
	b)	Pure component vapor pressure of two organic liquids X and Y by Antoine's equations are given by: $$\ln P_1^{sat} = 14.35 - \frac{2942}{T + 220}$$ $$\ln P_2^{sat} = 14.25 - \frac{2960}{T + 210}$$ Where P_1^{sat} and P_2^{sat} are in kPa and T is in °C. Calculate the composition of liquid and vapor in equilibrium at 77°C and 75 kPa.	CO3	PO2	**08**
		UNIT - IV			
6	a)	The azeotrope of benzene-cyclohexane system has a composition of 53.2 mol% benzene with boiling point of 350.6 K at 101.3 kPa. At this temperature, the vapor pressure of cyclohexane is 99.27 kPa. Determine the activity coefficients for the solution containing 10 mol% benzene.	CO3	PO2	**10**
	b)	What is meant by consistency in VLE data? Discuss the methods used to test the consistency of VLE data.	CO6	PO3	**10**
		UNIT - V			
7	a)	What is the significance of ln $(K/K_1) = -\Delta H^0/R \ (1/T-1/T_1)$. Derive Van'toff equation from the fundamentals.	CO5	PO3	**10**
	b)	In a laboratory investigation, ethanol is esterified to produce ethyl acetate and water at 100°C and 1 atm according to the reaction, $$CH_2COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$$ Estimate the equilibrium constant for the reaction at 100°C and also find the composition of the reaction mixture if 1 mole each of acetic acid and ethanol are present initially. Data: ΔG_{298}^0 for the reaction = 1160 x 4.186 J/mole ΔG_{298}^0 for the reaction = 1713 x 4.186 J/mole	CO5	PO3	**10**

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