Register No : _____

THE KAVERY ENGINEERING COLLEGE

(An Autonomous Institution)

B.E/B.TECH DEGREE END SEMESTER THEORY EXAMINATIONS, NOV /DEC 2024

Fifth Semester

Chemical Engineering

CH3501 - Chemical Engineering Thermodynamics - II

(Steam Tables may be permitted)

Regulations - 2021

Duration : 3 Hrs *Maximum : 100 Marks*

*PART – A (ANSWER ALL QUESTIONS) (Marks 10*2=20)*

Q. No	*Questions*	*BLT*	*CO*	*Marks*
1.	What are partial molar properties? Give any one property with example.	RE	1	2
2.	Outline the significance of Raoult's law as applicable to ideal solutions.	UN	1	2
3.	Illustrate the constant pressure liquid-liquid solubility diagram.	UN	2	2
4.	What is the effect of pressure on azeotropic composition?	RE	2	2
5.	How consistency test for VLE data can be determined?	RE	3	2
6.	Define the term tie line in boiling point diagram.	RE	3	2
7.	Recall the relation between standard free energy change and equilibrium constant.	RE	4	2
8.	Define equilibrium constant of a chemical reaction and how it is related to Kf and KP.	RE	4	2
9.	What is the result of liquefaction when a gas is cooled to a temperature in the two-phase region?	RE	5	2
10.	Define capacity of refrigeration.	RE	5	2

*PART – B (ANSWER ALL QUESTIONS) (Marks 5*13 = 65)*

Q. No			*Questions*	*BLT*	*CO*	*Marks*
11.	a	i	At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by $V= 109.4 \times 10^{-6} - 16.8 \times 10^{-6} x - 2.64 \times 10^{-6} x^2$, where x is the mole fraction of benzene and V has the units of m^3/ mol. Develop an expression for the partial molar volumes of benzene and cyclohexane.	AP	1	9
		ii	How will you select the standard states for gas and liquid components? Explain.	UN	1	4
			Or			
	b	i	Discuss Gibbs-Duhem equations and its various forms.	AP	1	9
		ii	Prove that the partial molar mass of a species in solution is equal to its molecular weight.	UN	1	4
12.	a		Develop the Clausius – Clapeyron equation using the criterion for phase equilibrium.	AP	2	13
			Or			

	b	The vapour pressure of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equations. $In\ P_1^s = 14.5463 - \frac{294046}{T - 35.93}$ $In\ P_2^s = 14.2724 - \frac{2945.47}{T\text{-}49.15}$ Where T is in K and P is in kPa. Assuming that the solutions formed by these are ideal, calculate. (a) x_1 and y_1 at 327 K and 65 kPa (b) T and y_1 at 65 kPa and x_1 = 0.4 (c) P and y_1 at 327 K and x_1 = 0.4 (d) T and x_1 at 65 kPa and y_1 = 0.4 (e) P and x_1 at 327 K and y_1 = 0.4 (f) The fraction of the system that is liquid and the composition of the liquid and vapour in equilibrium at 327 K and 65 kPa when the overall compositon of the system is 70 mole per cent acetone.	AP	2	13
13.	a	The following results were obtained by experimental VLE measurements on the system, ethanol (1)-benzene (2) at 101.3 kPa. Identify whether the data are thermodynamically consistent or not.	AP	3	13

X_1	0.003	0.449	0.700	0.900
Y_1	0.432	0.449	0.520	0.719
P_1^s,kPa	65.31	63.98	66.64	81.31
P_2^s,kPa	68.64	68.64	69.31	72.24

Or

	b	The Ethanol-Water system forms an azeotrope at 78.15℃ and the corresponding ethanol composition is 89.43 mole%. The vapour pressure of water at 78.15℃ is 329 mmHg and that of ethanol is 755 mmHg at the same temperature. Construct the equilibrium curve for the Ethanol-Water system at a total pressure of 760 mmHg.	AP	3	13
14.	a	Calculate the standard free energy change and equilibrium constant at 700 K for the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ Given that the standard heat of formation and standard free energy of formation of ammonia at 298 K to be -46,100 J/mol and -16,500 J/mol respectively. The specific heat (J/mol K) data are given below as function of temperature (K): $C_P = 27.27 + 4.93 \times 10^{-3} T \quad \text{for } N_2$ $C_P = 27.01 + 3.51 \times 10^{-3} T \quad \text{for } H_2$ $C_P = 29.75 + 25.11 \times 10^{-3} T \quad \text{for } NH_3$	EV	4	13

Or

	b i	Determine the relationship between equilibrium constant and standard Gibb's Free energy change.	EV	4	6
	ii	n-Butane is isomerised to i-butane by the action of catalyst at moderate temperatures. It is found that the equilibrium is attainted at the following compositions.	EV	4	7

Temperature, K	Mole % of n-butane
317	31.00
391	43.00

Assuming that activities are equal to the mole fractions, calculate the standard free energy of the reaction at 317 K and 391 K average value of heat of reaction over this temperature range.

15.	a	i	Explain the gas refrigeration cycle and its limitations.	EV	5	6
		ii	Develop an equation for C.O.P. of an ordinary vapour compression refrigeration system.	EV	5	7
			Or			
	b		A vapor compression cycle using NH_3 as refrigerant is employed in an ice manufacturing plant. Cooling H_2O at 288 K enter the condenser at a rate of 0.25 kg/sec and leaves at 300 K. Ammonic at 294 K condenses at a rate of 0.50 kg/min. Enthalpy of liquid ammonia at 294 K is 281.5 kJ/kg. The compressor efficiency is 90%. Saturated NH_3 vapor at 258 K and enthalpy of 1426 kJ/kg enters the compressor. Calculate the power requirement of the compressor and refrigeration capacity in tons.	EV	5	13

*PART – C (Marks 1*15 = 15)*

Q. No			*Questions*	*BLT*	*CO*	*Marks*
16.	a		For the binary mixture of A and B, the activity coefficients are given by. $1n\ \gamma_1 = AX_1^2$ and $1n\gamma_2 = AX_1^2$ The vapour pressure of A and B at 353 K are 119.96 kPa and 79.97 kPa respectively. Does an azeotrope exist at 353 k? If so, calculate is the azeotropic pressure and composition for A = 0.6.	EV	4	15
			Or			
	b	i	Prove that if Raoult's law is valid for one constituent of a binary solution over the whole concentration range; it must also apply to the other constituent.	EV	2	8
		ii	What is meant by a tie line? How does the tie line help in determining the amount of liquid and vapor in equilibrium? Explain.	EV	2	7