Register No : _____

THE KAVERY ENGINEERING COLLEGE

(An Autonomous Institution)

UG/PG DEGREE END SEMESTER THEORY EXAMINATIONS, APRIL/MAY 2026

Fifth Semester

Chemical Engineering

CH3501 - CHEMICAL ENGINEERING THERMODYNAMICS - II

(Steam Tables / Compressibility Charges can be permitted)

(Make suitable assumptions if necessary)

Regulations - 2021

Duration : 3 Hrs *Maximum : 100 Marks*

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

Q.No	*Questions*	*BTL*	*CO*	*Marks*
1.	Distinguish between molar volume and partial molar volume.	L2	1	2
2.	Define standard state of a substance.	L1	1	2
3.	Explain about fugacity.	L1	2	2
4.	What is miscibility gap in phase diagrams?	L1	2	2
5.	Give the importance of vapour liquid equilibrium.	L1	3	2
6.	What do you understand from thermodynamic consistency?	L2	3	2
7.	How would you predict the feasibility of a reaction from the value of the standard free energy change?	L2	4	2
8.	What do you mean by the number of independent reactions in a chemically reacting system? How would you determine it?	L2	4	2
9.	What is meant by capacity of a refrigerator?	L1	5	2
10.	Why is throttling used in practical refrigerators in place of turbine?	L2	5	2

*PART – B (ANSWER ALL QUESTIONS) (Marks 5*16 = 80)*

Q.No			*Questions*	*BLT*	*CO*	*Marks*
11.	a	i	Will it be possible to prepare 0.1 m^3 of alcohol-water solution by mixing 0.03 m^3 alcohol with 0.07 m^3 pure water? If not possible, what volume should be mixed to prepare a mixture of same strength and required volume? Density of ethanol and water are 789 and 997 kg/m^3 respectively. The partial molar volumes of ethanol and water at the desired composition are: Ethanol: 53.6×10^{-6} m^3/mol; water: 18×10^{-6} m^3/mol.	L3	1	8
		ii	The enthalpy at 300 K and 1 bar of a binary liquid mixture is $H = 400\ x_1 + 600\ x_2 + x_1x_2\ (40\ x_1 + 20\ x_2)$ where, H is in J/mol. For the given T and P, determine the following: (1) Expressions for H_1 and H_2 in terms of x_1 (2) Numerical values for pure component enthalpies H_1 and H_2	L3	1	8

Or

	b i	Derive the Gibbs – Duhem equation for the calculation of solution properties from knowledge of the partial properties.	L3	1	10
	ii	A binary liquid mixture has activity coefficients given by, $\ln \gamma_1 = Ax_2^2$, $\ln \gamma_2 = Ax_1^2$ Derive the expression for excess Gibbs free energy.	L3	1	6
12.	a	With neat sketches elucidate the boiling point (T-x-y) diagram and equilibrium distribution (x-y) diagram.	L3	2	16
		Or			
	b	Water (1) – hydrazine (2) system forms an azeotrope containing 58.5 % (mol) hydrazine at 393 K and 101.3 kPa. Calculate the equilibrium vapour composition for a solution containing 20 % (mol) hydrazine. The relative volatility of water with reference to hydrazine is 1.6 and may be assumed to remain constant in the temperature range involved. The vapour pressure of hydrazine at 398 K is 124.76 kPa.	L3	2	16
13.	a	Mixtures of n-Heptane (A) and n-octane (B) are expected to behave ideally. The total pressure over the system is 101.3 kPa. Using the vapour pressure data given below, (1) construct the boiling point diagram (2) construct the equilibrium diagram (3) Deduce an equation for the equilibrium diagram using an arithmetic average 'α' value.	L4	3	16

T, K	371.4	378	383	388	393	398.6
P_A^S, *kPa*	101.3	125.3	140.0	160.0	179.9	205.3
P_B^S, *kPa*	44.4	55.6	64.5	74.8	86.6	101.3

Or

	b	The following results were obtained by experimental VLE measurements on the system, ethanol (1) – benzene (2) at 101.3 kPa. Test whether the data are thermodynamically consistent or not.	L4	3	16

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

14.	a i	The standard heat of formation and standard free energy of formation of ammonia at 298 K are –46,100 J/mol and –16,500 J/mol respectively. Calculate the equilibrium constant for the reaction $N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$ at 500 K, assuming that the standard heat of reaction is constant in the temperature range 298 to 500 K.	L3	4	8
	ii	1 mole of steam undergoes the water-gas shift reaction at a temperature of 1100 K and a pressure of 1 bar. $CO\ (g) + H_2O\ (g) \rightarrow CO_2\ (g) + H_2\ (g)$ The equilibrium constant for the reaction is K = 1. Assuming ideal gas behaviour, calculate the fractional dissociation of steam in the following cases and discuss the effect of presence of excess reactant on the extent of reaction: (1) CO supplied is 100% in excess of the stoichiometric requirement. (2) CO supplied is only 50% of the theoretical requirement.	L3	4	8
		Or			

	b	i	Derive the expression which relates the equilibrium constant and standard free energy change.	L3	4	8
		ii	Derive the relationship between mole fraction of species in multiple reactions and the extent of reactions.	L3	4	8
15.	a	i	Elucidate the air-refrigeration cycle.	L3	5	10
		ii	A vapour compression refrigeration system with ammonia as the working fluid is to operate between 266K and 300K. Determine the following: (1) COP, given that the enthalpy of saturated vapour at 266K is 656kJ/kg and the enthalpy of superheated vapour leaving the compressor is 724 kJ/kg, enthalpy of saturated liquid at 300K is 144 kJ/kg. (2) COP, if a temperature approach of 5K is necessary in the evaporator and condenser, and the efficiency of the compressor is 75%. Enthalpy of saturated vapour at 261K is 625kJ/kg and the enthalpy of superheated vapour entering the condenser is 758 kJ/kg and enthalpy of saturated liquid at 305K is 159 kJ/kg. (3) The COP of an ideal Carnot refrigerator.	L3	5	6
			Or			
	b	i	Discuss in detail about the Linde process for gas liquefaction.	L3	5	10
		ii	Explain the performance & evaluation of vapour compression Refrigeration cycle.	L3	5	6