Reg. No.

B. E / B. TECH.DEGREE EXAMINATIONS, MAY 2024
Fifth Semester
CH18503- CHEMICAL ENGINEERING THERMODYNAMICS-II
(Chemical Engineering)
(Regulation 2018 / 2018A)

TIME:3 HOURS   **MAX.MARKS: 100**

CO1   Identify the property of solutions upon mixing and also about the excess property.

CO2   Explore and generate the phase diagram data and also about the effect of temperature and pressure on azeotropic conditions.

CO3   Impart knowledge on various models used to evaluate the equilibrium data and also to test the thermodynamic consistency.

CO4   Identify and calculate the equilibrium constant for various systems and analysis of simultaneous reactions.

CO5   Apply principles of refrigeration and its application.

PART- A(10x2=20Marks)
(Answer all Questions)

		CO	RBT LEVEL
1	State Duhem's theorem.	**1**	**2**
2	Intrepret the various excess properties.	**1**	**2**
3	n-Heptane and toluene form ideal solution. At 373 K, their vapour pressures are 106 and 74 KPa respectively. Determine the composition of the liquid and vapour in equilibrium at 373 K and 101.3KPa	**2**	**2**
4	List any four method of consistency tests for VLE data.	**2**	**2**
5	Differentiate between positive and negative deviations on non-ideality.	**3**	**2**
6	Sketch the Pxy diagram and locate the bubble point and dew point.	**3**	**2**
7	Indicate the Van't Hoff equation with its applications.	**4**	**2**
8	Estimate the equilibrium constant at 298 K of the reaction $N_2O_4(g) \rightarrow 2NO_2(g)$ given that the standard free energies of formation at 298K are 97,540 J/mol for N2O4 and 51,310 J/mol for NO2.	**4**	**2**
9	List some important refrigerants.	**5**	**2**
10	Define the term ton of refrigeration.	**5**	**2**

PART- B (5x 14=70Marks)
(Restrict to a maximum of TWO subdivisions)

		Marks	CO	RBT LEVEL

11(a) The partial pressure of Acetone(A) and Chloroform(B) were measured as 298K and are as follows: **(14)**   **1**   **3**

X_A	0	0.2	0.4
P_A	0	0.049	0.134
P_B	0.386	0.288	0.187

Calculate the activity coefficient of chloroform in acetone at 298K based on std. state as per Lewis-Randall rule.

Data: $K_B = 0.217$ bar vapour pressure of pure chloroform $P_B^S = 0.386$ bar

11(b) A vessel, divided into two parts by a partition, contains 4 mol of nitrogen gas at 348.15 K(75°C) and 30 bar on one side and 2.5 mol of argon gas at 403.15 K (130°C) and 20 bar on the other. If the partition is removed and the gases mix adiabatically and completely, Estimate the change in entropy? Assume nitrogen to be an ideal gas with $Cv = (5/2)R$ and argon to be an ideal gas with $Cv = (3/2)R$ **(14)**   **1**   **3**

12(a) The activity coefficients of benzene (A) and cyclohexane (B) mixtures at 40°C are given by RT ln γA = bXB2 and RT ln γB = bXA2 At 40°C, A and B form an azeotrope containing 49.4 mol percent A at a total pressure of 202.6 mm Hg. If the vapour pressures of pure A and pure B are 182.6 and 183.5 mm Hg respectively, calculate the total pressures of the vapour at temperature 40°C in equilibrium with a liquid mixture containing 12.6 mol% A.   **(14)**   **2**   **3**

(OR)

12(b) The vapour pressures of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equations   **(14)**   **2**   **3**

$$\ln P1s = 14.5463 - (2940.46/T-35.93)$$
$$\ln P2s = 14.2724 - (2945.47/T-49.15)$$

Where T is in KPa. Assuming that the solutions formed by these are ideal, calculate
    (a)   X1 & Y1 at 327 K and 65 KPa
    (b)   P & Y1 at 327 K and X1= 0.4
  (c)   P and X1 at 327 K and Y1 = 0.4

13(a) Ethanol (1) and benzene (2) system forms an azeotrope with 44.8mol% ethanol with a boiling point of 68.24°C at 760 mm Hg (760 torr). The saturation pressures of ethanol (1) and benzene (2) at 506mm Hg (506 torr)   **(14)**   **3**   **3**

and 517 mm Hg (517 torr) respectively. Estimate the van laar constant for the system and evaluate the activity coefficients for a solution containing 10 mol % ethanol

(OR)

13(b) Mixture of n-Heptane(A) and n-Octane (B) in ideal. The total pressure is 1 atm. **(14)** **3** **3** Using the vapour pressure data given construct (i) Boiling point diagram (ii) Equilibrium diagram and (iii) Deduce equation for the equilibrium diagram using average α values.

T(Kelvin)	371.4	378	383	388	393	398.6
P_A,(KPa)	101.3	125.3	140	160	179.9	205.3
P_B,(KPa)	44.4	55.6	64.5	74.8	86.6	101.3

14(a) Ethanol is manufactured by the vapor phase hydration of ethylene according to **(14)** **4** **3** the reaction:

$$C_2H_4(g)+H_2O(g) \rightarrow C_2H_5OH(g)$$
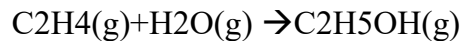
The reactor operates at 400K and 2 bar and the feed is a gas mixture of ethylene and steam in the mol ratio 1:3. The equilibrium constant is 0.25. Estimate the composition (mol%) of the equilibrium mixture. Assume ideal gas behavior.

(OR)

14(b) **(i)** Derive the relationship between equilibrium constant and standard free **(7+7)** **4** **3** energy change?

(ii) n-Butane is isomerised to i-butane by the action of catalyst at moderate temperatures. It is found that the equilibrium is attained at the following compositions.

Temperature,K	Mol %, n-butane
317	31.00
391	43.00

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

15(a) A vapour compression cycle using ammonia as refrigerant is employed in an   (14)   5   3
ice manufacturing unit plant. Cooling water at 288 K enters the condenser at a
rate of 0.25 Kg/s and leaves at 300 K. Ammonia at 294 K condenses at a rate of
0.5 Kg/minute. Enthalpy of liquid ammonia at 294 K is 281.5 KJ/kg. The
compressor efficiency is 90%. Saturated ammonia vapour at 258 K and
enthalpy of 1426 Kj/kg enters the compressor. What is the power requirement
of the compressor and refrigeration capacity in tons?

(OR)

15(b) Explain the Liquefaction process in detail with its types and sketch its   (14)   5   3
mechanism.

PART- C (1x 10=10Marks)
(Q.No.16 is compulsory)

	Marks	CO	RBT LEVEL
16. For the system ethyl ethanoate (i) /n-heptane (ii) at 343.15K	(10)	3	5

P_1^s = 79.8 KPa, P_2^s = 40.5 KPa, G^E/RT =0.95 X_1X_2. Assuming the modified
Raoult's law, $y_i P = x_i \ \gamma_i \ P_i^{\,sat}$ is applicable, determine the bubble point, y_1
calculation for x_1 = 0.05.

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