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ECH401

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : **151405**

Roll No.

B. Tech.

(SEM. IV) THEORY EXAMINATION, 2014-15

CHEMICAL ENGINEERING THERMODYNAMICS

Time : **3** Hours] [Total Marks : **100**

Note-(1) Assume suitable data if missing

(2) Use of steam table is allowed

1 Attempt any four parts of the following :- [5×4=20]

(a) An ideal gas at 2500 KPa is throttled adiabatically to 150 KPa. Determine the change in entropy.

(b) 10 kg water at 375K is mixed adiabatically with 30 kg water at 275K. what is the change in entropy? Assume that the specific heat of water is 4.2 kJ/Kg and is independent of pressure.

(c) Show that Cp-Cv=R for an ideal gas.

(d) What is clausius inequality ?

(e) A rigid and insulated tank of volume 2 m^3 is divided into two gases at 400 K & 3 MPa. While the second compartment contains the same gas at 600 K & 1 MPa. The partition is punctured and the gases are allowed to mix. Determine the entropy change of the gas. The isobaric molar heat capacity of gas is equal to (5/2)R.

(f) A motor car tyre has a pressure of 2 atm the room temperature of 270C. if the tyre suddenly bursts, find the resulting temperature. $\gamma = 1.4$

2 Attempt any two parts of the following. [10×2=20]

(a) The equation of state of a certain substance is given by the expression $V=(RT/P-C/T^3)$, and the specific heat is given by the relation $Cp=A+BT$ where A,B,C, are constants. Derive expressions for changes in internal energy, enthalpy and entropy for and an isothermal process.

(b) (i) Prove that $Cp-Cv= \beta^2 VT/k$, where β =coefficient of volume expansion and k=coefficient of compressibility

(ii) Derive fundamental property relation.

(c) (i) Find the fugacity coefficient at 1 bar, 5bar and 10 bar for a gas that follows the equation of state PV=RT (1-0.00513P), Where P is pressure in bar.

(ii) Explain the principle of corresponding states. What is accentric factor.

3 Attempt any two parts of the following : [10×2=2]

(a) The enthalpy of a binary liquid system of species 1 & 2 at fixed T & P is represented by the equation-

$$H = 400X_1 + 600X_2 + X_1X_2(40X_1 + 20X_2),$$

where H is in J/mol Determine expression for $\overline{H_1}$ & $\overline{H_2}$ as function of X_1

(b) (i) Derive the Clapeyron equation.

(ii) Explain the term Excess property and fugacity coefficient.

(c) The excess Gibbs energy of a binary liquid mixture at T & P is given by $G^E/RT = (-2.6.x_1 - 1.8x_2)x_1x_2$.

Find expression for $\ln\gamma_1$ & $\ln\gamma_2$ at T & P.

4 Attempt any **two** parts of the following. [10×2=20]

(a) Write short notes on Raoult's law and Henery law.

(b) (i) Draw P-xy & T-xy diagram for azeotropic mixture.

(ii) Define ideal solution. What is Lewis/Randall rule?

(c) (i) An equimolar solution of benzene & toluene is totally evaporated at a constant T of 363 K, At this temp. the vapor pressure of benzene & toluene are 135.4 & 54 KPa respectively. What are the pressures at the beginning & at the end of the vaporization process?

(ii) Show that multiple phases at the same T and P are in equilibrium when the fugacity of each constituent species is the same in all phases.

5 Attempt any **two** parts of the following : [10X2=20]

(a) (i) Derive the expression: $\ln K = -\Delta G°/RT$

(ii) A chemically reactive system contains the following species in the gas phases NH_3, NO, NO_2, O_2 & H_2O. Determine a complete set of independent reaction for this system. How many degree of freedom does the system have?

(b) Write short notes on: (i) Duhem's Theorem for reacting and non reacting system (ii) Phase rule for reacting system, (iii) Effect of temperature on the equilibrium constant using Vant Hoff equation.

(c) A feed stock of pure n-butane is cracked at 750 K and 1.2 bar to produce olefins. Only two reactions have favorable conversion at those conditions-

$$C_4H_{10} \rightarrow C_2H_4 + C_2H_6(I)$$
$$C_4H_{10} \rightarrow C_3H_6 + CH_4(II)$$

If these reactions reach equilibrium, what is the product composition? The equilibrium constant at 750 K are given- KI = 3.856 & KII = 268.4