

Printed Pages : 4



ECH401

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

PAPER ID : 151405

Roll No.

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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

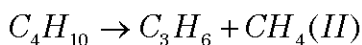
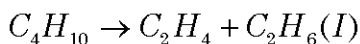
1 Attempt any four parts of the following :- [5×4=20]

- (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 $C_p - C_v = R$ for an ideal gas.
- (d) What is clausius inequality ?
- (e) A rigid and insulated tank of volume 2 m³ 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 27°C. 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 $C_p = A + BT$ 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 $C_p - C_v = \beta^2 VT/k$, 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, 5 bar 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 acentric factor.
- 3 Attempt any two parts of the following : [10×2=20]
- (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 $\frac{G^E}{RT} = (-2.6x_1 - 1.8x_2)x_1x_2$.
 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 Henry 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: $\ln K = -\frac{\Delta G^\circ}{RT}$
 (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-



If these reactions reach equilibrium, what is the product composition? The equilibrium constant at 750 K are given- $K_I = 3.856$ & $K_{II} = 268.4$
