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Total number of printed pages - 02

**B.TECH**  
**PCCH4401**

**7<sup>th</sup> Semester Regular / Back Examination 2016 - 17**  
**CHEMICAL ENGINEERING THERMODYNAMICS**

**BRANCH : Chemical**

**Time : 3 Hours**

**Max Marks : 70**

**Question Code :Y145**

**Answer Question No. 1 which is compulsory and any FIVE from the rest.**  
**The figures in the right-hand margin indicate marks.**

**Assume suitable notations and any missing data wherever necessary.**  
**Use of Steam Table is permitted. Answer all parts of a question at a place.**

1. Answer the following questions : **2 x 10**
- (a) For liquid water in equilibrium with a mixture of water vapour and nitrogen, find the number of degrees of freedom.
  - (b) The volume expansivity values for incompressible fluids and liquids are \_\_\_\_\_ and \_\_\_\_\_ respectively.
  - (c) What do you understand by polytropic process ?
  - (d) What is acentric factor ? Mention its significance.
  - (e) State Duhem's theorem.
  - (f) What do you understand by partial molar properties ?
  - (g) Write the summability relations.
  - (h) Write the basis for Gibbs' theorem.
  - (i) What are fugacity and fugacity coefficients ?
  - (j) State and explain Lewis/Randall rule.
2. (a) Calculate  $\Delta U$  and  $\Delta H$  for 2 kg of water when it is vaporized at constant temperature of  $100^{\circ}\text{C}$  and constant pressure of 101.325 kPa. The specific volumes of liquid and water vapour at these conditions are 0.00104 and  $1.673 \text{ m}^3/\text{kg}$ . For this change heat in the amount of 2256.9 kJ/kg is added to the water. **04**
- (b) Draw a neat PT diagram and explain the behaviour of pure substances. **06**
3. (a) For liquid acetone at  $20^{\circ}\text{C}$  and 1 bar,  $\beta = 1.487 \times 10^{-3}/^{\circ}\text{C}$ ,  $k = 62 \times 10^{-6}/\text{bar}$ , and  $v = 1.287 \text{ cm}^3/\text{g}$ . Find: (i) the value of  $\left(\frac{\partial p}{\partial T}\right)_v$  at  $20^{\circ}\text{C}$  and 1 bar, (ii) pressure generated by heating at constant  $v$  from  $20^{\circ}\text{C}$  and 1 bar to  $30^{\circ}\text{C}$ , and (iii) change in volume for a change from  $20^{\circ}\text{C}$  and 1 bar to  $^{\circ}\text{C}$  and 10 bar. **03**

(b) An ideal gas undergoes the following sequence of mechanically reversible process in a closed system. (i) from an initial state of 70°C and 1 bar, it is compressed adiabatically to 150°C, (ii) it is then cooled from 150°C to 70°C at P = constant, and finally (iii) it is expanded isothermally to its original state. Calculate W, Q, ΔU, and ΔH for each of the three processes and for the entire cycle.

Data:  $C_V = 3/2 R$ ,  $C_P = 5/2 R$ ,  $R = 8.314 \text{ J/mol.K}$ ,  $C_V = 12.471$  and  $C_P = 20.785 \text{ J/mol.K}$ .

**07**

4. A binary system of acetonitrile(1) and nitromethane(2) conforms closely to Raoult's law. Vapour pressures for the pure species are given by the following Antoine equations.

$\ln P_1^{sat} = 14.27 - \frac{2945.47}{T - 49.15}$  and  $\ln P_2^{sat} = 14.21 - \frac{2972.64}{T - 64.15}$ , where T is in kelvin. Prepare a graph showing T vs.  $x_1$  and T vs.  $y_1$  for a pressure of 70 kPa.

**10**

5. Derive the Gibb's/Duhem equation.

**10**

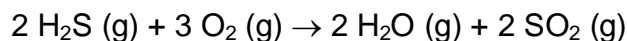
6. For H<sub>2</sub>O at a temperature of 300°C and for pressures upto 10,000 kPa calculate values of  $f_i$  and  $\Phi_i$  from data in steam tables and plot them vs. p.

**10**

7. (a) Discuss briefly about excess property relations.

**05**

(b) Develop expressions for the mole fractions of reacting species as functions of the reaction coordinate for a system initially containing 3 mol H<sub>2</sub>S and 5 mol O<sub>2</sub> and undergoing the reaction:



**05**

8. Write short notes on any **TWO**:

**5 x 2**

- (a) Virial equations of state
- (b) Partial properties in binary solutions
- (c) Ideal solution model
- (d) Multireactionstoichiometry

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