

**B.TECH.**  
**(SEM IV) THEORY EXAMINATION 2017-18**  
**CHEMICAL ENGINEERING THERMODYNAMICS**

Time: 3 hours

Total Marks: 100

Note: Attempt all questions. All question carries equal marks. Steam Table is allowed.

**SECTION-A**

**1. Attempt all questions in brief.**

**2 x 10 = 20**

- (a) Explain the P-x-y diagram.
- (b) Define *first law of thermodynamics*.
- (c) Define Activity coefficients.
- (d) Differentiate between ideal and non-ideal solution.
- (e) Define 'Van't Hoff equation'.
- (f) Write Margules equation.
- (g) Define T-x-y diagram.
- (h) Define Triple point
- (i) What do you mean by Retrograde Condensation?
- (j) Define fugacity.

**SECTION-B**

**2. Attempt any three of the following:**

**10x3 = 30**

- (a) The excess enthalpy (heat of mixing) for a liquid mixture of species 1 and 2 at fixed T and P is represented by the equation:  
$$H^E = x_1x_2(40x_1 + 20x_2)$$
Where  $H^E$  is in  $\text{Jmol}^{-1}$ , Determine expressions for  $\underline{H}_1^E$  and  $\underline{H}_2^E$  as function of  $x_1$
- (b) Explain P-x-y and T-x-y diagram for azeotropic mixture.
- (c) Prove that if Raoult's law is valid for one constituent of a binary solution over the whole concentration range, it must also be applied to the other constituent.
- (d) Explain the concept of first law of thermodynamics and law of conservation of energy.
- (e) Derive the following:

$$\ln K = \frac{-\Delta G^\circ}{RT}$$

### SECTION-C

3. Attempt any *one* part of the following: **10x1 =10**
- (a) What do you mean by 'Critical point for a pure substance'. Also discuss the virial expressions for compressibility factor  $Z$ .
- (b) Show that the internal energy of an incompressible substance is a function of temperature only,  $u = u(T)$ .
4. Attempt any *one* part of the following: **10x1 =10**
- (a) For pure liquid, derive the expression
- $$f_i = \phi_i^{sat} P_i^{sat} \exp[V_i^l(P - P_i^{sat})/RT]$$
- Where symbols have their usual meaning
- (b) Develop relation for equilibrium constants for gas phase reaction.
5. Attempt any *one* part of the following: **10x1 =10**
- (a) A pump operating at 75% efficiency has an inlet specific enthalpy of 180 Btu/lbm. The exit specific enthalpy of the ideal pump is 600 Btu/lbm. What is the exit specific enthalpy of the actual pump?
- (b) Discuss P-T and P-V diagram for a pure substance.
6. Attempt any *one* part of the following: **10x1 =10**
- (a) A mass of 200 g of saturated liquid water is completely vaporized at a constant pressure of 100 kPa. Determine the amount of energy transferred to the water.
- (b) Write short note on Gibbs-Duhem equation.
7. Attempt any *one* part of the following: **10x1 =10**
- (a) Determine the fugacity coefficients for nitrogen (A) and methane (B) in a nitrogen-methane mixture at 200 K and 30 bar, if the mixture contains 40 moles% nitrogen.
- Experimental virial coefficient data are as follows:
- $$B_{11} = -35.2 \quad B_{22} = -105.0 \quad B_{12} = -59.8 \text{ cm}^2\text{mol}^{-1}$$
- (b) Derive the fundamental property relation for single phase fluid system of variable mass and variable composition.