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

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

Note: **1**. Attempt all sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt *all* questions in brief. 2 x 10 = 20

a) Explain the Scope of second law of thermodynamics.
b) Define residual property.
c) Define isothermal compressibility.
d) What is Raoult's law?
e) Define partial molar property.
f) What do you mean by extent of reaction?
g) Define osmotic pressure.
h) What is non-ideal solution?
i) Differentiate between open system and closed system.
j) Define K value.

SECTION-B

2. Attempt any *three* of the following: 10 x 3 = 30

a. Derive a correlation for work done during an adiabatic process under reversible conditions in closed system.
b. A heat pump is to be used to heat a house during the winter. The house is to be maintained at 21 ^{0}C at all times. The house is estimated to be losing heat at a rate of 135000 KJ/hr when the outside temperature drops to -5^{0}C. Determine the minimum power required to derive this heat pump unit.
c. What is the change in entropy when 0.8 m^3 of CO_2 and 0.2 m^3 of N_2 each at 1 bar and 25^{0}C is blended to form a gas mixture at the same conditions? Assume ideal gases.
d. Define critical point. Discuss in detail the behavior of pure liquid with the help of P-V diagram.
e. For the system ethyl ethanoate (1)- n-heptane (2) at 343.15 K, assuming the system obeys modified Raoult's law predict whether azeotrope gets formed or not and if it gets formed calculate the azeotrope composition and pressure at T =343.15 K. At 343.15 K, $\ln\gamma_1 = 0.95x_2^2$, $\ln\gamma_2 = 0.95x_1^2$ P_1^{sat}=79.80 KPa; P_2^{sat}=40.50 KPa.

SECTION C

3. Attempt any one part of the following: 10 x 1 = 10

a) Describe different steps to find bubble point and dew point of a mixture.
b) Define partial molar property. Derive an equation for partial molar properties from an equation of solution property as a function of composition.

4. Attempt any one part of the following: 10 x 1 = 10

a) Discuss the equilibrium criteria to chemical reaction.

b) What is the effect of temperature on equilibrium constant? Using van't Hoff equation predict the effect of increasing the temperature on endothermic and exothermic reactions.

5. Attempt any one part of the following: 10 x 1 = 10

a) Derive the Gibbs/Duhem equation.

b) A mixture of component (1) and (2) follows Raoult's law. The pure component vapour pressure P_1^{sat} and P_2^{sat} in kPa are given by (t in ^{0}C)

$$\ln P_1^{sat} = 14.27 - \frac{2945}{t+224}$$

$$\ln P_2^{sat} = 14.20 - \frac{2978}{t+209}$$

At 76^{0}C and 80 kPa, determine the equilibrium liquid and vapour compositions.

6. Attempt any *one* part of the following: 10 x 1 = 10

a) Consider the reaction

$SO_2 + 1/2\ O_2 \rightarrow S0_3$

The pressure in the reactor is 1 atm and temperature is 749 K and at this temperature K =74. Determine moles of $S0_3$ formed and mole fraction of the species present in the reaction mixture at equilibrium for the cases given below. Assume ideal gas phase reaction.

(i) Initially the number of moles of SO_2 is 12, oxygen is 9 and $S0_3$ is zero.

(ii) Initially the number of moles of SO_2 is 24, oxygen is 18 and $S0_3$ is zero.

(iii) Initially the number of moles of SO_2 is 12, oxygen is 9, nitrogen is 79 and $S0_3$ is zero.

b) Determine the minimum pressure to desalinate sea water containing 3.5 g NaCl /100 g water at 25^{0}C.

7. Attempt any *one* part of the following: 10 x 1 = 10

a) With the help of fundamental property relation, show that multiple phases at the same T and P in equilibrium when the chemical potential of each constituent species is same in all phases.

b) Write notes on

i. Equilibrium and Stability

ii. Solid -Liquid Equilibrium

iii. Vapour-Liquid- Liquid Equilibrium

iv. Vapour-Liquid Equilibrium