Chemical Engg Thermodynamics II
04/12/14

T.E. Che...

Q.P. Code : 14948

(3 Hours)

[Total Marks :80

N.B. : (1) Question No 1 is compulsory
(2) Attempt any three questions from the remaining five questions
(3) Assume suitable data wherever necessary
(4) Figures to the right indicate full marks.

1. (a) Fill in the blanks :– 10

(i) At equilibrium the entropy of an isolated system ______
(ii) For a reversible reaction the Gibbs Energy is ______ at equilibrium.
(iii) For a gas phase reaction Kp is a function of ______ and ______
(iv) For an ideal solution the volume of mixing is ______
(v) When an ideal gas is mixed the entropy of mixing at constant temperature and pressure is ______

b (i) For an ideal solution the activity coefficient is : 10

(a) 1
(b) Greater than 1
(c) Less than 1
(d) Depends on the solution

(ii) For an ideal gas mixture the partial fugacity is equal to the

(a) Partial pressure of the component
(b) Vapor pressure of the component
(c) Partial volume of the component
(d) cannot be determined

(iii) The Raoults law is valid when :

(a) Both vapour and liquid is ideal
(b) Vapor is non ideal and liquid is ideal
(c) Liquid is non ideal but vapour is ideal
(d) Both vapour and liquid are non ideal.

(iv) The fugacity coefficient for an ideal gas mixture is :

(a) 1
(b) greater than 1
(c) less than 1
(d) depends on temperature and pressure

(v) For a maximum boiling azetrope the boiling temperature of the azetrope :

(a) is less than the low boiler and the high boiler
(b) less than the low boiler
(c) Higher than the high boiler
(d) Higher than the low boiler and the high boiler

2. (a) For the reaction A+ B $\longrightarrow$ 2C+ 3D $\Delta H(298)$=-200kJ/mol 10

It is a gas phase reaction. A and B are fed in equimolar quantities. Cp is 3R, where R is the universal gas constant. Calculate the amount of heat to be supplied to maintain the reactor a 400 K for 20 percent conversion.

(b) For the above reaction find the ΔG at 400 K 10

3. (a) At 25°C and atmospheric pressure the excess volumes of binary liquid mixtures of species 1and 2 are given by the equation 10

$$V^E = X_1X_2(30x_1 + 50x_2)$$

Where V^E is in cm^3 mol^{-1}. At the same conditions, V_1=120cm ^{3} mol^{-1}and V_2=150 cm^3 mo^{-1} . Determine the partial molar volumes $\overline{V_1}$ and $\overline{V_2}$ for an equimolar mixture of species 1and 2 at this condition.

(b) 10 moles of Nitrogen is mixed with 10 moles of Oxygen. This process is carried out at atmospheric temperature and pressure. The gases can be assumed to be ideal. Find the Gibbs free energy of the resulting mixture? The value of Cp is 29.1kJ/kmol-K. 10

4. (a) The partial molar volumes of acetone and chloroform are in a mixture in which mole fraction of chloroform is 0.47 are 74.71ml/mol,and 80.2 ml/mol, respectively. What is the volume of a solution of mass 100g. 10

(b) The boiling point estimation of n-octane is done by Joback group contribution method. The formula for this is $Tb(K) = 198 + \Sigma_i \vartheta_i \Delta T_b$ where ϑ_i is the number of groups and ΔT_b is the boiling point contribution. Find the boiling point of n-octane given that the boiling point contribution of non ring CH_3 group, non ring CHz group are 23.58 and 22.88, respectively. 10

5. (a) The Antoine's equation for a new refrigerant is given by the equation (psat) 10

$$\ln\left(\frac{Psat}{kPa}\right) = 13.79 - \frac{1971}{T - 28.30}$$

The simplified Clasius-Clapeyron equation is given as

$$\frac{dP^{sat}/psat}{dT/T^2} = \frac{\Delta H^{lv}}{R} \qquad T \text{ is in Kelvin}$$

The molecular weight of the refrigerant is given by as 120. Find the mass flow rate of refrigerant for 1T refrigeration

(b) R 12 is condensed at 30°C. It is then throttled to -5 °C. Find out the Refrigerant flow rate that enters the compressor for 1T of refrigeration. 10

Tsat	Psat	Hg kJ/kg	H_f kJ/kg
-5°C	0.2619 MPa	31.42	185.243
30°C	0.7449 MPa	64.539	199.475

It is assumed that the compressor discharge is at the saturated vapour condition. Find the work done by the compressor? Also calculate the COP.

6. (a) Prove that the fugacity of a liquid is equal to that of vapour at equilibrium 5

(b) With a neat diagram explain the Vapor Absorption Refrigeration System 5

(c) Write the equation of non-ideal vapour liquid equilibrium. Show that it is equal to Raoult's law as a special case. What is the special case? 5

(d) Derive the equation $\ln\left(\frac{K}{K_1}\right) = -\frac{\Delta H_{Reaction}}{R}\left(\frac{1}{T}-\frac{1}{T_1}\right)$. 5
