chem / VI / CBSGS / CET-II 13/12/16

Chemical Engg. Thermodynamics - II

Q.P. Code : 573902

(28)

(3 Hours) **[Total Marks : 80**

N.B. : (1) Question no.**1** is compulsory.
(2) Attempt any **THREE** of the remaining questions.
(3) **Figure** to the **right** indicates **full** marks.
(4) Assume suitable data wherever necessary.

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 system obeying Henrys law the product of the henrys constant and the mole fraction of a component is equal to ________ of the component in vapour phase.

iv) For an ideal gas mixture the total pressure is equal to the sum of ________

v) When an ideal gas is mixed the entropy of mixing at constant temperature and pressure is ________

b) **10**

i) For an ideal solution the activity coefficient is
a. 1 b. Greater that 1
c. Less that 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 that 1 d. depends on temperature and pressure

v) For a minimum boiling azetrope the boiling temperature of the azetrope
a. is less that the low boiler and the high boiler
b. less than the low boiler
c. Higher than the high boiler
d. Higher that the low boiler and the high boiler

[TURN OVER]

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2. a) A and Bare fed into a reactor. The reactor is operated isothermally at 400 K. The following reactions occur in the reactor. **10**

$A + B \rightarrow 3C + 2D$ $\Delta H(298) = -300 kJ/mol$ (1)

And

$A \rightarrow E$ $\Delta H(298) = -200 kJ/mol$ (2)

A is fed into the reactor at 10 mol/s. A and B are fed in equimolar quantities. The reactions are in gas phase, and the overall conversion of A is 20%. The flow rate of E in the exit of the reactor is 1 mol/s. C_p is 3R, where R is the universal gas constant. Calculate the amount of heat to be supplied to the reactor.

b) For the reaction A→2R, find the conversion at 450 K. The reaction is in gas phase, and the reactants and products are ideal gases. The specific heat at constant pressure (Cp) for the reactant as well as product is 3R. The entropy of formation for the reactant and product are zero at 298 K. The heats of reaction for the reactant and product, at 298 K are -10 kJ/mol and -12 kJ/mol. **10**

3. a) At dilute aqueous Sodium Carbonate solution of 4.76% (mol) is concentrated to 6.25%(mol), by adding crystals. The flow rate of the dilute solution is 10 mol/s. The mixing is carried out at 25°C. Calculate the amount of heat to be removed from the mixer? **10**

Heats of formation for compound and solutions at 298 K

$Na_2CO_3(c) = -270.3$ kcal/mol

$Na_2CO_3H_2O = -341.8$ kcal/mol

$Na_2CO_315H_2O = -273.13$ kcal/mol

$Na_2CO_320H_2O = -277.91$ kcal/mol

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 C_p is 29.1 kJ/kmol-K. **10**

4. a) A solution of acetone and chloroform has 47 mol% of Chloroform. The partial molar volumes of acetone and chloroform in this mixture in this mixture are are 74.71 ml/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 $T_b (K) = 198 + \Sigma_i \vartheta_i \Delta T_b$ 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 CH_2 group, are is 23.58 and 22.88, respectively. **10** chem / V / CBSGS / CET - II.

5\. a) An ideal ammonia absorption refrigeration system is used to cool an enclosure to -15°C. Heat is available in the generator at 110°C. Cooling water is available at 30°C. Assuming that cooling and heating are done isothermally, in all the exchangers, calculate the COP. The COP of absorption refrigeration system is given by $COP = \frac{T_R}{T_2 - T_R} \times \frac{T_1 - T_2}{T_1}$. T_R is the temperature of the evaporator, T_1 is the temperature of the generator, T_2 is the temperature of the Absorber/ Condenser. For 1 T refrigeration, what is the heat supplied in the generator, and heat to be removed from the absorber, if the heat removed from the condenser is 3 kW. Take 1 T refrigeration as 3.5 kW **10**

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 1 T of refrigeration. **10**

T_S	P_S	H_f kJ/kg	H_g 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. **20**

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

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?

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