Exam. Code: 0908
Sub. Code: 33363

2055

B.E. (Biotechnology) Fourth Semester

BIO-412: Thermodynamics

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: ***Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section. Assume missing data, if any.***

x-x-x

Q.1.a) Define a state function. Give two examples of a state function.

b) A gas is compressed from 0.8 m^3 to 0.3 m^3 at a constant pressure of 200 kPa. Calculate the work done on the gas during this process.

c) Define compressibility factor.

d) State Henry's law. How is it useful in determining the solubility of gases in liquids?

e) For the reaction $A \leftrightarrow B$, the equilibrium constant is 1 at 298 K. If initially 1 mol of A is present in the reaction, calculate the equilibrium compositions of A and B. (10)

SECTION-A

Q.2. One mole of air, initially at 150°C and 8 bar expands isothermally to a pressure such that when it is cooled at constant volume to 50°C its final pressure is 3 bar. Assuming air is an ideal gas for which $C_p = \frac{7}{2}R$ and $C_V = \frac{5}{2}R$, calculate W, Q, ΔU, and ΔH for the process. (10)

Q.3a). Calculate the pressure exerted by 3 moles of methane gas contained in a 0.015 m^3 vessel at a temperature of 400 K using (a) ideal gas equation (b) Van der Waals equation. Given Van der Waals constant a = 0.2283 Pa m^6/mol^2 and b = 4.28×10^{-5} m^3/mol.

b). A cyclic heat engine operates between a source temperature of 800°C and a sink temperature of 30°C. Calculate the least rate of heat rejection per kW work output of the engine. (5+5)

Q.4. What is inversion temperature? With the help of a diagram explain the Linde Hampson process for liquefaction of air. (10)

P.T.O.

SECTION-B

Q.5. The vapor pressure of n-pentane (1) and n-heptane (2) can be evaluated by the following Antoine equations

$$lnP_1^s(kPa) = 13.82 - \frac{2477.07}{T(K)-40} \qquad lnP_2^s(kPa) = 13.86 - \frac{2911.32}{T(K)-56.56}$$

Assuming n-pentane and n-heptane form an ideal solution, calculate

(a) x_1 and y_1 at 335 K and 95 kPa

(b) P and y_1 at 335 K and x_1=0.8

(c) P and x_1 at 335 K and y_1= 0.4 (10)

Q.6a). Calculate the volume of alcohol-water solution formed when 0.03 m^3 alcohol is mixed with 0.07 m^3 water. The partial molar volume s of ethanol and water at the desired compositions are 53.6×10^{-6} m^3/mol and 18×10^{-6} m^3/mol respectively. Density of ethanol is 789 kg/m^3 and that of water is 997 kg/m^3

b). In the water gas shift reaction:

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

One mole steam reacts with CO at temperature of 1100 K and 1 bar pressure. The equilibrium constant for the reaction, K=1. Assuming ideal gas behavior, calculate the extent of reaction if CO is supplied 100% excess of the stochiometric requirements. (5+5)

Q.7. Acetic acid is esterified in the liquid phase with ethanol at 373 K and atmospheric pressure to produce ethyl acetate and water according to the reaction

$$CH_3COOH(l) + C_2H_5OH(l) \rightarrow CH_3COOC_2H_5(l) + H_2O(l)$$

If initially there is one mole each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium. Given the values of $\Delta H^o_{f\,298}$ and $\Delta G^o_{f\,298}$ for the reaction are $-3640\,J$ and $-4650\,J$ respectively. (10)

x-x-x