Exam.Code:0908
Sub. Code: 6302

2053

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.

x-x-x

Q.1.a) A refrigeration machine operating at a condenser temperature of 290 K needs 1 kW of power per ton of refrigeration. Determine the coefficient of performance.

b) A sample of water absorbs 300 J of heat. The change in internal energy of the water is 120 J. How much work is done by the system?

c) The vapor pressure of benzene and toluene at 373 K are 105 kPa and 75 kPa respectively. Assuming benzene and toluene form an ideal solution determine the composition of liquid and vapor in equilibrium at 373 K and 100 kPa.

d) Differentiate between molar volume and partial molar volume.

e) What do you understand by dry and wet compression? (10)

SECTION-A

Q.2 One mole of air initially at 150°C and 8 bar pressure, undergoes the following mechanically reversible changes. It 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 as an ideal gas for which C_p= (7/2)R and C_v=(5/2)R, Calculate work done, heat transfer, change in enthalpy and change in internal energy for the process. (10)

Q.3a). Calculate the pressure of 0.5 moles of a gas occupying a volume of 2.5 L at a temperature of 400 K. The gas has the following properties: a = 4.17 L^2 bar/mol^2, b = 0.0821 L/mol. (R = 0.0821 L atm/mol K)

b). Two reversible heat engines A and B are arranged in series, A rejecting heat directly to B. Engine A receives 200 kJ at a temperature of 421°C from a hot source, while engine B is in communication with a cold sink at a temperature of 4 °C. If the work output of A is twice that of B, find (a) the intermediate temperature between A and B (b) the efficiency of each engine and (c) the heat rejected to the cold sink. (3,7)

Q.4a). What is the role of an evaporator in a vapor compression system?

b). Define Joule Thompson coefficient. With the help of a diagram explain the Linde Hampson process for air liquefaction. (3,7)

P.T.O.

SECTION-B

Q.5a). The equilibrium constant (K) for the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 230°C is 4.5×10^{-3}. Given that the standard enthalpy change ($\Delta H°$) for the reaction is -92 kJ/mol, Calculate the equilibrium constant at 330°C.

b). The partial molar volume of water (1) in its mixture with methanol (2) at 25°C and 1 atm can be approximated by $\overline{V_1} = 18.1 - 3.2\, x_2{}^2$. Develop an expression for the partial molar volume of methanol at the same conditions. Given V_2 at 1 atm and 25°C is 40.7 cm³/mol. Determine the partial molar volume of methanol at infinite dilution.

(5,5)

Q.6. The vapor pressure of n-pentane (1) and n-heptane (2) can be evaluated by the following Antoine equations

$lnP_1^s(kPa) = 13.8183 - \frac{2477.07}{T(K)-40}$ $\qquad$ $lnP_2^s(kPa) = 13.8587 - \frac{2911.32}{T(K)-56.56}$

Assuming n-pentane and n-heptane form an ideal solution calculate (a) x_1 and y_1 at 90°C and 90 kPa (b) P and y_1 at 90°C and x_1=0.4 (c) P and x_1 at 90°C and y_1= 0.4 (10)

Q.7. For the ammonia synthesis reaction given below, the standard heat of formation and standard free energy of formation of ammonia at 298 K are - 46.1 kJ/mol and -16.5 kJ/mol respectively. The specific heat (J/mol K) are given below

$Cp_{N_2} = 27.27 + 4.93\times10^{-3}\,T$

$Cp_{H_2} = 27.01 + 3.51\times10^{-3}\,T$

$Cp_{NH_3} = 29.75 + 25.11\times10^{-3}\,T$

Calculate the standard free energy change and equilibrium constant at 700 K.

(10)

x-x-x