Exam. Code: 0908
Sub. Code: 6302

2054

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) Differentiate between steady state and state of equilibrium.

b) An ideal gas is expanded isothermally at 600 K from 5 bar pressure to 4 bar. Calculate the work done and the heat supplied.

c) State the principle of the absorption refrigeration systems.

d) Define fugacity and fugacity coefficient.

e) The volume (m^3/mol) of a mixture of two liquids 1 and 2 is given by $V = 110 - 20x_1 - 2x_1^2$ at 1 bar pressure and 200 K. Find the expression for $\bar{V_1}$ *and* $\bar{V_2}$ (10)

SECTION-A

Q.2. One mole of an ideal gas initially at 30°C and 1 bar pressure is compressed isothermally to a point such that when it is heated at constant volume to 120°C its final pressure is 12 bar. Calculate the heat transfer, work done, change in internal energy, and change in enthalpy for the process. Take $C_p = \frac{5}{2}R$ and $C_v = \frac{7}{2}R$ (10)

Q.3a). Determine the pressure exerted by one-kilo mole of carbon dioxide occupying a volume of 0.381 m^3 at 310 K using (a) ideal gas equation (b) van der waals equation. Given van der waals constant a = 0.365 Nm^4/mol^2 and b = 4.28×10^{-5} m^3/mol.

b). A heat engine with a thermal efficiency of 30% is being used to drive a refrigerator with a coefficient of performance of 5. Calculate (i) the heat input into the engine for 1 MJ removed from the cold reservoir of the refrigerator (ii) heat rejected by the heat engine to the cold reservoir. (5+5)

Q.4. What is the principle of the Linde Hampson system for the liquefaction of air? Explain the process with the help of a neat diagram and also derive an expression for liquid yield. (10)

P.T.O.

SECTION-B

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

$lnP_1^s(kPa) = 16.68 - \frac{3640.2}{T(K)-53.54}$ $\quad$ $lnP_2^s(kPa) = 16.29 - \frac{3816.4}{T(K)-46.13}$

Assuming 2- propanol and water form an ideal solution calculate (a) x_1 and y_1 at 333 K and 30 kPa (b) P and y_1 at 333 K and x_1=0.8 (c) P and x_1 at 333 K and y_1= 0.4 (10)

Q.6a). The water gas shift reaction with 2 moles of water and 1 mole of carbon monoxide is carried out at 1100 K and 1 bar pressure. Calculate the fraction of steam reacted assuming the mixture behaves as an ideal gas.

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

b). Calculate the equilibrium rate constant at 300 K for the reaction $N_2O_4(g) \rightarrow 2NO_2$. Given the standard heat of reaction and standard free energy of reaction at 298 K are 57200 J/mol and 5080 J/mol respectively. (5+5)

Q.7. The following reaction reaches equilibrium at 650°C and 1 bar pressure

$$N_2(g) + C_2H_2(g) \rightarrow 2HCN(g)$$

If the system initially is an equimolar mixture of hydrogen and acetylene, what is the composition of the system at equilibrium? What is the effect of doubling the pressure? Assume ideal gases. Given

$Cp_{N_2} = 27.27 + 4.93 \times 10^{-3}T$

$Cp_{C_2H_2} = 50.98 + 16.23 \times 10^{-3}T$

$Cp_{HCN} = 39.38 + 11.3 \times 10^{-3}T$ (10)

x-x-x