Exam. Code: 0908
Sub. Code: 6702

1019

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, reasonably.

x-x-x

I 10×1

i. What is Gibbs phase rule for a nonreactive system?
ii. Define activity coefficient.
iii. Define partial molar properties.
iv. What is chemical potential?
v. What is enthalpy of a system? How is it related to internal energy?
vi. When muscles contract, chemical energy is converted to mechanical energy with the loss of heat. Define the law of thermodynamics which this example represents.
vii. Which molecule is considered to be the energy currency of cells?
viii. What is inversion temperature?
ix. Give examples of intensive and extensive properties.
x. A container filled with a sample of an ideal gas at the pressure of 1.5 atm. The gas is compressed isothermally to one-fourth of its original volume. What is the new pressure of the gas?

Section A

II (a) If a gas of volume 6000 cm^3 and at a pressure of 100 kPa is compressed quasistatically according to PV^2 = constant, until the volume becomes 2000 cm^3, determine the final pressure and the work transfer. 4

(b) 2 kilo mole of CO_2 occupies a volume of 0.380 m^3 at 313 K. Calculate the pressure using ideal gas equation and van der Waals equation. Take van der Waals constants to be a= 0.365 Nm^4/mol^2 and $b = 4.28\times10^{-5}$ m^3/mol. 6

III (a) What is the principle of operation of an absorption refrigeration system? 3

(b) Explain the Claude process for the liquefaction of air. Derive an expression for the liquid yield obtained from the process. 7

IV One mole of ideal gas, 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. Calculate the work, heat transferred, changes in internal energy and changes in enthalpy for the process. Take C_p= (7/2)R and C_v=(5/2) R. 10

P.T.O

Section B

V (a) Initially n_0 moles of ammonia are present which dissociate according to the equation $NH_3 \leftrightarrow \frac{1}{2} NH_2 + \frac{3}{2} H_2$. Show that at equilibrium $K = \frac{\sqrt{27}}{4} \frac{\varepsilon^2}{1-\varepsilon^2} P$. 5

(b) The enthalpy of a binary liquid system for species 1 and 2 at fixed Temperature (T) and pressure (P) is given by equation $H = x_1 x_2 (40x_1 + 20x_2)$ where H is in J/mole. Determine expression for $\overline{H}_1$ and $\overline{H}_2$ as a function of x_1, and the numerical values for the partial enthalpies at infinite dilution $\overline{H}_1^{\infty}$ and $\overline{H}_2^{\infty}$. 5

VI An equimolar mixture of $CH_4(g)$ and H_2O_2 (g) enters a reactor which is maintained at 1000K and 5 bar. The following reaction takes place 10

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

Calculate the equilibrium constant at 1000 K and estimate the degree of conversion of methane into products. Also estimate the composition of the reactor effluent assuming that the reaction mixture behaves like an ideal gas.

$C_p = a + bT + cT^2 + dT^3 + eT^{-2}$ (J/mol K),

$\Delta H^o_{rxn} = 206.408\ kJ$, $\Delta G^o_{rxn} = 141.933\ kJ$

$$C_{p_{CO}} = 28.068 + 4.631 \times 10^{-3}T - 0.258 \times 10^5 T^{-2}$$

$$C_{p_{H_2}} = 27.012 + 3.509 \times 10^{-3}T + 0.690 \times 10^5 T^{-2}$$

$$C_{p_{CH_4}} = 17.449 + 60.449 \times 10^{-3}T + 1.117 \times 10^{-6}T^2 - 7.204 \times 10^{-9}T^3$$

$$C_{p_{H_2O}} = 28.850 + 12.055 \times 10^{-3}T + 0.690 \times 10^5 T^{-2}$$

VII Binary system Acetonitrile (1)/Nitromethane (2) conforms closely to Raoult's law. Vapor pressure for the pure species are given by the following Antoine equations: 10

$$\ln P_1^{sat}(kPa) = 14.2724 - \frac{2945.47}{t(^0C) + 224}$$

$$\ln P_2^{sat}(kPa) = 14.2043 - \frac{2972.64}{t(^0C) + 209}$$

Prepare a t-x-y diagram for a pressure of 70kPa.

x-xx-x