Exam. Code: 0908
Sub. Code: 33363

2015

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

I **(a)** How is the temperature of an ideal gas related to pressure and volume in an adiabatic process? (5×2)

(b) The heat capacity of air can be calculated using the following equation: $C_p(J/molK) = 26.69 + 7.365 \times 10^{-3}T$. Calculate the heat given off by 1 mole of air when cooled from 500°C to -100°C at 1 atm pressure.

(c) Explain the principle behind the absorption refrigeration system.

(d) Define Chemical potential. What is its significance?

(e) A liquid mixture of benzene and toluene is in equilibrium with its vapor at 101.3 kPa and 373 K. The vapor pressures of benzene and toluene at 373 K are 156 and 63 kPa, respectively. Use Raoult's law to calculate the fraction of benzene in the liquid phase.

Section-A

II **(a)** One 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 a= 0.365 Nm^4/mol^2 and b = 4.28×10^{-5} m^3/mol. (5)

(b) A gas at a pressure of 100 kPa and volume 6000 cm^3 is compressed quasistatically according to PV^2 = constant, until the volume becomes one third of initial volume. Determine the final pressure and the work transfer. (5)

III One mole of ideal gas initially at 30°C and 1 bar pressure undergoes the following mechanically reversible changes. It 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 Q, W, ΔU and ΔH for the process. Take $C_p = \frac{7}{2}R$ and $C_v = \frac{5}{2}R$ (10)

IV **(a)** A reversible heat engine operates between hot reservoir at a temperature of 600 °C and cold reservoir at a temperature of 40 °C. The engine drives a reversible refrigerator that operates between reservoir temperatures of 40 °C and -20 °C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ. Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (5)

(b) What is inversion temperature? With the help of a diagram explain the linde Hampson process for air liquefaction (5)

P.T.O.

Section-B

V (a) Binary system 1-Chlorobutane (1) and Chlorobenzene (2) conforms closely to Raoult's law. Vapor pressure for the pure species are given by the following Antoine equations: (7)

$lnP_1^s(kPa) = 13.7965 - \frac{2723.73}{T(K)-54.89}$; $lnP_2^s(kPa) = 13.8635 - \frac{3174.78}{T(K)-61.45}$.

Calculate (i) x_1 and y_1 at 363 K and 90 kPa (ii) P and x_1 at 363 K and y_1=0.4.

(b) Briefly explain the thermodynamics of ATP hydrolysis in living cells. (3)

VI Calculate the standard free energy change and equilibrium constant at 500 K for the methanol synthesis reaction: (10)

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

Given that the standard heat of formation and standard free energy of formation of methanol at 298 K is $-90{,}135 J/mol\ and - 24{,}791\ J/mol$, respectively. The specific heat (J/mol K) data are given below:

$$Cp_{CO} = 28.07 + 4.63 \times 10^{-3}T - 0.26 \times 10^{5}T^{-2}$$

$$Cp_{H_2} = 27.01 + 3.51 \times 10^{-3}T + 0.69 \times 10^{5}T^{-2}$$

$$Cp_{CH_3OH} = 18.38 + 101.56 \times 10^{-3}T - 28.68 \times 10^{-6}T^{2}$$

VII Acetic acid is esterified in the liquid phase with ethanol at 100°C and atmospheric pressure to produce ethyl acetate and water according to the reaction (10)

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

If initially there is one mole each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reaction mixture at equilibrium. Given: ΔH^o_{rxn} and $\Delta G^o_{rxn}\ at\ 25°C\ is - 3640\ J\ and - 4650\ J$, respectively.

x-x-x