(29)

Exam.Code:0908
Sub. Code: 6702

1059

B.E. (Biotechnology) Fourth Semester
BIO-412: Thermodynamics

Allowed: 3 Hours **Max. Marks: 50**

Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section.

x-x-x

1.
a) Maximum work is done by the gas when it expands under ________ conditions.
b) Fugacity coefficient is an indicator of ________
c) Calculate the work done (J) when 2 moles of hydrogen gas expands isothermally and reversibly from 5 L to 15 L at 25°C.
d) State the third law of thermodynamics.
e) For an isothermal expansion of a perfect gas, the change in its internal energy is ________
f) Define coefficient of performance.
g) The greater the temperature, the ________ is the vapor pressure.
h) State and explain Raoult's law.
i) Compressibility factor Z is given by ________
j) What is chemical potential? Give its significance. (1×10)=10

SECTION-A

2a). A stream of warm water is produced in a steady flow mixing process by combining 1 kg/s of cold water at 25°C with 0.8 kg/s of hot water at 75°C. While mixing heat at a rate of 30 kJ/s is lost to the surroundings. Calculate the temperature of warm water output stream?

b). One mole of an ideal gas, initially at 30°C and 1 bar, 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 $C_v = \frac{5}{2}R$ (3,7)

3a). A heat engine is used to drive a heat pump. The heat transfers from the heat engine and the heat pump are rejected to the same sink. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Determine the ratio of the total heat rejection rate to the heat transfer to the heat engine.

b). Explain the vapor absorption refrigeration cycle. What are the advantages of an absorption refrigeration cycle over a vapor compression cycle. (5+5)

4a). With the help of a diagram explain the Linde Hampson process for air liquefaction. Also derive an expression in terms of enthalpies that can be used to calculate the liquid yield.

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b). Define Joule Thompson coefficient. Find the value of Joule Thompson coefficient for an ideal gas. (7+3)

SECTION-B

Q.5a). The equilibrium constant K for the reaction $CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$ at 1 bar and 298 K is 1.1582×10^5. Assuming that ΔH^o_{rxn} remains constant in the temperature range 298K to 1000 K, estimate the value of K at 1 bar and 1000 K.

b). If a stoichiometric mixture of N_2 (g) and H_2 (g) is fed to a reactor for the synthesis of ammonia and the reactor is maintained at 800 K and 250 bar, calculate the percentage of nitrogen that can be converted into ammonia and the molar composition of the reactor effluent assuming that the reaction mixture behaves like an ideal gas. The equilibrium constant K at 800 K is 1.1067×10^{-5}. (4+6)

Q.6a). Briefly explain the thermodynamics of ATP hydrolysis in living cells.

b). Assuming Raoult's law to be valid for benzene (1) and ethylbenzene (2) system, for which Antoine equations are

$$lnP_1^s(kPa) = 13.7819 - \frac{2726.81}{T(K)-55.58} \qquad lnP_2^s(kPa) = 13.9726 - \frac{3259.93}{T(K)-60.85}$$

Calculate (a) x_1 and y_1 at 363 K and 90 kPa (b) P and x_1 at 363 K and y_1=0.4 (3+7)

Q.7. Estimate the standard free energy change and equilibrium constant at 700 K for the reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Given that the standard heat of formation and standard free energy of formation of ammonia at 298 K is -46,100 J/mol and -16,500 J/mol respectively. The specific heat (J/mol K) data is given below

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

$$C_{p_{H_2}} = 27.01 + 3.51 \times 10^{-3}T$$

$$C_{p_{NH_3}} = 29.75 + 25.11 \times 10^{-3}T$$

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