Exam.Code:0907
Sub. Code: 6291

2074

B.E. (Biotechnology), Third Semester

BIO-311: Process Calculations

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. Use of psychometric chart and steam tables is allowed.***

x-x-x

Q.1.a) A dilute solution of 4% NaOH in an evaporator is concentrated to 25% NaOH. Calculate the amount of water evaporated per kg of feed.

b) If **z** (lbf) = a sin (Q), what are the units of a and Q?

c) The standard heat of reaction for $2CO \rightarrow 2C + O_2$ is $\Delta\widehat{H}_r^0 = 221\ kJ/mol$. Calculate the standard heat of formation of CO.

d) Specific heat at constant pressure for a vapor is 7 Cal/mol°C. The gas constant R is approximately equal to 2 Cal/mol K. Estimate specific heat at constant volume for the vapor.

e) A gas sample has a volume of 4.5 L, a pressure of 3.0 atm. and a temperature of 300 K. Calculate the number of moles of gas using the ideal gas law equation. (10)

SECTION-A

Q.2a) Consider the dimensionally homogeneous equation $D\,(ft) = 3t(s) + 4$. What are the dimensions of the constants 3 and 4? (ii) What are the units of 3 and 4? (iii) Derive an equation for distance in meters in terms of time in minutes.

b). A gaseous mixture analyzing $CH_4 = 10\%, C_2H_6 = 30\%\ and\ rest\ H_2$ at 15°C and 1.5 atm is flowing at the rate of 2.5 m^3/min. Find (i) the average molecular weight of the gas mixture (ii) weight % (iii) mass flow rate. (4,6)

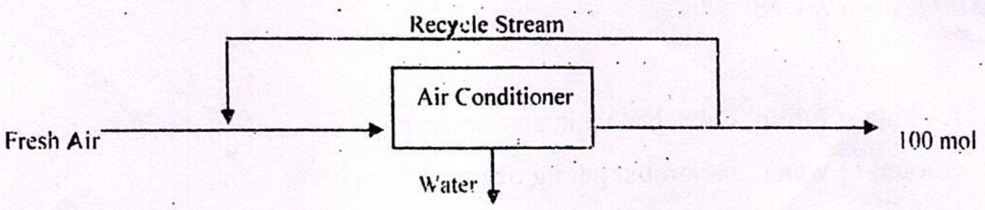
Q.3. In the synthesis of acrylonitrile, propylene, ammonia, and oxygen react to produce the desired product. The feed composition consists of 10 mole% propylene, 14 mole% ammonia, and 76 mole% air. Taking 100 mol of feed as a basis and a fractional conversion of 30% of the limiting reactant, determine the limiting reactant, the percentage by which the other reactant is in excess, and the molar amounts of all product gas constituents. (10)

$$C_3H_6 + NH_3 + \frac{3}{2}O_2 \rightarrow C_3H_3N + 3H_2O$$

Q.4. Fresh Air containing 5 mole % of water vapor is to be cooled and dehumidified to a water content of 1.5 mole % Water. A stream of fresh air is combined with a recycle stream of previously dehumidified air and passed through the cooler. The blended stream entering the unit contains 2.5 mole % water. In the air conditioner, some of the water in the feed stream

Contd....P/2

is condensed and removed as liquid. A fraction of the dehumidified air leaving the cooler is recycled and the remainder is delivered to a room. Taking 100 mol of dehumidified air delivered to the room as a basis of calculation, calculate the moles of fresh feed, moles of water condensed, and moles of dehumidified air recycled. (10)



SECTION-B

Q.5 Air at 50°C with a dew point of 4°C enters a textile dryer at a rate of 11.3 m^3/min and leaves saturated. The dryer operates adiabatically. Use the psychrometric chart to determine the absolute humidity and humid volume of the entering air. Determine the flow rate of dry air through the dryer, the final temperature of the air and the rate at which water is evaporated in the dryer. (10)

Q.6a). Argon gas in an insulated plasma deposition chamber with a volume of 2 L is to be heated by an electric-resistant heater. Initially, the gas, which can be treated as an ideal gas, is at 1.5 Pa and 300 K. Work done on the system is 480 J in 5 minutes. What is the final gas temperature and pressure in the chamber? The mass of the heater is 12 g and its capacity is 0.35 J/gK. Assume that the heat transfer through the walls of the chamber from the gas at this low pressure and in the short period considered is negligible.

b). 500 kg/h of steam drives a turbine. The steam enters the turbine at 44 atm and 450°C at a linear velocity of 60 m/s and leaves at a point 5 m below the turbine inlet at atmospheric pressure and a linear velocity of 360 m/s. The turbine delivers shaft work at a rate of 70 kW and the heat loss from the turbine is estimated to be 11.6 kW. Calculate the specific enthalpy associated with the process. (5,5)

Q.7. The standard heat of reaction for the oxidation of ammonia is

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO\ (g) + 6\ H_2O\ (v) \qquad \widehat{\Delta H_R^o} - 904.7\ kJ/mol$$

100 mol NH_3/s and 200 mol O_2/s at 25°C are fed into the reactor in which ammonia is completely consumed. The product gas emerges at 300°C. Calculate the rate at which heat must be transferred to or from the reactor. Take pressure as 1 atm.

Data: $\widehat{H_{O_2}}(g)\,at\ 300°C = 8.47\ kJ/mol$. $\widehat{H_{H_2O}}(v)\,at\ 300°C = 9.57\ kJ/mol$

$(C_p)_{NO(g)}(kJ/mol°C) = 29.50 \times 10^{-3} + 0.8188 \times 10^{-5}T - 0.2925 \times 10^{-8}T^2 + 0.3652 \times 10^{-12}T^3$ (10)

x-x-x