Exam. Code: 0907
Sub. Code: 6691

1129
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. Answer the following questions

a) 100 mol/min of C_4H_8 is fed into a reactor and 50% reacts. $C_4H_8 + 6O_2 \rightarrow 4\ CO_2 + 4H_2O$. Calculate the rate at which water is produced.

b) Sodium chloride weighing 600 kg is mixed with 200 kg Potassium chloride. Find the composition of the mixture in mass% and mole%

c) Explain the terms single pass conversion and overall conversion.

d) 44.8 Nm^3/h of air is equivalent to _____ kmol/h of air.

e) If the C_p for a vapor is 7 cal/mol.°C, estimate the C_v for the vapor. The gas constant R is approximately 2 cal/mol.K. (10)

SECTION-A

Q.2a) 10 kg of liquid A of specific gravity 1.17 is mixed with 5 kg of liquid B of specific gravity 0.83. Assuming that there is no volume change on mixing, what is the specific gravity of the mixture. (Take density of water as 1000 kg/m^3) (4)

b) The distance travelled by an object is related to the time (t) taken as $D(ft) = 3t(s) - 4$.

(i) If the equation is consistent in its units, what are the units of 3 and 4.
(ii) Derive an equation for the distance in meters and time in minutes.
(iii) Calculate the distance travelled by the object in meters in 30 minutes. (6)

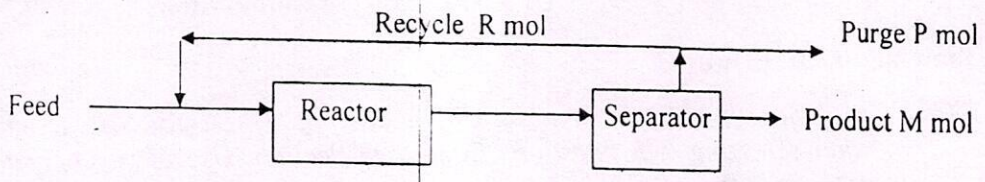
Q.3a). Iron reacts with steam according to the reaction: $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$. How many kilograms of iron and steam are required to produce 100 kg of hydrogen? (5)

b). It is required to make 1000 kg of mixed acid containing 60% H_2SO_4, 32% HNO_3 and 8% water by blending (i) spent acid containing 11.3 % HNO_3, 44.4% H_2SO_4 and 44.3 % H_2O, (ii) aqueous 90% HNO_3, (iii) aqueous 98% H_2SO_4. All percentages are by mass. Calculate the quantities of each of the three acids required for blending. (5)

Q.4. Carbon monoxide and hydrogen reacts to give methanol: $CO + 2H_2 \rightarrow CH_3OH$. The conversion of CO entering the reactor is only 20%. A feed stream consisting of 33% CO, 66.5% H_2 and 0.5% CH_4 is mixed with a recycle stream and sent to the reactor. The methanol leaving the reactor is separated and the unconverted gases are recycled. To prevent the accumulation of CH_4 and keep its concentration in the recycle stream at 3% a portion of the recycled stream is blown off. For 100 moles of fresh feed, determine (a) moles of recycle stream (b) moles of purge stream (c) composition of purge stream (d)

P.T.O.

moles of methanol produced.



(10)

SECTION-B

Q.5a) Caustic soda is concentrated from 10% to 50% in an evaporator. The feed at 305K enters at a rate of 1000 kg/h. The concentrated solution leaves the evaporator at 380 K and the vapor leaves at 373 K. Determine the heat to be supplied in the evaporator. Assume pressure to be 1 atm. Given: Enthalpy of 10% NaOH at 305 K is 116.3 kJ/kg and enthalpy of 50% NaOH at 380 K is 560.57 kJ/kg. (5)

b) The heat capacity of carbon dioxide is given by the relation

$$C_{p_{CO_2}}(\text{kJ/kmol K}) = 26.540 + 42.454\times10^{-3}T - 14.298\times10^{-6}T^2$$

Calculate the heat required to heat 1 kg of CO_2 from 300 K to 1000 K (5)

Q.6 A stream of air at 40°C and 10 % relative humidity is humidified in an adiabatic spray tower operating at 1 atm pressure. The emerging air is to have a relative humidity of 40%. Determine the absolute humidity and the adiabatic saturation temperature of the entering air. Use the psychrometric chart to calculate (i) the rate at which water must be added to humidify 1000 kg/h of the entering air and (ii) temperature of the exiting air. (10)

Q.7 A turbine discharges 200 kg/h of saturated steam at 10 bar absolute. It is desired to generate steam at 250°C and 10 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 10 bar. (i) If 300 kg/h of the product steam is to be generated, how much heat must be added to the mixer? (ii) If instead the mixing is carried out adiabatically, at what rate is the product steam generated? (10)

x-x-x