Fourth Semester B. Tech. (Chemical Engineering) (C. B. S.) Examination

PROCESS CALCULATIONS

BTCHE 401 T

Time : Three Hours] [Max. Marks : 80

N. B. : (1) All questions carry equal marks.
(2) Answer any four questions.
(3) Assume suitable data wherever necessary.

1. (a) A typical product gas composition in Lurgi process of coal gasification is as given below : (mole %)

H_2 = 38% , CO = 20.2% , CO_2 = 28.6% , CH_4 = 11.4% , C_2H_6 = 01% , H_2S = 0.5% and N_2 = 0.3% on dry basis.

Calculate :

(i) Average molecular weight of the gas mixture

(ii) Composition of the mixture on weight basis Atomic wts : C = 12 , H = 1 , O = 16 , N = 14 , S = 32. 10

(b) 25 kilogram of oxygen is stored in a cylinder at 13 atm and 30^0 C.

(i) Calculate the volume occupied by oxygen.

(ii) What is the density of O_2 at these conditions ? 10

2. (a) A plant for caustic production, concentrates a solution containing 10% wt NaOH, 10% NaCl and remaining water. If the final solution contains 50% NaOH and 1% NaCl by weight ;
Calculate :

(i) Kg of water evaporated per ton of initial solution.

(ii) Kg of NaCl precipitated per ton of initial solution.

(iii) Weight of the final solution. 10

(b) A slurry containing 75 wt % water is to be filtered.If 80% of water is removed by filteration and drying which reduces the weight of the material to 600 kg, Calculate :

(i) Original Weight of the slurry

(ii) Water content of concentrated slurry after drying and filteration. 10

3. (a) The dry bulb temperature and dew point of air samples are found to be 32.5^{0}C and 20.7^{0}C respectively.

Calculte :

(i) Absolute molal humidity

(ii) Absolute mass humidity

(iii) % relative humidity

(iv) % humidity

Data : Barometer reading – 745 mm Hg
Vapour Pressure of water —

20.7^{0}C – 19 mm Hg
32.5^{0}C – 38 mm Hg

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(b) Pure methane is completely burnt with air. The outlet gas from the burner which contains no oxygen is passed through a cooler where some of the water is removed. If the gas leaving the cooler is analysed for 0.8335 mole fraction N_2, then calculate :

(i) Analysis of the gas leaving the cooler.

(ii) Kg water condensed per mole CH_4 burned.

(iii) Partial pressure of components of the stream leaving the cooler at 1 atm. 12

4. (a) An evaporator is to produce 10,000 kg / hr of dry salt from a feed solution containing 15 wt% NaCl. The salt removed carries 18% of its weight as brine and the brine contains 20 wt % NaCl. Calculate :

(i) Feed rate to the evaporator.

(ii) Feed rate of the evaporator if the brine is separated from dry salt completely and recycled back to the evaporator. 8

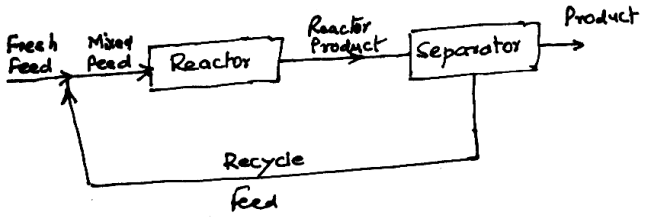
(b) The reaction to form ethylene oxide is 50% complete on a once through basis ; the reactants are fed in a stoichiometric ratio and all the unreacted reactants are separated and recycled.

What is the recycle ratio ?

The reaction taking place is as follows :

$$2\,CH_2 = CH_2 + 0.5\,O_2 \longrightarrow 2C_2\,H_4\,O$$

The schematic is as given below :



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5. (a) The molal heat capacity of CO_2 gas is given by

$$Cp = 26.54 + 42.45 \times 10^{-3}\,T - 14.29 \times 10^{-6}\,T^2$$

Where CP is in $kJ/(K\ mol.K)$ and T is in K. Calculate

(i) The mean molar heat capacity between 500 and 1000 k.

(ii) The heat required to raise the temperature of $200\,m^3/hr$ of CO_2 gas at STP from 500 to 1000 K ? 10

(b) Write the material and energy balance equations for a binary distillation column operated with reflux. 10

6. (a) A fuel analyses as : carbon 46 wt% , oxygen 23% , ash 5% and rest as moisture and hydrogen. Orsat analysis of fuel gas obtained after burning the fuel is as follows :

CO_2 14.9% , CO : 1.65% , O_2 3.45% and N_2 as 80% Calculate :

(i) Complete analysis of fuel

(ii) Fuel to air ratio (mass basis)

(iii) % Excess air used. 10

(b) Explain the following terms :

(i) Gross calorific value and Net calorific value

(ii) Proximate and Ultimate Analysis. 10

7. (a) Pure C_2H_4 is burned with 50% excess air. The % conversion of C_2H_4 is 75%. No CO is formed. Calculate the composition of the flue gas. 10

(b) Calculate the theoretical flame temperature for CO when burned with 60% excess air when both the reactants are at 410 K.
The Cp in $J/(mol.K)$ may be assumed to be constant.
$Cp(CO) = 29.23, Cp(O_2) = 35,$

$Cp(N_2) = 33, Cp\ (CO_2) = 53$

The standard heat of combustion at 298 K is -284 kJ / mol CO. 10