Printed Pages : 7 CH-301

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 9001 Roll No. | | | | | | | | | | |

B. Tech.

(SEM. III) EXAMINATION, 2007-08

PROCESS CALCULATIONS

Time : 3 Hours] *[Total Marks : 100*

Note : *(1) Attempt **all** questions. All questions carry **equal** marks.*

(2) State your assumptions clearly. Use of steam tables is permitted.

(3) Use programmable features of calculator is not desirable.

Data: R = 82.06 cm^3.atm (k.gmol)

1 Attempt any **four** of the following :

(a) Find the average molecular weight of a Gobar gas. It has the composition 30% CH_4, 50% CO_2 and 20% H_2O. 5

(b) A sample of bauxite has 30% alumina (Al_2O_3). What is the maximum amount of aluminium, which may be obtained per ton of bauxite (Mol. Wt. Al = 27) ? 5

(c) How is Raoults law used to describe the phase equilibrium for a gas-liquid system? 5

(d) Differentiate between the vapour pressure of miscible and immiscible liquid solutions. 5

(e) Nitrogen gas is filled in a cylinder of volume $0.1 m^3$ at a pressure of 5 atm. The weight of the empty cylinder, when it is evacuated, is 20 kg. What is the weight when it is filled with gas? (Temp = 25°C). 5

(f) A gas is being used in a reaction at atmospheric pressure. It has the following composition: CO_2 =0.1 kg mol, O_2 = 0.2 kg mol N_2 = 0.3 kg mol and H_2O = 0.05 kg mol. Find the concentration (partial pressure) of CO_2. 5

2 Attempt any **four** of the following :

(a) From the humidity chart for carbon tetrachloride-air system determine relative humidity. The dry bulb temperatures are 100° F and the dew point is 40° F. What is wet bulb temperature? 5

(b) Air at a flow rate of 100 kg/hr containing no CCl_4 is bubbled through a tank filled with CCl_4. The exit air is saturated with CCl_4 vapours. How much CCl_4 is evaporated in an hour? Temperature of the tank is 60° F. 5

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(c) Air containing CCl_4 vapours has following values. Dry bulb temperature 60 °F and relative humidity 90 %. It is heated to 80 °F and then cooled adiabatically to a temperature of 70 °F. How much CCl_4 per kg of air is remaining? 5

(d) With the help of humidity chart given calculate the volume of dry air and air saturated with CCl_4. Which is greater? 5

(e) Discuss the advantages of recycling and purging. 5

(f) Describe the steps involved in obtaining vapour-liquid equilibria from enthalpy-concentration chart. 5

3 Attempt any **two** of the following :

(a) A polymer blend is to be formed from the three compounds whose compositions and approximate formula are listed in the table. Determine the percentages of each compound, A, B, C to be introduced into the mixture to achieve the desired composition. 10

	Compound %			
Composition	A	B	C	Desired mixture
$(CH_4)_x$	25	35	55	30
$(C_2H_6)_x$	35	20	40	30
$(C_3H_8)_x$	40	45	5	40
Total	100	100	100	100

(b) A distillation column separates 5,000 kg/hr of a 60% benzene, 40% toluene mixture. The product recovered from the condensor at the top of the column contains 98% benzene and the bottom product from the column contains 95% toluene. A portion of the product is returned to the column as reflux, and the rest is withdrawn for use elsewhere. The compositions of the streams at the top of the column, the product withdrawn and the liquid refluxed are identical. Find the ratio of the amount refluxed to the product withdrawn. **10**

(c) Boron trichloride (BCl_3) is fed as a gas stream and used for doping silicon according to the following equation : **10**

$$4\,BCl_3 + 3Si \rightarrow 3SiCl_4 + 4B$$

Unreacted BCl_3 is recycled. Calculate the mole ratio of recycle to $SiCl_4$ exiting the separator. Feed contains the reactant in the stoichiometric ratio. The recycle stream is pure BCl_3. One pass conversion of $BiCl_3$ is 87%.

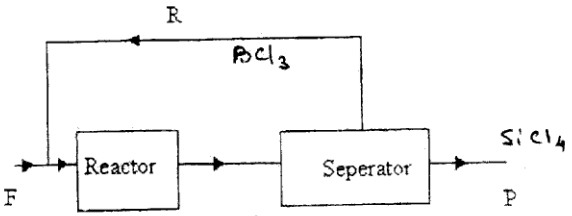

Fig. 1

4. Attempt any **two** of the following :

(a) Calculate the theoretical flame temperature (abiabatic flame temperature) for complete combustion of methane. Air is in 150% excess of required amount. Standard Heat of combustion of methane at 298K: -890.4 kJ/gmol. The temperatures are in K. **10**

Molar heat capacity (J/gmol.K) of methane, oxygen, nitrogen and water vapour are given below :

CH_4 : $34.31 + 5.469\times10^{-2}T + 0.3661\times10^{-5}T^2$

N_2 : $29.0 + 0.2199\times10^{-2}\ T-0.5723\times10^{-5}T^2$

O_2: $29.10 + 1.158\times10^{-2}\ T-0.6076\times10^{-5}T^2$

CO_2: $36.11+4.233\times10^{-2}\ T-2.887\times10^{-5}T^2$

$H_2O(g)$: $33.46+0.688\times10^{-2}\ T+0.7604\times10^{-5}T^2$

(b) (i) Determine the average specific heat for propane between the temperatures 50 and 300° C. The specific heat of CO_2 (kJ/gmol) is given below : **5**

C_p (propane) = $68.032+22.59\times10^{-2}\ T-13.11\times10^{-5}T^2 + 31.71\times10^{-9}T^3$

(ii) Determine the heat of reaction for the following reaction : **5**

n $C_4H_{10}(g) \rightarrow C_2H_4(g) + C_6H_6(g)$

The heat of formation are given as

$C_4H_{10}(g)$: -134.5 kJ/g mol;

$C_2H_4(g)$: + 52.283 kJ/g mol

$C_6H_6(g)$: + 82.927 kJ/g mol

(c) Discuss the variation of enthalpy of a substance with increasing temperature. The solid was heated so that it becomes vapour. **10**

Attempt any **two** of the following :

(a) A fuel contains 70% CH_4 and 30% nitrogen. It enters into the furnace at 30° C. The air entering the furnace at 25° C is only 90 % of the theoretically required. Calculate the composition of the flue gases. About 10% of the heat is lost to the atmosphere. The product is passed through a heat exchanger where the temperature of the gases leaving drops to 200°C. How much heat is received by the heat exchanger? The specific data are given as below. Specific heat values given below are in kJ/kgmol. Sp. heat of remaining compounds are given in other questions. Standard heat of reaction of CH_4 = -890.4 kJ/g mole. **10**

CH_4 : $34.31+5.469\times10^{-2}$ T-$0.3661\times10^{-2}T^2$

O_2 : $29.1 + 1.158\times10^{-2}$ T-$0.6076\times10^{-5}T^2$

N_2 : $29.0 + 0.2199\times10^{-2}$ T-$0.5723\times10^{-5}T^2$

(b) Wheat grains containing 0.05 kg water per kg of dry solid is to be dried to 0.001 kg water/ kg dry solid in a spouted bed. For each kg of dry grain 20 kgs of dry air pass through the dryer, leaving at a humidity of 0.05 kg water/kg dry air. The fresh air supplied is at a humidity of 0.01 kg water/kg dry air. A part of the air is recirculated. Calculate the fraction of air recirculated. Also calculate the kgs of water removed from 100 kgs of wheat grains fed to the spouted bed dryer. **10**

(c) Salt is being produced in an evaporator. It is fed with 5000 kg/hr of 15% solution of sodium chloride by weight 40° C. This is to be concentrated to 45% solution by weight. The evaporator is supplied with saturated steam at latent heat of 530 kcals/kg. Enthalpy of feed = 25 kcal/kg. Enthalpy of water vapor 600 kcal/kg. Determine the flow rates of thick liquor. How much steam is required? 10

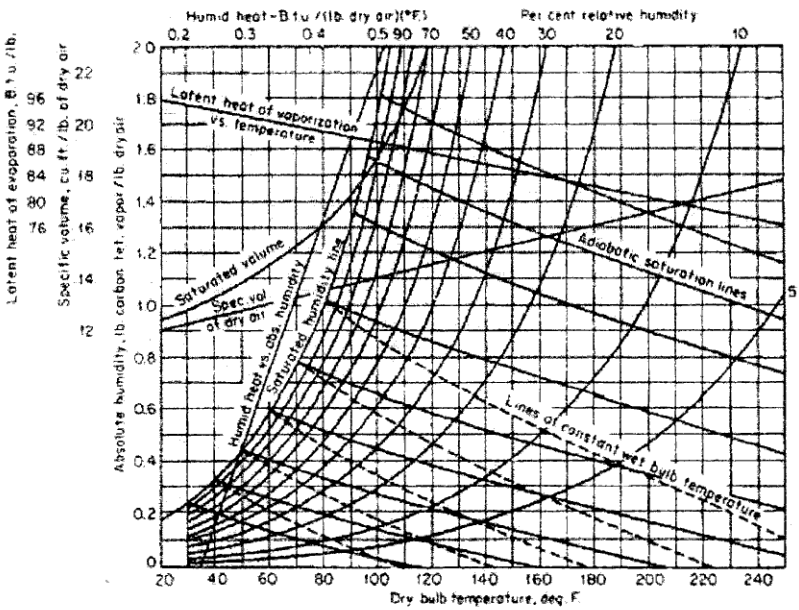

Fig. 2