S E / III / CBSGS / Chem / PC

QP Code:536800

[3 Hours] [Total Marks: 80]

(1) Q.1 is compulsory.
(2) Attempt any 3 from the remaining 5 questions.
(3) Use graph paper, if required.
(4) Assume suitable data if required and justify the same

1. a) A mixture of CH_4 and C_2H_6 has an average molecular weight of 22.4. Find mole percent of CH_4 and C_2H_6 in mixture. 5

b) Explain the outline of a procedure for material balance calculations 5

c) What you mean by excess and limiting reactant in a reaction. 5

d) Define (i) Adiabatic saturation temperature (ii) Percentage humidity. 5

2. a) Prove that for a ideal gas mixture mol% = volume% = pressure% 10

b) Make the following conversions: i) 245g/l of H_2SO_4 to normality ii) 3N H_3PO_4 to g/l iii) 36.5 g/l HCl to molarity iv) 2M K_2SO_4 to g/l v) 4.8 mg/ml $CaCl_2$ to normality. (Given atomic weights: H = 1; Cl = 35.5; O = 16; P = 31; K = 39) 10

3. a) Dryer system handles 1000 kg/day of wet solids. Wet solids containing 50 percent solids and 50 percent water are fed to the first dryer. From the first dryer the product that comes out has 20 percent moisture. This is admitted to second dryer from which the product coming out has 2 percent moisture. Calculate percent of original water that is removed in each dryer and the final weight of the product. 10

b) A feed to a continuous fractionating column analyses by wt. 28% benzene and 72% tolune. The analysis of the distillate shows 52 wt% benzene and 5 wt.% benzene as found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also calculate % recovery of benzene. 10

4. a) A storage tank of a demineralised water (DM) has a holding capacity of 1500 m^3 upto an overflow point. The inflow of DM water to the tank is 25 l/s having silica (as SiO_2) content of 0.005 mg/l. The supply of DM water to the high pressure boilers from the tank amount to 25 l/s. With time, the DM water quality deteriorates and the silica content in the feed DM water increases to 0.02 mg/l. Assume that the inflow into and the outflow from the tank remains constant at 25 l/s. Calculate the time required for the silica content in the storage tank to increase to 0.01 mg/l. 10

b) In production of chlorine gas by oxidation of HClgas , air is used 28 % in excess of that theoretically required. Based on 4 kmol HCl, Calculate i) 10

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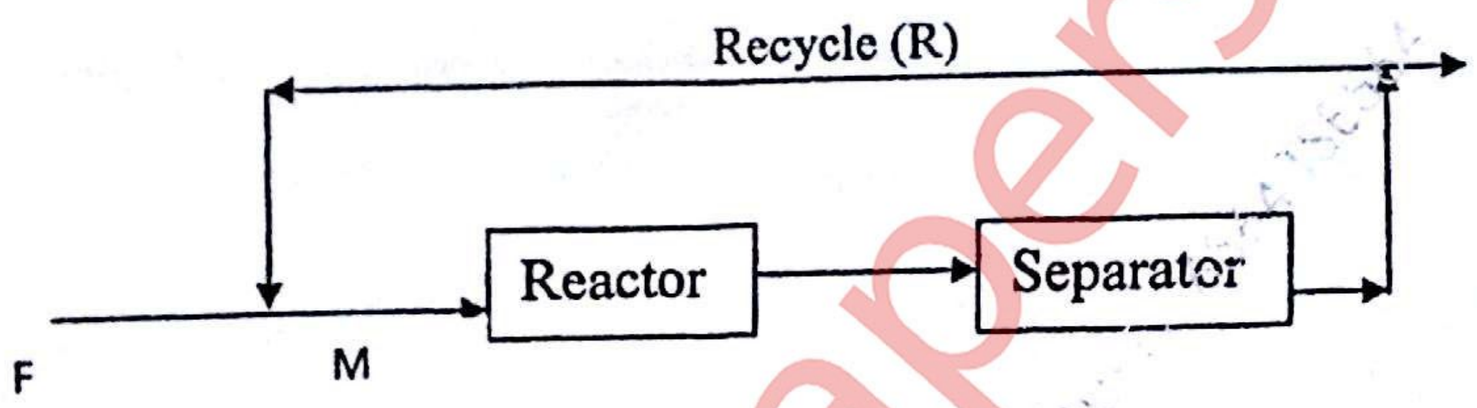
the weight ratio of air to hydrochloric acid gas in feed. ii) if oxidation is 80% complete, find the composition of product stream on mole basis.

5 a) N_2-H_2 mixture with a molar ratio of 1:3 is used for the manufacture of NH_3 where 18% conversion is achieved. After separating NH_3 from the product, the unconverted gases are recycled. The feed contains 0.2 moles of argon per 100 moles of N_2-H_2mixure. The tolerance limit of argon entering the reactor (i.e. in mixed feed) is 6 parts to 100 parts N_2-H_2mixure by volume. Calculate the fraction of recycle that must be continuously purged and overall yield of NH_3(F = feed; M = mixed feed). 10



b) Air contains 21 mol% O_2 and 79 mol% N_2 is to be heated from 303 K to 423 K. Calculate the heat required to be added if the air flow rate is 3 m^3(NTP) per minute using data given below: 10

$C_p^\circ = a + bT + cT^2 + dT^3$ (kJ/kmol-K)

gas	a	b x 10^3	c x 10^6	d x 10^9
O_2	26.0257	11.7551	-2.3426	-0.5623
N_2	29.5909	-5.141	13.1829	-4.968

6. a) Obtain an empirical equation for calculating the heat of reaction at any temperature T (K) for the reaction. 10

$CO\ (g) + 2\ H_2\ (g) \longrightarrow CH_3OH\ (g)$

Data: standard heat of reaction $\Delta H^\circ_R = -90.41$ KJ/mol;

C_p data:

For $CO_2(g)$ $C_p = 29.03 - 2.82 \times 10^{-3}T + 11.64 \times 10^{-6}T^2$

For $H_2(g)$ $C_p = 28.61 + 1.02 \times 10^{-3}T - 0.15 \times 10^{-6}T^2$

For $CH_3OH\ (g)$ $C_p = 21.14 + 70.84 \times 10^{-3}T + 25.86 \times 10^{-6}T^2$

C_p is in J/mol-K and T in K

b) Calculate the standard heat of formation of n-heptane gas at 298.15 K from its elements using Hess's law. 10

Data:

$C\ (s) + O_2\ (g) \longrightarrow CO_2\ (g)$ $\quad \Delta H_1 = -393.51$ kJ/mol

$H_2\ (g) + 0.5\ O_2\ (g) \longrightarrow H_2O\ (l)$ $\quad \Delta H_2 = -285.83$ kJ/mol

$C_7H_{16}\ (g) + 11\ O_2\ (g) \longrightarrow 7CO_2\ (g) + 8\ H_2O\ (l)$ $\quad \Delta H^\circ_c = -4853.43$ kJ/mol