Chemical Reaction Engineering –II (CHL 221)

Major Exam 2008 **Date: 27/11/2008**

M.M : 40 **Time : 8-10 AM**

Venue: Ex. Hall

1. The reaction $A \rightarrow B$ is carried out on a metallic surface. At high temperatures the reaction is mass transfer limited. The reaction is currently takes pace on a monolith catalyst where 45 percent conversion is achieved. It is proposed to increase the number of plates (n) from 100 to 200 for the same width (w) and to halve the length (L) of the reactor. What conversion can be expected for monoliths at high Reynold numbers? State all the assumptions made. Mass transfer correlation at high Reynold number for a monolith catalyst may be taken as $Sh = 0.0006 (Re/(L/2b))^{1.36}$, where $Sh = 8\ k_c b/D_{AB}$, and Reynold number $Re = 8\ b\rho\ u/\mu$. (8)

2. The irreversible gas phase dimerisation $2A \rightarrow A_2$, is carried out at 8.2 atm in a stirred contained solid reactor to which only pure A is fed. There is 40 g of catalyst in each of the four spinning baskets. The following runs were carried out 227 ^{0}C.

Total molar feed rate F_{T0} (g mol/min)	1.0	2.0	4.0	6.0	11.0	20.0
Mole fraction of A in exit	0.21	0.33	0.40	0.57	0.70	0.81

The experiment was also carried out at 237 ^{0}C at a total molar feed rate of 9 (g mol/min) in which the mole fraction of A in exit was 0.097.

(a) What is the apparent reaction order and apparent activation energy? (6)

(b) Determine true reaction order and activation energy. (3)

(c) Calculate the Thiele modulus and effectiveness factor for the above reaction system. (4)

3. Derive an expression for relating the time and conversion of solid during the roasting of iron Pyrites (FeS_2) ore. Assume that due to ash layer only diffusion through the ash layer controls the rate. State all the other assumptions made. (6)

4. Hydrogen sulfide (H_2S) is absorbed by a solution of monoethanolamine (MEA) in a packed column. At the top of the column the gas is at 30 atm and it contains 0.2 percent of H_2S , while the absorbent contains 250 mol/m^3 of free MEA. The diffusivity of MEA in solution is 0.8 times that of H_2S. The reaction is irreversible and instantaneous.

$H_2S + RNH_2 \dashrightarrow HS^- + RNH_3$

The mass transfer coefficients for gas and liquid and Henery law constant for the flow rates and packing used are:

$k_{Al}\, a = 0.035$

$k_{Ag}\, a = 60$ mol/m^3

H_A (Henery law constant) = 0.1 m^3. atm /mol .

Find the enhancement factor, Hatta number and rate of absorption of H_2S in MEA solution. (6)

5. The hydrogenation of 2-butyne, 4 –diol to butene diol is to be carried out in a slurry reactor using a palladium based catalyst. The reaction is first order in hydrogen and in diol. The initial concentration of diol is 3.5 kmol/m^3. Pure hydrogen is bubbled through the reactor at a pressure of 30 atm at 45 ^{0}C. The equilibrium hydrogen solubility at these conditions is 0.015 kmol/m^3, and the specific reaction rate is 0.05 m^6/kg.kmol.s. The catalyst charge is 0.2 kg/m^3 with a particle size of 0.01 cm and pellet density of 1600 kg/m^3. Calculate the percent of the overall resistance contributed by each of the transport steps and overall rate of reaction if organic conversion is 80 percent.

Additional data: Diffusivity 10^{-9} m^2/s for H_2 in organic liquid in catalyst pores

$k_b a_b = 0.3\ s^{-1}$ (bubble mass transfer coefficient)

$k_c = 0.005$ cm/s mass transfer coefficient for H_2 in organics

Pellet porosity =0.45, pellet tortuosity factor=1.5 and constriction factor =0.8

(7)