Reaction Engineering, Problem Sheet-3, 2017

Q1. The homogeneous gas phase reaction A→ 3R satisfactorily follows second-order kinetics. For a feed rate of 4 m^3/h of pure A at 350^0C and 5 atm, an experimental reactor(size: 25 mm IDpipe × 2 meter length) gives 60% conversion of A. A commercial plant is to be designed to process 320 m^3/h of feed containing 50 mole % A and 50 mole% inerts at 350 ^{0}C and 25 atm for obtaining 80% conversion of A.

(i) How many 2-m lengths of 25 mm ID pipes are needed for 80% conversion?

(ii) Should they (pipes) be arranged in parallel or in series?
(Assume ideal gas behavior and plug flow in the pipe)

Q2.The following kinetic data on the reaction, A→ R are obtained in an experimental packed bed reactor using various amounts of catalyst and a fixed rate, F_{A0}= 10 kg-mol/hr.

W, kg Cat	**1**	**2**	**3**	**4**	**5**	**6**	**7**
X_A	**0.12**	**0.20**	**0.27**	**0.33**	**0.37**	**0.41**	**0.44**

(a) Find the reaction rate at 40% conversion.
(b) For alarge packed bed reactor with afeed rate F_{A0}= 400 kg-mol/hr, how much catalyst would be needed for 40% conversion?
(c) How much catalyst would be needed in part(b) if the reactor employed a very large recycle reactor?

Q3. Kinetic experiments on the solid catalyzed gas-phase reaction A→ 3R with pure A are conducted at 8 atm and 700^0C in a basket reactor of 960 cm^3 in volume and containing 1 gm of catalyst of diameter d_P= 3 mm. Feed consisting of pure A is introduced at various rates in the reactor and partial pressure of A in the exit stream measured for each feed rate. The results are

Feed rate, liters/hr	100	22	4	1	0.6
$p_{A,out}/p_{A,in}$	0.8	0.5	0.2	0.1	0.05

Find a rate equation to represent the rate of reaction for the above catalyst.

Q4. The second order reaction A→ R is studied in a recycle reactor with very large recycle ratio, and the following data are recorded.

Void volume of reactor: 1 liter; weight of catalyst: 3 gm; Feed to the reactor: C_{A0}=2 mol/liter, v_0=1 liter/hr, $C_{A,out}$ =0.5 mol/liter.

(a) Find the rate constant for this reaction.
(b) How much catalyst is needed in a packed bed reactor for 80% conversion of 1000 liter/hr of feed of concentration C_{A0}=1 mol/liter?