**Assignment-2, Reaction Engineering, 2019**

1. At present the elementary liquid-phase reaction A + B R + S takes place in a plug-flow reactor feeding A and B in equimolar quantities with CAo = CBo = 1 mol/liter. The conversion is 96%



(a) If a mixed-rector ten times as large as the plug-flow reactor were hooked up in series with the existing unit, which unit should come first and by what fraction could production be increased for that setup?

(b) Does the concentration level of the feed affect the answer, and if so, in what way?

*Note:* Conversion is to remain unchanged.

**2.**  At present the elementary liquid-phase reaction A + B R + S takes place in a plug-flow reactor feeding A and B in equimolar quantities with CAo = CBo = 1 mol/liter. The conversion is 96%



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**3.** What operating condition minimizes the volume of recycle reactor needed to achieve CR = 0.9 for the reaction and feed of Problem-2 ? Compare this volume with that for plug flow and mixed flow.

1. The conversion for our elementary second-order liquid reaction

2A 2R is 2/3 when operating in an isothermal plug flow reactor with a recycle ratio of unity. What will be the conversion if the recycle stream is shut off ?



1. 100 l/h of radioactive fluid having a half life of 20 h is to be treated by passing it through two mixed flow reactors in series. The volume of each mixed flow reactor in series is 40000 liter. How much has the activity decayed in passing through this reactor system? This reaction follows first-order kinetics.
2. The kinetics of the aqueous-phase decomposition of A is investigated in two mixed reactors in series, the second having twice the volume of the first reactor. At steady state with feed concentration of 1 mol/L and mean residence time of 96 sec in the first reactor, the concentration in the first reactor is 0.5 mol/L and in the second is 0.25 mol/L. Find the kinetic equation for the decomposition.
3. The elementary irreversible aqueous-phase reaction A + B→R +S is carried out isothermally as follows. Equal volumetric flow rates of two liquid streams are introduced into a 4-liter mixing tank. One stream contains 0.020 mol A/liter and the other 1.40 mol B/liter. The mixed stream is then passed through a 16-liter plug flow reactor. We find that some R is formed in the mixing tank, its concentration being 0.002 mol/liter. Assuming mixing tank as a mixed reactor, find the concentration of R at the exit of the plug flow reactor as well as the fraction of initial A that has been converted in the system.
4. Reactant A(A→R, CA0= 26 mol/m3) passes in steady flow through four equal-size mixed flow reactors in series(τtotal= 2min). When steady-state is achieved the concentration of A is found to be 11,5,2,1 mol/m3 in the four units. For this reaction, what must be τplug so as to reduce CA from CA0 = 26 to CAf =1 mol/m3?
5. One hundred moles of A per hour are available in a concentration of 0.1mol/liter by a previous process. This stream is to be reacted with B to produce R and S by the following aqueous-phase elementary reaction:

A + B R + S, k = 5 liters/mol . hr



The amount of R required is 95 mol/hr. In extracting R from the reacted mixture A and B are destroyed, hence recycle of unused reactants is of out of question. Calculate the optimum reactor size and type as well as feed composition for this process.

*Data:*B costs Rs. 56.25/mol in crystalline form. It is highly soluble in the aqueous solution and even when present in large amounts does not change the concentration of A in solution. Capital and operating costs are Rs.0.68/hr.liter for plug flow reactors, Rs0.18/hr.liter for mixed flow reactors.



1. We are consideringgetting something of value from a waste stream of a process. This stream (20,000 liters/day) contains chemical A(0.01 kg/liter) which can be hydrolyzed in an aqueous solution to give chemical R(value = 50 Rs/kg transformed). Product R can be recovered from the solution at negligible cost while unreacted A goes to waste. From the following information calculate the size of mixed reactor and conversion level which will maximize

(a) the profits,

(b) the rate of return on investments.

*Data:*  On an annual basis the cost of reactor and supporting equipment, including depreciation and interest charges is

F= 11250 V1/2 Rs, where V in liters

Labour and operating costs = 1000 Rs./operating day (assuming 300 operating days/yr.)

The hydrolysis reaction is first order with respect to A with a rate constant k = 0.25 hr-1.

1. An isothermal reversible reaction A ⇄ B is carried out in an aqueous solution in a stirred tank of volume 60 m3. The reaction is first-order in both directions. The forward rate constant is 0.4 h-1 and the equilibrium constant is 4.0. The feed to the plant contains 100 kg/m3 of A and enters at the rate of 12 m3/h. Reactor effluents pass to a separator, where B is completely recovered. A fraction y of the unreacted effluent is recycled as a solution containing 100 kg/m3 of A and the remainder is discarded.

Product B costs $2./kg and operating costs are $50 per cubic meter of solution entering the separator. What value of y maximizes the operational profit of the plant ? What fraction of A fed to the plant is converted at the optimum condition ?