10.37 HW 3
Spring 2007

Problem 1. A CSTR of volume 0.602 liters (constant density liquid phase) is operated in which the following reaction occurs:

$$A + B \rightarrow C + D$$

The feed rate of A is 1.16 liters/hr of a solution at concentration 5.87 mmol/L. The feed rate of B is 1.20 liters/hr at a concentration of 38.9 mmol/L. The outlet concentration of species A is 1.094 mmol/L.
Calculate the rate constant for this reaction assuming a mass-action rate law of the form:

$$r = k[A][B].$$

Problem 2. Consider the catalyzed reaction:

$$A + B \rightarrow B + C$$

with the second-order rate constant 1.15 x 10^{-3} m^3/mol/ksec. The rate law is

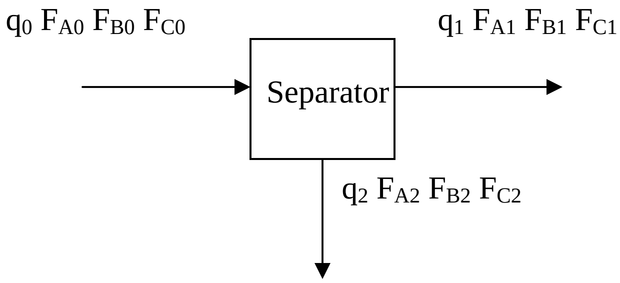
$$r = k[A][B].$$

What volume of CSTR would be necessary to give 40% conversion of species A if the feed concentration of A is 96.5 mol/m^3, the feed concentration of B is 6.63 mol/m^3, and the flow rate is 0.5 m^3/ksec?

Problem 3. Two configurations of CSTRs are contemplated for performing reversible hydrolysis of compound A to produce compounds B and C. The forward reaction is pseudo-first-order with respect to A, with rate constant k_1= 1.82 x 10^{-4} s^{-1}. The reverse reaction is second-order with rate constant k_{-1} = 4.49 x 10^{-4} $M^{-1}s^{-1}$.
(1) $A \rightarrow B + C; \quad r_1 = k_1[A]$
(2) $B + C \rightarrow A; \quad r_2 = k_{-1}[B][C]$
The feed is a dilute aqueous solution of A (concentration 0.25 mol/L) at a rate of 0.25 liters per hour.

Consider the following two configurations:
a) a single 15 liter CSTR.

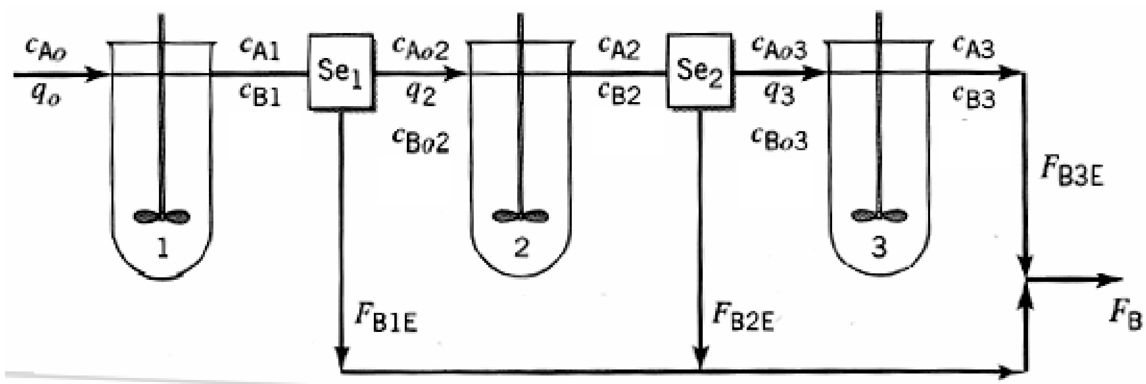
b) three 5-liter CSTRs in series, with 75% of product species B & C selectively removed between stages 1 and 2 and between stages 2 and 3, with appropriate adjustment in flow rate; the volumetric flow rates in the two streams leaving a separator are proportional to the total number of moles of A, B, and C in each stream. See the separator diagram below.



If q is the volumetric flow rate and F is the molar flow rate, then the separator follows the relationships:

$$F_{A2} = 0$$
$$F_{B2} = 0.75 F_{B0}$$
$$F_{C2} = 0.75 F_{C0}$$
$$\frac{q_1}{q_2} = \frac{F_{A1} + F_{B1} + F_{C1}}{F_{A2} + F_{B2} + F_{C2}}$$

A full flow diagram is shown below.



Determine the steady-state production of compound B in mol/h for options a) and b).