MFR Practice Problem

You work for a Pharmaceutical company and need to produce the antibiotic tetracycline. You run a 35 L mixed flow reactor at a constant concentration of tetracycline of 12 mg/L, with a constant flow rate of 1 L/min. Assume tetracycline decomposes in a 2nd order rxn with respect to its concentration, with a kinetic rate constant of 0.015 L/min-mg.

What concentration of tetracycline should be fed into the reactor?

Answer:

$V = 35\ L \quad q = 1\ L/min \quad k = 0.015\ L/min\text{-}mg$
$C_A = 12\ mg/L$

$$\tau = (C_{A0} - C_A)/-r_A = (C_{A0} - C_A)/(kC_A^2)$$

$$C_{A0} = \tau k C_A^2 + C_A = (V/q)kC_A^2 + C_A$$
$$= (35/1)*(0.015)*(12) + 12$$

$$= \mathbf{87.6\ mg/L}$$

PFR/MFR practice problem

An ideal plug flow reactor has a volume of 120 L with a flow rate of 15 L/min and an initial concentration of 28 mol/L. The reaction A=> B has a kinetic rate constant of 4.7 L/mol-min.

A. Determine the outlet concentration of reactant from the reactor.

Answer:

$$\tau = V/q = 120/15 = \mathbf{8\ min}$$

$$C_{A0}k\tau = X_A/(1-X_A) = (28\text{ mol/L})(4.7\text{ L/mol-min})(8\text{ min})$$
$$= 1052.8$$

$$1052.8 - 1052.8X_A = X_A \implies \mathbf{X_A = 0.999}$$

$$C_A = C_{A0}(1-X_A) = 28(1-0.999) = \mathbf{0.0266\ mol/L}$$

B. A mixed flow reactor of 600 L is available at the same conditions. Calculate the outlet concentration of species A.

Answer:

$$\tau = V/q = 600 \text{ L}/15 \text{ L/min} = 40 \text{ min}$$

$$k\tau = (C_{A0} - C_A)/C_A^{\,2}$$

$$C_A^{\,2}(4.7)(40) + C_A = 28$$
$$C_A^{\,2}(188) + C_A - 28 = 0$$

$$\frac{-1 \pm \sqrt{1^2 - 4(188)(-28)}}{2(188)} = 0.383 \text{ mol/L} = C_A$$

$$X_A = 1-(C_A/C_{A0}) = 1-(0.383/28) = 0.986$$