Problem 1: Fogler, 1-15(a-c), p. 33

The reaction

\[ A \rightarrow B \]

is to be carried out isothermally in a continuous-flow reactor. Calculate both the CSTR and PFR reactor volumes necessary to consume 99% of reactant A (i.e., \( C_A = 0.01 C_{A0} \)) when the entering molar flow rate is 5 mol/h, assuming the reaction rate \( -r_A \) is:

(a) \( r_A = k \) with \( k = 0.05 \frac{\text{mol}}{\text{h} \cdot \text{dm}^3} \)

(b) \( r_A = k C_A \) with \( k = 0.0001 \text{ s}^{-1} \)

(c) \( r_A = k C_A^2 \) with \( k = 3 \frac{\text{dm}^3}{\text{mol} \cdot \text{h}} \)

The entering volumetric flow rate is 10 dm\(^3\)/h. Note: \( F_A = C_A v \). For a constant volumetric flow rate \( v = v_0 \), then \( F_A = C_A v_0 \). Also, \( C_{A0} / v_0 = [5 \text{ mol/h}]/[10 \text{ dm}^3/\text{h}] = 0.5 \text{ mol/ dm}^3 \).

Problem 2:

The reaction \( A \rightarrow B \) has a reaction rate coefficient of \( k = 0.01 \text{ sec}^{-1} \). For \( C_{A0} = 2.0 \text{ moles/liter} \), what time is required for 90% conversion in a constant-volume batch reactor? Compared to 99% conversion? Compared to 99.9% conversion?

Problem 3: Levenspiel, 3-21, p. 90

Find the first-order rate constant for the disappearance of A in the gas-phase reaction \( 2A \rightarrow R \) if, on holding the pressure constant, the volume of the reaction mixture, starting with 80% A, decreases by 20% in 3 min.
Problem 4: Fogler, 2-8(a-c), p. 74

In bioreactors, growth is generally autocatalytic in that the more cells you have, the greater the growth rate

\[
\text{Cells + nutrients} \xrightarrow{\text{cells}} \text{more cells + product}.
\]

The cell growth rate, \( r_g \), and the rate of nutrient consumption, \( r_s \), are directly proportional to the concentration of cells for a given set of conditions. A Levenspiel plot of \( \frac{1}{-r_s} \) as a function of nutrient conversion \( X_s = \frac{(C_{S0} - C_S)}{C_{S0}} \) is given below in Figure P2-8.

![Levenspiel plot for bacteria growth, Problem 4.](image)

For a nutrient feed rate of 1 kg/hr with \( C_{S0} = 0.25 \text{ g/dm}^3 \), what chemostat (CSTR) size is necessary to achieve:

(a) 40% conversion of the substrate.
(b) 80% conversion of the substrate.
(c) What conversion could you achieve with an 80-dm\(^3\) CSTR? An 80-dm\(^3\) PFR?
Problem 5: Fogler, 2-9(a, b, e), p. 74

The adiabatic exothermic irreversible gas-phase reaction

\[ 2A + B \rightarrow 2C \]

is to be carried out in a flow reactor for an equimolar feed of A and B. A Levenspiel plot for this reaction is shown in Figure P2-9 below.

(a) What PFR volume is necessary to achieve 50% conversion?
(b) What CSTR volume is necessary to achieve 50% conversion?
(e) What conversion can be achieved in a \(6 \times 10^4\) m\(^3\) CSTR or also in a \(6 \times 10^4\) m\(^3\) PFR?

![Levenspiel plot for Problem 5](figure)

Problem 6:

Our ancestors made vinegar by aerobic bacterial fermentation of alcohol, which is derived from sugar. It is now made by carbonylation of methanol, which is derived by reaction of synthesis gas, which is obtained by steam reforming of methane.

(a) Write out balanced chemical reactions for these processes.
(b) Compare the industrial price/mass of acetic acid (provide the complete reference details for your source) with its price/mass (in dilute water solution) in the grocery store.
Problem 7:

Formulas are shown below for some organic chemicals that are produced by the chemical and pharmaceutical industries. Some of these are molecules that you eat or use every day and some of these you really want to avoid. From your previous courses in organic chemistry and biochemistry, match the following compounds with their respective molecular formulas.

____ 1.  sucrose
____ 2. glucose
____ 3. fructose
____ 4. fat
____ 5. soap
____ 6. detergent
____ 7. vitamin C (ascorbic acid)
____ 8. 2,4,5-T (Agent Orange)
____ 9. dioxin
____ 10. DDT
____ 11. ibuprofen
____ 12. aspirin
____ 13. Tylenol\textsuperscript{TM} (acetaminophen)
____ 14. Contac\textsuperscript{TM} (phenylpropanolamine)
____ 15. Valium\textsuperscript{TM} (diazepam)
____ 16. amphetamine
____ 17. methamphetamine
____ 18. Roundup\textsuperscript{TM} (glyphosphate)
____ 19. PCB
____ 20. chlorophyll
____ 21. citronella
____ 22. morphine
____ 23. heroin
____ 24. thalidomide
____ 25. penicillin
____ 26. glycerin
27. caffeine
28. citric acid