CRE Chapter 1
Assignment 1

P1-6$_B$ **Example 1-1** Calculate the volume of a CSTR for the conditions used to figure the plug-flow reactor volume in Example 1-1. Which volume is larger, the PFR or the CSTR? Explain why. Suggest two ways to work this problem incorrectly.

P1-7$_A$ Calculate the time to reduce the number of moles of A to 1% of its initial value in a constant-volume batch reactor for the reaction and data in Example 1-1.

P1-8$_A$ What assumptions were made in the derivation of the design equation for:
(a) the batch reactor?
(b) the CSTR?
(c) the plug-flow reactor (PFR)?
(d) the packed-bed reactor (PBR)?
(e) State in words the meanings of $-r_A$, $-r'_A$, and r'_A. Is the reaction rate $-r_A$ an extensive quantity? Explain.

P1-12$_A$ The United States produced 32.5% of the world's chemical products in 2002 according to "Global Top 50," *Chemical and Engineering News*, July 28, 2003. Table P1-12.1 lists the 10 most produced chemicals in 2002.

TABLE P1-12.1. CHEMICAL PRODUCTION

2002 Chemical	*Thousands of Metric Tons*	*1995 Rank*	*2002 Chemical*	*Thousands of Metric Tons*	*1995 Rank*
1. H_2SO_4	36,567	1	6. H_2	13,989	—
2. N_2	26,448	2	7. NH_3	13,171	6
3. C_2H_4	23,644	4	8. Cl_2	11,362	10
4. O_2	16,735	3	9. P_2O_5	10,789	—
5. C_3H_6	14,425	9	10. $C_2H_2Cl_2$	9,328	—

Reference: *Chemical and Engineering News*, July 7, 2003, *http://pubs.acs.org/cen/*

(a) What were the 10 most produced chemicals for the year that just ended? Were there any significant changes from the 1995 statistics? (See Chapter 1 of 3rd edition of *Elements of CRE*.) The same issue of *C&E News* ranks chemical companies as given in Table P1-12.2.
(b) What 10 companies were tops in sales for the year just ended? Did any significant changes occur compared to the 2002 statistics?
(c) Why do you think H_2SO_4 is the most produced chemical? What are some of its uses?
(d) What is the current annual production rate (lb/yr) of ethylene, ethylene oxide, and benzene?
(e) Why do you suspect there are so few organic chemicals in the top 10?

P1-13$_A$ Referring to the text material and the additional references on commercial reactors given at the end of this chapter, fill in Table P1-13.

TABLE P1.13 COMPARISON OF REACTOR TYPES

Type of Reactor	*Characteristics*	*Kinds of Phases Present*	*Use*	*Advantages*	*Disadvantages*
Batch					
CSTR					
PFR					
PBR					

P1-15$_B$ The reaction

$$A \longrightarrow B$$

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

(a) $-r_A = k$ with $k = 0.05 \dfrac{\text{mol}}{\text{h}\cdot\text{dm}^3}$ (*Ans.*: $V = 99$ dm^3)

(b) $-r_A = kC_A$ with $k = 0.0001$ s^{-1}

(c) $-r_A = kC_A^2$ with $k = 3 \dfrac{\text{dm}^3}{\text{mol}\cdot\text{h}}$ (*Ans.*: $V_{CSTR} = 66{,}000$ dm^3)

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, $C_{A0} = F_{A0}/v_0 =$ [5 mol/h]/[10 dm^3/h] = 0.5 mol/dm^3.)

(d) Repeat (a), (b), and (c) to calculate the time necessary to consume 99.9% of species A in a 1000 dm^3 constant volume batch reactor with $C_{A0} = 0.5$ mol/dm^3.

P1-16$_B$ Write a one-paragraph summary of a journal article on chemical kinetics or reaction engineering. The article must have been published within the last five years. What did you learn from this article? Why is the article important?