CBE 401: Chemical Reactor Fundamentals
Spring 2012
Homework Assignment

1. Batch Reactor Analysis via Analytical Expressions

Consider the following isomerization reaction

$$A \rightarrow B$$

with an elementary mechanism such that the rate is

$$r = kC_A$$

where the rate constant is given by

$$k = k_o \exp\left(-\frac{E_a}{RT}\right)$$

The temperature is 300 K. The activation energy is 5000 J/mol. The rate constant prefactor is 10.0 s^{-1}. The initial concentration of A is 10.0 mol/liter.

(a) Provide an analytical expression for the residence time required to achieve a specified conversion for this reaction in a batch reactor.
(b) What residence time is required to reach a conversion of 95%?
(g) What conversion will one obtain if the residence time is 10 s?

2. CSTR Analysis via Analytical Expressions

Consider the following isomerization reaction

$$A \rightarrow B$$

with an elementary mechanism such that the rate is

$$r = kC_A$$

where the rate constant is given by

$$k = k_o \exp\left(-\frac{E_a}{RT}\right)$$

The temperature is 300 K. The activation energy is 5000 J/mol. The rate constant prefactor is 10.0 s^{-1}. The inlet flowrate is 2 liters/sec. The concentration of A in the inlet stream is 10 mol/liter.

(a) Provide an analytical expression for the residence time required to achieve a specified conversion for this reaction in a batch reactor.
(b) What is the Damköhler number for 95% conversion?
(c) What residence time is required to reach a conversion of 95%?

3. PFR Analysis via Analytical Expressions
Consider the following isomerization reaction

$$A \rightarrow B$$

with an elementary mechanism such that the rate is

$$r = kC_A$$

where the rate constant is given by

$$k = k_o \exp\left(-\frac{E_a}{RT}\right)$$

The temperature is 300 K. The activation energy is 5000 J/mol. The rate constant prefactor is 10.0 s^{-1}. The initial concentration of A is 10.0 mol/liter. The volumetric flowrate is 2 liter/sec.

(a) Provide an analytical expression for the reactor volume required to achieve a specified conversion for this reaction in a PFR.
(b) What length is required to reach a conversion of 95% if your PFR is a circular pipe with diameter 0.10 m?
(c) What conversion is obtained in a PFR of length 2 m, if your PFR is a circular pipe with diameter 0.10 m?