Chemical Reaction Engineering
Lecture 5: Review of Undergraduate Material

Jayant M. Modak
Department of Chemical Engineering
Indian Institute of Science, Bangalore
Objective

- Ideal reactors – mass balances
- Ideal reactors - comparison
General mole balance

$F_{j0}, F_j$ – molar flow rate (moles/min)
$v_0, v$ – volumetric flow rate (dm$^3$/min)
$G_j$ – molar generation rate (moles/min)
$V$ – Volume (dm$^3$)
$C_j$ – concentration (moles/dm$^3$)
$t$ – time (min)
General mole balance

\[ F_{j0} - F_j + \int r_j \, dV = \frac{dN_j}{dt} \]
Batch Reactor

\[ \frac{dN_j}{dt} = r_j V \]
Continuous-Stirred Tank Reactor

\[ V = \frac{F_{j0} - F_j}{-r_j} \]
Plug flow reactor

\[ \frac{dF_j}{dV} = r_j \]
Packed bed reactor

\[
\frac{dF_j}{dW} = r'_j
\]
Example

\[ A_1 \rightarrow \text{products} \]

\[ \tau = \int_{C_{10}}^{C_1} \frac{dC_1}{r} \]

\[ \tau = \frac{C_{10} - C_1}{r} \]
Ideal reactors - comparison

\[ r = kC_1^n \]
Ideal reactors - comparison

\[ \tau = \int_{C_1}^{C_{10}} \frac{dC_1}{r} \]

\[ \tau = \frac{C_{10} - C_1}{r} \]
Nominal space times

(Engineering of Chemical Reactions, Schmidt)

Figure 3-7  Plot of nominal space times (or reactor residence times) required for several important industrial reactors versus the nominal reactor temperatures. Times go from days (for fermentation) down to milliseconds (for ammonia oxidation to form nitric acid). The low-temperature, long-time processes involve liquids, while the high-temperature, short-time processes involve gases, usually at high pressures.
Summary

- Mole balances
- Ideal flow pattern
- Batch and continuous reactors
- Plug flow reactor
- Residence time