Chemical Reaction Engineering

Lecture 5: Review of Undergraduate Material

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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

$$F_{j0} - F_j + \int^{V} r_j \, dV = \frac{dN_j}{dt}$$

Batch Reactor

$$\frac{dN_j}{dt} = r_j V$$

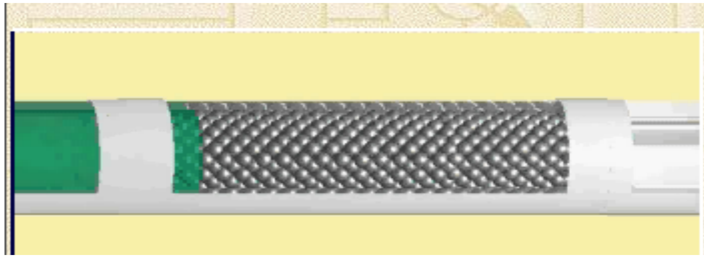
Continuous-Stirred Tank Reactor

$$V = \frac{F_{j0} - F_j}{-r_j}$$

Plug flow reactor

$$\frac{dF_j}{dV} = r_j$$

Packed bed reactor



$$\frac{dF_j}{dW} = r_j'$$

Example

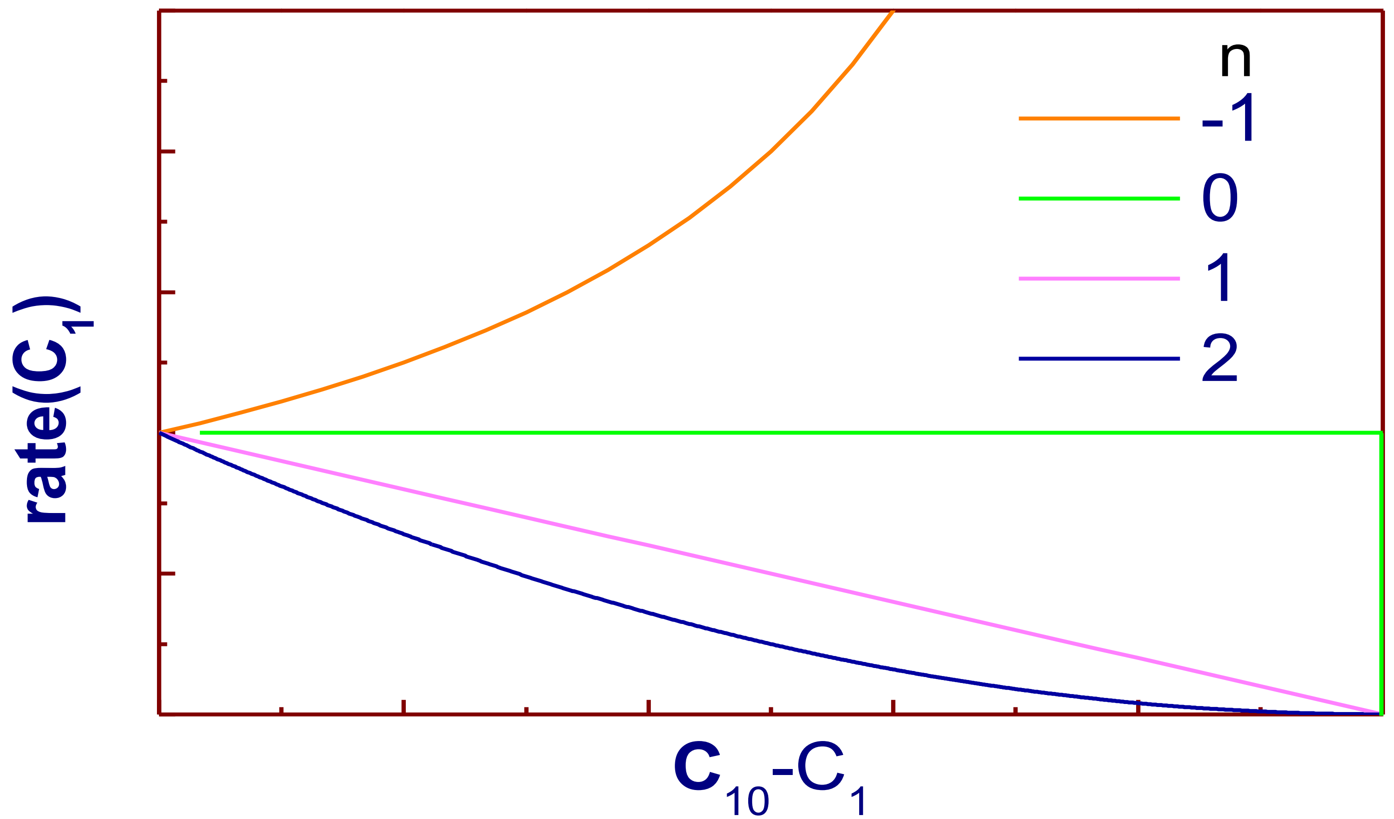
$$A_1 \rightarrow products$$

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

$$\tau = \frac{C_{10} - C_1}{r}$$

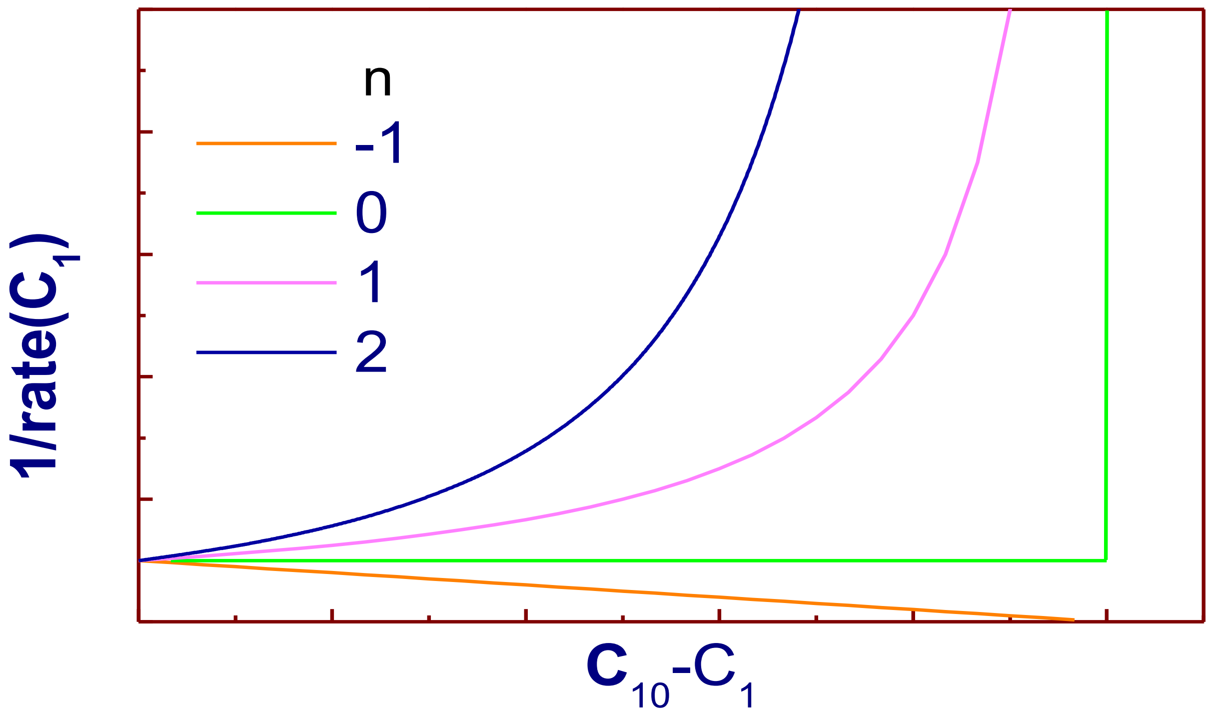
Ideal reactors - comparison

$$r = kC_1^n$$



Ideal reactors - comparison

$$\tau = \int_{C_{10}}^{C_1} \frac{dC_1}{r} \qquad \tau = \frac{C_{10} - C_1}{r}$$



Nominal space times

(Engineering of Chemical Reactions, Schmidt)

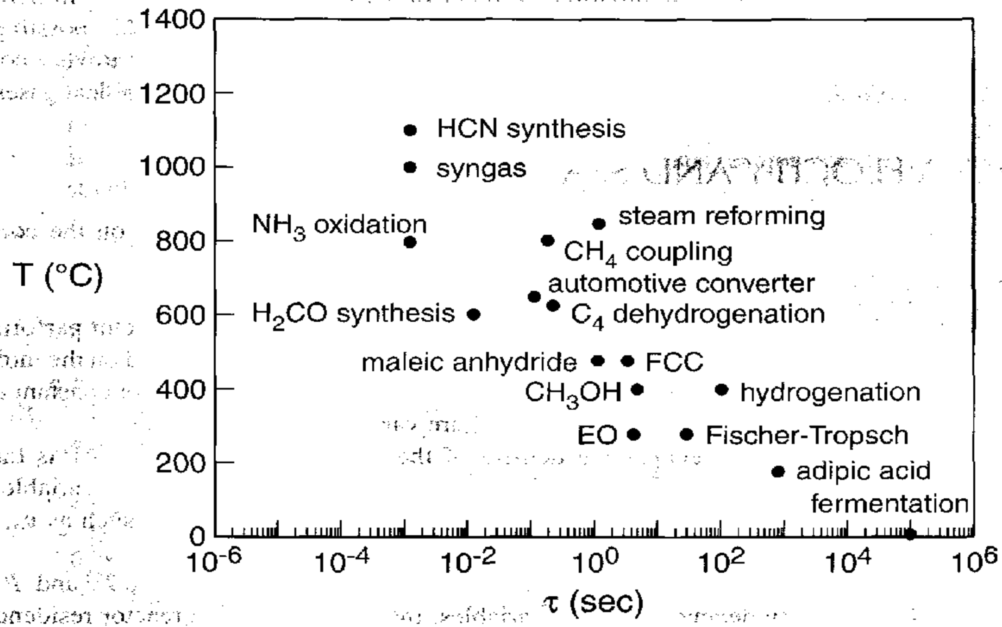


Figure 3–7 Plot of nominal space times (or reactor residence times) required for several important industrial reactors versus the nominal reactor temperatures. Times go from days (for fermentation) down to milliseconds (for ammonia oxidation to form nitric acid). The low-temperature, long-time processes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