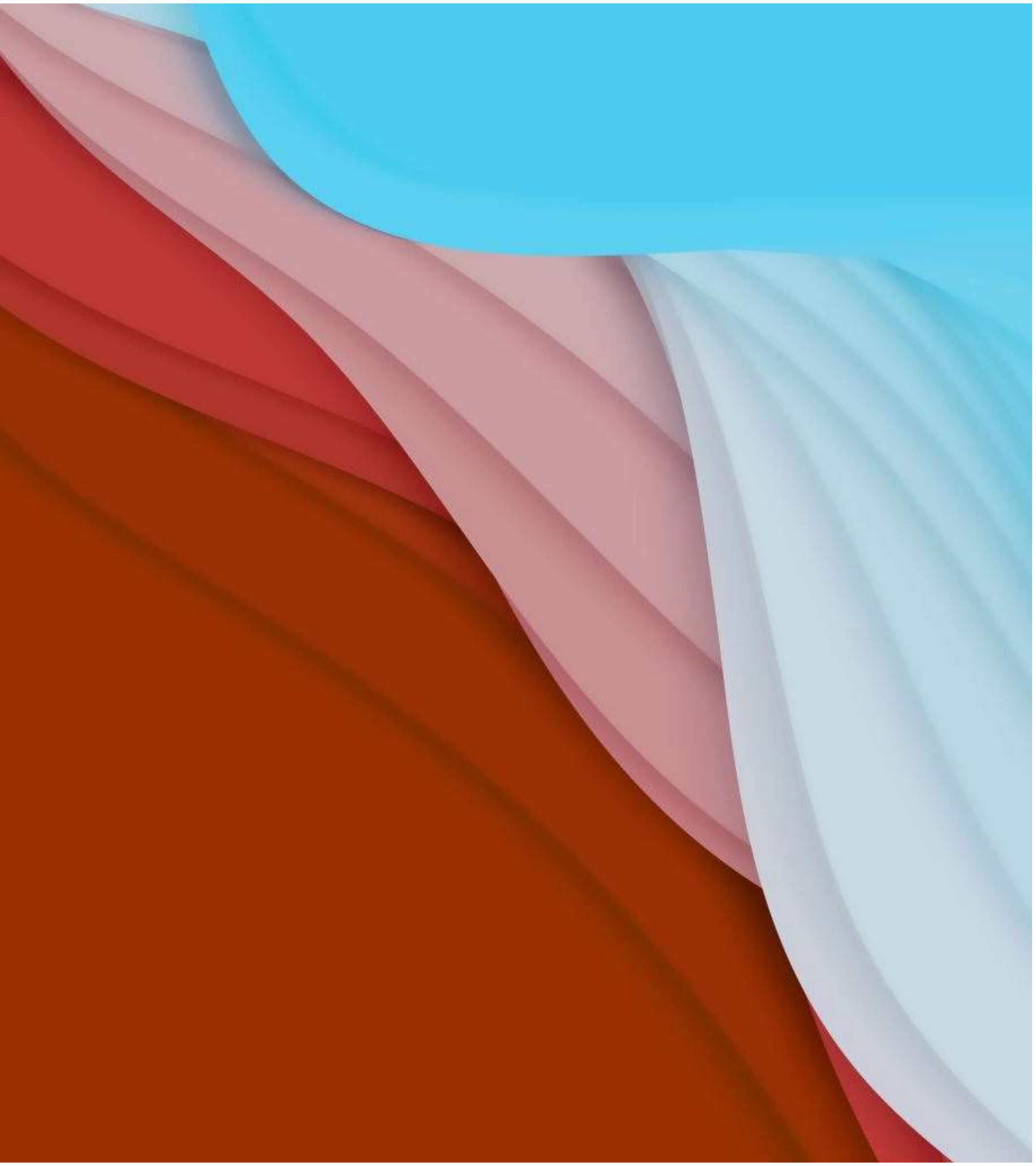


CEN416
PROCESS DESIGN II

Quantitative Analysis

MFR

$$F_{A0} = F_A + (-r_A)V$$

$$\frac{V}{v} = \tau_m = \bar{t}$$

$$vC_{A0} = vC_A + k_1 C_A V$$

$$\frac{C_A}{C_{A0}} = \frac{1}{1 + k_1 \tau_m}$$

$$vC_{R0} = vC_R + (-r_R)V$$

$$0 = vC_R + (-k_1 C_A + k_2 C_R)V$$

$$\frac{C_R}{C_{A0}} = \frac{k_1 \tau_m}{(1 + k_1 \tau_m)(1 + k_2 \tau_m)}$$

Quantitative Analysis

MFR

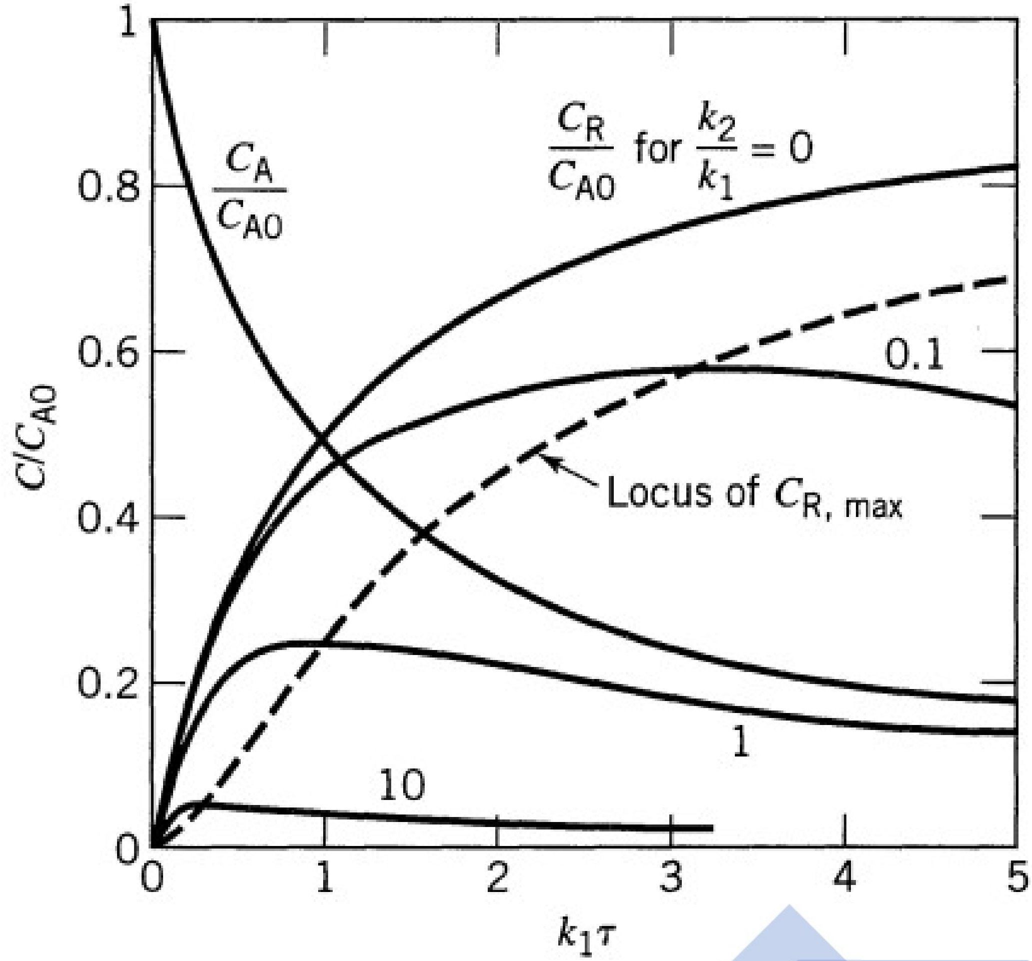
$$C_A + C_R + C_S = C_{A0} = \text{constant} \Rightarrow \frac{C_S}{C_{A0}} = \frac{k_1 k_2 \tau_m^2}{(1 + k_1\tau_m)(1 + k_2\tau_m)}$$

$$\tau_{m,\text{opt}} = \frac{1}{\sqrt{k_1 k_2}}$$

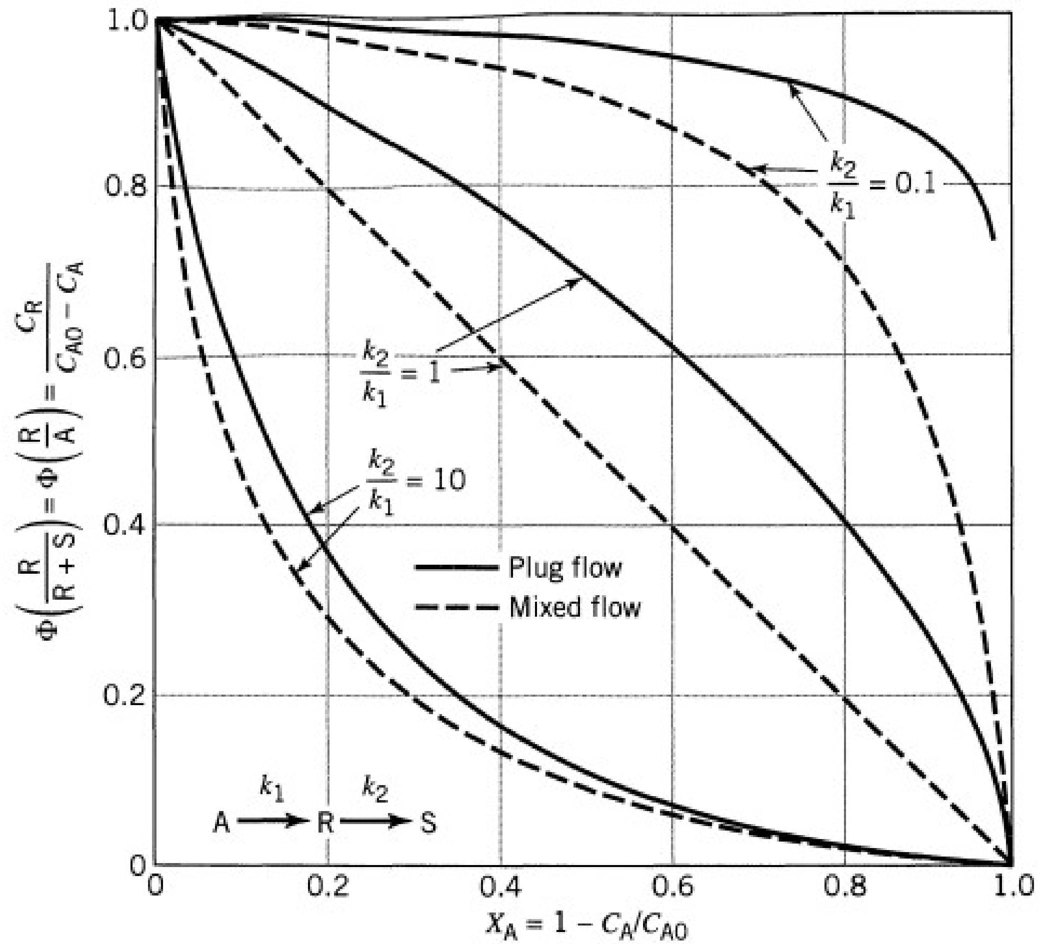
$$\frac{C_{R,\max}}{C_{A0}} = \frac{1}{[(k_2/k_1)^{1/2} + 1]^2}$$

Quantitative Analysis

MFR



- Comparison of the fractional yields of **R** in mixed flow and plug flow reactors for the unimolecular-type reactions



Product Distribution and Temperature

If two competing steps in multiple reactions have rate constants $\boldsymbol{k_1}$ and $\boldsymbol{k_2}$ then the relative rates of these steps are given by

$$\frac{k_1}{k_2} = \frac{k_{10}e^{-\mathbf{E}_1/\mathbf{R}T}}{k_{20}e^{-\mathbf{E}_2/\mathbf{R}T}} = \frac{k_{10}}{k_{20}}e^{(\mathbf{E}_2 - \mathbf{E}_1)/\mathbf{R}T} \propto e^{(\mathbf{E}_2 - \mathbf{E}_1)/\mathbf{R}T}$$

$$\frac{k_1}{k_2} = \frac{k_{10}e^{-\mathbf{E}_1/\mathbf{R}T}}{k_{20}e^{-\mathbf{E}_2/\mathbf{R}T}} = \frac{k_{10}}{k_{20}} e^{(\mathbf{E}_2 - \mathbf{E}_1)/\mathbf{R}T} \propto e^{(\mathbf{E}_2 - \mathbf{E}_1)/\mathbf{R}T}$$

This ratio changes with temperature depending on whether $\mathbf{E_1}$ is greater or smaller than $\mathbf{E_2}$, so

$$\text{when } T \text{ rises} \begin{cases} k_1/k_2 \text{ increases if } \mathbf{E}_1 > \mathbf{E}_2 \\ k_1/k_2 \text{ decreases if } \mathbf{E}_1 < \mathbf{E}_2 \end{cases}$$

REFERENCES

1. Sinnot, R.K. 1999, Coulson's & Richardson's Chemical Engineering, Volume 6, Chemical Engineering Design, ButterWorth Heinemann, Oxford.

2. Turton R., Bailie R.C., Whitin W.C., Shaeiwitz J.A. 1998, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall, New Jersey.