- The batch reactor is well suited to produce small amounts of material and to produce many different products from one piece of equipment.

- For the chemical treatment of materials in large amounts the continuous process is nearly always found to be more economical.

- For a given duty the ratio of sizes of mixed and plug flow reactors will depend on the extent of reaction, the stoichiometry, and the form of the rate equation.

  - MFR

    $$\tau = [Co - C]/(-r) = CoX/(-r)$$

  - PFR

    $$\tau = \int dC/r = Co \int dX/(-r)$$

$$-r_A = -\frac{1}{V}\frac{dN_A}{dt} = kC_A^n$$

With constant density, or $\varepsilon = 0$, this expression integrates to

$$\frac{(\tau C_{A0}^{n-1})_m}{(\tau C_{A0}^{n-1})_p} = \frac{\left[\dfrac{X_A}{(1-X_A)^n}\right]_m}{\left[\dfrac{(1-X_A)^{1-n}-1}{n-1}\right]_p}, \qquad n \neq 1$$

or

$$\frac{(\tau C_{A0}^{n-1})_m}{(\tau C_{A0}^{n-1})_p} = \frac{\left(\dfrac{X_A}{1-X_A}\right)_m}{-\ln(1-X_A)_p}, \qquad n = 1$$

(2)

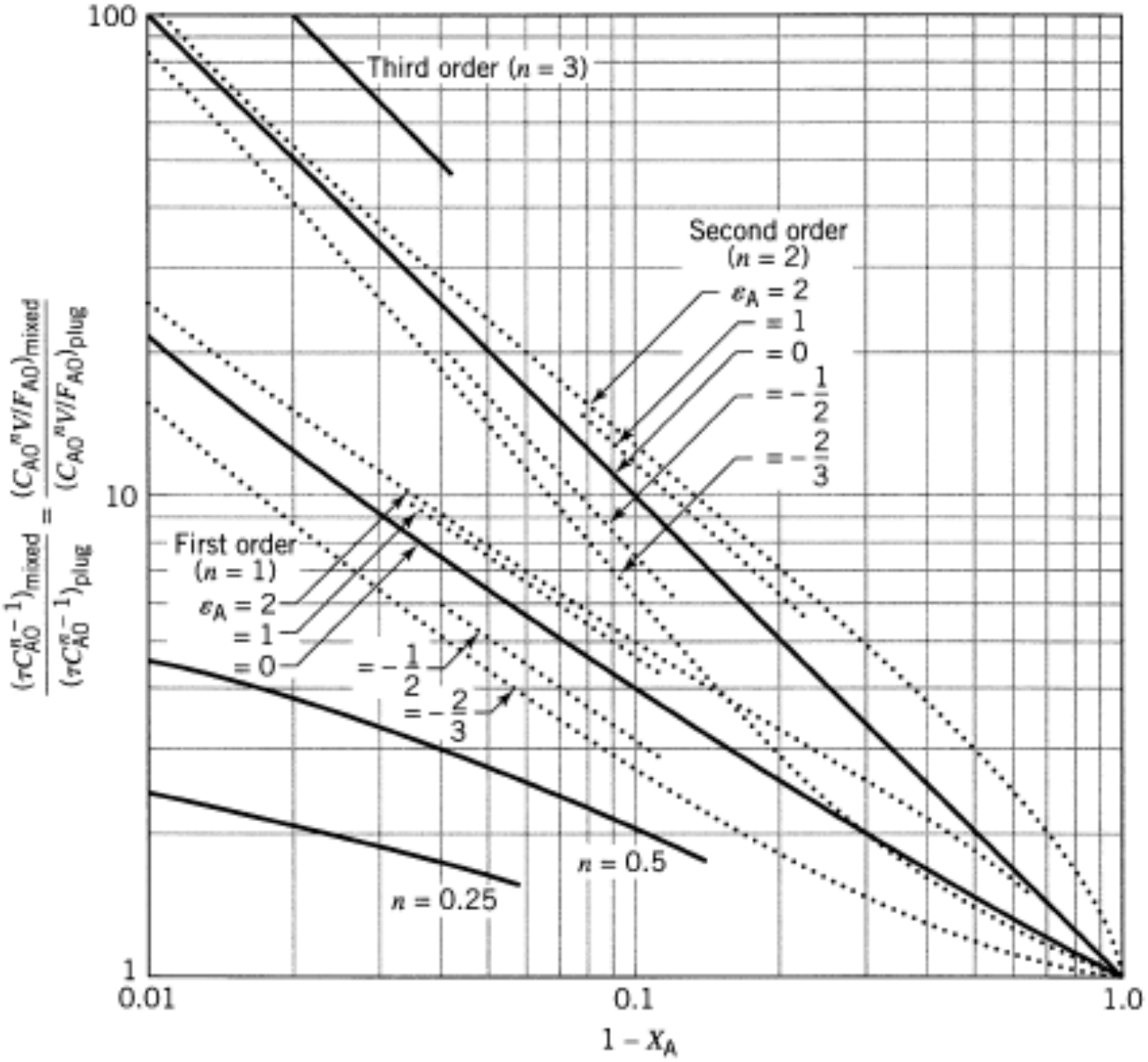


Figure 6.1 Comparison of performance of single mixed flow and plug flow reactors for the nth-order reactions

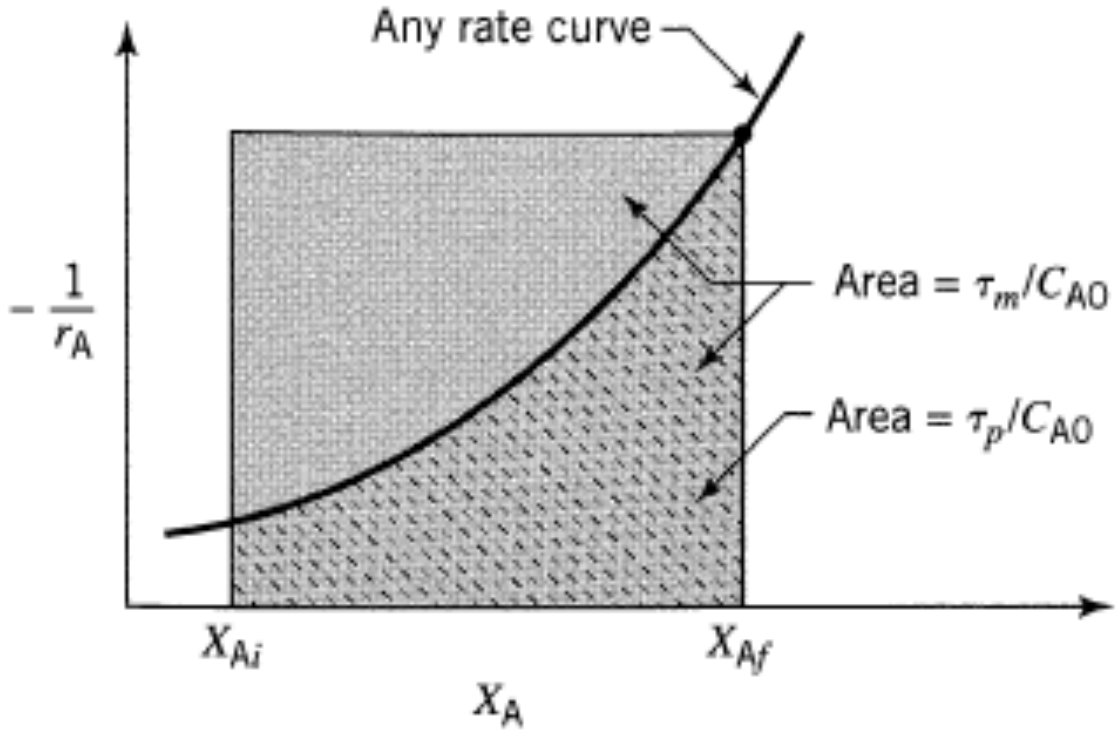
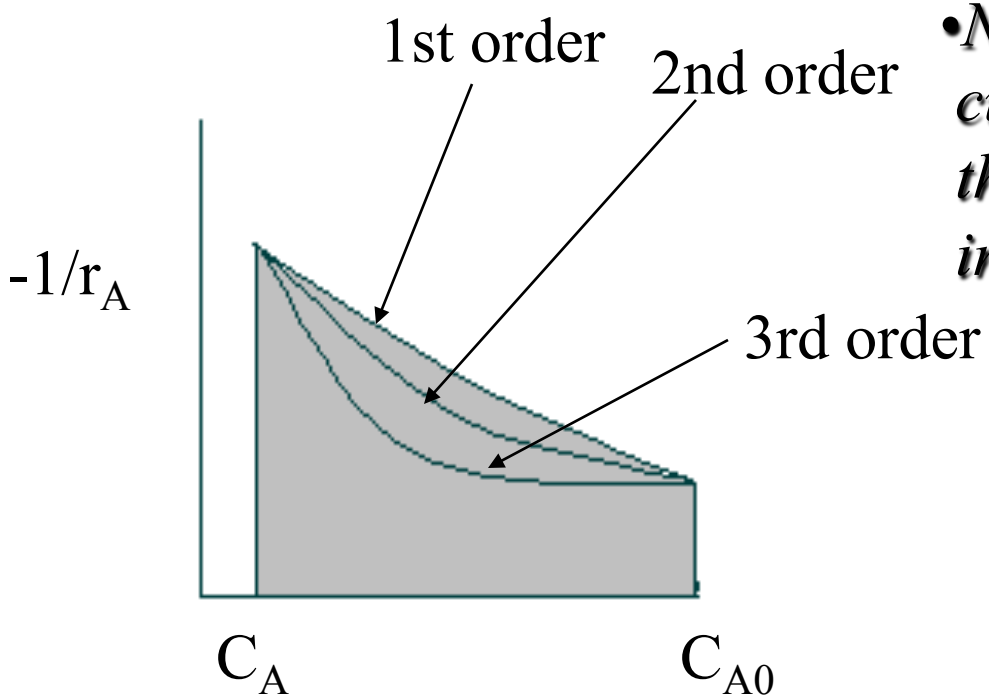


Figure 6.2 Comparison of performance of mixed flow and plug flow reactors for any reaction kinetics.

The ratio of shaded and of hatched areas gives the ratio of space-times needed in these two reactors.

Higher Order Reactions

- Reactors containing higher order reactions get a better performance.
- As the order of reaction increases, you want to use a plug flow reactor.



- ***Notice area under curve decreases as the order of rxn increases.***

More examples: batch, PFR, MFR

Your boss wants you to choose a reactor for the enzymatic conversion of glucose to ethanol.

$$\mathbf{C_6H_{12}O_6 + 3H_2O \longrightarrow 3C_2H_5OH + 3/2O_2}$$

The rxn is run in a large excess of water so the rxn only depends on the concentration of glucose [G].

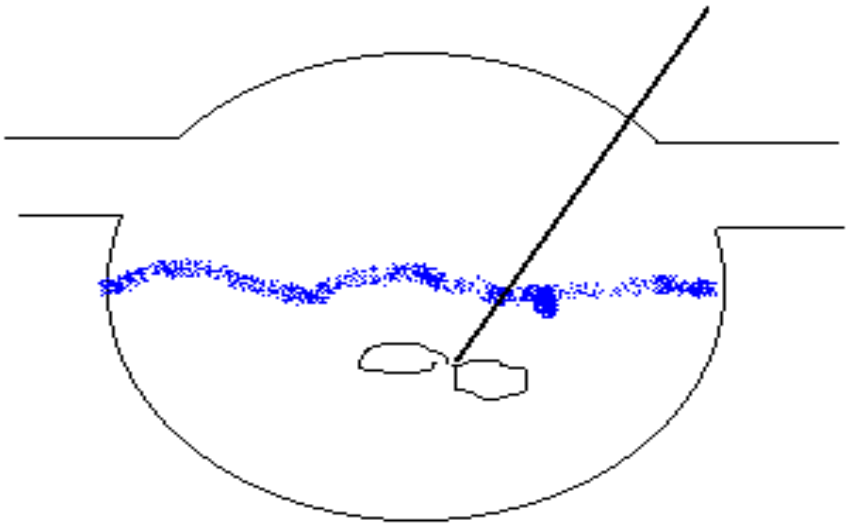
Assume a fixed amount of enzyme.

$K_m = 5$ mol/m^3

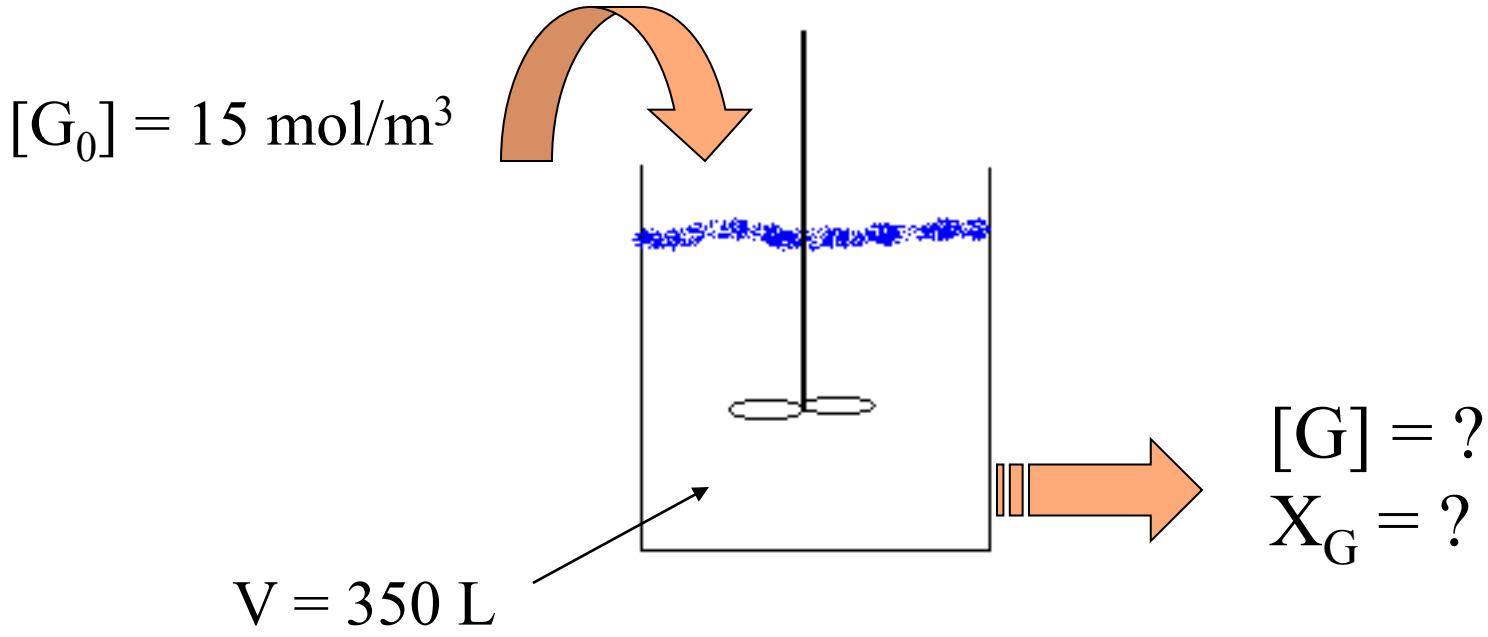
$V_m = 0.1$ mol/m^3-min

$[G_0] = 15$ mol/m^3

A) You have a tank of volume 350 L. Using it as a batch reactor, find the time needed to reach a conversion of 75%.



B) You can install pumps in the 350 L tank that will provide a flow rate of 25 L/min. If you run the tank as a mixed flow reactor what conversion can you obtain?



C) You may instead use a large pipe as a plug flow reactor. Its length is 20 m and its diameter is 0.6 m.
What conversion can you get?