**Isotherm batch reactor, isotherm plug flow reactor**

$$t = c_{j0}\int_0^X \frac{dX}{-\nu_j r}$$

| Type of reaction | | $t = c_{A0}\int_0^X \frac{dX}{-\nu_A r}$ | $t$ | $X$ |
|---|---|---|---|---|
| A→B<br>Zero order | $r = k$ | $t = \frac{c_{A0}}{k}\int_0^X dX$ | $\frac{c_{A0}\cdot X}{k}$ | $\frac{k\cdot t}{c_{A0}}$ |
| A→B<br>First order | $r = k\cdot c_A = k\cdot c_{A0}\cdot(1-X)$ | $t = \frac{1}{k}\int_0^X \frac{dX}{(1-X)}$ | $-\frac{1}{k}\ln(1-X)$ | $1-e^{-k\cdot t}$ |
| A→B<br>Order m (m≠1) | $r = k\cdot c_A^m = k\cdot c_{A0}^m\cdot(1-X)^m$ | $t = \frac{c_{A0}^{1-m}}{k}\int_0^X \frac{dX}{(1-X)^m}$ | $\frac{(1-X)^{1-m}-1}{k\cdot c_{A0}^{m-1}\cdot(m-1)}$ | $1-\left(1+(m-1)\cdot k\cdot t\cdot c_{A0}^{m-1}\right)^{\frac{1}{1-m}}$ |
| 2A→P v. A+B→P<br>2nd order ($c_{A0} = c_{B0}$) | $r = k\cdot c_A^2 = k\cdot c_{A0}^2\cdot(1-X)^2$ | $t = \frac{1}{k\cdot c_{A0}}\int_0^X \frac{dX}{(1-X)^2}$ | $\frac{(1-X)^{-1}-1}{k\cdot c_{A0}} = \frac{1}{k\cdot c_{A0}}\cdot\frac{X}{1-X}$ | $\frac{k\cdot t\cdot c_{A0}}{1+k\cdot t\cdot c_{A0}}$ |
| A+B→P<br>2nd order($c_{A0} < c_{B0}$) | $r = k\cdot c_A\cdot c_B =$<br>$= k\cdot c_{A0}\cdot(1-X)\cdot(c_{B0}-c_{A0}\cdot X)$ | $t = \frac{1}{k}\int_0^X \frac{dX}{(1-X)\cdot(c_{B0}-c_{A0}\cdot X)}$ | $= \frac{1}{k\cdot(c_{B0}-c_{A0})}\cdot\ln\frac{c_{B0}-c_{A0}X}{c_{B0}(1-X)}$ | $\frac{c_{B0}\cdot(e^{k\cdot t\cdot(c_{B0}-c_{A0})}-1)}{c_{B0}\cdot e^{k\cdot t\cdot(c_{B0}-c_{A0})}-c_{A0}}$ |
| $A \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} B$<br>$c_{B0}=0$ | $r = k_1 c_A - k_{-1}c_B =$<br>$= k_1 c_{A0}(1-X) - k_{-1}c_{A0}\cdot X =$<br>$= c_{A0}\cdot k_1(1-\frac{k_1+k_{-1}}{k_1}X)$ | $t = \frac{1}{k_1}\int_0^X \frac{dX}{(1-\frac{k_1+k_{-1}}{k_1}X)}$ | $-\frac{1}{k_1+k_{-1}}\ln(1-\frac{k_1+k_{-1}}{k_1}X)$ | $\frac{k_1}{k_1+k_{-1}}(1-e^{-(k_1+k_{-1})\cdot t})$ |

**Isothermal, continuous stirred tank reactor**

$V = \dot{V} \cdot \bar{t}$ thus $\frac{1}{\bar{t}} \cdot (c_{j0} - c_j) + \nu_j \cdot r = 0$

$$\frac{1}{\bar{t}} \cdot \frac{(c_{j0} - c_j)}{c_{j0}} + \frac{\nu_j \cdot r}{c_{j0}} = 0 \Rightarrow \frac{1}{\bar{t}} \cdot X = -\frac{\nu_j \cdot r}{c_{j0}}.$$

| Type of reaction | | $\bar{t}$ | $X$ |
|---|---|---|---|
| A→B<br>Zero order | $r = k$; $\frac{1}{\bar{t}} \cdot X = -\frac{-1 \cdot k}{c_{A0}}$ | $\frac{c_{A0} \cdot X}{k}$ | $\frac{k \cdot \bar{t}}{c_{A0}}$ |
| A→B<br>1st order | $r = k \cdot c_A = k \cdot c_{A0} \cdot (1 - X)$<br>$\frac{1}{\bar{t}} \cdot X = k \cdot (1 - X)$ | $\frac{1}{k} \frac{X}{1 - X}$ | $\frac{k \cdot \bar{t}}{1 + k \cdot \bar{t}}$ |
| A→B<br>Order m (m≠1) | $r = k \cdot c_A^m = k \cdot c_{A0}^m \cdot (1 - X)^m$<br>$\frac{1}{\bar{t}} \cdot X = k \cdot c_{A0}^m \cdot (1 - X)^m$ | $\frac{1}{k \cdot c_{A0}^{m-1}} \cdot \frac{X}{(1 - X)^m}$ | $\frac{k \cdot \bar{t} \cdot c_{A0}^{m-1}}{1 + k \cdot \bar{t} \cdot c_{A0}^{m-1}}$ |
| 2A→P v. A+B→P<br>2nd order ($c_{A0} = c_{B0}$) | $r = k \cdot c_A^2 = k \cdot c_{A0}^2 \cdot (1 - X)^2$<br>$\frac{1}{\bar{t}} \cdot X = k \cdot c_{A0}^2 \cdot (1 - X)^2$ | $\frac{1}{k \cdot c_{A0}} \cdot \frac{X}{(1 - X)^2}$ | $\frac{2k \cdot \bar{t} \cdot c_{A0} + 1 - \sqrt{1 + 4k \cdot \bar{t} \cdot c_{A0}}}{2k \cdot \bar{t} \cdot c_{A0}}$ |
| A+B→P<br>2nd order ($c_{A0} < c_{B0}$) | $r = k \cdot c_A \cdot c_B =$<br>$= k \cdot c_{A0} \cdot (1 - X) \cdot (c_{B0} - c_{A0} \cdot X)$<br>$\frac{1}{\bar{t}} \cdot X = k \cdot c_{A0} \cdot (1 - X) \cdot (c_{B0} - c_{A0} \cdot X)$ | $\frac{1}{k} \cdot \frac{X}{(1 - X) \cdot (c_{B0} - c_{A0} \cdot X)}$ | $\frac{1 + (c_{B0} + c_{A0}) \cdot k \cdot \bar{t} - \sqrt{(1 + (c_{B0} - c_{A0}) \cdot k \cdot \bar{t})^2 + 4k \cdot \bar{t} \cdot c_{A0}}}{2k \cdot \bar{t} \cdot c_{A0}}$ |