Note

$$aA + bB \longrightarrow xX + yY$$

$$\text{rate} = A^{\alpha} B^{\beta} X^{\gamma} Y^{\eta}$$

① $$\text{rate} = \frac{1}{\nu_P}\frac{dP}{dt} = \frac{1}{\nu_R}\frac{dR}{dt}$$

$\nu_A = -a$ $\nu_X = x$

$\nu_B = -b$ $\nu_Y = y$

② $$\text{rate} = \frac{1}{\nu_P}\frac{dP}{dt} = -\frac{1}{\nu_R}\frac{dR}{dt}$$

$\nu_A = a$ $\nu_X = x$

$\nu_B = b$ $\nu_Y = y$

FIRST ORDER

$$A \xrightarrow{k} P$$

$$\text{rate} = k[A]$$

$$\nu_A = +1$$

$$\nu_P = +1$$

$$\text{rate} = \frac{1}{\nu_P}\frac{d[P]}{dt} = -\frac{1}{\nu_A}\frac{d[A]}{dt}$$

$$\frac{d[A]}{dt} = -k[A]$$

$$[A(t)] = A_0 e^{-kt}$$

$$\ln[A] = \ln A_0 - kt$$

$$[A(t_{1/2})] = A_0 e^{-kt_{1/2}}$$

$$\frac{[A(t_{1/2})]}{A_0} = \frac{1}{2} = e^{-kt_{1/2}}$$

$$-\ln 2 = -k t_{1/2}$$

$$\boxed{k = \frac{\ln 2}{t_{1/2}}}$$

$$\frac{d[P]}{dt} = k[A(t)] = kA_0 e^{-k\tau}$$

$$[P(t)] = P_0 + k\int_0^t A_0 e^{-ks}\, ds$$

$$[P(t)] = P_0 + \cancel{k} A_0 \int_0^t e^{-ks}\, k ds$$

$$P_0 - A_0 e^{-ks}\Big|_0^t$$

$$\boxed{[P(t)] = P_0 + A_0[1 - e^{-kt}]}$$

$$A \xrightarrow{k_A} I \xrightarrow{k_I} P$$

$$\frac{d[A]}{dt} = -k_A [A]$$

$$\frac{d[I]}{dt} = k_A [A] - k_I [I]$$

$$\frac{d[P]}{dt} = k_I [P]$$

$A_0 \neq 0 \quad I_0 = 0 \quad P_0 = 0$

$$[A(t)] = A_0 e^{-k_A t}$$

$$\frac{d[I]}{dt} + k_I [I] = k_A [A] = k_A A_0 e^{-k_A t}$$

$$\frac{d}{dt}\left[e^{k_I t} [I]\right] = k_A A_0 e^{-k_A t} e^{k_I t}$$

$$e^{k_I t} [I(t)] = k_A A_0 \int_0^t e^{(k_I - k_A)s} \, ds$$

$$= \frac{k_A A_0}{k_I - k_A} \left[e^{(k_I - k_A)t} - 1 \right]$$

$$[I(t)] = \frac{k_A A_0}{k_I - k_A} \left[e^{-k_A t} - e^{-k_I t} \right]$$

$$A_0 = [A(t)] + [I] + [P]$$

$$[P(t)] = A_0 - [A(t)] - [I(t)]$$

$k_A >> k_I$ Rate determining step II

$k_A << k_I$ Rate determining step I

$$A \longrightarrow P$$

$$A \xrightarrow{k_A} I_1 \xrightarrow{k_1} I_2 \xrightarrow{k_2} P$$

$$\frac{d}{dt}[A] = -k_A [A]$$

$$\frac{d}{dt}[I_1] = k_A [A] - k_1 [I_1]$$

$$\frac{d}{dt}[I_2] = k_1 [I_1] - k_2 [I_2]$$

$$\frac{d}{dt}[P] = k_2 [I_2]$$

Steady state approximation

$$\frac{dI_1}{dt} = \frac{dI_2}{dt} = 0$$

① $$[A(t)] = A_0 e^{-k_A t}$$

$$k[A(t)] = k_1 \bar{I}_1 \Rightarrow [\bar{I}_1(t)]_{ss} = \frac{k_A}{k_1} A_0 e^{-k_A t}$$

$$k_1 \bar{I}_1 = k_2 [\bar{I}_2] \Rightarrow [I_2(t)]_{ss} = \frac{k_1}{k_2} \frac{k_A}{k_1} A_0 e^{-k_A t}$$

$$[I_2(t)]_{ss} = \frac{k_A}{k_2} A_0 e^{-k_A t}$$

$$\boxed{[P(t)] = \frac{k_A^2}{k_1} A_0 e^{-k_A t}}$$

$$\frac{d}{dt}[I_1(t)]_{ss} = -\frac{k_A^2}{k_1} A_0 e^{-k_A t} \neq 0$$

SS approximation valid when

$$\frac{k_A^2}{k_1} A_0 e^{-k_A t} \ll 1$$

$$k_1 \gg k_A$$

$$A + B \xrightarrow{k} P$$

$$\text{rate} = k[A][B]$$

$$\frac{d[A]}{dt} = -k[A][B]$$

$$\frac{d[B]}{dt} = -k[A][B]$$

$$\frac{d[P]}{dt} = k[A][B]$$

$$X = \frac{[A]+[B]}{2} \quad \Rightarrow [A] = X + y$$

$$Y = \frac{[A]-[B]}{2} \quad \Rightarrow [B] = X - y$$

$$\frac{dX}{dt} = -k(X+y)(X-y) = -k(X^2 - y^2)$$

$$\frac{dy}{dt} = 0 \Rightarrow y(t) = \text{CONST} = A_0 - B_0 \equiv y_0$$

$$\frac{dX}{dt} = -kX^2 + ky_0^2$$