$$A \rightleftarrows B$$

$$A \rightleftarrows B \checkmark$$

$$A \rightleftarrows C \checkmark$$

$$A \xrightarrow{k_1} \underset{\sim}{B} \xrightarrow{k_2} C$$

$$-\frac{d[A]}{dt} = k_1 [A] \Rightarrow \boxed{[A] = [A]_0 e^{-k_1 t}}$$

$$\boxed{\frac{d[B]}{dt} = k_1 [A] - k_2 [B]}$$

$$\frac{d[B]}{dt} + k_2 [B] = k_1 \cdot [A]_0 e^{-k_1 t}$$

$$\underbrace{e^{k_2 t} \frac{d[B]}{dt} + k_2 e^{k_2 t} [B]} = k_1 [A]_0 \times e^{-(k_1 - k_2)t}$$

$$\frac{d}{dt}\left(e^{k_2 t} [B] \right) = k_1 [A]_0 e^{-(k_1 - k_2)t}$$

$$\int_{t=0}^{t=t} d\left(\underbrace{e^{k_2 t} [B]}\right) = k_1 [A]_0 \int_0^t e^{-(k_1 - k_2)t} dt$$

$[B] = 0$ at $t = 0$

$$e^{k_2 t} [B] = k_1 [A]_0 \left. \frac{-e^{-(k_1 - k_2)t}}{k_1 - k_2} \right|_0^t$$

$$e^{k_2 t}[B] = \frac{k_1 [A]_0}{k_1 - k_2} \left\{ 1 - e^{-(k_1 - k_2)t} \right\}$$

$$\boxed{[B] = \frac{k_1 [A]_0}{k_1 - k_2} \left(e^{-k_2 t} - e^{-k_1 t} \right)}$$

$$\frac{d[C]}{dt} = k_2 [B] = \ldots$$

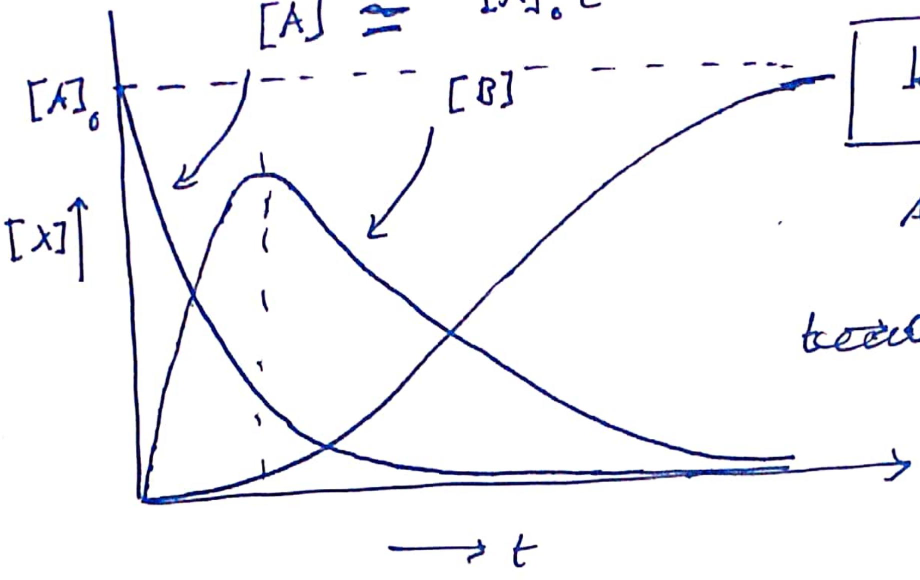
	$A \longrightarrow$	$B \longrightarrow$	C
$t = 0$	$[A]_0$	0	0

$$t = t \qquad [A] + [B] + [C] = [A]_0$$

$$[C] = [A]_0 - ([A] + [B])$$

$$\boxed{[C] = [A]_0 \left\{ 1 - \frac{k_1}{(k_1 - k_2)} e^{-k_2 t} - \frac{k_2}{k_2 - k_1} e^{-k_1 t} \right\}}$$

$[A] \approx [A]_0 e^{-k_1 t}$



$\boxed{k_1 \gg k_2}$

$A \rightarrow B \dashrightarrow C$

$$e^{-x} = \frac{1}{e^{x}} = \frac{1}{1 + x + \frac{x^2}{2} + \dots}$$

$\approx 1 \quad x \ll 1$

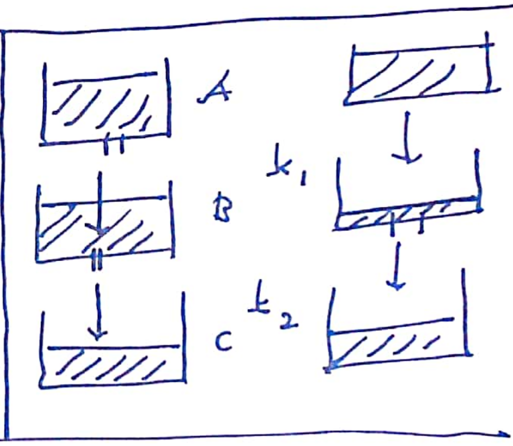
$\approx 0 \quad x \gg 1$

$t \to 0$

$$[B] \approx \frac{\cancel{k_1}}{\cancel{k_1}} [A]_0 \left(1 - e^{-k_1 t}\right)$$

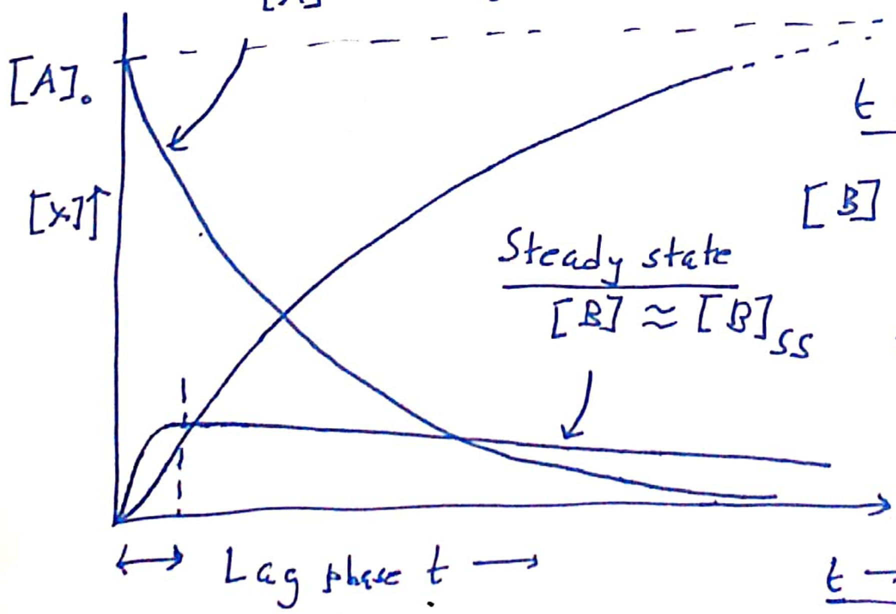
$t \to \infty$

$$[B] \approx \frac{\cancel{k_1}}{\cancel{k_1}} [A]_0 \, e^{-k_2 t}$$



$\boxed{k_2 \gg k_1}$

$[A] = [A]_0 e^{-k_1 t}$



$t \to 0$

$$[B] \approx -\frac{k_1}{k_2}[A]_0 \left(e^{-k_2 t} - 1\right)$$

Steady state

$$[B] \approx [B]_{ss} = \frac{k_1}{k_2}[A]_0 \left(1 - e^{-k_2 t}\right)$$

$t \to \infty$

$$[B] \approx \frac{k_1}{k_2}[A]_0 \, e^{-k_1 t}$$

$$\left.\frac{d[B]}{dt}\right|_{ss} \approx 0$$

Composite

$$A + B \longrightarrow P$$

$$\underbrace{A + B \rightleftarrows}\underbrace{I \longrightarrow P}$$

$H_2 + I_2 \longrightarrow 2HI$

$H_2 + Br_2 \longrightarrow 2HBr$

$\text{Rate} = k_1 [H_2][I_2]$

Equilibrium / RDS approximation

① $A + B \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} I$ — fast equilibrium

② $I \xrightarrow[k_2]{} P$ — slow | rate-determining step

$$\text{Rate} : \frac{d[P]}{dt} = k_2 [I]$$

At eqm

$$(\text{Rate})_1 = (\text{Rate})_{-1}$$

$$k_1 [A][B] = k_{-1} [I]$$

$$[I] = \frac{k_1}{k_{-1}} [A][B] = (K_{eq})_1 [A][B]$$

$$\boxed{\frac{d[P]}{dt} = \left(k_2 \frac{k_1}{k_{-1}}\right) [A][B]} = k_{obs} [A][B]$$

Steady-state approx.

① $A + B \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} I$

② $I \xrightarrow[k_2]{} P$

$$\left.\frac{d[I]}{dt}\right|_{ss} \approx 0$$

At ss

$$\frac{d[I]}{dt} = k_1 [A][B] - k_{-1}[I] - k_2 [I] = 0$$

$$[I]\Big|_{ss} = \frac{k_1 [A][B]}{k_{-1} + k_2}$$

Rate: $\frac{d[P]}{dt} = k_2 [I]$

$$\boxed{\frac{dP}{dt} = \frac{k_2 k_1}{k_{-1} + k_2} [A][B]}$$

$$\simeq \frac{k_2 k_1}{k_{-1}} [A][B] \equiv \text{Rate}\Big|_{\text{RDS Approx}}$$

$$A + B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} I \xrightarrow{k_2} [P]$$

$$A + B \xrightarrow[k_1]{} I \xrightarrow[k_2]{} P$$

$$A + B \underset{\text{fast}}{\rightleftharpoons} I \xrightarrow[\text{fast}]{} P$$

SSA

k_2 fast

k_{-1} fast

$\equiv$

$A + B \rightleftharpoons I$

EA

$$A + B + C \longrightarrow P$$

Expt $\frac{d[P]}{dt} = \frac{k_1 [A]^{1.5}}{k_2 [B] + c}$

$$A + B \rightleftharpoons I \qquad I + C \longrightarrow P$$