① Enzyme Kinetics : Rates of change.

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_3} E + P$$

Four equations for the rate of changes (E, S, ES, P):

$$\frac{d(E)}{dt} = (k_2 + k_3)(ES) - k_1(S)(E)$$

$$\frac{d(S)}{dt} = k_2(ES) - k_1(S)(E)$$

$$\frac{d(ES)}{dt} = k_1(E)(S) - (k_2 + k_3)(ES)$$

$$\frac{d(P)}{dt} = k_3(ES)$$

② $E = 1\ \mu M$ $\quad S = 10\ \mu M$ $\quad ES = P = 0$.

$k_1 = 100/\mu M/min$ $\quad k_2 = 600/\mu M/min$ $\quad k_3 = 150/\mu M/min$.

$$\frac{d(E)}{dt} = (600 + 150) \times 0 - 100(10)(1) = -1000$$

$$\frac{d(S)}{dt} = 600 \times 0 - 100(10)(1) = -1000$$

$$\frac{d(ES)}{dt} = 100(10)(1) - (600 + 150)(0) = 1000$$

$$\frac{d(P)}{dt} = 150(0) = 0$$

③ steady-state approximation :

$$\frac{d(ES)}{dt} = 0$$

since $E_0 = E + ES$

∴ we have $E = E_0 - ES$

$$k_1(S)(E) = k_2(ES)$$

$$k_1(S)(E_0 - ES) = k_2 ES$$

$$k_1(S)(ES) = k_1(S)(E_0) - k_2 ES$$

$$(k_1(S) + k_2)(ES) = k_1(S)(E_0)$$

$$ES = \frac{k_1(S)(E_0)}{k_1(S) + k_2} = \frac{k_1 S(E_0) \div k_1}{(k_1(S) + k_2) \div k_1} = \frac{S(E_0)}{S + k_2/k_1}$$

since V is the rate of change of the product P.

$$V = \frac{d(P)}{dt} = k_3(ES)$$

$$= k_3 \cdot \frac{S(E_0)}{S + k_2/k_1}$$

let $V_{max} = k_3(E_0)$

$$V = V_{max} \cdot \frac{S}{S + k_2/k_1}$$

Plot: