

abbreviations:

[E] = concentration of enzyme

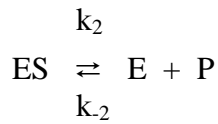
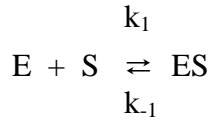
[E]<sub>o</sub> = initial or original concentration of enzyme

[S] = concentration of substrate

[P] = concentration of product

[ES] = concentration of the enzyme-substrate complex

The reaction mechanism is



where the initial rate of the reaction

$$\text{rate} = k_2 [ES] \quad [1].$$

The steady-state approximation assume that the [ES] is steady, i.e. a constant, thus

$$\begin{aligned} \frac{d[ES]}{dt} &= \text{rate of formation} - \text{rate of break-down} = 0 \\ &= \{k_1 [E] [S] + k_{-2} [E] [P]\} - \{k_{-1} [ES] + k_2 [ES]\} = 0 \end{aligned} \quad [2].$$

As

$$[E] = [E]_o - [ES] \quad [3]$$

$$\text{and at the beginning of the reaction,} \quad [P] = 0 \quad [4]$$

the substitution of [3] and [4] into [2] followed by rearrangement yields

$$[ES] = \frac{[E]_o [S]}{\frac{k_{-1} + k_s}{k_1} + [S]} = \frac{[E]_o [S]}{K_m + [S]}, \quad [5]$$

$$\text{where } K_m = \frac{k_{-1} + k_s}{k_1}.$$

Substitution of [5] into [1], yields

$$\text{Rate} = \frac{k_s [E]_o [S]}{K_m + [S]} = \frac{\text{rate}_{\max} [S]}{K_m + [S]}.$$

The above expression is known as the Michaelis-Menten equation, which describes the kinetics of an enzyme reacting with a single substrate.