Michaelis-Menten enzymkinetik

http://en.wikipedia.org/wiki/Michaelis%E2%80%93Menten_kinetics

Formler:

$$E + S \underset{k_r}{\overset{k_f}{\rightleftharpoons}} ES \xrightarrow{k_{cat}} E + P$$

$$[E] + [ES] = [E]_0$$

$$K_m = \frac{k_r + k_{cat}}{k_f}$$

$$K_d = k_r / k_f$$

$$V_{\max} = k_{cat}[E]_0$$

Differentialligningssystem:

$$\begin{aligned}
d[S]/dt &= -k_f[E][S] + k_r[ES] \\
d[E]/dt &= -k_f[E][S] + k_r[ES] + k_{cat}[ES] \\
d[ES]/dt &= +k_f[E][S] - k_r[ES] - k_{cat}[ES] \\
d[P]/dt &= +k_{cat}[ES]
\end{aligned}$$

1) Ligevægts approksimation:

$$k_f[E][S] = k_r[ES]$$

2) Kvasi-steady-state approksimation:

$$k_f[E][S] = k_r[ES] + k_{cat}[ES]$$

Udledning af formler:

1) Ligevægts approksimation:

$[E] + [ES] = [E]_0 \Leftrightarrow [E] = [E]_0 - [ES]$
indsættes i:

$\boldsymbol{k_f \cdot [E] \cdot [S] = k_r \cdot [ES]}$
Og får hermed:

$$k_f \cdot \left([E]_0 - [ES]\right) \cdot [S] = k_r \cdot [ES] \Leftrightarrow k_f \cdot [E]_0 \cdot [S] - k_f \cdot [S] \cdot [ES] = k_r \cdot [ES] \Leftrightarrow k_f \cdot [E]_0 \cdot [S] = k_f \cdot [S] \cdot [ES] + k_r \cdot [ES] \Leftrightarrow$$

$$k_f \cdot [E]_0 \cdot [S] = \left(k_f \cdot [S] + k_r\right) \cdot [ES] \Leftrightarrow [ES] = \frac{k_f \cdot [E]_0 \cdot [S]}{k_f \cdot [S] + k_r} \Leftrightarrow [ES] = \frac{[E]_0 \cdot [S]}{\frac{k_r}{k_f} + [S]} \Leftrightarrow$$

$$\underline{\underline{[ES] = \frac{[E]_0 \cdot [S]}{K_d + [S]}}}$$

Fra differentialligningssystemet har vi:

$$\frac{d[P]}{dt} = + k_{cat} \cdot [ES]$$

derfor gælder

$$\underline{\underline{v = \frac{d[P]}{dt}}} = k_{cat} \cdot \frac{[E]_0 \cdot [S]}{K_d + [S]} = \frac{k_{cat} \cdot [E]_0 \cdot [S]}{K_d + [S]} = \underline{\underline{\frac{V_{\max} \cdot [S]}{K_d + [S]}}}$$

Følgende formel er hermed udledt:

$$v = d[P]/dt = \frac{V_{\max}[S]}{K_d + [S]}$$

2) Kvasi-steady-state approksimation:

$[E] + [ES] = [E]_0 \Leftrightarrow [E] = [E]_0 - [ES]$
indsættes i:
$\boldsymbol{k_f \cdot [E] \cdot [S] = k_r \cdot [ES] + k_{cat} \cdot [ES]}$
Og får hermed:

$$k_f \cdot \left([E]_0 - [ES]\right) \cdot [S] = k_r \cdot [ES] + k_{cat} \cdot [ES] \Leftrightarrow k_f \cdot [E]_0 \cdot [S] - k_f \cdot [S] \cdot [ES] = k_r \cdot [ES] + k_{cat} \cdot [ES] \Leftrightarrow k_f \cdot [E]_0 \cdot [S] = k_f \cdot [S] \cdot [ES] + k_r \cdot [ES] + k_{cat} \cdot [ES] \Leftrightarrow$$

$$k_f \cdot [E]_0 \cdot [S] = \left(k_f \cdot [S] + k_r + k_{cat}\right) \cdot [ES] \Leftrightarrow [ES] = \frac{k_f \cdot [E]_0 \cdot [S]}{k_f \cdot [S] + k_r + k_{cat}} \Leftrightarrow [ES] = \frac{[E]_0 \cdot [S]}{\frac{k_r + k_{cat}}{k_f} + [S]} \Leftrightarrow \underline{\underline{[ES] = \frac{[E]_0 \cdot [S]}{K_m + [S]}}}$$

Fra differentialligningssystemet har vi:

$$\frac{d[P]}{dt} = + k_{cat} \cdot [ES]$$

derfor gælder

$$\underline{\underline{v = \frac{d[P]}{dt}}} = k_{cat} \cdot \frac{[E]_0 \cdot [S]}{K_m + [S]} = \frac{k_{cat} \cdot [E]_0 \cdot [S]}{K_m + [S]} = \underline{\underline{\frac{V_{\max} \cdot [S]}{K_m + [S]}}}$$

Følgende formel er hermed udledt:

$$v = d[P]/dt = \frac{V_{\mathbf{max}}[S]}{K_m + [S]}$$