# Steady-state approximation

Consider a general reaction shown in the rate scheme:

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C \xrightarrow{k_3} D$$

Express the rate scheme in terms of kinetic equations. Assuming that $k_2 >> k_1$ and $k_3 >> k_2$ determine an expression for the rate of formation of product D as a function of the concentration of the starting compound A.

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Express the rate scheme in terms of kinetic equations.

Solution: First we express the mechanistic rate scheme in terms of kinetic equations.

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

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

$$\frac{d[C]}{dt} = k_2[B] - k_3[C]$$

$$\frac{d[D]}{dt} = k_3[C]$$

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Assuming that $k_2 >> k_1$ and $k_3 >> k_2$ determine an expression for the rate of formation of product D as a function of the concentration of the starting compound A.

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

Therefore,

$$k_1[A] = k_2[B]$$

$$\frac{d[C]}{dt} = k_2[B] - k_3[C] \approx 0$$

Therefore,

$$k_1[A] = k_2[B] = k_3[C]$$

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Since

$$k_1[A] = k_2[B] = k_3[C]$$

Finally, we can write

$$\frac{d[D]}{dt} = k_1[A]$$