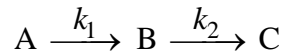


Problem 2-10 Consecutive reactions, intermediate maximal concentration

The rate constants of the two first-order consecutive reactions



are $k_1 = 3.09 \cdot 10^{-4} \text{ s}^{-1}$ and $k_2 = 6.18 \cdot 10^{-3} \text{ min}^{-1}$. Calculate what time is needed to reach the maximal concentration of the intermediate B and the value of this concentration in case that the initial concentration of A was $c_{A0} = 0.2 \text{ mol dm}^{-3}$.

$$[\tau_{\max} = 1.48 \text{ h}, c_{B\max} = 0.1155 \text{ mol dm}^{-3}]$$

Solution:

$$c_{A0} = 0.2 \text{ mol dm}^{-3}$$

$$k_1 = 3.09 \cdot 10^{-4} \text{ s}^{-1}$$

$$k_2 = 6.18 \cdot 10^{-3} \text{ min}^{-1} = 6.18 \cdot 10^{-3} / 60 = 1.03 \cdot 10^{-4} \text{ s}^{-1}$$

$$c_B = \frac{k_1 \cdot c_{A0}}{k_2 - k_1} \cdot [\exp(-k_1 \cdot \tau) - \exp(-k_2 \cdot \tau)]$$

maximum:

$$\frac{dc_B}{d\tau} = \frac{k_1 \cdot c_{A0}}{k_2 - k_1} [-k_1 \cdot e^{-k_1 \cdot \tau_{\max}} + k_2 \cdot e^{-k_2 \cdot \tau_{\max}}] = 0$$

$$k_1 \cdot e^{-k_1 \cdot \tau_{\max}} = k_2 \cdot e^{-k_2 \cdot \tau_{\max}}$$

$$\frac{k_1}{k_2} = e^{(k_1 - k_2) \cdot \tau_{\max}}$$

$$\tau_{\max} = \frac{\ln \frac{k_1}{k_2}}{k_1 - k_2} = \frac{\ln \frac{3.09 \cdot 10^{-4}}{1.03 \cdot 10^{-4}}}{3.09 \cdot 10^{-4} - 1.03 \cdot 10^{-4}} = 5333.07 \text{ s} = 1.4814 \text{ h}$$

$$c_{B\max} = \frac{3.09 \cdot 10^{-4} \cdot 0.2}{1.03 \cdot 10^{-4} - 3.09 \cdot 10^{-4}} \cdot [\exp(-3.09 \cdot 10^{-4} \cdot 5333.07) - \exp(-1.03 \cdot 10^{-4} \cdot 5333.07)]$$
$$= 0.11547 \text{ mol dm}^{-3}$$