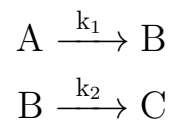


We are going to study the following chemical reaction



where A , B and C are the concentrations of three substances and k_1 , k_2 are the reaction rates.

The initial concentrations $A(t_0)$, $B(t_0)$, $C(t_0)$ should be 1.0, 0.0, 0.0, respectively. In the following we will investigate four different cases $k_2 = 1, 10, 100, 1000$, with $k_1 = 1$ in all cases. The first 10s of the reaction dynamics should be calculated using different numerical methods. The following questions should be answered:

- the corresponding (linear) system of first order ODEs needs to be determined: $\dot{x} = f(x, t)$
- implement the following numerical methods and compare the performance and stability: explicit Euler, Heun, (implicit Euler)
- compare with the analytical solution (or with the timeintegrators provided by `scipy.integrate`)

$$C(t) = A_0 [1 - e^{-k_1 t} (1 + k_1 t)] \quad \text{if } k_1 = k_2$$

$$C(t) = A_0 \left[1 - \frac{k_2 e^{-k_1 t} - k_1 e^{-k_2 t}}{k_2 - k_1} \right] \quad \text{if } k_1 \neq k_2$$

- What are the maximum step-sizes that lead to stable results? Calculate the eigenvalues of the Jacobian matrix $J = \frac{\partial f}{\partial x}$ and compare the stability behaviour with the theoretical predictions (optional)
- visualize the stable solution

