Exercise 4.1.

Calculate depth of penetration for typical gas \((D = 1 \text{ cm}^2/s)\), liquid \((D = 10^{-5} \text{ cm}^2/s)\) and solid in high temperature \((D = 10^{-10} \text{ cm}^2/s)\) for:

- 1 second
- 1 hour
- 1 day
- 1 month

Exercise 4.2.

Prove that the function \(c_i(x, t) = \frac{M}{2\sqrt{D_i t}} e^{-(x-\mu)^2/4D_i t}\) fulfills a diffusion equation:

\[
\frac{\partial c_i}{\partial t} = D_i \frac{d^2 c_i}{dx^2}
\]

Exercise 4.3.

Find concentration \(c(x)\) for a closed system of length \(d\) in a steady state, if \(c(x, t=0)\) was given by equation:

\[
c(x, t = 0) = 10 + \frac{20x}{d}
\]

For:

- Neumann boundary conditions \(J(0, t) = J(d, t) = 0\)
- Dirichlet boundary conditions

Exercise 4.4.

Temperature distribution in an isolated rod of length \(l=10\text{cm}\), is in \(t=0\) given by:

\[
T(x, 0) = 5 \left(x - \frac{1}{3}\right)^2
\]

Calculate temperature distribution in a steady state, assuming Dirichlet boundary conditions.

Exercise 4.5.

Sample of thickness \(l=20\text{cm}\) has following boundary conditions:

- On left side: NBC \(J(0, t) = 0,0005 \text{ mol/cm}^2s\)
- On right side: DBC \(c(l, t) = 0,005 \text{ mol/cm}^3\)
Find a steady state concentration profile for diffusion coefficient \( D = 10^{-5} \, \text{cm}^2 / \text{s} \).

**Exercise 4.6.**

On the plot below it can be seen how the self-diffusion coefficient of Pb depends on the temperature (or to be more precise \( 1/T \)). Knowing, that the diffusion coefficient can be described by the Arrhenius relation:

\[
D = D^0 \exp \left( \frac{-\Delta H}{k_B T} \right)
\]

find:

- value of the enthalpy of activation
- depth of penetration in 450K after two days
- depth of penetration in 550K after two days

Value of \( D^0 \) equals \( 4.1868 \times 10^{-5} \, \text{[m}^2/\text{s}] \)