Exercise 4.1.

Calculate depth of penetration for typical gas ($D = 1\left[\frac{cm^2}{s}\right]$), liquid ($D = 10^{-5}\left[\frac{cm^2}{s}\right]$) and solid in high temperature ($D = 10^{-10}\left[\frac{cm^2}{s}\right]$) for:

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

Exercise 4.2.

Prove that the function $c_i(x,t) = \frac{M}{2\sqrt{D\pi t}}e^{-(x-\mu)^2/4Dt}$ 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=10cm, is in t=0 given by:

$$T(x,0) = 5\left(x - \frac{l}{3}\right)^2$$

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

Exercise 4.5.

Sample of thickness l=20[cm] has following boundary conditions:

- On left side: NBC J(0,t)=0,0005$\left[\frac{mol}{cm^2 s}\right]$
- On right side: DBC c(l,t)=0,005$\left[\frac{mol}{cm^3}\right]$

Find a steady state concentration profile for diffusion coefficient $D = 10^{-5}\left[\frac{cm^2}{s}\right]$.

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 $4{,}1868 \cdot 10^{-5}$ [m^2/s]