# Exercise 2.1-2

## Derive numbers for $v_0$, $v_D$, $\tau$, and *l*

- Show that the claims made in the backbone text are actually true (for room temperature = **300 K**). Use the following equations taken from the backbone:
  - For the average velocity $v_0$ of a particle zooming around in the crystal:

$$v_0 = \left(\frac{3k_BT}{m}\right)^{1/2}$$

  - For the mean time $\tau$ between scattering:

$$\tau = \frac{\sigma \cdot m}{n \cdot e^2}$$

  - For the drift velocity $v_D$

$$v_D = -\frac{E \cdot e \cdot \tau}{m}$$

  - For the mean free path length *l* obtained for $v_D$ **= 0**:

$$l = 2 \cdot v_0 \cdot \tau$$

- Of course, you need numbers for the concentration ***n*** of the free carriers and for the specific conductivity σ
  - Since we are essentially considering metals, you assume for a start that you have **1** free electron per atom if you want to find a number for ***n***. Here are a few data needed for the calculation:

| Atom | Density [kg $m^{-3}$] | Atomic weight [$1.66 \cdot 10^{-27}$ kg] | Conductivity σ [$10^7\ \Omega^{-1}\ m^{-1}$] | Atomic density *n* [$m^{-3}$] ??? |
|---|---|---|---|---|
| Na | 970 | 23 | 2.4 | |
| Cu | 8.920 | 64 | 5.9 | |
| Au | 19.300 | 197 | 4.5 | |

- You may run into some trouble with the dimensions. Just look at conversions from, e.g. **eV** to **J**, from Ω to **V** and **A**, and at the relations beween Volt, Ampere, Watts and Joule.

**Solution**