

Solution to Exercise 3.2-3

Illustration

How large will be the distance **d** between the (center of gravity) of the positive and negative charges for reasonable field strengths and atomic numbers, e.g. the combinations of

- 1 kV/cm
- 100 kV/cm
- 10 MV/cm
- , the last one being about the ultimate limit for the best dielectrics there are,
- $z = 1$ (H, Hydrogen)
- $z = 50$ (Sn (= tin), ...)
- $z = 100$ (?)

From the backbone we have a relation for **d** as a function of **z**, **m** the radius **R** of the atom, and the field strength **E**:

$$d_E = \frac{4 \pi \epsilon_0 \cdot R^3 \cdot E}{ze}$$

We need to look up some number for the radius of the three atoms given (try this link), then the calculation is straight forward - let's make a table:

Atom	R	d(1 kV/cm)	d(100 kV/cm)	d(10 MV/cm)
z = 1				
z = 50				
z = 100				

- Compared to the radius of the atoms, the separation distance is tiny. No wonder, electronic polarization is a small effect *with spherical atoms!*

Calculate the "spring constant" and from that the resonance frequency of the "electron cloud" (assume the nucleus to be fixed in space).

If you don't know off-hand the resonance frequency of a simple harmonic oscillator - that's fine. If you don't know exactly what that is, and where you can look it up - you are in deep trouble.

- Anyway, in [this link](#) you get all you need. In particular the resonance (circle) frequency ω_0 of a harmonic oscillator with the mass **m** and the spring constant **k_S** is given by

$$\omega_0 = \left(\frac{k_S}{m} \right)^{1/2}$$

- How large are the spring constants? That is question already answered in the backbone, so we import the equation

$$k_S = \left(\frac{(ze)^2}{4 \pi \epsilon_0 \cdot R^3} \right)$$

Again, let's make a table for the answers:

Atom	Spring constant	ω_0
$z = 1$		
$z = 50$		
$z = 100$		