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**		