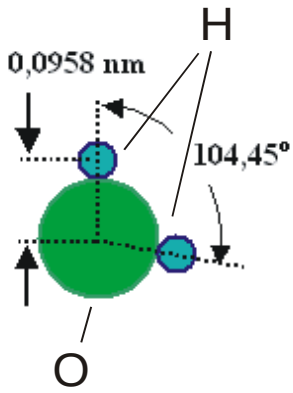
Prof. Dr. H. Föll
Chair for general materials science

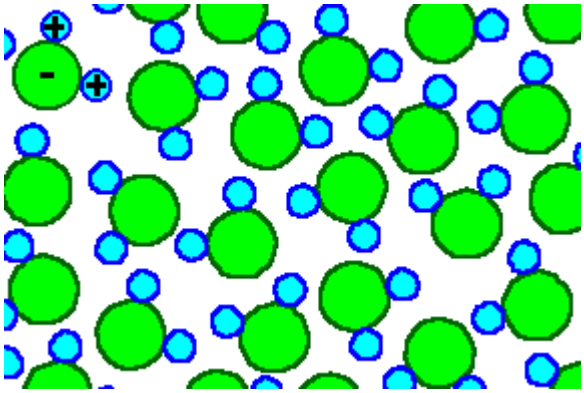
Exercises " Advanced materials B"

#4

Exercise 4: Orientation polarization



(a)



(b)

Fig. 1: (a) H_2O molecule, **(b)** Schematic snapshot of the distribution of water molecules in a liquid.

The permanent dipole moment of a single water molecole is $p = 6*10^{-28}$ Ccm and the molar weight of water is M = 18 g/mol**.** Without an external electrical field all dipoles are oriented randomly.

a) Draw the direction of the dipole moment of each H_2O in **Fig. 1b**.
b) What is the sum of the dipole moments in this case?
c) How may the dipole distribution look at the next snapshot a few ms later?
d) Calculate the molecular density of H_2O!
e) Calculate the polarization for the case that all dipoles are aligned along the field!
f) Describe qualitatively how the dipole configuration changes if a field is applied!

The dielectric constant of water is ε_r = 78.5.
g) If you use the macroscopic polarization formula $P = \chi \cdot \varepsilon_0 \cdot E$, what polarization results at E = 100000 V/cm? What does this mean physically, or better, how could the dipoles be distributed on a snapshot like in **Fig. 1b**?
h) Draw and discuss the polarization as a function of the external field strength. Use the three polarization values you have (no field; E = 100000 V/cm; all dipoles aligned).
i) Explain why $SiCl_4$ only has ε_r = 2.4, while CHN has ε_r = 114 (all liq. @ 20 °C)!
j) What happens when the liquid freezes?