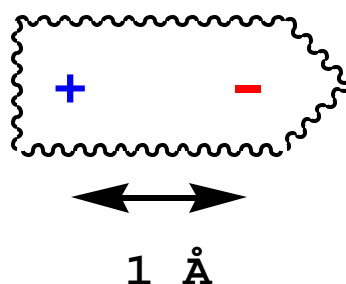


## Dipole Moments\*

We will not cover this topic in class but the following provides a brief review. In most covalent bonds, the bonding e's are not shared equally by the two connected atoms because the atoms have different electronegativities. This gives rise to a "bond dipole" and the vector addition of all bond dipoles produces a molecular dipole. That is, there is an overall charge imbalance in the molecule and the molecule has a dipole moment that can be measured experimentally.



The above blob represents some molecule with centers of + and - charge separated by 1 Å. If the magnitudes of the charges are +1 and -1 (electron units), then the dipole moment of the blob would be....

$$m = Q * d = 4.8 \text{ D}$$

The Debye (D) is the standard unit used for dipole moments. Ignore the treatment given in your text book which shows  $3.336 \times 10^{-30} \text{ C}\cdot\text{m} = 4.8 \text{ D}$  and just remember that  $(1 \text{ e}) \times (1 \text{ Å}) = 4.8 \text{ D}$ .

Use  $[4.8 \text{ D}/\text{e}\cdot\text{Å} = 1]$  as a conversion factor. This is all you need.

If the dipole moment and d are known (experimentally measured), then Q can be

calculated. Note that we calculate the magnitude of  $Q$ . It is unsigned.

**Example:**  $\mu$  of H-Cl is 1.08 D and the H...Cl distance ( $d$ ) is 1.36 Å. What is  $Q$ ?

$$1.08 \text{ D} = Q \times 1.36 \text{ \AA}$$

$$Q = \frac{1.08 \text{ D}}{1.36 \text{ \AA}} \times \left[ \frac{1 \text{ e} \cdot \text{\AA}}{4.8 \text{ D}} \right]$$

$$Q = 0.16 \text{ e}$$

From this calculation for H-Cl, the H and Cl charges are +0.16 and -0.16, respectively.

Note, if a molecule is perfectly symmetrical and contains polar bonds the dipole moment will be exactly 0 D even if there is unequal e-sharing in bonds. A molecule cannot have a dipole moment if the centers of + and - charge coincide. Examples are  $\text{CO}_2$  and  $\text{CH}_4$ . How about water; will it have a dipole moment?

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