Dipole Moments

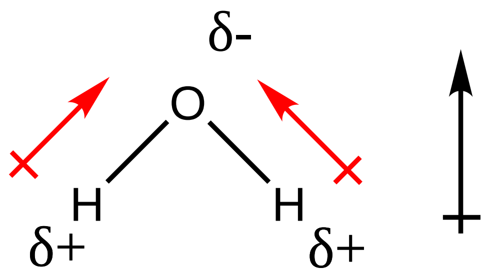
Skills to Develop

- Describe the significance of dipole moments

Dipole moments are a measure of how much how much charge separation exists in a bond or a molecule. We have talked about similar ideas before, because molecular dipole moments are important for solvation. We defined dipoles here when introducing magnetism, and discussed polarity also. To review, the electric dipole moment is defined as

$$\mu = q \times d \tag{1}$$

where q is the partial charge on each end and d is the distance between the charges. "Each end" could mean each end of a bond (each atom), or each end of a molecule, like water. The total dipole moment of a molecule is the vector sum of all the bond dipoles.



The bond dipole moments (red) and total dipole moment (black) in water, shown pointing from positive to negative.

Why do Dipole Moments Matter?

Dipole moments tell us, on average, where the electrons in a molecule are. They can also tell us the shape of molecules. For instance, if H_2O were linear, the 2 O-H bond dipoles would cancel each other out, and the whole molecule would be non-polar. Since we know water is polar, it has to have a bent shape.

Also, molecular dipole moments are very important for many properties, such as ability to dissolve solutes, melting and boiling points, and reactivity in general. Dipole moments (actually, change in dipole moments due to molecular vibration) are also involved in whether molecules absorb certain energies of light, which is important for the greenhouse effect. CO_2 and methane cause climate change because they can absorb IR light. Although these molecules are too symmetrical to have permanent dipole moments, vibrations can produce small temporary dipole moments that allow them to absorb light.

How do we Measure Dipole Moments?

We can measure molecular dipole moments by measuring the dielectric constant of a material (how much the material weakens the Coulomb forces when it is between the charges). Generally, materials with large dipoles have **high dielectric** constants. In Coulomb's law, the dielectric constant D reduces the force between charges.

$$F = \frac{kQq}{Dr^2} \tag{2}$$

Bigger D means less force. To measure bond dipole moments, we can measure the dielectric constants of diatomic molecules (in the gas phase, if the diatomic molecule doesn't exist as a solid or liquid).

Outside Link

- CrashCourse Chemistry: Polar and Non-Polar Molecules (11 min)

Contributors and Attributions

- Emily V Eames (City College of San Francisco)