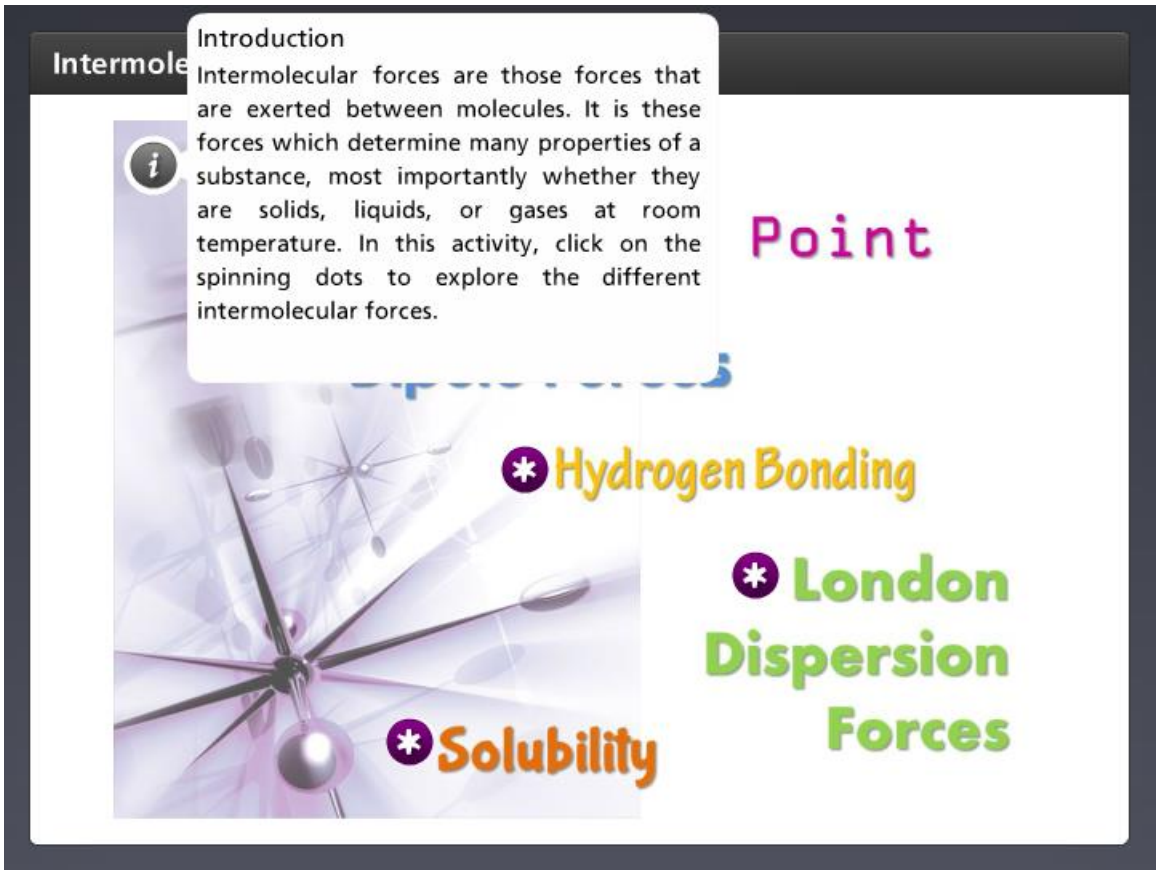
Module 4: Bonding, Formula Writing, and Nomenclature
Topic 8 Content: Intermolecular Forces Notes

Introduction



Intermolecular forces are those forces that are exerted between molecules. It is these forces which determine many properties of a substance, most importantly whether they are solids, liquids, or gases at room temperature. In this activity, click on the spinning dots to explore the different intermolecular forces.

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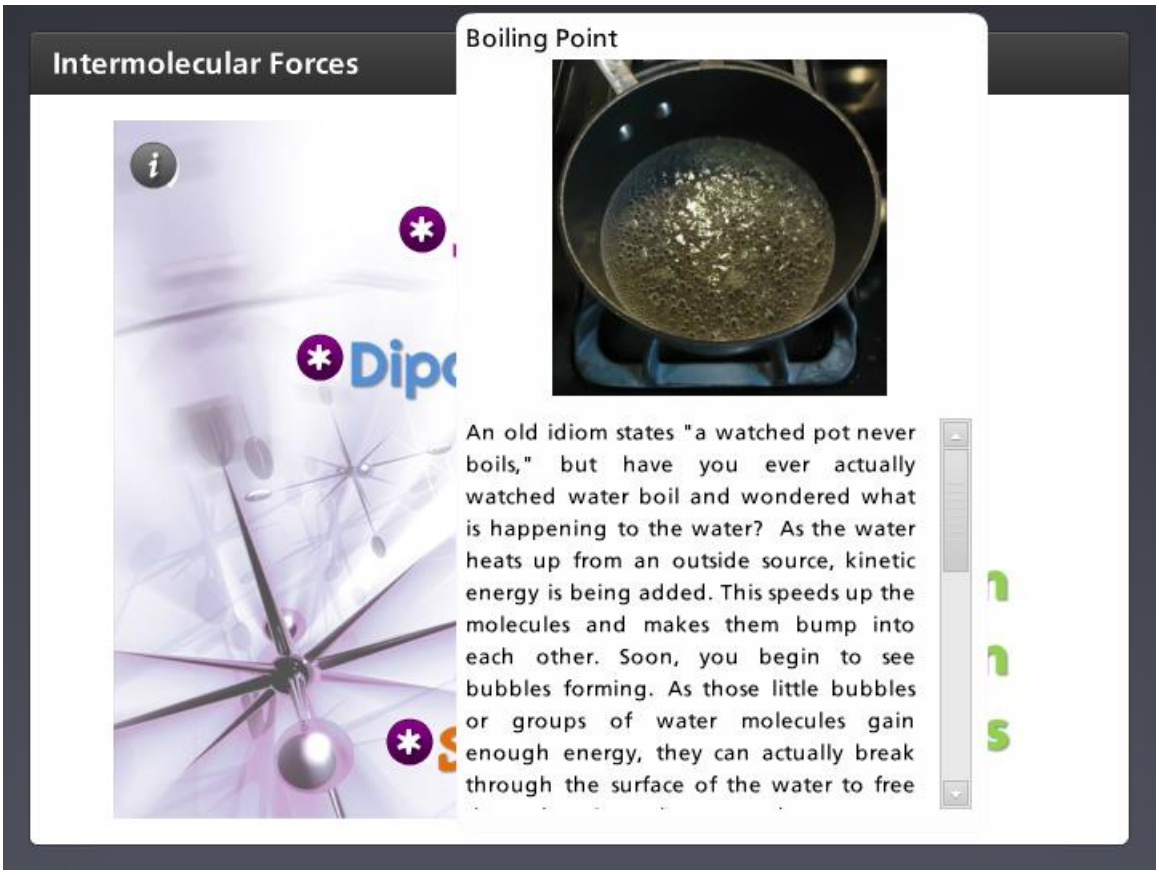
Boiling Point



An old idiom states "a watched pot never boils," but have you ever actually watched water boil and wondered what is happening to the water? As the water heats up from an outside source, kinetic energy is being added. This speeds up the molecules and makes them bump into each other. Soon, you begin to see bubbles forming. As those little bubbles or groups of water molecules gain enough energy, they can actually break through the surface of the water to free themselves into the atmosphere as gas. When this happens, water has reached its boiling point.

Water particles are very attracted to each other, so it takes a lot of energy to break the forces of attraction between the molecules. This means that water has a relatively high boiling point. Other substances, like carbon dioxide, are not so attracted to each other. They will have a fairly low boiling point. Boiling point is a good measure of the forces of attraction between molecules. Remember, the forces of attraction between molecules are termed intermolecular forces. These forces are weaker than ionic and metallic forces. This explains why salts and metals have high melting points and low boiling points.

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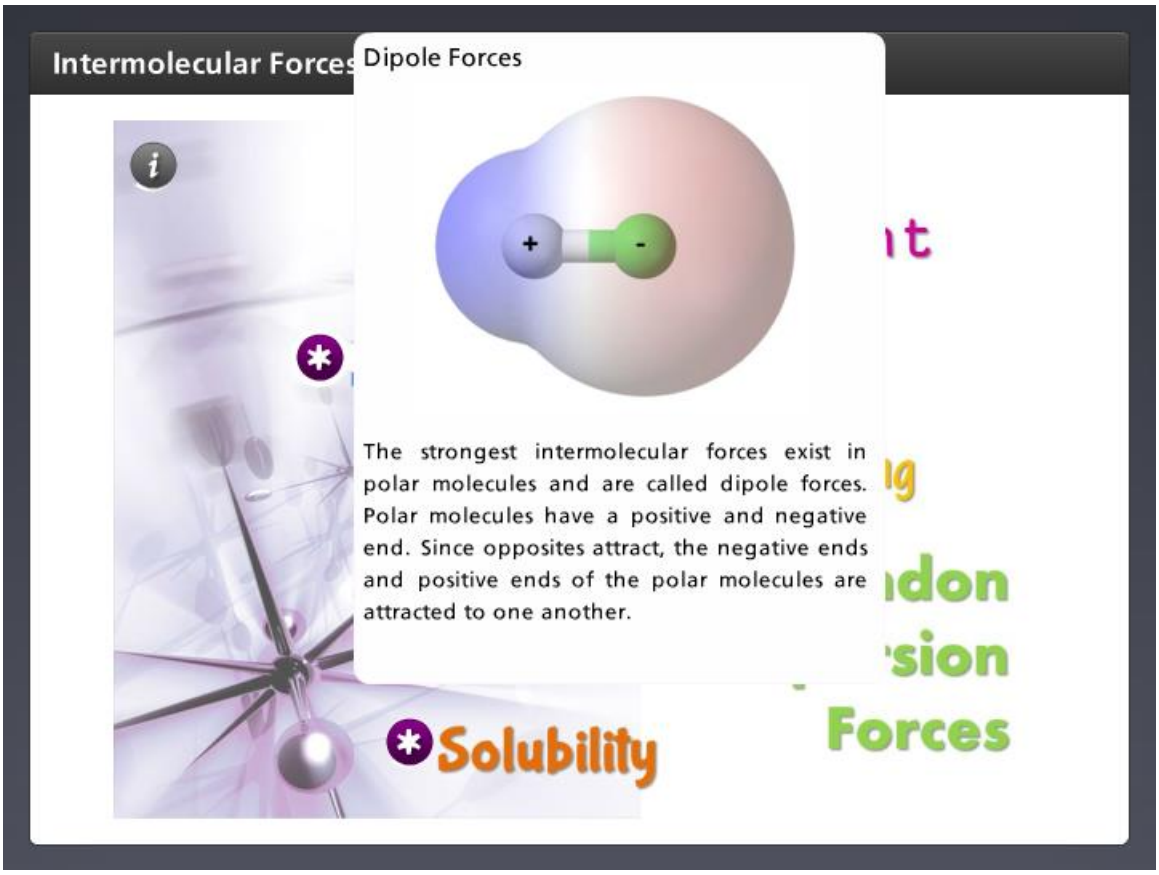
Dipole Forces



The strongest intermolecular forces exist in polar molecules and are called dipole forces. Polar molecules have a positive and negative end. Since opposites attract, the negative ends and positive ends of the polar molecules are attracted to one another.

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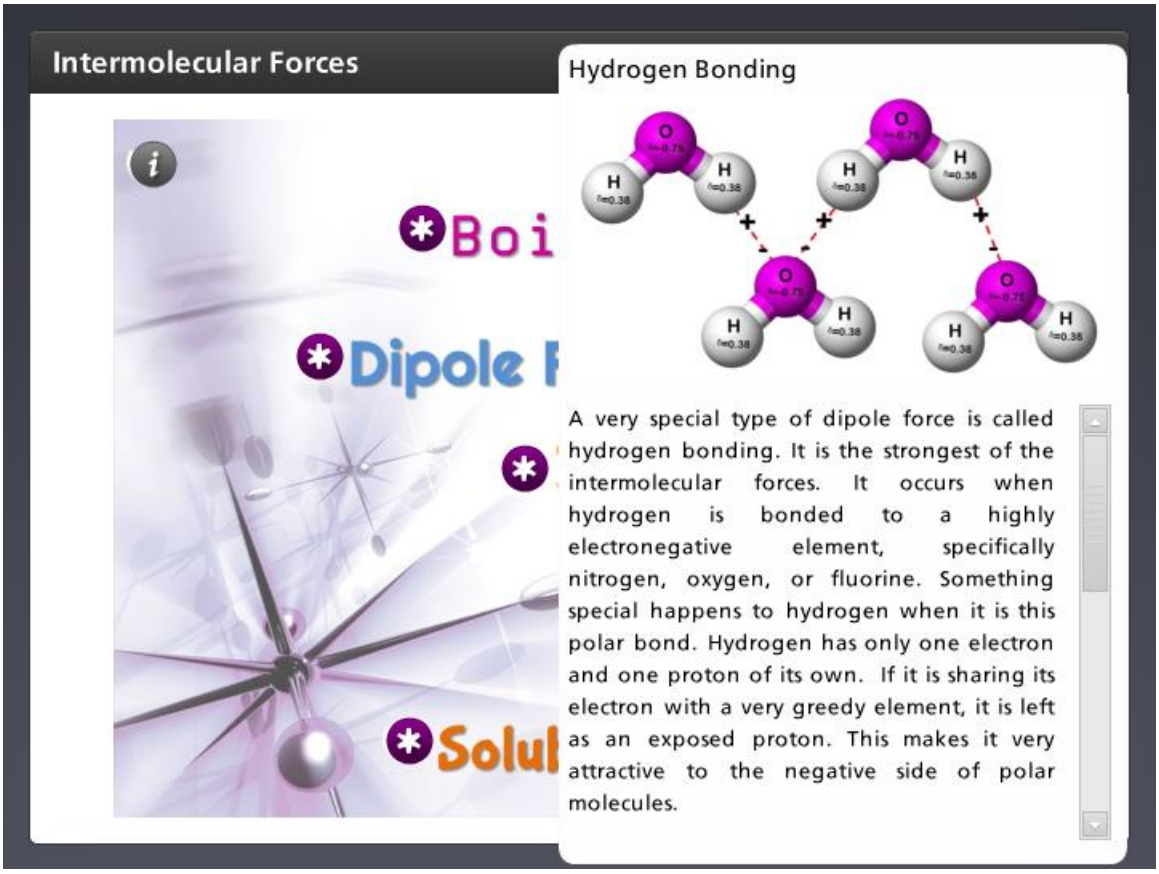
Hydrogen Bonding



A very special type of dipole force is called hydrogen bonding. It is the strongest of the intermolecular forces. It occurs when hydrogen is bonded to a highly electronegative element, specifically nitrogen, oxygen, or fluorine. Something special happens to hydrogen when it is this polar bond. Hydrogen has only one electron and one proton of its own. If it is sharing its electron with a very greedy element, it is left as an exposed proton. This makes it very attractive to the negative side of polar molecules.

One of the most important molecules that exhibits hydrogen bonding is water. This intermolecular force is responsible for some very special properties of water including high boiling point, high heat of vaporization, low vapor pressure, and high surface tension. Water is an extremely good solvent because of hydrogen bonding. Did you know that water expands as it freezes? This is also because of hydrogen bonding. When water is in a liquid state, the molecules are free to move around. As it freezes, the hydrogen bonds hold the water molecules in a rigid framework in which the water molecules are held further apart than they are in the liquid state. This property lowers the density of solid water (ice) allowing it to float on liquid water.

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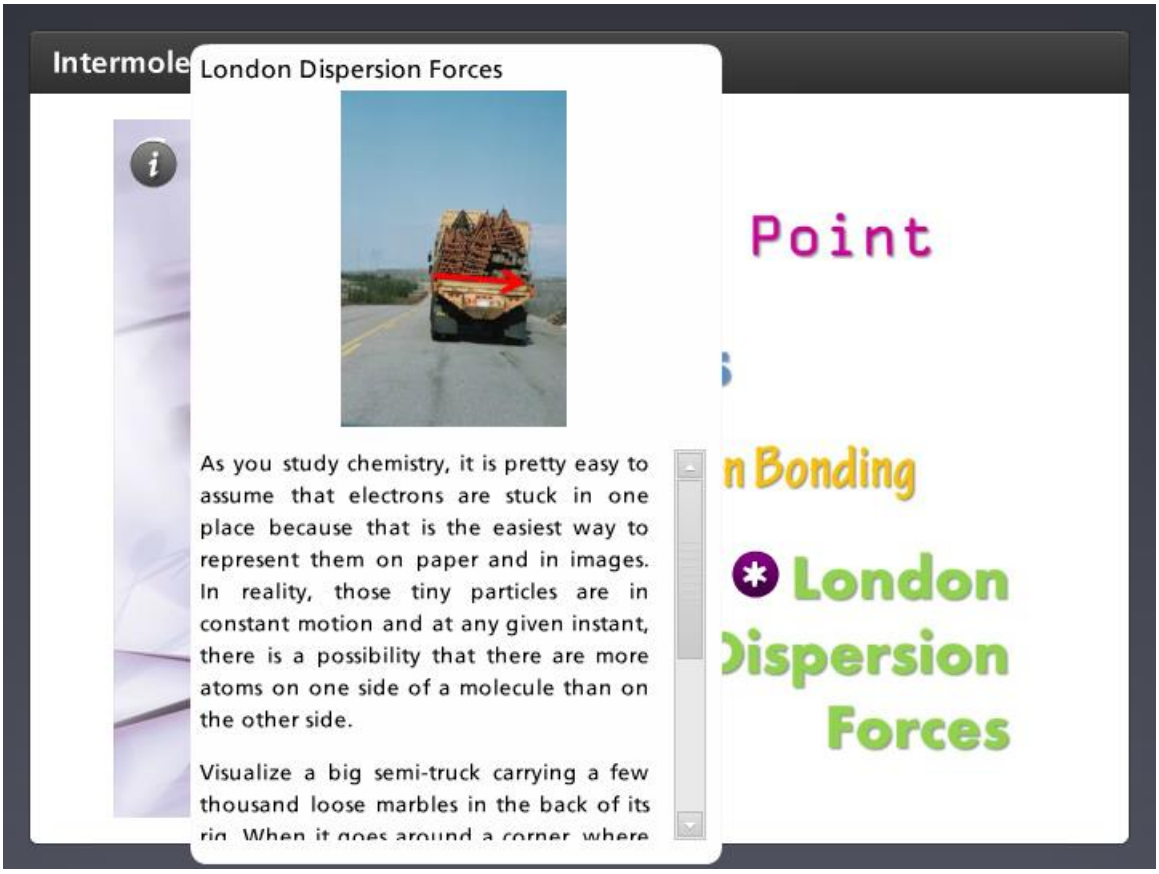
London Dispersion Forces



As you study chemistry, it is pretty easy to assume that electrons are stuck in one place because that is the easiest way to represent them on paper and in images. In reality, those tiny particles are in constant motion and at any given instant, there is a possibility that there are more atoms on one side of a molecule than on the other side.

Visualize a big semi-truck carrying a few thousand loose marbles in the back of its rig. When it goes around a corner, where do the marbles go? All of the marbles would swing to one side of the rig. The same thing is possible in a molecule; the greater the number of electrons, the greater the effect. These forces are termed London dispersion forces. London dispersion forces exist for all molecules, but they are the only intermolecular force for nonpolar molecules.

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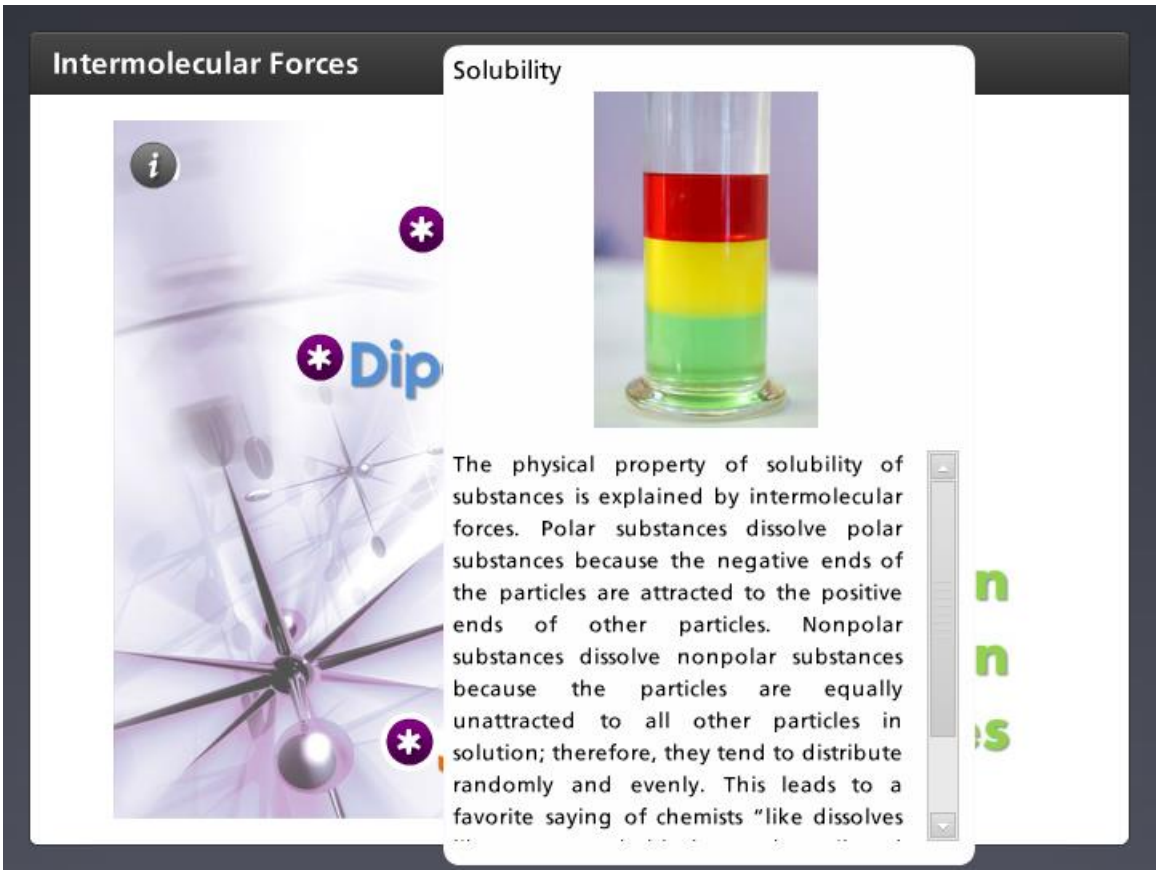
Solubility



The physical property of solubility of substances is explained by intermolecular forces. Polar substances dissolve polar substances because the negative ends of the particles are attracted to the positive ends of other particles. Nonpolar substances dissolve nonpolar substances because the particles are equally unattracted to all other particles in solution; therefore, they tend to distribute randomly and evenly. This leads to a favorite saying of chemists “like dissolves like." You probably know that oil and water will not mix. This is because oil is nonpolar and vinegar is polar.