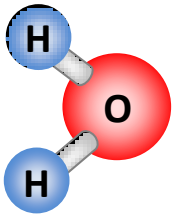
3.6 Water

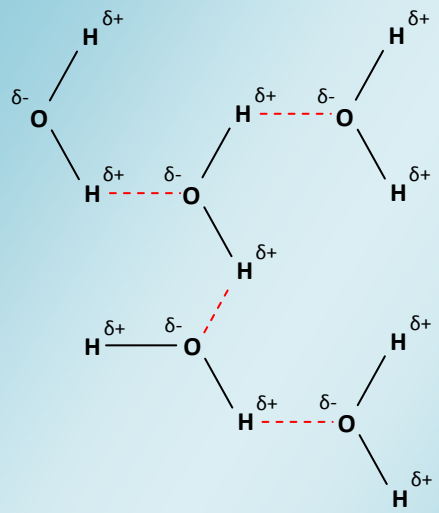
The biological significance of the molecule water



Water is a very special substance, and this is all down to their **hydrogen bonds** (for a detailed explanation of hydrogen bonding and how it works, see 3.1 Biochemistry and Chemical Bonds). The molecule consists of *one oxygen* atom covalently bonded to *two hydrogen* atoms. However, the electrons are not shared perfectly evenly: the oxygen atom is capable of pulling them towards itself and further away from the hydrogen atoms. The result is that the oxygen part of the molecule becomes slightly *negatively* charged, and the hydrogen atoms slightly *positively charged*. Water is therefore described as a **polar** molecule (polar means charged internally).

Within liquid water, it is the many thousands of these hydrogen bonds which allow the polymerised molecules to exist as they do, and the fact that they are constantly making and breaking bonds that give it its properties. The network they form allows the molecules to slide over each other as the new bonds form and then break. This makes it more difficult for the water molecules to escape and become a gas, explaining the need to heat it up to 100°C to make it boil.

Hydrogen bonding in water



Hydrogen bonds form between slightly positively charged and slightly negatively charged areas of separate molecules. This happens in water between an oxygen of one water molecule and a hydrogen of another, because the oxygen part of a water molecule tends to drag the shared electrons towards itself, leaving the hydrogen atoms slightly more positive, and causing the oxygen atom to become slightly more negative

At lower temperatures, water has less **kinetic energy** and so they move less readily. Hydrogen forms are forming, but not breaking very frequently – this is because it takes energy to break bonds, but energy is *released* in the making of bonds. When water becomes a solid (**ice**), the hydrogen bonds hold the structure in a **semi-crystalline** form.

The **solubility** of a substance in water depends on whether or not water molecules can interact with the substance. Any molecule which is *polar*, like water is, will dissolve in water. This is because the **solute** (substance being dissolved) has slightly positive and slightly negative parts which can interact with the water molecules. The water molecules will then cluster around the slightly charged parts of solute molecules, which separates solute molecules, so they are dissolved.

Water has many various other properties. One is called **cohesion**, which can be shown if you place a drop of water onto a waxy surface, such as the cuticle of a leaf. It forms a spherical perfect drop. This is because the hydrogen bonds pull water molecules in at the surface.

Its properties in its solid form, *ice*, also are unusual. Strangely, ice is less dense than water. As water cools, its density increases until the temperature reaches 4°C, and then the density decreases again. This property would mean that ice is able to float on liquid water, which it is able to do. When this happens, it insulates the water below, allowing organisms to live under the ice.