Properties of Water

Kimberly Hatch Harrison

Water is known as "the Solvent of Life." The biochemical reactions that keep us alive all happen in a watery environment. That's why it's important to understand the properties of water, even when water is not a direct participant in these reactions.

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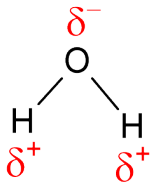
Water is essential for life as we know it. Living cells are 75-95% water, depending on the organism. Biochemical molecules are even classified based on how they interact with water: everything that is soluble in water is called "hydrophilic," while materials that are not water-soluble are known as "hydrophobic."

There are some unusual physical and chemical properties of water that make it well-suited to support life. Almost all of these unusual properties are the result of water molecules being extensively hydrogen bonded to each other.

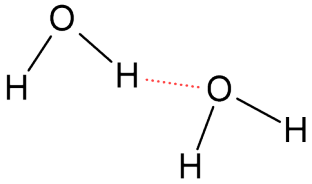
8 Special Properties of Water

1. Water is polar



A single water molecule is held together by polar covalent bonds. Oxygen is more electronegative than hydrogen, so the electrons in the H–O bond spend more time closer to the oxygen atom. That side of the water molecule has a partial negative charge (shown with a lowercase Greek letter delta minus: δ-).The other side (next to the hydrogens) then has a partial positive charge (delta plus: δ+) because the electrons spend less of their time there. The polar nature of water influences all of its interactions with biochemical molecules. Nonpolar (hydrophobic) molecules will act to exclude water, which is another kind of interaction in itself.

2. Water molecules form hydrogen bonds with each other



Pay special attention to this property–it explains virtually all of the unusual behaviors of water. Water molecules are very likely to form hydrogen bonds between different water molecules (*not* within a single water molecule, that's a polar covalent bond).[1] Hydrogen bonds are weaker than covalent bonds. Picture them blinking on and off–that's why they're shown as a dotted line rather than a solid line. This means water, as a material, is fairly interconnected to itself, which leads to several interesting emerging properties.[2]

[1] Common misconception

[2] That is, you don't see these properties from one water molecule–only when you consider many water molecules together.

3. Water is cohesive

Because water is extensively hydrogen bonded, it behaves differently than materials where their molecules are not stuck together. For instance, you can see a drop of water beading up into a round shape (compared to, say, a drop of alcohol that lies flat). This is important when you consider how body fluids move in plants and animals.

4. Water has high surface tension

Because water is extensively hydrogen bonded (and is cohesive), it forms almost a *skin* on its surface. High surface tension means water can support a surprising amount of weight before something sinks. This provides a new place to support some forms of life–like a stick insect or Jesus lizard, running across the surface of a body of water.

5. Water adheres to surfaces

Because of its ability to form hydrogen bonds, water can stick to certain surfaces. This is especially important for moving water (and watery liquids) through living tissues, like how water moves through a plant through the process of transpiration.[3]

[3] The combination of cohesion and adhesion move water molecules in an unbroken column from the roots of a plant all the way up through the leaves.

6. Water has high specific heat

Because of water's extensive hydrogen bonding, it's hard to raise its temperature (compared to other liquids). You have to add enough heat energy to break the hydrogen bonds between water molecules before they are free to start vibrating faster.[4] Because cells are mostly made of water, this makes it easier for living creatures to maintain a constant body temperature.

[4] Increased vibration = increased kinetic energy = increased temperature

7. Water has high heat of vaporization

Because of water's extensive hydrogen bonding, it takes a lot of energy for water to evaporate. Before it can change from liquid to gas, it has to break all those hydrogen bonds holding the water molecules together. Then the individual water molecules can start vibrating with higher kinetic energy, eventually breaking free and leaving as a gas (water vapor). Living organisms can take advantage of this in

the form of "evaporative cooling"–when water evaporates, it carries away heat energy, leaving a cooler animal behind (think of how a dog pants to cool off).

8. Solid water is less dense than liquid water

When water changes from liquid to solid (ice), the molecules are held frozen in a fixed structure. Ice has a lot of open space between water molecules, compared to how they are closer together in liquid water. This is to say, ice is less dense than liquid water[5], which means ice floats on top of liquid water. Again, this provides additional habitats for living organisms (like polar bears). It also insulates the liquid water underneath, keeping fish and other aquatic creatures alive in cold weather.

[5] In most materials, the solid form is denser than the liquid.

Additional Resources

Properties of Water (Video)