Properties of Water

What Makes Water So Special?

Why?
When you hear that NASA’s space probes are looking for ‘evidence of life’ on other planets, do you know what that means? They are looking for evidence of liquid water. Water is fundamental for all life; without it every living thing would die. Water covers about 70% of Earth’s surface and it makes up 65-75% of our bodies (82% of our blood is water). Even if water might seem boring to you—no color, taste, or smell—it has amazing properties that make it necessary for supporting life.

Model 1 – The Molecular Structure of Water

1. How many hydrogen atoms are in a molecule of water?
   There are two hydrogen atoms in a molecule of water.

2. How many oxygen atoms are in a molecule of water?
   There is one oxygen atom in a molecule of water.

3. What holds the hydrogen atoms to the oxygen atom?
   A covalent bond holds the hydrogen atoms to the oxygen atom.

4. The shading around the molecules represents the relative density of electrons shared by the atoms. What does this indicate about the density of electrons around the oxygen atom as compared to the density of electrons around the hydrogen atoms?
   The density of the electrons around the oxygen atoms are much stronger than the density of electrons around the hydrogen atoms.

5. Key Concept: Where is the majority of negative charge on the water molecule?
   The majority of the negative charge in a water molecule is around the oxygen atom.

STOP
6. Looking at your answers to Question 1 and 2 from Model 1, tell what atoms are represented by:
   a. The small, unshaded circles in Model 2.
      The small unshaded circles represent hydrogen.
   b. The larger gray shaded circles in Model 2.
      The larger gray shaded circles represent oxygen.

7. What do the solid lines between the small and large circles represent?
   The solid line between the small and large circles represents a strong covalent bond.

8. According to Model 2, what is represented by the dotted lines?
   The dotted lines represent a weak attraction between the water molecules.

9. Remember that electrons in a water molecule are more dense around the oxygen atom and less dense around the hydrogen atoms.
   a. What kind of charge would the oxygen atom have compared to the hydrogen atoms?
      The oxygen atom has a negative charge.
   b. What kind of charge would the hydrogen atoms have compared to the oxygen?
      The hydrogen atom has a positive charge.

10. Describe the arrangement of the water molecules in Model 2 with one another.
    The hydrogen of one molecule of water is attracted to the oxygen of another water molecule.

11. Describe the cause of the attractions between molecules of water.
    The hydrogen of one water molecule is attracted to the oxygen of another water molecule because oppositely charged ions attract each other.

12. If another water molecule was added to the group in Model 2 at the upper right side, which of its atoms would be connected to the existing molecule with a dotted line? Describe your reasoning.
    The new atom would be oriented so that the oxygen would be connected to the existing hydrogen by a dotted line. This is because the opposite charges of the molecules will attract each other.

STOP
Read This!

The bonding electrons in some molecules are not equally shared between the atoms. These neutral molecules with a difference of charge across the molecule are called polar molecules. Because of the arrangement of the atoms and electrons in a water molecule, there are two differently charged areas of the molecule even though the molecule is neutral overall. The hydrogen molecules are slightly positive, while the oxygen is slightly negative. The positive area charge (hydrogen) of one water molecule is attracted to the negative area (oxygen) of a different water molecule. This weak attraction is often referred to as hydrogen bonding.

13. In the space below, draw 10 water molecules to create a cluster. Be sure to indicate the hydrogen bonds that link the water molecules.
Extension Questions

14. Other polar molecules include nucleic acids and some proteins. Look at the DNA sketch provided and predict how the two strands are attracted to one another. One strand of DNA will contain hydrogen that is slightly positively charged. It will be attracted to a slightly negative ion on the other strand, creating hydrogen bonds to hold the two strands together.

15. Some molecules that are covalently bonded do not have a difference in charge across the molecule. These molecules are referred to as nonpolar. What arrangement of electrons would result in a nonpolar molecule? The electrons will be distributed evenly around both nuclei.

16. Some examples of nonpolar molecules include fats, oils, and waxes. How do these substances interact with water? They separate from the water.

17. What prediction would you make about why oil and water interact in the way described above? Oil is nonpolar and water is polar. Therefore, they do not interact with each other and will separate.