Water Molecule Coloring – based on The Biology Coloring Book & Middle School Chemistry

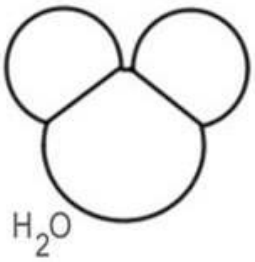
Key Concepts

- The water molecule, as a whole, has 10 protons and 10 electrons, so it is neutral.
- In a water molecule, the oxygen atom and hydrogen atoms share electrons in covalent bonds, but the sharing is not equal.
- In the covalent bond between oxygen and hydrogen, the oxygen atom attracts electrons a bit more strongly than the hydrogen atoms.
- The unequal sharing of electrons gives the water molecule a slight negative charge near its oxygen atom and a slight positive charge near its hydrogen atoms.
- When a neutral molecule has a positive area at one end and a negative area at the other, it is a polar molecule.

The compound with the emperical formula H_2O is familiar to yus as water. Because of the peculier orbitals that elevtrons "like" to occupy, the water molecule is not symmetrical. The two hydrogen atoms are more toward one side than the other.

The electrons that that the oxygen is sharing with the hydrogen are not shared equally. They spend more time around the oxygen atom atom than the hydrogen atom. This gives the oxygen atom a distinct, but weak, negative charge. The electrons spend enough less time around the hydrogen's atom atoms that they don't quite neutralize the positive charge of they hydrogens protons so the hydrogen's protons, so the hydrogen atoms aquire a distinct, but weak, positive charge. Such molecules are called "polar" because they have distinctive regions or "poles" with opposite electric charges. Since water molecules are polar, they are able to dissolve ionic compoinds readily.

HYDROGEN (yellow)
OXYGEN (red)



COLOR the water molecule as indicated.
Label the one oxygen & two hydrogen, indicating which are positive & negative

Key Concept

- Water molecules attract one another based on the attraction between the positive end of one water molecule and the negative end of another.

Water molecules are rather strongly held together by the attraction between the positive charges on the hydrogen atom of one water molecule and the negative charges on the oxygen atom of other water molecules. Such bonds between hydrogen atoms in a polar molecule and a negatively charged atom in some other molecule are called "hydrogen bonds." They are of great importance in determining the behavior of water.

COLOR the water molecules as you did above.
COLOR the areas where the hydrogen bonds form **BLUE**

11 Water Molecules

1. The oxygen atom of H_2O has a (positive, negative) charge. (circle one)
2. The hydrogen atoms of H_2O have a slight (positive, negative) charge. (circle one)
3. When molecules have regions with opposite electrical charges they are referred to as:
4. Since water molecules are polar, they can do what easily to ionic compounds?
5. Do water molecules have a strong attraction to each other?
6. What are the bonds called between a hydrogen atom in a polar molecules & a negatively charged atom?

12
UNUSUAL PROPERTIES OF WATER

Modern chemistry and physics have disclosed that water is vastly different from almost any other small molecule. Its unusual properties are a direct result of the polar nature of the water molecule explained in Plate 11.

Color title A and the related illustration.

Water is not only a *good solvent,* it is the best. It dissolves more different substances than any other solvent known. This is because so many other molecules are ionic or polar, and their electrical charges make them attracted to the water molecules, causing them to stay in solution. Thus we find that water dissolves many kinds of salts and sugars, many proteins, such as gelatin, and a variety of hormones that dissolve in our blood (since blood is mostly water) and regulate various life processes. Even nonpolar molecules dissolve to some extent if they are small. Thus enough oxygen dissolves to allow fish and other aquatic animals to survive, and enough carbon dioxide dissolves to enable algae and many plants to live underwater.

Color title B and the related illustration.

A capillary is any tube of extremely small diameter, including the tiniest of our blood vessels. If a capillary tube is made of glass or any other substance that is polar, water will spontaneously climb up inside it without having to be pumped in any way. The smaller the tube, the higher the water climbs. The attraction is so great between the water molecules and the molecules of the tube that water will climb in defiance of the force of gravity. This is termed *capillary action.*

Color title C and the related illustration.

Water is also unusual in being able to absorb a lot of heat energy without having its temperature increase by very much. (A scientist would say it has a *high specific heat.*) An amount of heat that will raise the temperature of a container of water by 10 degrees will raise the temperature of an equal weight of alcohol by 20 degrees and an equal weight of iron by 94 degrees. Water molecules are held together so strongly by their hydrogen bonds that an amount of heat that will get other molecules moving much faster will not speed up water molecules much at all. This property of water helps to reduce temperature fluctuations in the animal or plant body, and it also makes for mild climates in the vicinity of large bodies of water.

Color titles D and E and the related illustrations.

Heat of vaporization is the amount of heat energy required to evaporate a given weight of a liquid. Water has a very *high heat of vaporization,* which means that it takes a lot of heat to evaporate just a little water. This keeps water in many more lakes and ponds during the summer than would be the case if water had a lower heat of vaporization. Heat of fusion is the heat energy that must be removed from a given weight of water in order to freeze it. Water's relatively *high heat of fusion* means that it takes much longer for lakes and streams to freeze in the winter, allowing living things more time to adjust to the change.

Color title F and the related illustration.

Hydrogen bonds hold water molecules together so tightly that the water's surface acts like a membrane. The insect known as the water strider is actually able to walk on that surface without breaking through.

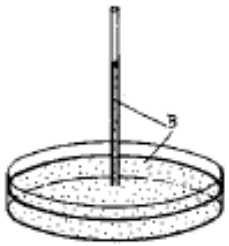
Color title G and the related illustration.

Almost everything contracts when it is cooled, and water is no exception, up to a point. That point is 3.8°C. When cooled below that temperature, water molecules slow down and start to arrange themselves into a crystal structure in which each water molecule is hydrogen-bonded to four other water molecules. This structure is completed when the water freezes. What is most unusual is that this crystal structure takes up more space than the same molecules did in the liquid state, so ice is less dense than water, and it floats. The water below is still at 3.8°C. Since ice is a good insulator, lakes and ponds can freeze over in the winter without freezing all the living things in the water below. If ice didn't float, lakes would freeze from the bottom up, and many of them would eventually freeze solid, killing all life in them.

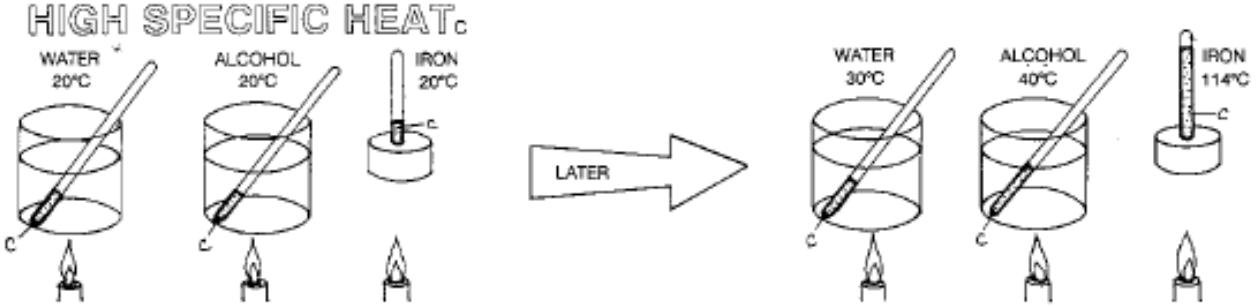
UNUSUAL PROPERTIES OF WATER.

GOOD SOLVENT A

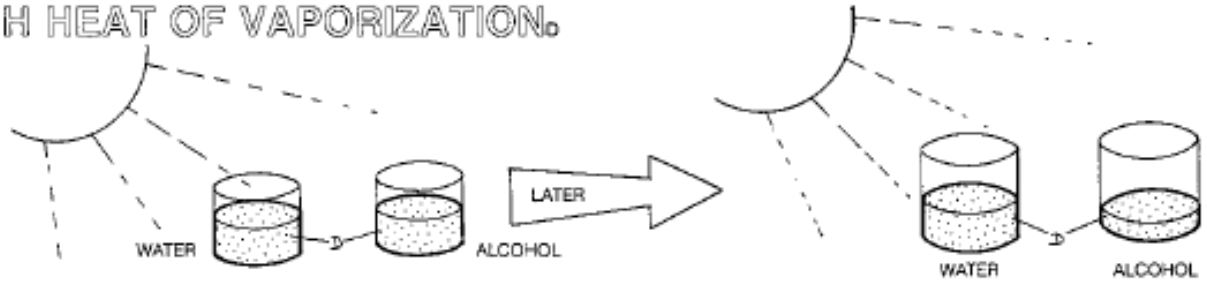
CAPILLARY ACTION B



HIGH SPECIFIC HEAT C



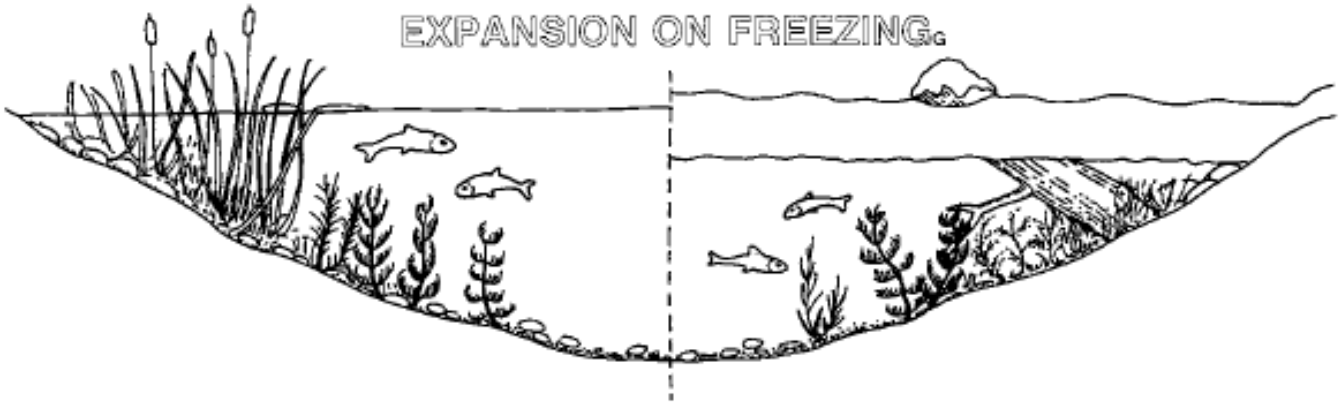
HIGH HEAT OF VAPORIZATION D



HIGH HEAT OF FUSION E

HIGH SURFACE TENSION F

EXPANSION ON FREEZING G



12 Unusual Properties of Water

1. How does water compare as a solvent?

2. Why is water such a good solvent?

3. What is a capillary?

4. What will water do in a tube made of glass or a polar substance?

5. What is this defiance of the forces of gravity termed?

6. What is it called that water can absorb a lot of heat energy without having its temperature increase?

7. How does having a high specific heat affect plants or animals?

8. What is it called that water takes a lot of heat to evaporate it?

9. How does having a high heat of vaporization affect lakes & ponds?

10. What is it called that water needs a lot of heat energy to be removed before it freezes?

11. How does having a high heat of fusion affect lakes & streams?

12. Hydrogen bonds hold water molecules together so tightly that the water's surface acts like a ____.

13. At what temperature do water molecules contract & begin to form a crystal structure?

14. Is ice more or less dense than water?

15. What would happen if ice didn't float?