Name_____
Period:_____ Date:_____

Unit 7: Water The Universal Solvent

Water is a chemical! *H_2O*

The formula H_20 tells us that one molecule of water is comprised of 2 atoms of hydrogen and one atom of oxygen bonded together. The bonds which hold the hydrogen and oxygen together are called covalent bonds - they are very strong.

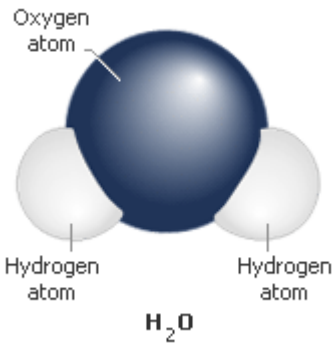
Water plays an important role as a chemical substance. Its many important functions include being a good solvent for dissolving many solids, serving as an excellent coolant both mechanically and biologically, and acting as a reactant in many chemical reactions.

Blood, sweat and tears... all solutions of water.

Here are ten properties of water that are familiar to us all:

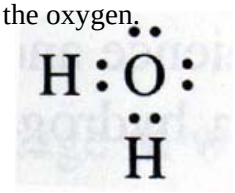
1. It's colorless
2. It's odorless
3. It dissolves nearly everything
4. It exists in three forms: liquid, solid, gas
5. It sticks together into beads or drops;
6. It's tasteless
7. It feels wet
8. It's distinctive in sound when dripping from a faucet or crashing as a wave
9. It can absorb a large amount of heat;
10. It's part of every living organism on the planet.

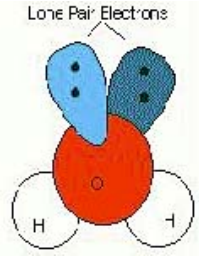
WATER'S STRUCTURE



Why does the water molecule look bent?

The water molecule maintains a bent shape (bent at 107.5 degrees actually) because of two considerations. First the tetrahedral arrangement around the oxygen and second the presence of lone pair electrons on the oxygen.



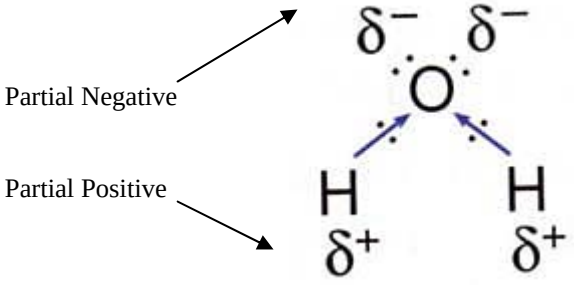


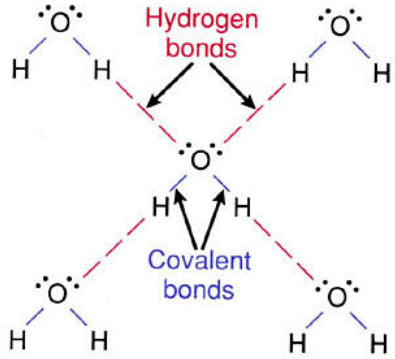
Does this shape make water unusual?

YES! But it's not just that the molecule is bent that makes it special.
Water is also highly *polar* - the two sides of water have very different charge.

WATER FORMS HYDROGEN BONDS

Because water has a slightly negative end and a slightly positive end, it can interact with itself by STICKING to one another. The positive hydrogen end of one molecule can attract the negative lone pair of another water molecule. This interaction is call "Hydrogen Bonding". It is a type of weak electrostatic attraction (positive to negative). Because each and every one of the water molecules can form four Hydrogen Bonds, an elaborate network of molecules is formed.





Hydrogen bonding in water.

ADHESION & COHESION

Water is attracted to other water. This is called *cohesion*. Water can also be attracted to other materials. This is called *adhesion*. Both of these properties are due to hydrogen bonding!

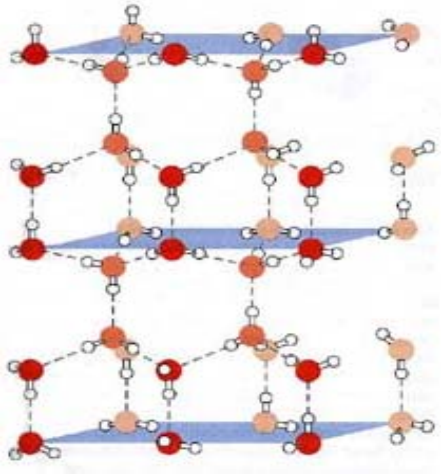
Water's Properties

Water exists in three forms

Water can exist on our planet in three physical states. Water can be a liquid (water), a gas (clouds), or a solid (ice). Think about this. If the ambient conditions of Earth were much cooler (or at higher pressure), we would all be frozen. Alternatively, if the Earth was hotter than Hades, we would be bathed in perpetual clouds (like Venus).

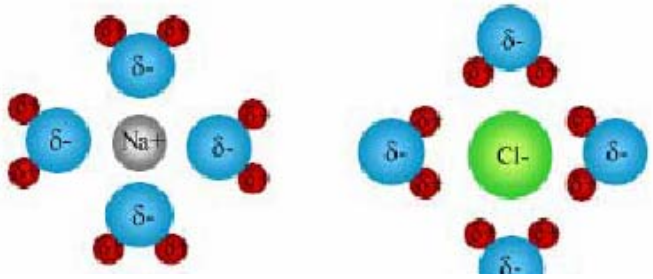
Ice Floats

The solid state of most things are much denser than the liquid state and therefore sink. Usually what happens when a solid is formed is that the molecules become more tightly packed together. But water is weird - the solid state is less dense than the liquid.



Water as a Solvent

The partial charge that develops across the water molecule helps make it an excellent solvent. Water dissolves many substances by surrounding charged particles and 'pulling' them into solution. For example, common table salt, sodium chloride, is an ionic substance that contains alternating sodium and chlorine ions. In a similar fashion, any substance that carries a net electrical charge, including both ionic compounds and polar covalent molecules can dissolve in water. This idea also explains why some substances do NOT dissolve in water. Oil, for example, is a non-polar molecule. Because there is no net electrical charge across an oil molecule, it is not attracted to water molecules and, therefore, it does not dissolve in water.

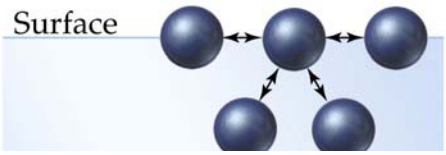


High Specific Heat:

Specific heat of a substance is the heat needed (gained or lost) to change the temperature of 1gram of a substance 1degree Celsius. A Kilocalorie or large C equals 1,000 small calories. It takes 1,000 calories to raise 1,000 grams of water 1 degree C. This high specific heat allows water to act as a heat sink. Water will retain its temperature after absorbing large amounts of heat, and retain its temperature after losing equally large amounts of heat. The reason for this is that hydrogen bonds must absorb heat to break. They must release heat when they form. The Ocean acts as a tremendous heat sink to moderate the earth's temperature.

Surface Tension

Surface Tension: Hydrogen bonding causes neighboring water molecules to be attracted to one another. Molecules at the surface of liquid water have fewer neighbors and, as a result, have a greater attraction to the few water molecules that are nearby. It makes the surface of the liquid slightly more difficult to break through than the interior. When a small object that would normally sink in water is placed carefully on the surface, it can remain suspended on the surface due to surface tension. Surface tension is related to the cohesive properties of water.



Capillary Action

Surface tension is related to the cohesive properties of water. *Capillary action* however, is related to the adhesive properties of water. You can see capillary action 'in action' by placing a straw into a glass of water. The water 'climbs' up the straw. What is happening is that the water molecules are attracted to the straw molecules. When one water molecule moves closer to the straw molecules the other water molecules (which are cohesively attracted to that water molecule) also move up into the straw.

Plants take advantage of capillary action to pull water from the roots into and up their stems.

Name:_____

Due Date:_____

WATER THE UNIVERSAL SOLVENT PRACTICE

1) Water is often called the _____ solvent because many substances can dissolve in it.
(look in the title)

2) The chemical formula for water is _____. The molecule is composed of one _____ atom and two _____.atoms.

3) Is water a part of every living organism on earth? Yes or No. Does pure water have an odor? Yes or No

4) Draw a sketch of water. Make sure to 1) Label the oxygen and hydrogen atoms and 2) Label which atoms carry a partial positive charge and which carry a partial negative charge.

5) What type of bond holds the hydrogens and oxygen in water together?_____

Is this type of bond considered a strong or a weak bond?_____

6) Why is water considered a polar molecule?

7) _____ bonding makes water molecules 'stick' together. When water sticks to other water molecules it is called, _____. When water molecules stick to other molecules it is called _____.

8) How does the structure of water cause it to form hydrogen bonds?

9) What are the three states that water exists on Earth as? _____, _____, _____

Compared to other compounds, do you think it is odd that at room temperature water can exist in this many states? Why?

10) What is weird about the fact that ice floats?

11) What is surface tension?

12) Briefly describe how water dissolves NaCl.

13) Describe why water can NOT dissolve nonpolar substances, like oil.

14) What property of water do plants take advantage of to get water from its roots to its stems?

15) Now that you have read about water, why do you think water forms drops that are round?

16) Water has a high specific heat. This means that water can hold a lot of heat and act like a heat sink. What body of water serve as a heat sink for the Earth?_____

Based on your reading, try these questions…

17) Fish survive through severe winters because of the property of water that allows water to —
    a. form chemical bonds as it freezes, raising the water temperature below the ice
    b. increase in density while it freezes, dissolving more oxygen from the air
    c. expand when it freezes, creating a floating and insulating layer of ice
    d. precipitate vital nutrients when it freezes, increasing the food supply

18) What characteristic of water remains the same no matter what is dissolved in it?
    a. The ratio of hydrogen to oxygen
    b. The ability to refract light
    c. The hydroxide ion concentration
    d. The freezing temperature

19) If the properties of water were to change so that the solid form was denser than the liquid form, organisms living in a cold pond environment would be less likely to survive because water would no longer —
    a. dissolve enough oxygen from the air
    b. produce solutions containing vital nutrients
    c. remain neutral, instead becoming highly acidic
    d. produce a floating insulating layer of ice

20) Which property of water is the main reason it is such an effective solvent?
    a. It's high specific heat
    b. The ease in which it changes state
    c. The polar nature of it's molecules
    d. It's ability to form hydrogen bonds.

21) When water and oil are shaken together, they might appear mixed for a time, but soon separate into layers. Oil and water are not soluble in each other, so they are said to be immiscible. Which of the following factors is the reason oil and water are immiscible.?
    a. The temperature it too low
    b. They were shaken but not consistently stirred
    c. No catalyst was added
    d. Oil is nonpolar and water is polar.

22) Table salt, the ionic compound sodium chloride, dissolved in water. Water's ability to dissolve sodium chloride is related to the
    a. Number of protons present in each atom's nucleus.
    b. Number of electrons present in a water molecule.
    c. Polarity and structure of water.
    d. Amount of solution you are trying to make.

23) Water will not dissolve nonpolar substances , such as grease on clothing. However, adding soap to the water helps remove the grease from the fabric. The best explanation as to why this process occurs is that…
    a. Soap is an ionic substance and ionic substances dissolve in both water and grease
    b. Soap molecules contain sodium or potassium ions, which dissolve grease
    c. Soap molecules have a polar end that dissolves in water and a nonpolar end that dissolves in grease
    d. Water does not dissolve the grease; water just washes the grease away

24) What kind of BEAR will dissolve in water? A _____ bear!