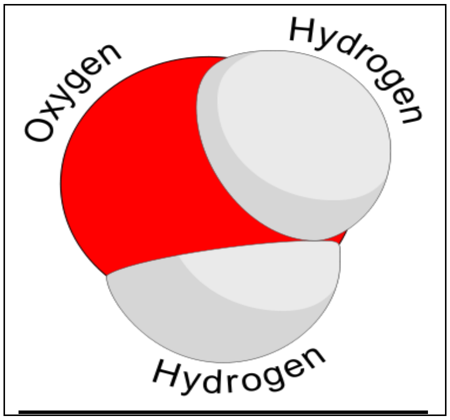
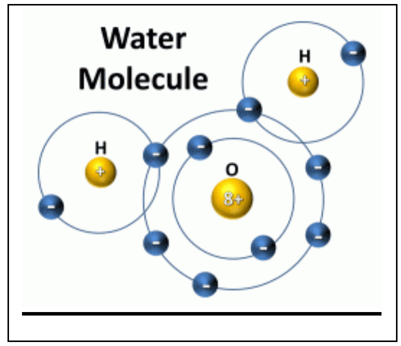
WATER, SOLUTIONS AND pH LAB

BACKGROUND:

BONDS WITHIN WATER MOLECULES:





Two pictures of water molecules are shown above. The first water molecule is a space-filling model. The second water molecule shows how electrons are shared between hydrogen and oxygen. It also shows the relative amount of negative charge possessed by oxygen and explains why the water molecule is polarized.

BONDS BETWEEN WATER MOLECULES

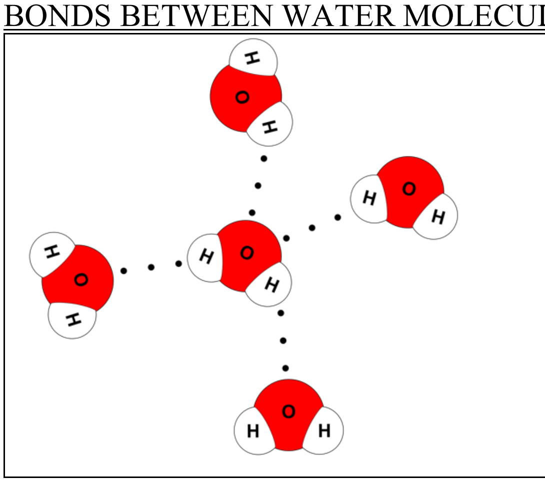


Figure A

Figure A above shows five water molecules. These water molecules are held to each other by hydrogen bonds. Hydrogen bonds occur because the negative charge on the oxygen of one water molecule 'pulls' on the positively charged hydrogen of another molecule. Hydrogen bonds only occur between two water molecules.

The bonds within one water molecule are called polar covalent bonds. In a covalent bond, atoms share electrons. In a 'polar' covalent bond, more of the negative charge is towards one side of the bond, and the positive charge is towards another side of the bond. Therefore, this bond is polarized.

ADHESION, COHESION and SURFACE TENSION

Adhesion is the ability of water to stick to others substances. For example, water can stick to the side of a swimming pool. **Cohesion** is the ability of water molecules to stick to themselves (H-bonds). Cohesion causes the surface of the water to have **tension** and tests can be done to measure the relative tension of different aqueous solutions.

CAPILLARY ACTION

Capillary action, the seemingly magical way in which water is drawn up by tubes with small diameters, involves forces known as cohesion and adhesion. Adhesion causes water molecules to cling to the sides of small pores, cylinders, and other tiny spaces. Cohesion enables water molecules to pull other water molecules up behind them.

SPECIFIC HEAT

Water has a high **specific heat.** Specific heat refers to the amount of energy (heat) required to raise the temperature of a specific substance. Water maintains its temperature well because it would require a lot of energy to change that temperature. This is why people like to live near the water. The temperatures are often much more constant. It is also why the human body is over 60% water. Also, if you are boiling pasta, add salt to the water while waiting for it to boil. Salt breaks the hydrogen bonds between water molecules, and then the surface tension is disrupted and the water molecules move around faster. The specific heat has been lowered. Boiling then occurs.

SOLUTIONS, SOLVENTS, CONCENTRATION, SOLUTES

Water is a **solvent**. Substances dissolve in water. The substances that dissolve in water are called **solutes.** A solute dissolved in a solvent is called a **solution.** The **concentration** of a solution is the amount of a solute dissolved in a solvent. A concentration is expressed in a number of fashions. For example, a percent solution is the number of grams of a solute dissolved in 100 milliliters of water.

LIKE DISSOLVES IN LIKE:

"Like dissolves in like" is a basic rule of chemistry. Water is a polar molecule. The hydrogens are positively charged and the oxygens are negatively charged. The oxygen is very electronegative. It pulls the electrons from hydrogen, making hydrogen more positively charged. Therefore, the water molecule becomes polarized. Polarized means that there is a separation of charges within the molecule. Only polar substances will dissolve in polar substances. Nonpolar means that there is an equal distribution of charge across the molecule. Only nonpolar substances will dissolve in nonpolar substances because "like dissolves in like." Nonpolar substances are hydrophobic (water-fearing). Polar substances are hydrophilic (water-loving). Amphipathic substances have both polar and nonpolar components (e.g. phospholipids that make up cell membranes, which will be discussed in future classes).

pH – THE POWER OF HYDROGEN

pH refers to whether a substance is acid or base. Technically, it is the negative log of the hydrogen ion concentration. But best to think of pH as a measure of how much free hydrogen ion (H^+) is present in a solution. The pH scale runs from 0-14. The low end, below 7, is acid, and the high end, above 7 is basic. 7 is neutral. The numbers are based on powers of 10, and therefore, each number has a ten-fold difference in the concentration of hydrogen ions as compared with the next number. So a substance with a pH of 8 has ten times more hydrogen ions than a substance with pH = 9. Likewise, a substance that has a pH = 7 has 100 times more hydrogen ions than a substance with pH = 9. The higher you go on the pH scale, the fewer the hydrogen ions are free in solution. An acid can also be viewed as a substance that freely gives up its hydrogen ions in solution. HCl is a very strong acid because it rapidly dissociates into free H^+ ion (and free Cl^- ion). HCl is stomach acid. But vinegar is a weak acid (acetic acid) because it does not dissociate and give up free H^+ ions as well as HCl. An example of a very basic solution are your cleaning fluids, such as drain cleaner.

LAB:

ACTIVITY 1 – POLARITY AND THE BONDING OF WATER

Answer the following questions based on your reading above and lecture materials. Use a separate sheet of paper.

1. What causes polarity?
2. Why does polarity allow water to be such a good solvent?
3. How many hydrogen bonds can you see in Figure A above?
4. How many polar covalent bonds would you find in a single water molecule?
5. *Draw three water molecules* hydrogen bonded to one another, using H for hydrogen and O for oxygen. Do NOT draw the space-filling bulbs of the picture presented. Label charges, atoms and bonds.
6. How many hydrogen bonds are in your picture above?
7. How many covalent bonds are in your picture above?

ACTIVITY 2 – THE RELATIONSHIP BETWEEN SALT AND WATER

Measure 10 grams of sodium chloride (NaCl) and add this to a beaker of 100 ml water, and stir the salted water.

Questions:

8. What happened to the salt above?
9. Name the solute, solvent, solution in your situation above.
10. Draw a *molecular* picture of what happens when NaCl is mixed with water. You will have to show that Na separates from Cl. What bonds with what? Do not draw a beaker. Draw molecules!

ACTIVITY 3 – SURFACE TENSION

A - Use a dropper and add water to the top of a penny, counting the drops.

Questions:

11. How many drops could you fit onto the penny?
12. What term have you learned that means "water sticking to itself"
13. What is the property responsible for the term you wrote in the question above?

B - Use salt water from a previous experiment. Use a new dropper. Add drops of salt water to the penny, counting the drops.

Questions:

14. Explain any differences between adding pure water versus adding salt water to the penny.
15. Explain what properties account for differences you observed:
16. When water droplets form a dome-shape on top of a penny, what is holding the water together?

ACTIVITY 4 – POLAR AND NONPOLAR

Observe your instructor's water bottle *filled with cooking oil and water* (which has blue food coloring in it)

Questions:

17. What do you observe?
18. In your observation, which molecules are polar and which are nonpolar?
19. In your observation, which molecules are hydrophilic and which are hydrophobic?
20. Draw a water molecule and label the + and – charges on the molecule to show you understand its polarity.
21. Why does water have this charge separation?
22. Describe what happens (refer to charges) in a hydrogen bond.

ACTIVITY 5 - pH

Using information from lecture, answer the following questions.

Questions:

23. What is pH?
24. Name some molecules that are considered acid. Think of your kitchen
25. Name some molecules that are considered base.
26. Explain why water has a neutral pH
27. Which has more hydrogen ions, an acid or a base?

MATERIALS FOR LAB:

Plastic bottle filled half with cooking oil and half with water
Table salt
250 ml beaker
Gram scale (digital)
Water (tap)
Glass rod or wooden stir sticks
2 pennies
2 plastic droppers (1 ml)