**The Properties of Water Lab**

**Background:**

Water is a polar covalent molecular compound with ionic characteristics that make it perfect to support life processes. In fact, organisms are made up of 40 to 95 % water. The following lab will introduce you to some of the characteristics of this precious liquid.

This lab will investigate the following properties of water:

-surface tension

-cohesiveness

-universal solvent

-capillary action

-high latent heat

-high density in liquid phase

You should also realize that all properties of water are consequences of the chemical arrangement of the water molecule.

Water, H2O, is a polar molecule. The oxygen atom shares the pair of electrons with hydrogen in an unequal manner. Since oxygen is more electronegative than hydrogen, it has the tendency to pull the electrons towards itself more than hydrogen does. Consequently, a partial charge results at each end of the water molecule. Oxygen will have a negative partial charge and hydrogen will be slightly positive.

These partial charges result in the ability of water to exhibit what is called in chemistry as an intermolecular force, specifically a Hydrogen bond, a weak yet important attraction between the hydrogen of one molecule and the oxygen of a neighbor water molecule. H-bonds are important because they allow water molecules to:

1. stick to other water molecules -cohesion

2. stick to surfaces- adhesion

3. absorb large amounts of heat before changing phase or boiling – high latent heat

4. dissolve numerous substances - Universal solvent

As you try to find an ideal definition for each one of the properties mentioned above (in bold), keep in mind the chemical composition of water we just reviewed. Remember also the definition of the states of matter: solid, liquid, and gas. A common misconception among students is that a water molecule breaks up into its components -H and 0- when it becomes a gas. What actually happens is that the H-bonds between water molecules break allowing the water molecules to detach from each other as they change from a liquid to a gas. If individual H2O molecules dissociated when in gaseous state, we would not call them "water vapor".

Solutions are homogeneous mixtures comprised of a solute (the dissolved substances) mixed in a solvent (what it is dissolved in). In living systems water is considered the universal solvent. Solutions are physical combinations, not chemical combinations.

As we discussed in class, there are two types of covalent bonds, polar and non-polar. Molecules joined by polar covalent bonds are not "sharing" the electrons evenly and will have resulting areas of partial charge around different areas of the molecule. Molecules joined by nonpolar covalent bonds are "sharing" the electrons evenly and will not have areas of partial charge around the molecule. Ions are single atoms or groups of atoms that have gained or lost electrons and now have a resulting charge.

This lab explores the interaction of various solvents and solutes related to the specific characteristics of their bonds. We will be looking at two different types of crystal solids and two types of liquid solvents. While we are investigating physical "mixtures", the chemical nature of the solvent and solute will impact the resulting solution.

There are many ways that this is relevant to life. Water is a very polar molecule. The oxygen has a partial negative charge and the hydrogens have a partial positive charge. Salts are comprised of positive ions and negative ions. The negative end of water is attracted to and surround the positive ions and the positive end of water are attracted to and surround the negative ions. Most biologically important small molecules in our body are either polar or salts. Water is the ideal solvent to dissolve them all. We can apply the same argument to oceans and rivers. They also dissolve important nutrients for all the life forms that call these bodies of water home.

Oils and detergents also have important properties with water. Oil is not soluble in water. We observe this when we observe that water and oil do not mix. Water is polar and oil is very non-polar. They avoid each other. Since oil is lighter than water it floats, and if you look at the top of the water, most of the oil will accumulate in one glob, minimizing its surface with the water. When you shake it and force the oil to go into solution, it forms little balls, because the spherical shape has the smallest surface area with water for any given volume. When the balls of water get very small, they can stay suspended in the water for longer, but will eventually float to the surface again and reform the glob.

Detergents are molecules which have polar ends, usually charged, which love water and non-polar ends, which love grease. When we shake the water, oil and detergent, the non-polar end of the detergent becomes embedded in the grease ball (like dissolves like) leaving all the polar ends of the detergent facing the water. Thus, the small droplets of oil have become surrounded by the detergent. The surface of this new "fuzzy" grease ball is the polar ends of the detergent, which have an affinity for water and can stay suspended in it longer, and do not stick to the side of the bottle to avoid water, like the grease alone did.

Water organizes detergent into soap bubbles. In the soap bubble, the detergent forms a water sandwich, with detergent as an outer and inner layer and water in the middle. Of course, the polar ends of the detergent face the inner water layer and the non-polar ends of the detergent are on the outside. Alcohol is not polar enough to do this very well.

Water's chemical formula is H2O. As the hydrogen atoms are "attached" to one side of the oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are and a negative charge on the other side, where the oxygen atom is. This uneven distribution of charge is called polarity. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." As the right-side diagram shows, the side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of a different water molecule. (If the water molecule here looks familiar, remember that everyone's favorite mouse is mostly water, too). This property of water is known as cohesion.

All these water molecules attracting each other mean they tend to clump together. This is why water drops are, in fact, drops! If it wasn't for some of Earth's forces, such as gravity, a drop of water would be ball shaped -- a perfect sphere. Even if it doesn't form a perfect sphere on Earth, we should be happy water is sticky. Water is called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals, and nutrients.

Water, the liquid commonly used for cleaning, has a property called surface tension. In the body of the water, each molecule is surrounded and attracted by other water molecules. However, at the surface, those molecules are surrounded by other water molecules only on the water side. A tension is created as the water molecules at the surface are pulled into the body of the water. This tension causes water to bead up on surfaces (glass, fabric), which slows wetting of the surface and inhibits the cleaning process. You can see surface tension at work by placing a drop of water onto a counter top. The drop will hold its shape and will not spread.

In the cleaning process, surface tension must be reduced so water can spread and wet surfaces. Chemicals that are able to do this effectively are called surface active agents, or surfactants. They are said to make water "wetter." Surfactants perform other important functions in cleaning, such as loosening, emulsifying (dispersing in water) and holding soil in suspension until it can be rinsed away. Surfactants can also provide alkalinity, which is useful in removing acidic soils

**Investigating the Properties of Water: Lab Procedures**

 Part A. Pennies

1. How many drops of water do you think will fit on the head of a penny?

 Make your hypothesis here.

2. Using a dropper slowly drop water onto a penny counting each drop.

 How many drops of water did fit on the head of a penny? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. What does this activity tell you about one of water’s properties?

4. Draw what the penny looks like, as viewed from the side, before it overflowed.

Part B. Wax Paper

5. Place several drops of water on a piece of wax paper. You may use a drop of food coloring to color the water if you wish.

 What happens to the water droplets as you roll them around on the wax paper?

6. What does this activity tell you about one of water’s properties?

7. Give the scientific term used to describe the property of water you discovered in parts A and B.

 Explain this property in molecular terms.

Part C. Soap

8. Place a couple drops of water on your piece of wax paper. Add some pepper to the top of the water drops.

 Draw a diagram of the water droplet from the side perspective.

9. Place a toothpick in soap and dip it into the water droplet.

 Draw a diagram of the result.

10. What effect does soap have on water? Use scientific language you learned in parts A and B in your answer.

 Explain this effect in molecular terms.

Part D. Surface Tension

11. Fill a beaker or cup till it is just about to overflow

 Balance a paper clip on the surface of water,. (hint: don’t let your fingers touch the water)

 Touch the paper clip once it is balanced. What happens?

12. Balance the paper clip again. Add a few grains of detergent to the water and record what happens.

 What does this tell you about the properties of water?

13. Clean the beaker so there is no detergent remaining.

Part E.

14. Fill a cup 1/3 of the way with water.

15. Add two drops of food coloring to it. Allow the water to become a uniform color before moving on to the next step.

16. Add a small amount of cooking oil to the beaker of water.

17. Describe what happened when the water and oil were poured into the same cup.

18. Empty the contents of your cup into the sink, and clean the interior of the beaker.

19. Using the same beaker (which should now be clean), add a small amount of salt to a cup filled with water.

20. Describe what happened when the salt and water were placed in the same beaker.

21. Rinse the contents of the cup in the sink, and clean the inside of the beaker.

Part F.

1. In a clean, **dry** cup, add a small amount of baking soda. Then add a small amount of cream of tartar.

2. Describe what happened when the dry baking soda and dry cream of tartar were mixed.

3. Now, slowly add water to the mixture.

4. Describe what happened when water was added to the mixture of baking soda and cream of tartar.

5. Rinse the contents of the cup in the sink, and clean the cup.

**Analysis**

 Part I. Polarity of water

 Water is a polar molecule, meaning it has one end with a slight positive charge and another end with a slight negative charge. Molecules without positive and negative ends are called nonpolar. As a general rule, water is good at dissolving polar and ionic compounds, but does not dissolve nonpolar compounds.

1. Based on your observations for part I, which substance was nonpolar, the cooking oil, or the salt? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Based on your observations for part I, which substance was polar or ionic? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Part II. Water as a catalyst for chemical reactions

 Water is needed for most chemical reactions that take place within living organisms.

3. What evidence do you have, based on your observations in part II, that water is needed for a chemical reaction to take place?

Parts III and Surface Tension and Cohesion

 Water molecules are attracted to each other because of their polarity. The positive and negative ends attract one another like magnets. This attraction is called cohesion. They stick together. At the surface, this produces a “film” that covers the surface and holds it. This film is called surface tension.

 4. When you placed the paper clip on top of the water, was it floating? If not, then what was holding it up?

 5.Why do you think the paper clip sank to the bottom of the beaker when you added a drop of mild detergent to the beaker?

Part IV. Cohesion and Adhesion

 When water sticks to something, we call this adhesion. When you step out of the shower and see tiny droplets of water on your skin, that is an example of adhesion. In a plant, cohesion and adhesion help the plant by allowing water to travel upwards away from the roots to deliver water to all parts of the plant.

 6.Explain why the penny was able to hold so many drops of water before it overflowed.

 7. What caused the water to spill over?

 8. How did the droplet of water on the surface of the penny demonstrate both adhesive

 and cohesive properties of water?

**Teacher Materials List**
Pennies (Part A)

Plastic Dropper (Part A)

Wax Paper (Part B)

Food Coloring (Part B)

Soap (Part C)

Toothpicks (Part C)

Pepper (Part C)

Cups (Part D)

Paperclips (Part D)

Beakers (Part E)

Food Coloring (Part E)

Cooking Oil (Part E)

Baking Soda (Part F)

Cream of Tarter (Part F)