

IB Biology**The Properties of Water****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

good solvent

density

cohesiveness

capillary action

high latent heat

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 water molecule and the oxygen of a neighboring 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 polar and charged substances – **good solvent**

Investigating the Properties of Water**Part A: Pennies and Water**

1. How many drops of water do you think will fit on the head of a penny?
2. Make a hypothesis in your lab notebook.
3. Using a dropper slowly drop water onto a penny counting each drop.
4. On your data sheet, draw what the penny looks like, as viewed from the side, before it overflowed.

Question 1: How many drops of water did fit on the head of a penny?

Part B: Milk, Dye and Soap

1. Pour enough whole milk in the petri dish to cover the entire surface about 1/4 inch deep.
2. Add one drop of each different color food dye to each quadrant of milk in the petri dish, careful not to mix the dye.
3. With a single toothpick, add a small amount of detergent into the center of the petri dish containing milk. Hold the toothpick still and wait to see what happens.
4. Draw a diagram of the experiment before and after the soap was added to the milk.

Question 2: What effect does soap have on the milk?

Question 3: Explain this effect in molecular terms.

Part D: Surface Tension

1. Fill a small beaker or cup till it is just about to overflow.
2. Balance a paper clip on the surface of water (Hint: Don't let your fingers touch the water!).
3. Touch the paper clip once it is balanced. Describe what happens.
4. Balance the paper clip again.
5. Add one drop of dish soap solution to the water.
6. Record what happens in your lab notebook.
7. Clean the beaker so there is no detergent remaining.

Question 4: What does this activity tell you about the properties of water?

Part E: Water and Solubility

1. Fill a small beaker 1/3 of the way with water.

2. Add two drops of food coloring to it. Allow the water to become a uniform color before moving on to the next step.
3. Add a small amount of cooking oil to the beaker of water.
4. Record your observations in your lab notebook.
5. Empty the contents of your beaker into the sink, and clean the interior of the beaker.
6. Using the same beaker (which should now be clean), add a small amount of salt to a beaker filled with water.
7. Record your observations in your lab notebook.
8. Rinse the contents of the beaker in the sink, and clean the inside of the beaker.

Part F: Water and Solubility

1. In a clean, dry beaker, add a small amount of baking soda.
2. Add a small amount of cream of tartar and mix the two chemicals together.
3. Record what happens in your lab notebook.
4. Now, slowly add water to the mixture.
5. Record what happens in your lab notebook.
6. Rinse the contents of the beaker in the sink, and clean the beaker.

Part G: Density of Water

1. Add 90 ml of water to a graduated cylinder.
2. Add enough ice to bring the water level to the top edge of the cylinder.
3. Immediately measure the temperature of the top, middle and bottom of cylinder.
4. Repeat the measurements after 4 minutes and when the ice is melted.
5. Graph your results.
6. Discuss what the water level and graph teaches you about water's density as related to temperature.

Analysis Questions:

Polarity of Water-

Water is a **polar** molecule, meaning it has one end with a slight positive charge and another end with a slightly 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 which substance was nonpolar and polar?

Water as a Catalyst for Chemical Reactions-

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

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

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**.

3. When you placed the paper clip on top of the water, was it floating? If not, then what was holding it up?
4. Why do you think the paper clip sank to the bottom of the beaker when you added a drop of detergent to the beaker?
5. Based on the results of your lab, what can you infer about the structures of water, fat, and soap (i.e. which have similar structures, which have different structures)?

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. This 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?

Based on the experiments you performed with water, you will now design your own experiment to investigate the properties of water. There are two options you can base your design on or you can research further ideas and present them to your instructor for approval. This experiment will be designed and conducted individually.

Option A: Factors Affecting Evaporation of Water

Water has a very high heat of vaporization, in other words water will absorb a lot of energy (usually as heat) before changing its state, from solid to liquid to gas. This property is important to life on Earth. In this investigation you will determine the affect that a factor has on the rate of evaporation.

1. Construct a list of possible factors that might affect the rate of evaporation.
2. Choose **one** factor to investigate.
3. Write out the purpose (question), hypothesis (in the if...then form), and procedures for this lab.
4. Carry out your investigation.
5. Record your results and display them effectively in a graph.
6. Write a conclusion that answers your question.
7. Be sure to find and cite in your conclusion at least **one credible outside source** of information that discusses the factor investigated.
8. Evaluate your experiment based on the IB lab notebook guidelines.

Option B: Factors Affecting Emulsion of Lipids in Water

The role of milk in nature is to nourish and provide immunological protection for young mammals. Milk has a very high nutritional value and is a very complex food. Milk's general composition consists mostly of water with equal parts of fat, protein, and sugars. Milk also contains important vitamins and minerals. Milk is classified into different types based upon the amount of fat. Skim milk contains 0g fat per 250 mL serving; 2% milk contains 2g fat per 250 mL serving, whole milk contains 8g fat per 250 mL serving; half-and-half cream contains 8g fat per 2 tablespoon serving. The cream is called half-and-half because it is half cream and half milk.

If raw milk is left to stand, the fat will separate from the milk, rise, and form a cream layer. To prevent this from happening to the milk you buy at the store, the milk goes through a process called homogenization. Homogenization of milk breaks up the fat into small fat globules and spreads them throughout the milk. The fat globules (0.1 to 15 μm in diameter) are basically suspended in the milk.

Milk is a complicated substance made up of many parts that are attracted to some substances while repelling others. These interactions cause milk to act in an interesting way when mixed with substances such as dish soap. Soap cleans dishes by breaking up fat or grease and allowing it to flow in the water down the drain. Food coloring is mostly water with added dye particles. In this investigation you will determine the affect that a factor has on the rate of the interaction between milk and soap, with food dye to help you visualize the process.

1. Construct a list of possible factors that might affect the rate of interaction between soap, dye and milk.
2. Choose **one** factor to investigate.
3. Write out the purpose (question), hypothesis (in the if...then form), and procedures for this lab.
4. Carry out your investigation.
5. Record your results and display them effectively in a graph.
6. Write a conclusion that answers your question.
7. Be sure to find and cite in your conclusion at least **one credible outside source** of information that discusses the factor investigated.
8. Evaluate your experiment based on the IB lab notebook guidelines.