LAB 3 BIOLOGICAL PRINCIPLES I

Properties of Water; pH & Ocean Water

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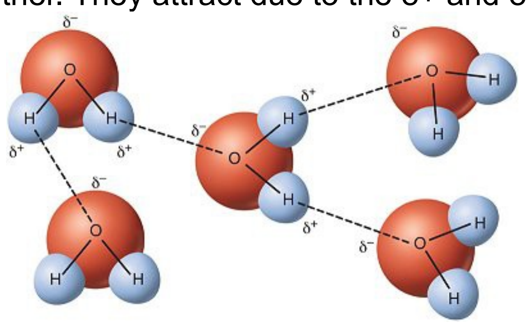
Introduction

To fully understand the behavior of the water molecule, you must first understand its structure. The water molecule has two hydrogen atoms covalently bonded to one oxygen atom. The attraction of the oxygen nucleus for the shared electrons is stronger than the hydrogen's nuclear attraction for the shared electrons. As a result of this unequal pull on the electrons, the oxygen end of the molecule has a slight negative charge while the hydrogen end of the molecule has a slight positive charge. A molecule with unequal electron sharing is called a **polar molecule**.

As a result of this uneven charge distribution, water can form a special type of bond, a hydrogen bond. It is important to note that a hydrogen bond is an attraction between the oppositely charged ends of two polar molecules. It is **not** used to create molecules or compounds. The image below shows the attractions between the (δ-) oxygen of one molecule to the (δ+) hydrogen of the other. They attract due to the δ+ and δ- polarity.



MODULE 1: Water as a charged molecule

MATERIALS

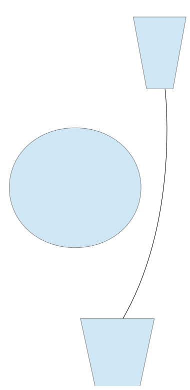
- buret
- buret stand
- clamp
- funnel
- tap water
- piece of wool fabric
- balloon
- 250-ml beaker

PROCEDURE

1. Clamp the buret to the stand.
2. Place the funnel in the opening on top of the buret and place the beaker below it. Close the stopcock (turn it so it is laying horizontally).
3. Fill your buret half full with tap water using the funnel. Be careful because it fills quickly.
4. Take the glass rod and rub it vigorously with the wool until the glass is warm to the touch. (The glass rod will develop a positive charge because the wool will strip some of the electrons from the glass).
5. **Hypothesis:** The next step will ask you to place the charged rod next to a thing stream of water. Do you think the water will be attracted to the glass rod or repelled by it? Explain.

It will be attracted to the water; Because the positive charge of the balloon attracts the negatively charged water.

6. Open the stopcock (turn it vertically) and allow the water to slowly stream into the beaker.
7. Hold the side of the glass rod about 5 mm away from the side of the water stream. **Do not let the glass rod touch the water stream.**
8. **Draw** and **describe** what happened when you hold the positively charged rod next to the water stream.



The balloon attracted the stream of water, as predicted.

9. Did your result support your hypothesis? Explain why or why not.

Yes. The balloon did attract the stream of water.

MODULE 2: Cohesion and adhesion

INTRODUCTION

Water molecules are attracted to each other and to other molecules that are polar. **Cohesion** refers to the bonding of water molecules to each other. The slightly positive pole of a water molecule is attracted to the slightly negative pole of another water molecule. **Adhesion** refers to the bonding of water to other polar molecules. The weak attractions between polar molecules are **hydrogen bonds.** These bonds give water many unique properties. Cohesion between water molecules results in a high **surface tension**, a measure of how much energy is required to break the surface of a liquid. Surface tension is responsible for the ability of small insects to “walk” on water.

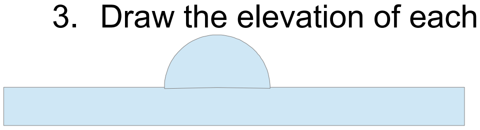
The following three “mini-experiments” will help you visualize water's cohesive properties.

MATERIALS

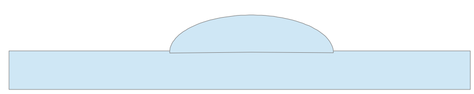
- Clean microscope slide
- Ethanol in a dropper bottle
- Water in a dropper bottle
- Petri dish
- Tap water
- Lens paper
- Straight pin
- 2 toothpicks
- Detergent in a dropper bottle
- Small diameter capillary tube
- Large diameter capillary tube
- Green colored water

PROCEDURE – Experiment #1

1. Place one drop of water on one end of the microscope slide.
2. Place one drop of ethanol on the other end of the slide.
3. Draw the elevation of each drop, as viewed from the side:



Water



Ethanol

4. What is the diameter of each drop (in mm)?
   Water: 8 mm   Ethanol: 10 mm

PROCEDURE – Experiment #2

1. Fill the Petri dish half full with tap water.
2. Place a piece of lens paper on the surface of the water.
3. Carefully place a straight pin on the lens paper.
4. Using the toothpicks, push down the corners of the lens paper allowing the pin to rest on the surface of the water.

Describe how the surface of the water around the pin appears.

It is indented.

5. Add a drop of detergent to the dish.

Why does the pin rest on the surface of the water when it is denser than the water?

The surface tension held the pin up.

6. Empty and rinse the Petri dish.
7. Describe what happened to the pin when the detergent was added. Explain why this occurred.

The pin dropped. The detergent reduced the density of the water, thus reducing and breaking the surface tension.

PROCEDURE – Experiment #3

1. Fill the Petri dish half full with colored water.
2. There are two capillary tubes of different diameters. Using the words, cohesion and adhesion, hypothesize what will happen when you stand the tubes in the colored water.

Due to cohesion, the larger tube has more water sticking to itself. The smaller tube uses adhesion, with less cohesion, due to the smaller diameter. Thus, the small tube will have more water rise.

3. Stand both the large and small diameter capillary tubes in the water and hold them there for 5 seconds.
4. Remove the tubes.
5. Observe and record the heights of the water (in mm). How high did the water rise in each capillary tube?
   Smaller diameter tube: 40 mm Larger diameter tube: 20 mm

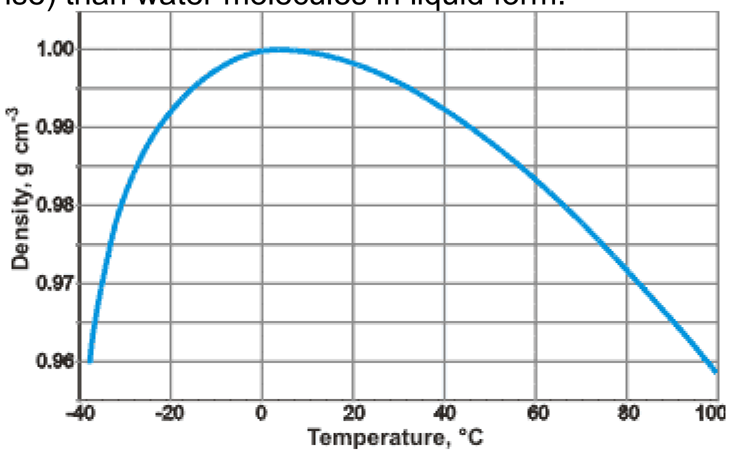
6. What is the relationship between the inner diameter of the tube and the height to which the water will rise?
   The thinner the inner diameter is, the higher the water will rise.

7. Does this result support your hypothesis? Explain.
   Yes, the smaller tube had a higher water level.

MODULES 3: The density of water

INTRODUCTION

One of water's more unique properties is how its density will change in response to changes in temperature. With most substances, density will increase as the temperature decreases. Water, however, reaches its maximum density at 4°C. Below this temperature, the hydrogen bonds between water molecules become longer, causing the water molecules to move farther apart. As a result, water molecules in ice form are less closely packed (and therefore are less dense) than water molecules in liquid form.



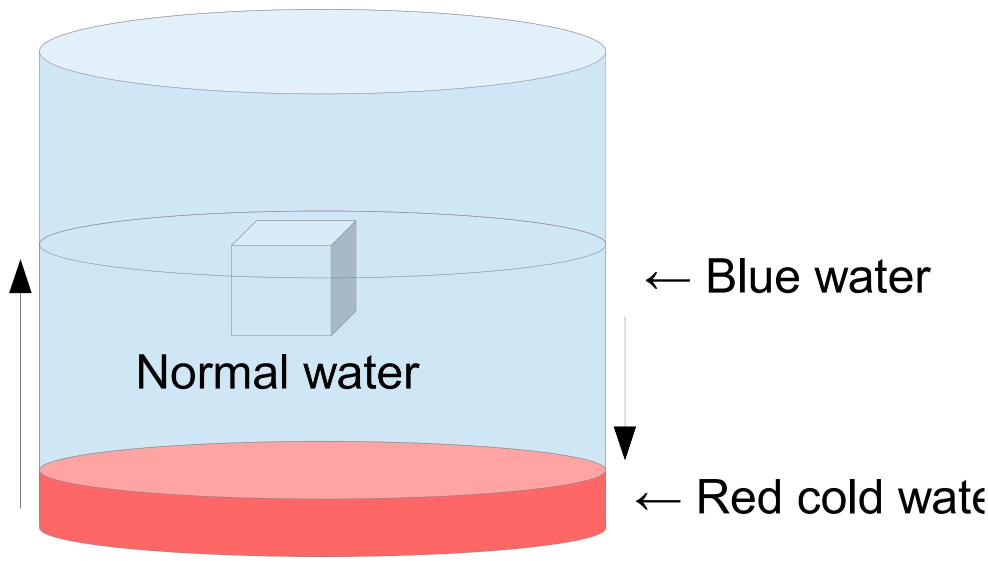
MATERIALS

- 1000-ml beaker
- Hot tap water
- Piece of white paper
- Cold red water
- 10-ml pipette
- Green pipette pump
- Blue ice cubes
- Thermometer

PROCEDURE

1. Put approximately 800 ml warm tap water (35-40 °C) into the 1000-ml beaker.
2. Place the beaker on the white paper. This will allow the effects of the two colors to be better visualized.
3. Take up 10 ml of cold red water into the pipette.
4. With the pipette held 2 cm from the bottom of the beaker, dispense the red water slowly. This should form a red layer on the bottom of the beaker.
5. Why does the cold red water remain on the bottom of the beaker?
   It is denser than the warm water.
6. Gently place a blue ice cube on top of the water.
7. Explain why the ice cube floats.
   It is less dense than the warm water, this is because the density to temperature relationship is a parabola, with the peak density at 4°C.

8. Draw what you observed when you added the blue ice cube to the beaker of water.



9. Using your observations above regarding the way the ice melted and the water moved, describe what happens in a frozen pond during a spring thaw. How is this an advantage to the organisms living in the pond?

The ice at the top melts, sinking to the bottom. Then, the colder water at the bottom warms up, pushing nutrients and itself up.

MODULE 2: CO_2 and ocean acidification

6. How do you think a change in pH of the ocean might impact ocean life?

It will accelerate the rate of which the acid will dissolve calcium carbonate.

7. Do you expect the buffering capacities of ocean and fresh waters to be different? Why or why not?

Yes, they will be different. The ocean will have a larger capacity due to the larger presence of carbonate.

pH	Ocean water	Pond water
Initial	8.6	7.5
After 5 drops of HCl	8.4	6.8
After 5 more drops (10 total)	7.7	4.9
After 5 more drops (15 total)	7.6	4.1
After 5 more drops (20 total)	7.3	3.9
After 5 more drops (25 total)	7.2	3.8
After 5 more drops (30 total)	6.9	3.7
After 5 more drops (35 total)	6.3	3.7
After 5 more drops (40 total)	5.9	3.6
After 5 more drops (45 total)	5.1	3.6
After 5 more drops (50 total)	4.5	3.6

DISCUSSION / OBSERVATION

1. Describe what happened to the egg shell in the instructor demonstration. Why did we use vinegar and the egg as a demonstration of ocean acidity affecting marine life?

The egg shell dissolved. The egg simulates the eggs of marine life, while the vinegar represents decrease in pH in the ocean.

2. What is different about the ability of the ocean water to resist a pH change, or buffer, compared to the pond water? What is in the ocean water that allows it to do this?

Ocean water has a higher buffering capacity than the pond water. Molecules like carbonate and bicarbonate are present in the ocean water, and act as a buffer.

3. Why will rising CO2 levels in the atmosphere lower the pH of the ocean and other bodies of water?

CO_2 dissolves into the water and reacts with it, forming carbonic acid. This lowers the pH of the water.

4. What might happen in regard to climate change (global warming) as the ocean becomes “saturated” with CO_2 and its buffering capacity is maxed out?

Because of CO_2's heat-trapping properties, the ocean will heat up, increasing the global temperature.