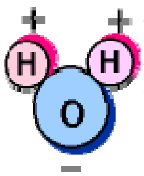
ES 106 Laboratory # 1
PROPERTIES OF WATER

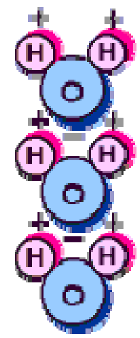
Introduction

What are the physical and chemical properties of water that make it so unique and necessary for living things? When you look at water, taste and smell it - well, what could be more boring? Pure water is virtually colorless and has no taste or smell. But the hidden qualities of water make it a most interesting subject. In today's lab, you will explore some of the properties of water. You will also be introduced to the concept of density as a property of matter.

Water's Chemical Properties



You probably know water's chemical formula is H_2O. As the diagram to the right shows, that is one atom of oxygen bound to two atoms of hydrogen. 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. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." As the left-side diagram shows, the side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of a different water molecule.



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.

Water's Physical Properties

Pure water has a neutral pH. Pure water has a pH, of about 7, which is neither acidic nor basic. 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 is unique in that it is the only natural substance that is found in all three states -- liquid, solid (ice), and gas (steam) -- at the temperatures normally found on Earth. Earth's water is constantly interacting, changing, and in movement.

- Water freezes at 32^o Fahrenheit (F) and boils at 212^o F at sea level (but 186.4° at 14,000 feet). In fact, water's freezing and boiling points are the baseline with which temperature is measured: 0^o on the Celsius scale is water's freezing point, and 100^o is water's boiling point. Water is unusual in that the solid form, ice, is less dense than the liquid form, which is why ice floats.
- Water has a high specific heat. This means that water can absorb a lot of heat before it begins to get hot. This is why water is valuable to industries and in your car's radiator as a coolant. The high specific heat of water also helps regulate the rate at which air changes temperature, which is why the temperature change between seasons is gradual rather than sudden, especially near the oceans.
- Water has a very high surface tension. In other words, water is sticky and elastic, and tends to clump together in drops rather than spread out in a thin film. Surface tension is responsible for capillary action, which allows water (and its dissolved substances) to move through the roots of plants and through the tiny blood vessels in our bodies.
- Here's a quick rundown of some of water's properties:
  - Weight: 62.416 pounds per cubic foot at 32°F (0º C)
  - Weight: 61.998 pounds per cubic foot at 100°F
  - Weight: 8.33 pounds/gallon, 0.036 pounds/cubic inch.
  - Density: 1 gram per cubic centimeter (cc) at 39.2°F, 0.95865 gram per cc at 212°F

Goals and Objectives

- Be able to define specific heat, surface tension, and polar molecule.
- Be able to define and calculate density.
- Observe the effects of the polar nature of water on its properties.
- Apply the Scientific Method to identify materials based on their properties.

Name________________________

Lab Day/Time_________________

Pre-lab Questions – Complete these questions before coming to lab.

1. Define the following terms.

   B. Density **mass per unit volume**

   $$d = \frac{m}{v}$$

   C. Polar Molecule **covalently bonded unlike nonmetals which have a charge imbalance because electrons are unequally shared**

   D. Surface tension **elasticity of a liquid, strength of the air-fluid interface**

   E. Specific heat **quantity of heat required to raise the temperature of one gram of a substance one degree celsius**

2. The mass of a rock is 84 g. You determine the volume of the rock to be 30 cm^3. What is the density of the rock in kg/m^3?

$$\frac{84g \cdot \frac{1kg}{1000g}}{30cm^3 \cdot \left(\frac{1m}{100cm}\right)^3} = 2800\frac{kg}{m^3}$$

3. Calculate the following temperature conversions: Note: $F = \frac{9}{5}C + 32$

   A. 32 ºF to ºC $\frac{5}{9}(32^o F - 32) = 0^o C$

   B. 100 ºC to ºF $\frac{9}{5}100^o C + 32 = 212^o F$

   C. 46 ºF to ºC $\frac{5}{9}(46^o F - 32) = 7.8^o C$

   D. 25 ºC to ºF $\frac{9}{5}25^o C + 32 = 77^o F$

Part A – Determination of Density by Water Displacement

Density is defined as mass per unit volume (density = mass/volume). The units of density are commonly expressed as grams/cubic centimeter (g/cm^3). As noted above, the density of pure water is 1 g/cm^3; also note that 1 cm^3 = 1 milliliter (1mL).

Activity:

You will be determining the density of two cylinders composed of unknown metals. Mass will be measured using the balances provided, and volume will be measured by water displacement. Once the densities of the metals are calculated, you will compare your calculated value to a list of standard values to determine the metal that composes your cylinders.

Procedure

1. Select two metal cylinders. Make sure they are different metals (i.e., with different masses). Weigh the two metal cylinders and record their masses.

   Metal Cylinder #1 ____

   Metal Cylinder #2 ____
2. Determine the volume of the cylinders by following these steps:
   a. Place approximately 15 mL of water in a small graduated cylinder. Record this as your initial volume in the table below.
   b. Carefully place the metal cylinder into the graduated cylinder so that it is totally immersed. Record this as you final volume in the table below. Now determine the volume of the each cylinder.

	Metal Cylinder #1	**Metal Cylinder #2**
Final Volume		
Initial Volume		
Volume of cylinder	**Most were about 6 mL**	**Same as 6 cm^3**

3. Calculate the density of the two metal cylinders. Be sure to show your work. Use units in formulas

<u>Metal Cylinder #1</u>: density = _____________ **<u>Metal Cylinder #2</u>: density =** ____________

49.3g/6.4 cm^3=7.7g/cm^3 steel	**49.9g/7 cm^3=7.1 g/cm^3 steel**
56.4g/6.5mL=8.4 g/cm^3 copper	**57.4g/6.2 cm^3=9.25 g/cm^3 copper**
56.9g/6.75 cm^3=8.4 g/cm^3 copper	**18.2g/6.6 cm^3=2.75 g/cm^3 aluminum**
18.2g/6.5 cm^3=2.8 g/cm^3 aluminum	**17.9g/6 cm^3=2.98 g/cm^3 aluminum**
54.9g/6.7 cm^3=8.2 g/cm^3 brass	**53.9g/6.5 cm^3=8.3 g/cm^3 brass**
54.6g/6.5 cm^3=8.4 g/cm^3 brass	**54.8g/6.5 cm^3=8.4 g/cm^3 brass**

4. Based on you your calculated densities determine which metal composes the cylinders.

   Metal Cylinder #1 ____

   Metal Cylinder #2 ____

Table: Standard densities of some metals (g/cm^3).

Metal	**Density** (g/cm^3)
Aluminum	2.70
Brass	8.56
Copper	8.80
Lead	11.00
Steel	7.83

5. To see how close a measurement is to a standard value, a percent error is determined. Use the equation below to calculate error:

$$\frac{\text{Expected Value} - \text{Observed Value}}{\text{Expected Value}} \text{ X } 100\% = \text{Percent Error}$$

Calculate the percent error for both of the metal cylinders. Show your work below.

Metal Cylinder #1 **Metal Cylinder #2**

$$\left|\frac{2.7g/cm \;\; - 2.8g/cm^3}{2.7g/cm^3}\right| \cdot 100\% = 3.7\% \quad \textit{(For example)}$$

6. List and briefly discuss two factors that contributed to the error you just calculated.

Hard to read volume of water **impurities on metal cylinder**
Bubbles clinging to cylinder **friction/inaccuracies in balance**
Splashing water **(“Human Error” needs to be defined as to what human did wrong)**

Part B – Exploring some Properties of Water

For this part of the lab you will explore a variety of properties of water.

Activity 1:

Carefully place a dry pin on water in a watch glass so the water supports its weight (**Hint**: fill watch glass to near top and gently insert pin from side). While the pin is on the water, gently add a drop of detergent near the pin. What happened to the pin? Note your observations.
Maybe you got it to float

Does a pin "float" on water in the same way as a block of wood?
No, it's surface tension that keeps it there

Activity 2:

Tie a piece of thread in a loop (> 1" in diameter) and float it on water in the watch glass. Add a drop of detergent inside the loop. What happened to the thread loop? Note your observations.
Maybe it floated at first, then loop shrank with detergent

Thoroughly clean the watch glass to remove all traces of detergent. Float another loop of thread as before. Predict what will happen if you add a drop of detergent outside the loop.

Try it. Note your observations.
Maybe it floated at first, then loop expanded slightly with detergent

Activity 3:

Predict the number of drops of water you can fit on a penny. ________**?**___________

Use the dropper to place water, one drop at a time on the penny until it spills off the penny. How many drops did it hold? _____**20 to 50**______________

Activity 4:

Place a piece of wax paper over a piece of newspaper. Place a few drops of water on the wax paper. Look at the newsprint. What happens to the appearance of the newsprint? Note your observations.
Acted as magnifying glass

Part C –Which clear liquid is water?

You are on the Planet WOU and are in need of water. The residents of Planet WOU – the WOLFIANS – do not speak any Earth languages, but you are trying to communicate with them. All that the Wolfians are able to understand is that you need a clear liquid. They do not understand the various properties and characteristics of water that you are trying to explain to them. They bring your group samples of 4 clear liquids that they have located on Planet WOU. You are now faced with a serious predicament. If you drink the wrong liquid, you could become violently ill or die. On the other hand, if you don't get any more water, you will also die. Hence, the conundrum: Which of these liquids is water?

Activity:
Your spacecraft has many testing materials onboard, including a known sample of water, which you can use to explore all the liquids. You check the spacecraft manual for situations of this nature, and identify a series of experiments, tests, or procedures that should enable you to distinguish water from the other liquids with a great degree certainty. In order to be extra sure of your identification of water (after all, your life is on the line), you must also design one other experiment, test, or procedure to confirm the other tests. Your group can use the data table on the following page to summarize your observations. Remember, there is no taste testing, smelling, or touching of the liquids allowed.

After you have completed your experiments be sure to clean up completely.

Do not put any other materials into the large test tubes labeled 1-5. The samples that you receive in the number test tubes are all that you get to use. Carry out your experiments on the liquids in small test tubes, watch glasses, and beakers using as little of the unknown liquids as possible for each test.

DATA TABLE:

Question asked:	Known Water sample	Unknown Liquid 1	Unknown Liquid 2	Unknown Liquid 3	Unknown Liquid 4
What is the pH of the liquid?			**This one is water**		
Which materials float on the liquid (check: ice, toothpick, and oil)					
Which materials dissolve in the liquid (check: salt, sugar, and baking soda)? Note any reactions.					
How much does the temperature change when placed in a hot water bath for three minutes? Cold water bath?					
How long does it take for ½ teaspoon (2.5 ml) of the liquid to evaporate? (Use a small beaker for this test and be very careful!)					
Student designed test: (describe in space provided)					

Questions

1. Based on your tests, which sample is most likely water?

   Liquid 2 is water

   If you are unable to determine which one is water, make sure you indicate which ones are not water.

   #1 had high pH

   #3 left residue on evaporation

   #4 fizzed upon addition of solutes

2. How confident are you in your determination? Briefly explain.

3. Briefly outline the procedure that you followed to solve this problem.

4. Which test was the most effective in addressing the needs of the problem? Explain why you think it was so effective.

5. Which test was the least effective in addressing the needs of the problem? Explain why you think it was so ineffective.

Name__________________________

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POST-LAB ASSESSMENT

1. Imagine that you have a piece of granite with of density 2.65 g/cm^3. If the mass of the piece of granite is 120 g, what is the rock sample's volume?

$$\frac{120\text{g}}{2.65\ \text{g/cm.}^3} = 45.3\ \text{cm}^3$$

2. Suppose that you are doing dishes after a greasy meal. You take a greasy pan and fill it with water. A thin film of grease completely covers the surface of the water in the pan (yuck!). You place a drop of Dawn dishwashing liquid in the middle of the pan and the grease shoots away from the drop towards the sides of the pan. "Wow!" you exclaim to yourself "Dawn really does take grease out of the way, just like in the commercial." Using what you observed in today's lab, what actually happened? Do you think this behavior would only happen with Dawn, or would other dishwashing liquid produce this effect as well? (If you have never seen the Dawn commercial on TV, try this experiment at home with a greasy pan.)

3. Imagine that you have a 2 inch long, 0.5 inch diameter rod made of a clear material. Your goal is to determine what material makes up the rod. Your first guesses as to the composition of the rod are glass and ice. To test these hypotheses, you place the rod in a beaker of water and it sinks to the bottom. Could the rod be made of glass or ice? After this experiment, have you uniquely determined the composition of the rod, or is there another clear material in addition to glass that would sink to the bottom of a beaker of water? Can you think of a test to distinguish between this material and glass?

GS106 Key Lab 1
Properties of Water

	Metal Cylinder #1 gold in color	Metal Cylinder #2 silver in color
Mass	57.05 g	17.9 g
Final vol	21.5 ml	21.5 ml
Initial vol	15 ml	15 ml
Vol of cyl.	6.5 ml	6.5 ml
Density (m/v)	57.05g/6.5ml = 8.77g/ml	17.9g/6.5ml = 2.75g/ml
Compostion	brass → 8.56g/ml	aluminum→ 2.70 g/ml

% error

$$\frac{(8.56g/ml)-(8.77g/ml)}{(8.56g/ml)} *100 = -2.45\%$$

$$\frac{(2.7g/ml)-(2.75g/ml)}{(\cancel{8.56}\ 2.7\ g/ml)} *100= -1.85\%$$

Possible reasons for the error include rounding errors, not reading the volume accurately, not weighing the cylinders accurately. **NEVER say human error**. Tell me what the error is!

Part B:

Activity 2: this activity looks at surface tension and water and how it changes due to the addition of a detergent. The detergent causes a lower surface tension due to the disruption of the hydrogen bonds between the water molecules. You should have noticed that when you dropped the detergent in the center of the thread that it "pushed" the thread out from the center and then the thread sank. The thread sinks because of lower surface tension. When the detergent is dropped beside the thread, it causes the thread to be "pushed" to the side of the dish.

Activity 3: Surface tension is also responsible for the number of water drops you can put on a penny. The idea behind surface tension is that water molecules attract each other so they "pull" together. This "stickiness" allows many drops to be placed on a penny. I got 31 drops. The number varies between 20 and 35. Why is there so much variance? What are possible sources of error?

Part C

The purpose of these experiments was not just to figure out which sample was water but to do a series of experiments in a consistent manner. Some of the important techniques include washing your equipment with distilled water between experiments and making sure volumes of solids and liquids were the same for each experiment. Additionally, observation is also very important. For example, noticing if something totally dissolves or how the oil floats on the liquid. The page below were the results of my experimentation and some of the things I noted:

PG10:

Based on my experiments I decided #2 was the water sample. This was due to the pH, The way the oil floated on the surface (similar to the water sample), and the evaporation experiment. I decided 1 wasn't based on the pH value, 3 wasn't since it left a residue after evaporation and it didn't dissolve the salt or sugar, and 4 wasn't due to the way the oil spread out on the top of the solution rather than beading up.

Be sure you spend some time thinking about the most and least effective tests and the "whys" associated with them. Make sure the why you come up with is specific and not a generic answer.

Experiment	Water	Liquid 1	Liquid 2	Liquid 3	Liquid 4	Comments
pH	7	10	7	7	6	It was important to let the ph strips sit for a couple of min to get an accurate read
Float: ice toothpick oil	 yes yes yes (beaded)	 yes yes yes	 yes yes yes	 yes yes yes	 yes yes yes	Note: the oil in 1 & 2 beaded up but the oil in 3 & 4 spread out
Dissolution salt (15 sec) sugar (30 sec)	 yes yes	 partial yes	 yes yes	 no no	 yes yes	I only used a pinch of each and the same volume of liquid
Temp. Change hot cold	 80.7-22.4= **58.3** 24.7-4.2= **20.5**	 84.2-21.8= **62.4** 25.2-2.7= **22.5**	 83.9-22.8= **61.1** 24.8-2= **22.8**	 82.8-22.9= **59.9** 24.9-4.9= **20**	 83.9-23.6= **60.3** 24.3-3.7= **20.6**	
Evaporation: time comments	 6.5 min	 6 min left funky residue	 7 min	 5 min crystallized	 9 min	This information I took off labs that were turned into me.
Student test: I used the drops on a penny for this test	First test 32 Second test 24	14	20	33	31	the second test on the water sample was done after the other samples were tested so the penny was just dried off for all the tests