



# Lesson 2: The Science of Water

## Student Materials

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# The Science of Water Lab Activities: Student Directions

## Lab Station A: Surface Tension Lab

### Purpose

The purpose of this lab is to investigate the property of the surface tension of water. This lab will look at the way that water sticks to itself to make a rounded shape, the way that water behaves as a “skin” at the surface, and a comparison of water’s surface tension with two other liquids, oil and soapy water.

### Safety Precautions

- Wearing goggles is dependent on your school’s safety criteria.
- Caution needs to be exercised around hot plates and the alcohol burner.
- Caution needs to be exercised around hot water and hot glassware.
- Do not eat or drink anything in the lab.
- Do not wear open-toed sandals in the lab.
- Wear long hair tied back to prevent touching the substances at the lab stations.

### Materials

- 3 pennies
- Available water
- Small containers of water, oil, and soapy water
- A dropper for each of the containers
- A square, about 4” x 4”, of wax paper

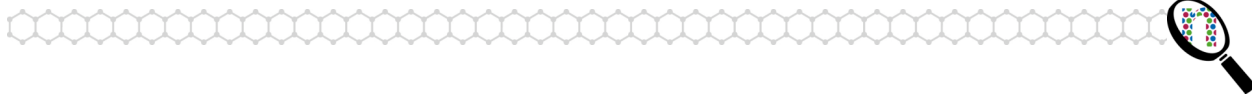
### Procedures

#### Counting Drops on a Penny

1. Check to make sure all of the materials needed are at your lab station.
2. Using a dropper bottle containing only water, count the number of drops of water that you can balance on top of a penny. When the water falls off of the penny, record the number of drops. Wipe the water off of the penny.
3. Repeat this procedure of counting and recording drops with oil and then with the soapy water.

#### Comparing the Shape of a Drop

4. Drop a small sample of each of the liquids—water, oil, and soapy water—on the wax paper. Draw the shape and label the shape of the drops made by each of the liquids on your worksheet. Wipe off the wax paper.
5. Answer the questions on your worksheet.



## Lab Station B: Adhesion/Cohesion Lab

### Purpose

The purpose of this lab is to investigate the property of **cohesion** and **adhesion** of water.

- **Cohesion** is the molecular attraction exerted between molecules that are the same, such as water molecules.
- **Adhesion** is the molecular attraction exerted between unlike substances in contact.

Cohesion causes water to form drops, surface tension causes them to be nearly spherical, and adhesion keeps the drops in place (<http://en.wikipedia.org/wiki/Adhesion>).

This lab will work with capillary tubing of various diameters to see the rate at which water is able to “climb” up the tubes. This is very similar to the way that water enters a plant and travels upward in the small tubes throughout the plant’s body. The “stickiness” of the water molecule allows the water to cling to the surface of the inside of the tubes.

You will see how the diameter of the tube correlates with the rate of traveling up the tube by measuring how high the dye-colored water column is at the end of the time intervals.

### Safety Precautions

- COOL GLASSWARE FOR A FEW MINUTES BEFORE PUTTING INTO THE COOLING BATH OR THE GLASSWARE WILL BREAK.
- Wearing goggles is dependent on your school’s safety criterion.
- Do not eat or drink anything in the lab.
- Do not wear open-toed sandals in the lab.
- Wear long hair tied back.

### Materials

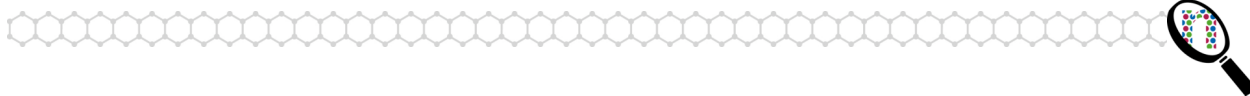
- 4 pieces of capillary tubing of varying small sized diameters (no greater than 7mm in diameter), 8-24 inches in length
- Metric ruler
- Pan of dyed (with food coloring) water into which to set the capillary tubing
- Clamps on ring stands to stabilize the tubing so that it remains upright in a straight position

### Procedures

1. Check to make sure all of the materials needed are at your lab station.
2. Set the capillary tubing into the dye-colored water from the largest diameter tubing to the smallest. Make certain they are all upright and secure.
3. Record the height of each of the tubes in the table on your worksheet every 2 minutes.



4. After 10 minutes, release the capillary tubing, wrap the tubing in paper towels, and deposit them in an area designated by your teacher.
5. Answer the questions about this experiment on your lab sheet.



## Lab Station C: Can You Take the Heat?

### Purpose

The purpose of this lab is to investigate the heat capacity of water. You will measure the temperature of water (specific heat of water is 4.19 kJ/kg.K) and vegetable oil (specific heat of vegetable oil is 1.67 kJ/kg.K) over equal intervals of time, and will record your data and findings on your lab sheet.

**Specific heat** is the amount of energy required to raise 1.0 gram of a substance 1.0° C.

### Safety Precautions

- Cool hot glassware slowly. Wait a few minutes before placing in cold water or the glass will break.
- Wearing goggles is dependent on your school's safety criterion.
- Do not eat or drink anything in the lab.
- Do not wear open-toed sandals in the lab.
- Wear long hair tied back.
- Use caution when working with fire or heat. Do not touch hot glassware.

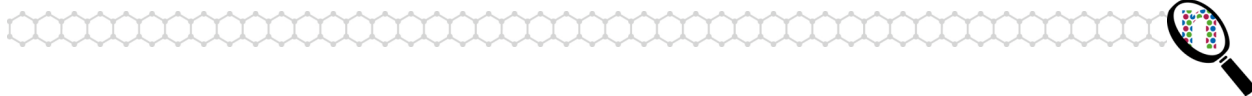
### Materials

Assemble two Erlenmeyer flasks or beakers, each containing one of the liquids, with a thermometer suspended into each liquid, from a clasp attached to a stand, inserted about midway into the liquid.

- 2 equal amounts, about 100 mL, of water and vegetable oil
- 2 250-mL Erlenmeyer flasks or 2 250-mL beakers
- 2 thermometers
- 2 Bunsen burners or 1-2 hot plates
- 2 ring stands: each ring stand will have a clamp to hold the thermometer. Use a screen if using a Bunsen burner rather than hot plate(s).
- Cold water bath for cooling the Erlenmeyer flasks or beakers

### Procedures

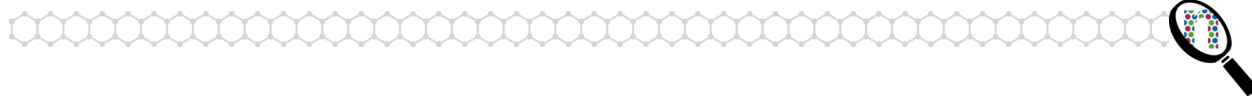
1. Set the cooled flasks containing their solutions on the ring stands or hot plate.
2. Take the initial temperature reading of each of the liquids.
3. Turn on the hot plate to a medium temperature, or, if using Bunsen burners instead, light them, adjusting the flame of each to the same level.
4. Record the temperature of the liquid in each flask every 2 minutes until 4 minutes after each liquid boils. Record the temperature in the table on your lab sheet.



5. After recording the final temperatures, move the Erlenmeyer flasks or beakers with tongs or a heat-resistant set of gloves into the cooling bath. Add small amounts of ice as needed to keep the water temperature cold.

**DO NOT THRUST HOT GLASSWARE DIRECTLY INTO ICY WATER  
BEFORE COOLING BECAUSE THE GLASS WILL BREAK!**

6. Answer the questions about this experiment on your lab sheet.



## Lab Station D: Liquid at Room Temperature Data Activity

### Purpose

The purpose of this activity is to discover how unusual it is, based on a substance's molecular weight, that water is a liquid at room temperature.

### Safety Precautions

None are needed, since this is a paper and pencil activity.

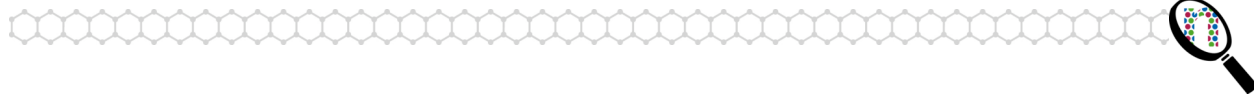
### Materials

- Water is Weird! Data Table
- Lab worksheet for recording trends

### Procedures

Data table 1 shows the physical properties of a variety of substances. This table is typical of one that a chemist would examine to look for trends in the data. For instance, is there any correlation with the color of the substance and its state of matter? Is there any correlation between the state-of-matter of a substance and its density? How does water compare to other substances?

1. Examine the data table. Look for relationships between the physical properties of some of these substances. What do you notice that fits into any patterns? What is the opposite or is unusual to the most common pattern?
2. Discuss the trends with your lab partner. Record your thoughts on your lab worksheet.
3. Answer the questions about this experiment on your lab worksheet.



## Water is Weird! Data Analysis Activity

### Water is Weird! How Do We Know?

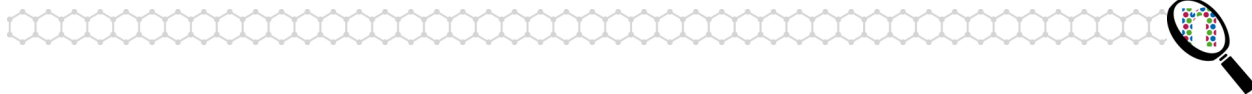
We have been discussing the many ways that water is weird. Water seems pretty common to us. How do we know that it is unusual? Let's compare water to some other substances and see what we can find, using the data table below.

Record the trends that you notice on your lab worksheet.

**Data Table 1: Physical Properties of Some Substances**

| Substance      | Formula                       | Molar mass, grams | State of matter at normal room conditions | Color                | Specific Heat J/g K | Density of gas, liquid, or solid        | Boiling Temperature, °C |
|----------------|-------------------------------|-------------------|---|----------------------|---------------------|---|-------------------------|
| Water          | H <sub>2</sub> O              | 18.0              | liquid                                    | colorless            | 4.19                | 0.997 g/cm <sup>3</sup>                 | 100                     |
| Methane        | CH <sub>4</sub>               | 16.0              | gas                                       | colorless            |                     | 0.423 <sup>-162</sup> g/cm <sup>3</sup> | -161.5                  |
| Ammonia        | NH <sub>3</sub>               | 17.0              | gas                                       | colorless            |                     | 0.70 g/L                                | -33                     |
| Propane        | C <sub>3</sub> H <sub>8</sub> | 44.1              | gas                                       | colorless            |                     | 0.493 <sup>25</sup> g/cm <sup>3</sup>   | -42.1                   |
| Oxygen         | O <sub>2</sub>                | 32.0              | gas                                       | colorless            | 0.92                | 1.308 g/L                               | -182.9                  |
| Carbon dioxide | CO <sub>2</sub>               | 44.0              | gas                                       | colorless            |                     | 1.799 g/L                               | -78.5                   |
| Bromine        | Br <sub>2</sub>               | 159.8             | liquid                                    | red                  | 0.47                | 4.04                                    | 58.8                    |
| Lithium        | Li                            | 6.94              | solid                                     | silvery, white metal | 3.58                | 0.534 g/cm <sup>3</sup>                 | 1342                    |
| Magnesium      | Mg                            | 24.3              | solid                                     | silvery, white metal | 1.02                | 1.74 g/cm <sup>3</sup>                  | 1090                    |





## Lab Station E: Now You See It, Now You Don't A Dissolving Lab

### Purpose

The purpose of this activity is to introduce the idea that different types of liquids may dissolve different substances.

### Safety Precautions

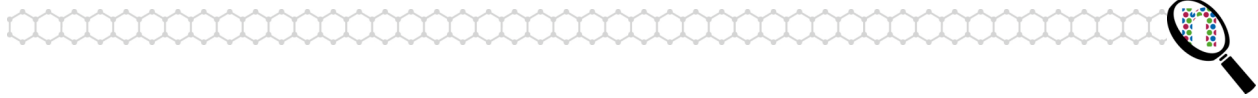
- Wearing goggles is dependent on your school's safety criterion.
- Do not eat or drink anything in the lab.
- Do not wear open-toed shoes.
- Tie long hair back.

### Materials

- 6 plastic cups
- 6 plastic spoons
- Water
- Oil
- Granulated salt
- Granulated sugar
- Iodine crystals

### Procedures

1. Fill 3 plastic cups  $\frac{1}{3}$  to  $\frac{1}{2}$  full with water.
2. Fill 3 plastic cups  $\frac{1}{3}$  to  $\frac{1}{2}$  full with oil.
3. Put about a half-teaspoon of salt into the water in one cup and another half-teaspoon of salt into the oil in one cup.
4. Stir each for about 20 seconds or until dissolved.
5. Record your observations in the table on your lab sheet.
6. Repeat this procedure with sugar.
7. Repeat this procedure using iodine crystals BUT only drop 2 or 3 crystals into the water and into the oil.
8. Record your observations and answer the questions about this experiment on your lab sheet.



## Lab Station F: Predict a New World! Inquiry Activity

### Purpose

We all know that ice floats; we take it for granted. However, in nature, the solid form of a substance being less dense than the liquid form is extraordinary. What we don't know or think about much is how our world would be affected if ice did not float in water. This "thought" activity explores the worldly implications if ice had a greater density than water.

### Safety Precautions

None are required because this is a paper and pencil activity.

### Materials

- A fish bowl with some fish and live plants

### Procedures

1. Read the following. Look at the fish bowl. Think. Write your thoughts on your lab worksheet.

Assume that there will be one change in the way that nature behaves: On the day after tomorrow, worldwide, ice (the solid form of water) will now become denser than water, rather than its current state, which is less dense.

What will be the impact of this change?



*Figure 1. Beautiful lake in early winter. [1]*

2. Discuss this with your lab partner.
3. Answer the questions about this experiment on your lab worksheet.

### Reference

1. [http://snow.reports.co.nz/snow\\_ida\\_800.jpg](http://snow.reports.co.nz/snow_ida_800.jpg)



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## The Science of Water Lab Activities: Student Worksheets

**Directions:** Go to the lab stations assigned by your teacher. Follow the directions for each lab that are posted at each of the lab stations. Conduct the lab activity and record your data on the lab write-up sheet. Answer the questions asked on the lab sheet. Be sure to pay special attention to the purpose of each lab before beginning the lab. You are encouraged to talk to your lab partners about the lab and to ask your teacher questions.

### Lab Station A: Surface Tension Lab

#### Drops of Water

Fill in the table below with the number of drops you added to the penny of each substance before the liquid spilled over.

|                 | Water | Oil | Soapy Water |
|-----------------|-------|-----|-------------|
| Number of Drops |       |     |             |

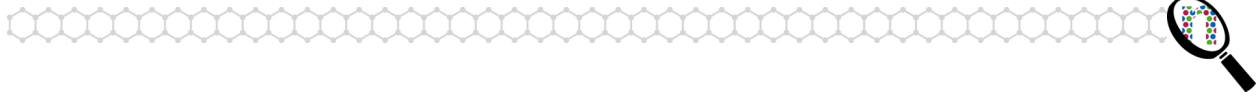
#### Questions

1. What does a high surface tension do to the number of liquid molecules that can stay together?
2. Based on your evidence, compare the surface tension of these four substances.
3. After placing a few drops of each of the liquids on the wax paper, draw what the drops look like from the side view. Be sure to capture the relative height/flatness of the drop

Water

Oil

Soapy Water



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## Lab Station B: Adhesion/Cohesion Lab

### Questions

1. Define adhesion
  
2. Define cohesion
  
3. Ask your teacher to provide you with the diameter of the capillary tubes if they are not labeled. In the table below, record the height of the liquid in capillary tubing of different diameters as you take your measurements.

| Diameter of capillary tubing |  |  |  |  |
|------------------------------|--|--|--|--|
| 2 minutes                    |  |  |  |  |
| 4 minutes                    |  |  |  |  |
| 6 minutes                    |  |  |  |  |
| 8 minutes                    |  |  |  |  |
| 10 minutes                   |  |  |  |  |

4. Based on your evidence, what statement can you make about water's speed of climbing a capillary tube relative to the diameter (size of the opening) of the capillary?
  
  
  
  
  
  
  
  
  
  
5. What does this mean about how fast water is able to "climb" tubes within plants?



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## Lab Station C: Can You Take the Heat? Student Lab Sheet

**Specific heat** is the amount of energy that it takes to raise 1.0 gram of a substance  $1.0^{\circ}\text{C}$ .

Fill out the table as you conduct your experiment.

| Liquids    | Water Temperature | Vegetable Oil Temperature |
|------------|-------------------|---------------------------|
| 2 minutes  |                   |                           |
| 4 minutes  |                   |                           |
| 6 minutes  |                   |                           |
| 8 minutes  |                   |                           |
| 10 minutes |                   |                           |
| 12 minutes |                   |                           |
| 14 minutes |                   |                           |

### Questions

1. Based on your evidence, which substance has the highest specific heat? The lowest?
2. Think about and explain the relationship between high specific heat of a liquid and hydrogen bonding.
3. Compare the boiling temperatures of water and of oil. What is the relationship between hydrogen bonding and boiling temperature?
4. What happened to the temperature of the water and the oil after boiling? Explain why.



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## **Lab Station D: Liquid at Room Temperature Data Activity**

### **Questions**

1. What trends do you notice in the data table? Explain.
2. What is unusual about the most common pattern? Explain.
3. How does water compare to other substances?



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## Lab Station E: Now You See It, Now You Don't A Dissolving Lab

A **solvent** is the liquid that is doing the dissolving. A **solute** is the substance that will be dissolved in the liquid.

Record your observations about how quickly and thoroughly each of the solutes dissolves in water and oil in the table below.

| SOLVENT | SOLUTES |       |                 |
|---------|---------|-------|-----------------|
|         | Salt    | Sugar | Iodine Crystals |
| Water   |         |       |                 |
| Oil     |         |       |                 |

### Questions

1. Summarize what you found in your experiment, based on your recorded observations.
  
  
  
  
  
  
  
  
  
  
2. Why do you think that some substances dissolve easier in one type of liquid than in another?



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## **Lab Station F: Predict a New World! Inquiry Activity**

### **Questions**

1. Summarize your thoughts about the impact on the world if ice were denser than water.





Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## The Science of Water: Student Quiz

Write down your ideas about each question below.

1. Why does all bonding occur between atoms, ions, and molecules?
2. Draw a water molecule. Label the atoms that make up the water molecule with their chemical symbol. If there is an electrical charge or a partial electrical charge on any of the atoms, indicate that by writing the symbols on the atoms:  
 $+$  = positive charge                       $-$  = negative charge  
 $\delta^+$  = partial positive charge       $\delta^-$  = partial negative charge
3. Explain the term “polar” molecule.
4. Why does water have an increased surface tension compared to most other liquids?



5. What is “hydrogen bonding”? What makes these bonds unique?
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6. a. Define or describe “specific heat.”
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- b. How does water’s specific heat have an impact on our climate?
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7. Is water’s specific heat, compared to other liquids:  
High  or Average  or Low  ?
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8. Are water’s melting and boiling temperatures, compared to other liquids:  
High  or Average  or Low  ?
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9. a. What happens to the temperature of the water in a pot on a heated stove as it continues to boil?
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- b. Explain what the energy is being used for that is heating the water at the boiling temperature.



10. Explain how a spider can walk on water.

11. Fill out the following table: Name and explain five of water's unique properties, and provide an example of the phenomenon in nature caused by each of these properties.

| <b>Property of Water</b> | <b>Explanation of Property</b> | <b>Phenomenon Property Causes</b> |
|--------------------------|--------------------------------|-----------------------------------|
|                          |                                |                                   |
|                          |                                |                                   |
|                          |                                |                                   |
|                          |                                |                                   |
|                          |                                |                                   |



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## Reflecting on the Guiding Questions: Student Worksheet

Think about the activity you just completed. What did you learn that will help you answer the guiding questions? Jot down notes in the spaces below.

1. Why are water's unique properties so important for life as we know it?

What I learned in these activities:

What I still want to know:

2. How do we make water safe to drink?

What I learned in these activities:

What I still want to know:

3. How can nanotechnology help provide unique solutions to the water shortage?

What I learned in these activities:

What I still want to know:

4. Can we solve our global water shortage problems? Why or why not?

What I learned in these activities:

What I still want to know: