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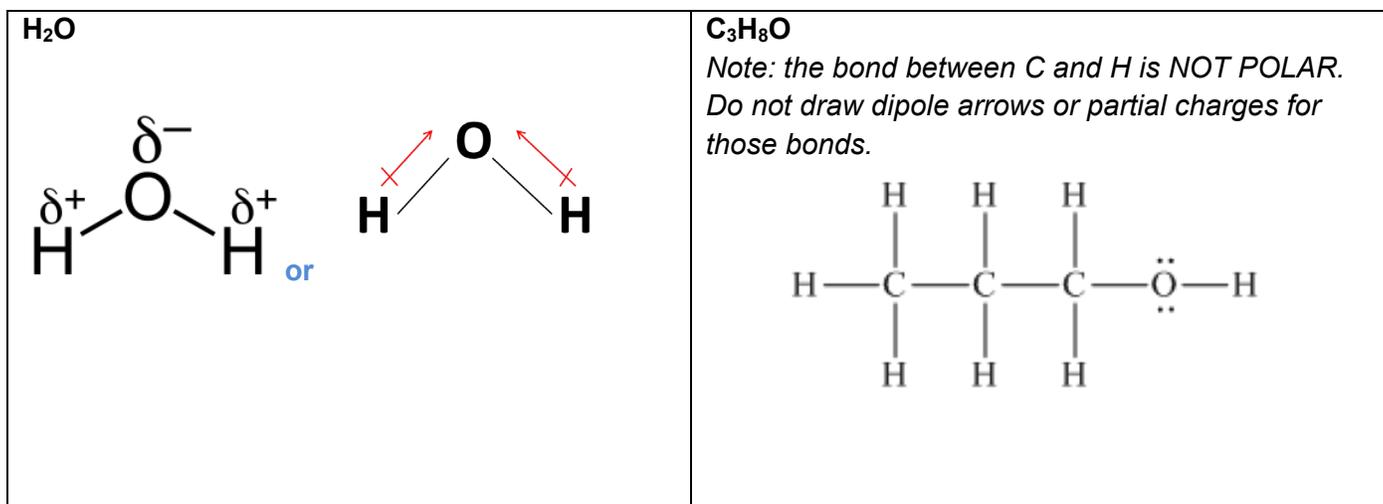
## Intermolecular Forces Lab Worksheet - Answer Key



**Directions:** Today you will complete two experiments that compare the properties of water to isopropanol (a type of rubbing alcohol). Before conducting each experiment, you will first read about the experiment and then make a prediction about what you think will happen. Afterward you do the experiment, you will write an explanation of what was happening at the atomic level that let us observe these properties.

**Introduction:** In many ways, water is a miracle liquid. It is essential for all living things on earth and it is often referred to as a universal solvent because many substances dissolve in it. Water displays unusual properties due to the ways the individual water molecules interact with each other.

1. Draw the structural formula (with lone pairs) for the two molecules we will be comparing today, water ( $\text{H}_2\text{O}$ ) and isopropanol ( $\text{C}_3\text{H}_8\text{O}$ ). Draw a dipole arrow to show the direction the electrons are being pulled and label the areas of partial positive and negative charges.



2. Which molecule is more polar? water

### **Experiment #1: Penny**

How many drops of water fit on the head of a penny? How many drops of isopropanol fit on the head of a penny?

### **Prediction:**

- a. I think \_\_\_\_\_ drops of water will fit on the head of the penny because \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

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b. I think \_\_\_\_\_ drops of isopropanol will fit on the head of the penny because \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Procedure:**

1. Place one penny on a paper towel.
2. Drop water onto the surface of the penny, slowly, one drop at a time using the **dropper bottle with water**.
3. Count how many drops it takes until the water spills off the penny.
4. Record the number of drops.
5. Repeat steps A through D for isopropanol using the **dropper bottle with isopropyl alcohol**.
6. Compare the number of drops of isopropanol to the number of drops of water.

**Observations:**

	Drops that fit on the penny
Water	Answers will vary
Isopropanol	Answers will vary

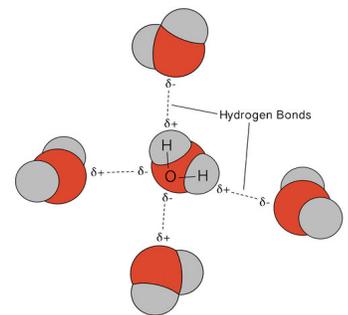
**Conclusions:**

Were your predictions correct? Explain. Answers will vary  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Reading:**

Since the hydrogen and oxygen atoms in the water molecule carry opposite (partial) charges, nearby water molecules are attracted to each other. The attraction between the  $\delta^+$  hydrogen and the  $\delta^-$  oxygen in adjacent molecules is called **hydrogen bonding**.

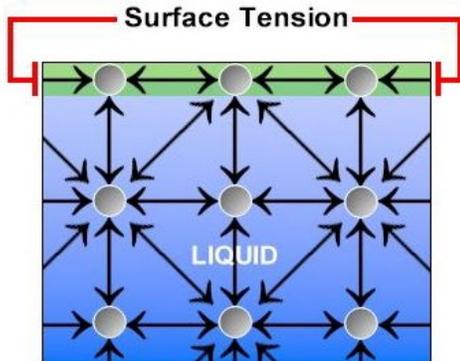
Hydrogen bonding is an **intermolecular force**. Intermolecular forces are forces between molecules in a substance. Hydrogen bonding is one of the strongest intermolecular forces and causes water to have many unusual properties.



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Neighboring water molecules are attracted to one another. Molecules at the surface of liquid water have fewer neighbors and, as a result, have a greater attraction to the few water molecules that are nearby. This enhanced (greater) attraction is called **surface tension**. It makes the surface of the liquid water slightly more difficult to break through than the interior of the water.



**Surface tension** (seen on the left) is the force between water molecules at the surface of a sample of liquid water. These molecules form stronger hydrogen bonds with each other than the molecules below. A water strider is an insect that takes advantage of this property of water – the insect can walk along the surface without breaking through.

**Explanation:** Why did more water drops fit on the surface of the penny than isopropanol drops? Use evidence from the reading about **hydrogen bonding** and **intermolecular forces** in your response.

Answers will vary but should make note of the fact that isopropanol does not have surface tension in the same way that water does because it does not feature hydrogen bonding between molecules due to the lack of polarity.

### **Experiment #2: Evaporation Rates**

*Which evaporates faster, water or isopropanol?*

**Prediction:** Do you think water or isopropanol will evaporate faster? Why? Answers will vary

### **Procedure:**

1. Dip one end of a Q-tip in water. Shake off excess water.
2. Dip one end of a different Q-tip in isopropanol. Shake off excess isopropanol.
3. At the same time, draw (streak) the tips of each Q-tip across a paper towel in **two parallel lines**.
4. Time how long it takes for each streak to evaporate.
5. Watch and wait to determine which liquid evaporates first. (This may take a few minutes.) Record your observations.

### **Observations:**

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	Time to evaporation
Water	Answers will vary
Isopropanol	Answers will vary

**Conclusions:**

Were your predictions correct? Explain. Answers will vary

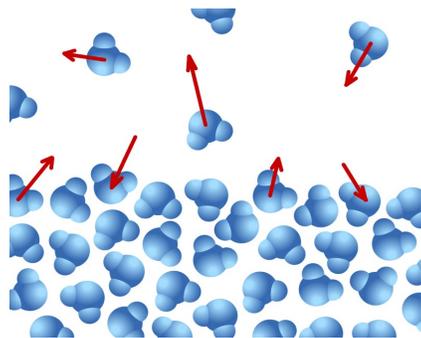
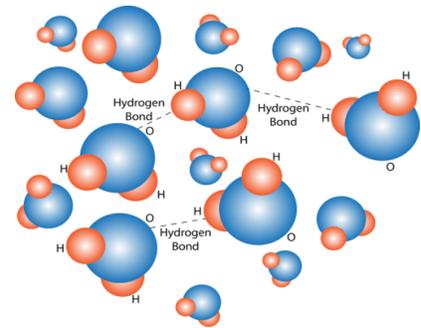
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**Reading:**

Since the hydrogen and oxygen atoms in the molecule carry opposite partial charges, nearby water molecules are attracted to each other. The attraction between the  $\delta+$  hydrogen and the  $\delta-$  oxygen in adjacent molecules is a special type of intermolecular force called **hydrogen bonding** that causes water molecules to “stick” together in liquid form. This force has to be overcome in order for liquid water to become a gas. It takes a lot of energy to overcome the force of hydrogen bonding.



When enough energy has been added to water it boils and turns from liquid to gas. This happens at a temperature of  $100^{\circ}\text{C}$ . Isopropanol turns from liquid to gas at  $82.5^{\circ}\text{C}$ . Since the vaporization of isopropanol occurs at a lower temperature than water, this means it takes less energy to turn isopropanol into a gas, and therefore it will evaporate faster than water. Isopropanol has weaker intermolecular forces holding its molecules together so it takes less energy (a lower temperature) to separate the molecules to enter the gas phase.

**Explanation:** Why does isopropanol evaporate faster than water? Use the terms **hydrogen bonding** and **intermolecular forces** in your response.

Answers will vary but should make note of the fact that isopropanol does not have hydrogen bonding between molecules due to the lack of polarity which results in the molecules “sticking together” more. Since the molecules are more stuck together, it takes more energy to separate their bonds resulting in a higher boiling point.