Name: Period:

The Properties of Water: Observations, Guided Reading, and Analysis

Part 1: Some background information

Water: structural formula and properties.	**Isopropyl Alcohol: structural formula**

Part 2: Observations

1. Work with a partner. Have your partner close their eyes. Put a drop of alcohol on the back of their hand. Next to that, put a drop of water. Don't tell them which one is which. Use the tip of the dropper to spread both of them out. Feel how the drops are different. Describe the difference, and try to guess which drop is which liquid. Organize your observations and record below.

Water	Alcohol

2. Put a drop of alcohol on a penny. Do the same with a drop of water. Look at them from the side. Sketch each one, and describe how they're different.

Water	Alcohol

3. Repeat what you did above with wax paper. Look at each drop from the side. Sketch each one, and describe how they're different.

Water	Alcohol

4. Put ONE drop of water on a penny, and ONE drop of alcohol on a second penny. Use the tip of each dropper to spread out each drop. Compare the speed of evaporation for the one drop of alcohol, and the one drop of water. Create a data table, run at least two trials, and determine an average:

5. Use a dropper to pile drops of water on a penny. COUNT THE NUMBER OF DROPS YOU CAN PILE ON BEFORE THE WATER SPILLS OVER THE EDGE. Then do the same with alcohol. Make a data table where you record what happens. Add other qualitative observations.

6. Class demonstration. Compare what happens when you try to dissolve salt in water, and when you try to dissolve it in alcohol.

7. Take a cup or beaker, and fill it about 2/3 with water. Try to float a small paper clip on the water's surface. Then take your same paper clip, and try to float it on the beaker filled with alcohol at the front of the room. Describe your results.

Preliminary explanation: How would you summarize the difference between how water behaves and how alcohol behaves.? What do you know about water and alcohol that can explain any or all of these observations?

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Part 2. Guided Reading: Understanding Water

If you want to understand water, you can start by comparing it not to alcohol, but to methane, CH_4. Methane is the gas that we use for cooking and heating. It consists of one carbon atom that is covalently bonded to four hydrogen atoms. Carbon has 6 protons, 6 neutrons, and 6 electrons. Hydrogen has one proton and one electron. Use that information to draw two diagrams of methane: one that shows electron sharing, and one that shows methane's structural formula, with a dash representing a shared pair of electrons.

Methane, showing electron sharing	**Methane, structural formula**

As you can see, the carbon and hydrogen each share a pair of electrons. Those four shared pairs make up the four covalent bonds that hold the molecule together. In methane, that electron sharing is pretty much equal. The result is that there are no unbalanced electrical charges on any part of methane molecule. Unlike a magnet, methane has no positive or negative pole. Methane molecules aren't attracted to one another (or to anything else). The result of that is that methane, at room temperature, is a gas.

Water, though it's actually a smaller and lighter molecule than methane, is very different. Oxygen has 8 protons, 8 neutrons, and 8 electrons. Use that information to draw a diagram of a water molecule that shows electron sharing between the single oxygen and the two hydrogens. Then, draw the structural formula.

Water, showing electron sharing	**Water, structural formula**

As you can see, one side of water has more of the negatively charged electrons. The other side, by contrast, has the positively charged protons – the nuclei of the hydrogen atoms – exposed. As a result, each water molecule is like a magnet, with each side having an opposite charge. The oxygen side of the molecule is negatively charged, and the hydrogen side is positively charged. Draw the structural formula again, showing these charges.

Water, structural formula, showing the charges

These charged regions make water like a magnet. Magnets, you remember, have a north and a south pole. The opposite poles attract, and the same poles repel (push away). Magnets, in other words, are polar, and water molecules are too. However, instead of having a north and a south pole, water molecules have a positively charged side (where the hydrogens are) and a negatively charged side (where the electrons are).

This organization of charges is called *polarity*. The result of this polarity is that water molecules interact with each other just like magnets do: opposite poles attract, and their like poles repel. Water molecules, in other words, will form bonds with one another. And this bond that forms between one water molecule and the next has its own name: it's called a *hydrogen bond*.

Draw two water molecules, showing hydrogen bonds. Use ". . . " to represent the hydrogen bond.

Draw four water molecules, showing hydrogen bonds. Use ". . . " to represent the hydrogen bond.

Hydrogen bonds are relatively weak—they're much weaker, for example, than the covalent bonds which hold the atoms of a water molecule together. But, they change everything about water's properties. To begin with, hydrogen bonds make water a liquid. Water molecules literally stick together. So instead of flying apart, as molecules of a gas will do, water molecules, at room temperature, will stay in a container. This explains why methane is a gas at room temperature, while water is a liquid.

We saw many other properties of water in our lab comparing water and alcohol. Alcohol's formula is C_3H_8O. Its structure can be drawn as follows.

Isopropyl alcohol, C_3H_8O, structural formula

The -OH at the end gives alcohol a slight charge on that end. But, overall, alcohol is much *less* polar than water. And this explains many of the differences between them.

Let's start with the way that water and alcohol drops look when you put them on any non-absorbent surface, like a penny, plastic, or wax paper. Using your data from the lab, redraw the shape of these drops below.
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Water drop on a penny	**Alcohol drop on a penny**

Because the water molecules are grabbing onto one another through hydrogen bonds, a water drop can maintain some of the spherical shape it has when it comes out of the water dropper. The hydrogen bonds, in other words, are resisting the force of gravity, which is pulling the water molecules down. Because alcohol is so much less polar, it can't resist gravity, and all of the molecules are pulled down into a flat sheet over the penny's surface.

Hydrogen bonding also explains why a drop of alcohol is able to evaporate so much more quickly than a drop of water. Here's what happens. All molecules are in constant motion. The warmer the molecules are, the faster they move. Even at room temperature, some of those alcohol molecules are moving so fast that they can jump away from the other molecules in the drop, and enter the air as a vapor. Because there's very little attraction between the alcohol molecules, eventually all of the alcohol molecules jump into the air, and the entire drop evaporates.

In water, because of hydrogen bonding, the situation is different. The water molecules, like the alcohol molecules, are also vibrating and moving. But hydrogen bonds keep the molecules from jumping away from the drop, so that the drop didn't evaporate during the minute or so that you were observing it.

This also explains why the alcohol molecules felt so much cooler than the water molecules. When a molecule changes from liquid form to a gas, it carries its heat energy away from the liquid that it's in, and brings that energy into the air. That reduces the overall amount of energy in the liquid, which lowers its temperature. When you put a drop of alcohol on your hand, the heat in your hand made the alcohol molecules vibrate. As they jumped into the air, they carried heat away, which made your hand feel cooler.

Because of hydrogen bonding, the heat on your hand didn't make the water evaporate (though it did warm up the water molecules). But because those molecules stayed right on your hand, no heat was carried away, and you didn't have a sensation of coolness.

This, by the way, is how your body uses perspiration to maintain homeostasis in body temperature. As your body temperature goes up, you respond by releasing sweat onto your skin. If there's enough heat, those water molecules will start moving around quickly enough to jump away from your body. This carries away heat, and lowers your body temperature.

We also compared water and alcohol in terms of their ability to dissolve salt. We observed that the water could dissolve salt, and alcohol couldn't. The reason has to do with water's polar nature. Table salt is an ionic compound. It consists of sodium and chlorine atoms that have traded electrons and become charged particles, or ions. The sodium ions are positively charged, and the chlorine ions are negatively charged. You can draw this below, using the symbol Na for sodium and Cl for chlorine.

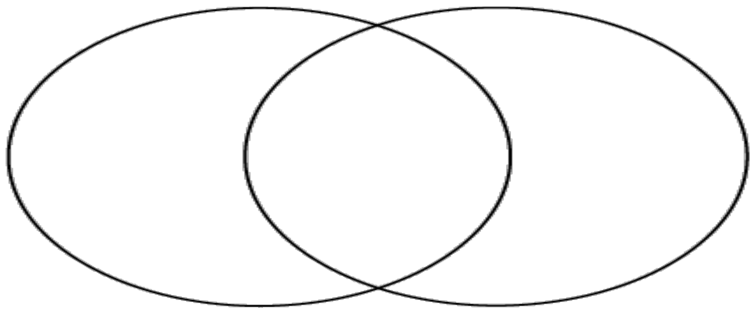
Table salt (sodium chloride), showing its ionic structure	How water dissolves table salt

When you put salt into water, the water molecules pull the sodium and chlorine ions apart. The positive charges on water are attracted to the negative chlorine, and the negative charges on water are attracted to the positive sodium. You can sketch this interaction in the space above.

Because alcohol is only slightly polar, alcohol can't break the ionic bond between sodium and chlorine. Instead of dissolving, the salt crystals stay together on the bottom of the cup.

3. Comparing Water and Alcohol

Water *Alcohol*



Write it! Think, Pair Share, Agree, then write

1. Water and alcohol *are similar* because they're both ________________________. However, water *is unlike* alcohol because____

2. *Unlike* alcohol, which does not ____, water ____. As a consequence, ____

3. *A distinction between* alcohol and water is that ______________________ evaporates at a lower temperature than ____________ because ____.

Part 4. Checking Understanding from the Reading and Lab

4. Why is water a liquid at room temperature, and why is methane a gas?

5. Why is water more like a magnet than either methane is or alcohol is?

6. What is polarity?

7. Compare hydrogen bonds and covalent bonds by checking the boxes that apply.

	Hydrogen Bond	Covalent Bond
Occurs *between* water molecules		
Occurs *within* molecules		
Is an extremely strong force		
Is a relatively weak force		

Part 5. Applying what you've learned

8. Which causes which: does hydrogen bonding cause polarity, or vice versa? Explain. ____________________________ ____

9. When placed on wax paper, water will ____ This shape is a result of ____. By contrast, alcohol will ________________ _____________________ This is because ____ ____

10. When exposed to the same amount of heat, water will ____ much less than alcohol. This is because ____ ____

11. A bug called a water strider can stand up on water. This can occur because water is a __________________________ molecule that forms ____ with other water molecules. As a result, __________ ____

12. When mixed with water, salt will ____ , whereas the same amount of salt mixed into alcohol will not ___________________. This is because ____ ____