Laboratory: Intermolecular Forces (IMF)

Report Requirement: Answer all of the questions/do all the computations requested in *italics*. Questions not in italics do NOT need to be answered. You do NOT have to write a formal lab report. You should write your answers into a word processing program and save the file. Go into the Lab-IMF Report and cut and paste the answers to each question in the appropriate space. There is no additional Drop Box. (Lab-IMF Report can be found on the Content page or under Assignments → Quizzes.)

Labs not submitted in the appropriate area will *not* be graded.

Report Scoring: 20 points total. Questions valued as marked.

Working with a Partner: You are permitted to work with a partner. If you do so, the experimental data reported may be the same, but you need to write your own answers to each question. At the beginning of each question you should note that you worked with a partner by writing "Lab Partner (fill in name)."

Goals:

1. To explore the polarity of water.
2. To examine the relationships between structure, intermolecular forces and polarity.

Materials Needed:

Plastic water bottle, plastic ruler or plastic pen
Wool or cotton fabric (or you can use the hair on your head!)
Balloon (you may find one in your Lab Kit)
Styrofoam and/or paper – torn into small pieces
3 pennies with paper towel or Kleenex to dry them in between trials
3 plastic pipets ("droppers") (from your other lab kits)
A room where it is not too humid (try to perform on a day when it's not raining)

Chemicals Needed:

Tap water
Rubbing Alcohol (Isopropyl alcohol)
Another common household chemical. You must use one of the following:

- mineral spirits (paint thinner – check ingredients)
- vegetable oil
- acetone (nail polish remover)
- ethyl acetate (non-acetone nail polish remover)

From the Clinicsville Animal Hospital:

Have you ever seen a spider striding across the surface of the water and wondered how he does it? He's not simply floating - the spider is more dense than water. So what the heck is going on?!! See if you can come up with a good hypothesis after performing these experiments.

Lab Directions

Experiment 1: Bending Water

1. At a faucet, turn on a small stream of water – try to get it to be the smallest stream possible but still a continuous stream (not drops). Rub the plastic item (bottle, pen, or ruler) against the wool or cotton cloth (or the hair on your head) to "statically charge" it. Move the plastic item close to the stream of water, but do not let it touch. Watch as the stream moves toward the ruler.
2. Repeat the above with a blown up balloon.
3. Find some bits of Styrofoam and tiny pieces of paper. Rub the plastic item or balloon with the cloth and then bring it close to the bits of Styrofoam and paper. Try to find other things that will react to the charged plastic item or balloon.

   Question #1: ***(3 points)*** *Describe your observations from all 3 parts of experiment 1.*

   Question #2: ***(1 point)*** *Which material (plastic item or balloon) seemed to have the strongest affect on the stream of water?*

What caused the bending of the water?

As you may know, a "static charge" is a buildup of a charge on an item. This could be due to the object gaining extra electrons, which are negatively charged, or it could be due to the object losing electrons, making the object positively charged. In our case, your plastic item and balloon likely gained excess electrons (because it did the rubbing, picking up the electrons).

Water molecules are polar which means they have a "dipole" (i.e. two poles: a positive and a negative). This is because their molecular shape is "bent" (i.e. the hydrogens are *not* 180^o apart but rather more like 104.5^o). The oxygen on the molecule pulls some of the "electron density" towards itself since oxygen is more electronegative than hydrogen. This gives the oxygen a "partial" negative (represented by the red in Figure 1). It is not a full negative because oxygen is not an ion where it would completely own the electrons. They are still shared with the hydrogen, though shared unequally. This leaves the hydrogens feeling a slight positive (represented by the blue in Figure 1). So the molecule has 2 poles: an area where the electron density is more concentrated (on the oxygen) and an area where the electron density is less (on the hydrogens). See Figures 2 & 3. Note that the Greek letter delta, δ, represents a *partial* (rather than a full) charge.

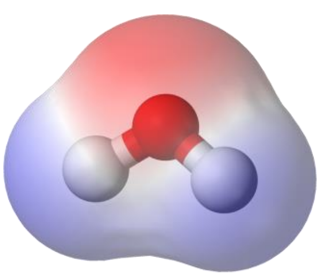


FIGURE 1: Water molecule electron density https://en.wikipedia.org/wiki/Chemical_polarity#/media/File:Water-elpot-transparent-3D-balls.png

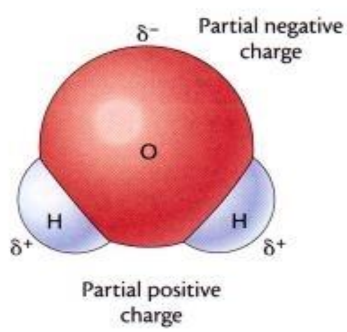


FIGURE 2: Partial Charges in water molecule https://www.quora.com/What-is-a-polar-molecule

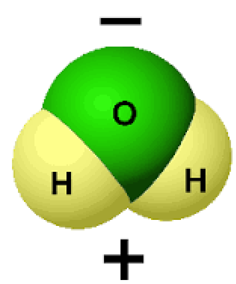


FIGURE 3: Dipole in water molecule https://www.quora.com/What-does-polar-mean#!n=12

You have likely heard the phrase "opposites attract". Since your plastic item was likely negatively charged, it must have attracted the positive portion of the water molecule. This means the molecules flipped so that the positive portion of the water molecules were closer to the negatively charged object.

Question #3 ***(4 points)*** *What do you think would happen to the stream of water if the charged object were positively charged? Do you think the stream of water would be repelled, attracted or unaffected by the positively charged object? EXPLAIN WHY.*

<u>Experiment 2: Drops on a penny</u>

1. First practice using a dropper/pipet with a cup of water. Notice that if you put the dropper in the water first and *then* squeeze it, bubbles will come out. Instead, the proper way to use the dropper is to squeeze it while it is *not* in the liquid, don't let go, and then put the tip in the liquid, slowly loosen your grip on the bulb to draw the liquid up. Practice making drops. The goal is to make evenly sized drops. How does this work? When you squeeze the bulb, you are pushing air out. When releasing your grip with the tip in a liquid, the liquid will get pushed up into the pipet to equalize the pressure in the bulb and outside (the atmospheric air pressure actually pushes up the liquid. There is no such force as "sucking a liquid up.") We will be dropping liquid onto a penny. Be sure your drops are even and that the tip of the pipet is close to the penny without touching the liquid that is already on the penny.

Good technique is critical. Notice how close the pipette is to the penny:

2. With a dropper, penny and cup of water, count how many drops of water can fit on the penny. Remember to aim for even drops, close to the penny but don't let the dropper tip touch the penny. Repeat this 3 times – *make sure you thoroughly dry the penny between each trial.* Find the average number of drops of water you can fit on the penny.

3. Repeat the above experiment with rubbing alcohol. Use a new pipet (but don't discard the other ones.)

   Question #4: ***(4 points)*** *Record and report your results for each experiment (water and then alcohol drops on the penny). Make sure that you include the individual results and the average.*

<u>Why could so many drops fit on the penny?</u>

As we've already learned, water has a dipole. Because opposites attract, just like magnets, water molecules stick to each other really well. The term for this is **cohesion**. (Note that in figure 4 below, water *molecules* are simply represented by a sphere.) The force that is **between** two water molecules, holding them together, is called a **hydrogen bond,** a type of **intermolecular force** ("inter" means "**between**"). Note that a hydrogen bond is *different* than the covalent bonds between the H's and O atoms that hold one water molecule together, labelled in Figure 5 below. The **hydrogen bonds between <u>molecules</u>** are represented by dotted lines. The **covalent bonds between <u>atoms</u>** ***within*** the molecule are generally shown by solid lines.

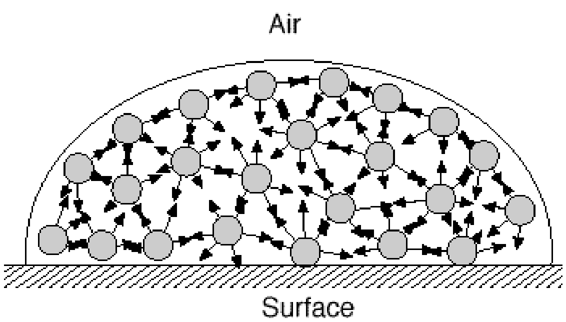


Figure 4: Cohesion of molecules
https://manoa.hawaii.edu/exploringourfluidearth/chemical/properties-water/hydrogen-bonds-make-water-sticky

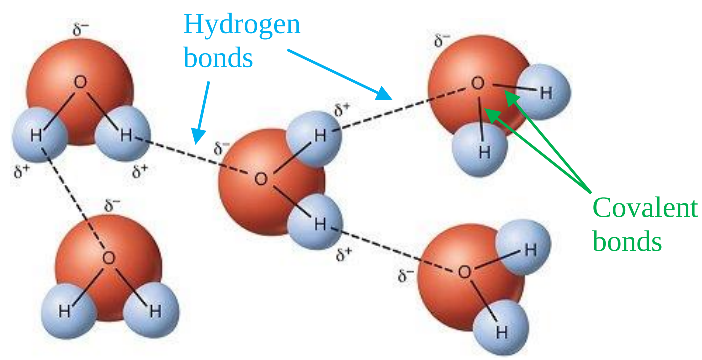


Figure 5: Hydrogen bonding in water
http://www.lifeharmonizer.name/index.php?id=585

Here is one more picture to distinguish between hydrogen bonding and covalent bonding. Note that covalent bonds are much stronger than hydrogen bonds. When we boil water, we break the hydrogen bonds first and still have water molecules; they are just separated from each other but are still intact molecules. The O-H covalent bonds **within** the molecule do not break.

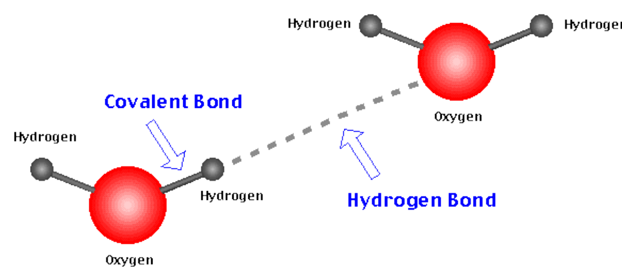
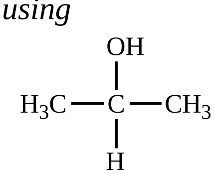


Figure 6: Hydrogen bonding vs covalent bonding in water
http://www.physicsofmatter.com/NotTheBook/Talks/Ice/Ice.html

*Question #5: **(4 points)** Explain the difference between your results in using water vs. rubbing alcohol on the penny based on your knowledge of polarity and cohesion. Look at the structure of each compound and use intermolecular forces to justify your answer. Hint – the structure of isopropyl alcohol is shown to the right. Compare it to the structure of water and think about int**er**molecular forces (i.e.* **between** *the molecules).*



Isopropyl Alcohol

5. Try the drops on a penny experiment using another household chemical. Choose one of the following as your chemical: mineral spirits (paint thinner – check ingredients), vegetable oil, acetone (nail polish remover) or ethyl acetate (non-acetone nail polish remover). Repeat it 3 times. Be careful to avoid fires or excessive contact– these items are all flammable, and most are irritants or harmful, especially if swallowed.

> *Question #6:* ***(3 points)*** *- Report your results (3 trials plus an average) and* *explain* *your conclusions about the cohesive forces in this molecule. It is a good idea to look up the structure of your chemical so that you know what types of intermolecular attractions are possible – in other words, don't tell me something hydrogen bonds when it does not have anything that can hydrogen bond.*

6. Evaluate the lab by answering the following question:

> *Question #7:* ***(1 point)*** *Please give constructive feedback regarding this lab. Was it worthwhile? Did it illustrate CHE 106 concepts? What did you gain/learn from doing the experiments that you did not learn from the text alone? What would you keep/recommend in future semesters? What would you change?*

This is not a particularly long lab, but the emphasis - both for your learning and my grading - is on your thought process.

Looking ahead...
Hold on to the pipets/droppers; they may be useful in later labs.

You should write your answers into a word processing program and save the file. Go into the Lab-IMF Report and cut and paste the answers to each question in the appropriate space. (Lab-IMF Report can be found on the Content page or under Assignments → Quizzes.)

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