Module 7; Strengths of Intermolecular Forces

Procedures and Data

In this activity, you will watch an animation of intermolecular forces for comparison and then use a simulation to investigate them and determine how they relate to change in state.

Part One: Comparing Strengths of Intermolecular Forces

1. Click on the following link to open a short (1 minute 19 seconds) YouTube Video. Put it on a split screen so you can answer the following questions while you watch the video. You can use "k" to pause and restart.
   https://youtu.be/zDVDoWpdrxg

Molecule in image	Name of Force	Describe (or draw) the intermolecular force shown
The yellow molecule represents two atoms bonded together to make a nonpolar molecule with no partial charges (until induced). You can imagine O_2 as an example.		
The red/blue molecule represents a polar molecule. You can imagine HCl with the hydrogen carrying the partial positive charge and the chlorine carrying the partial negative charge.		
The red/white molecules represent a polar molecule as well. You can imagine this as water with the oxygen carrying the partial negative charge and the hydrogens with the partial positive.		

2. Why is the London Dispersion Force so weak?

3. What causes the permanent dipoles found in molecules that can form dipole-dipole forces and hydrogen bonds?

4. Why is the Hydrogen bond so strong?

5. Which atoms are required for molecules to form Hydrogen bonds?

6. What do STRONG intermolecular forces mean in terms of melting and boiling points. Why?

Part Two: Comparing Dipole-Dipole and London Forces

1) Open the following simulation and put it on a split screen. (You may need to cut and paste into the browser if the link isn't working.)

   https://learn.concord.org/eresources/745.run_resource_html

2) You should see the simulation.
3) From the drop down "select a pair of molecules" menu, Select "pull apart two polar molecules" and make a note of the arrangement – opposites attract. (You can imagine that the molecule is H-Cl with the blue positive representing hydrogen and the red negative representing chlorine).
4) Play with the simulation: click-and-drag the star to "feel" how hard it is to pull apart the molecules; move the molecule back and watch it stick together; notice that when it sticks together it always has opposite poles attract; you can even move the star and then let go – watch as the molecules are pulled together by the dipole-dipole forces.
5) Now select "pull apart two nonpolar molecules" and make a note that there are no +/- signs, because these molecules are nonpolar.
6) Play with the simulation and watch how much easier it is to pull part these molecules. They ONLY have London-dispersion forces of attraction; no dipole-dipole forces.
7) After you separate them, try to get them to stick back together by dragging the molecule in.
8) Select "pull apart a nonpolar and polar molecule" and play with the simulation.
9) Rank the strength of the force (1 = strongest) based on the simulation:

	Rank 1 = strongest
Between two non-polar molecules	
Between two polar molecules	
Between a polar and non-polar molecule	

1) Compare the specificity of the polar molecule when interacting with another polar molecule or with a non-polar molecule. Does the red atom on the moving molecule always interact with the same atom on the stationary molecule?

Part Three: Hydrogen-Bonding forces

ALL covalent molecules which have N-bonded-to-H, or O-bonded-to-H, or F-bonded-to-H exhibit hydrogen bonding forces. Because H is such a low electronegativity nonmetal and N, or O, or F are such high electronegativity nonmetals, H-bonding is a VERY strong type of dipole-dipole force. Hydrogen-bonding forces are so strong they given their own name (not dipole-dipole). Molecules with H-bonding also have L-D forces in addition to the H-bonding forces. Common molecules with H-bonding are: H_2O, NH_3, HF, C_2H_5OH (alcohol), CH_3NH_2, etc.

1. Open the following simulation in a split screen:

https://learn.concord.org/eresources/769.run_resource_html

2. Deselect “show hydrogen bonds” and “show partial charges”. You will see water molecules.

What does the white color represent?	
What does the red color represent?	

3. Then check “show hydrogen bonds” and “show partial charges.” The “+” and “-“ signs actually represent δ+ (partial positive) and δ- (partial negative). These partial charges are based on low and high electronegativity and create a very polar molecule.

4. Click the play button (way at the bottom after a lot of blue empty space) to observe these water molecules as they move around, and the dotted lines represent the hydrogen-bonding that occurs.

5. Play with the simulation by clicking “cool” and watch the particles slow down and begin to get closer together – this would eventually lead to freezing. Answer the questions in the table below.

Cool it all the way down to watch water freeze. Wait – it takes a while. Describe frozen water at the molecular level:	
Click “heat” and watch the particles move faster and further apart – this would eventually lead to melting and boiling. Stop at the point when you would consider water to be liquid. Compare liquid water at the molecular level to frozen water.	
Then heat it up some more. Stop at the point when you would consider water to be a gas (steam). Compare gaseous water at the	

molecular level to the other states.	

6. Continue to play with the simulation by checking and un-checking any of the boxes and heating/cooling and noting the formation of hydrogen-bonding forces when particles get close together. Be sure to check the slow-motion and watch that for a while; it's easiest to see the hydrogen bonds in slow motion.

Part Four: Freezing, Melting and Boiling

The physical processes of freezing, melting and boiling involve the making and breaking of intermolecular forces.

1. Open the following link in a split screen and click on preview:

https://learn.concord.org/eresources/749.run_resource_html

1) There are two images. One is an image of a bunch of polar molecules and one is an image of a bunch of nonpolar molecules. Answer the questions in the table below:

Which image (left or right) is for polar molecules?	
How do you know?	
Which image (left or right) has stronger intermolecular forces?	
Make a prediction: Which image (left or right) will boil faster?	
Which button (cool or heat) would you select for boiling?	
Run your experiment. To do this, press "play" at the very bottom of the screen (after all the blue space). And immediately select the correct button (cool or heat) for boiling. Record your observations	
Now freeze the two different molecules. Record your observations:	
Expand your screen so that you can see the gray dashed lines between molecules. You will see them best at about 400K. These gray dashed lines are intermolecular forces.	

What is the name of the force between molecules in the left image?	
What is the name of the force between molecules in the right image?	

POST LAB QUESTIONS

Complete the tables below

Molecules	Polar or Nonpolar Molecules	Kind of Force between molecules	Rank strength of force from 1 to 3 (1= strongest)	Rank boiling point from 1-3. (1 = highest)
H_2 and H_2				
HBr and HBr				
HF and HF				

Molecules	Polar or Nonpolar Molecules	Kind of Force between molecules	Rank strength of force from 1 to 2 (1= strongest)	Rank boiling point from 1 to 2. (1 = highest)
H_2 and H_2				
Br_2 and Br_2				

Look up the boiling points of H_2 and Br_2 in ˚C. Record them. Are they consistent with your predictions?