Name:
Period:
Date:

Activity: Intermolecular Forces

In this activity, students will use a simulation to investigate different types of intermolecular forces and how they relate to physical properties (boiling point and solubility).

Objectives

By the end of this lesson, students should be able to

- Better understand the relative strengths of intermolecular forces.
- Relate intermolecular forces to physical properties

Part One: London-dispersion Forces

ALL covalent-bonded molecules exhibit London-dispersion forces. Nonpolar molecules have ONLY London-dispersion forces.

London Dispersion forces are due to temporary and induced dipoles from the natural repulsion between electrons and attraction of electrons to protons. L-D forces are the weakest IMF, but are the strongest in nonpolar molecules. L-D force increases as the size of the nonpolar molecule surface increases, due to a larger number of mobile electrons.

1) Watch the following video: https://www.youtube.com/watch?v=H37-r-t0bf4
2) Notice that a NONPOLAR electron cloud can repel another electron cloud if they get close enough to each other. This temporary repulsion deforms the electron cloud and makes it temporarily polar. This temporary dipole creates just enough attraction for nonpolar molecules to have some IMF attraction.

Part Two: Comparing dipole-dipole and L-D Forces

ALL polar molecules exhibit dipole-dipole forces due to their permanently polar structure. Polar molecules also have L-D forces *in addition* to their dipole-dipole forces.

Dipole-dipole forces are another type of IMF involving permanently polar molecules. This type of IMF is generally stronger than L-D force. In order to have dipole-dipole forces, two polar molecules must get close enough for the opposite poles to be attracted. Dipole-dipole forces increase as the polarity of the molecule increase (larger electronegativity difference).

1) Open the following simulation and click "Run Model": http://concord.org/stem-resources/comparing-dipole-dipole-london-dispersion
2) Select "pull apart two polar molecules" and make a note of the arrangement – opposites attract.
3) 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 under the word "attraction" and then let go – watch as the molecules are pulled together by the dipole-dipole forces.
4) Now select "pull apart two nonpolar molecules" and make a note that there are no +/- signs, because these molecules are nonpolar. 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.
5) Select "pull apart a nonpolar and polar molecule" and play with the simulation.

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 and click “Run Model”: http://concord.org/stem-resources/hydrogen-bonds-special-type-attraction
2) Begin by checking “show hydrogen bonds” and “show partial charges.” REMEMBER – water is NOT ionic. The “+” and “-“ signs are based on low and high electronegativity and create a very polar molecule. Click the play button to observe these water molecules as they move around and the dotted lines represent the hydrogen-bonding that occurs.
3) 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. Click “heat” and watch the particles move faster and further apart – this would eventually lead to melting and boiling.
4) 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.

FEEL the difference in IMF between actual molecules:

1) Open the following simulation and click “Run Model”: http://concord.org/stem-resources/comparing-attractive-forces
2) Select "pull apart Br_2 and Br_2." Feel how difficult it is to pull apart the two molecules and record.
3) Select "pull apart H_2 and H_2." Feel how difficult it is to pull apart the two molecules and record. Compare to the feeling of separating the Br_2 molecules. Why was it easier to separate the H_2? What type of forces do H_2 and Br_2 have?
4) Select "pull apart HBr and HBr." Feel how difficult it is to pull apart the two molecules and record. What type of forces do HBr molecules have? Compare the strength to the forces in H_2 and Br_2.
5) Select "pull apart Br_2 and HBr." Compare the strength of the forces.

Use your observations and PREDICT the forces in HF

6) IF you used HF and HF in this same simulation, predict the observations in the Data Table below

	Relative force to pull apart	Polar or nonpolar?	IMF
Br_2 and Br_2			
H_2 and H_2			
HBr and HBr			
H_2 and HBr			
PREDICT: HF and HF			

Analysis

Considering the observed IMF and strength of those forces, complete the following questions with your best predictions.

1) Rank the following molecules from lowest to highest boiling point: H_2, Br_2, and F_2. Explain your prediction based on IMF.

2) Predict which of the following has the highest boiling point: HF or HBr. Explain your prediction based on IMF.

3) You can play with this simulation to observe how different IMF can impact boiling point (boiling temp) http://concord.org/stem-resources/boiling-point
4) Consider water, H_2O. Predict how water’s boiling point compares to HBr and HF? Explain your prediction based on IMF.

5) Look up the boiling points of H_2, H_2O, Br_2, F_2, HBr, and HF. Were your predictions correct? Explain.