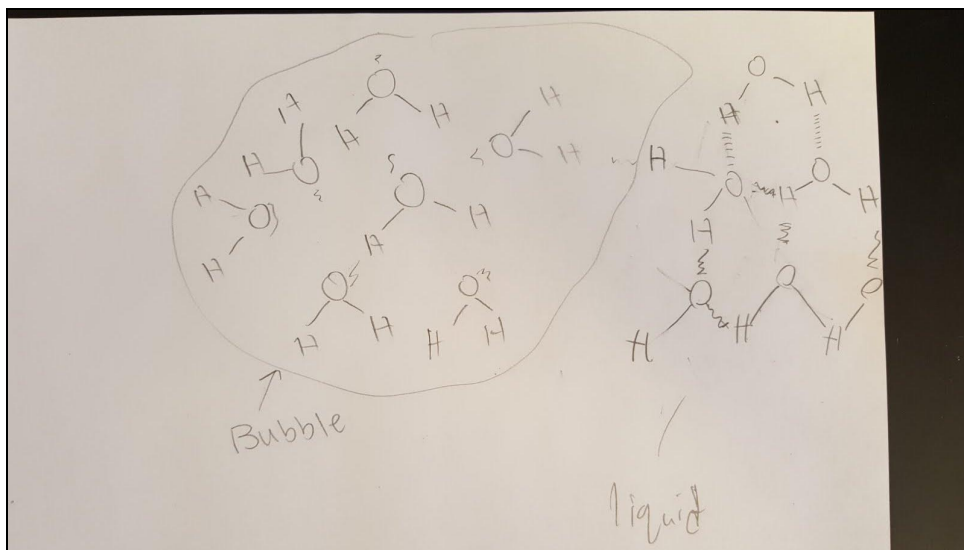


Summaries

Days 1 & 2: Hexane vs. Water

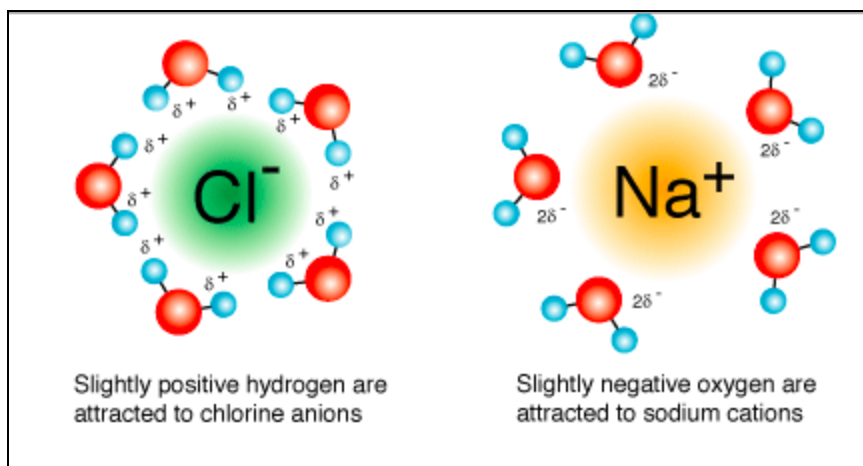
- We began the day by exploring the structure of a “bubble of boiling water”. We realized that the bubble contained water molecules that are in the gas phase, and thus, are just further away from one another. The below student produced diagram shows this process well. Other student diagrams can be seen [here](#).



- We continued class by exploring the mixing of four different substances: Hexane, water, iodine and copper (II) sulfide. It was discovered that the hexane and water separated from one another and when mixed, the iodine turned the hexane layer purple, while the copper (II) sulfide crystals turned the water layer blue. See pic below of the water, hexane iodine combo:



- We realized that the positive copper ions were drawn to the partially negative head of water molecules while the negative sulfide ions were drawn to the partial positive tails of the water molecule. Click [here](#) for information on the specifics of the activity. The below image shows this process well (note: NaCl is used instead of CuS).



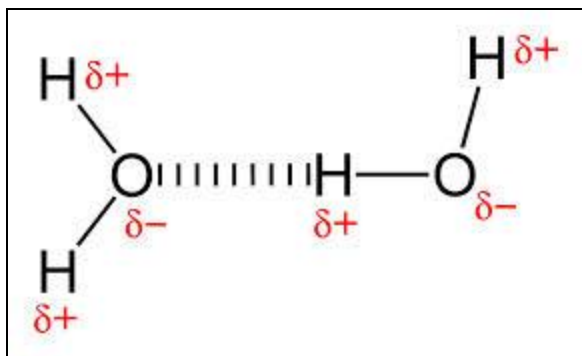
Days 3: Pure Substances

- We did an activity to determine the strength of IMF forces within four different substances via how fast they evaporated. We discovered that the substances that evaporated quickly had weak IMF forces acting between them. Click [here](#) for an example. We then created a chart to outline the different IMFs acting between different substances (see image below).

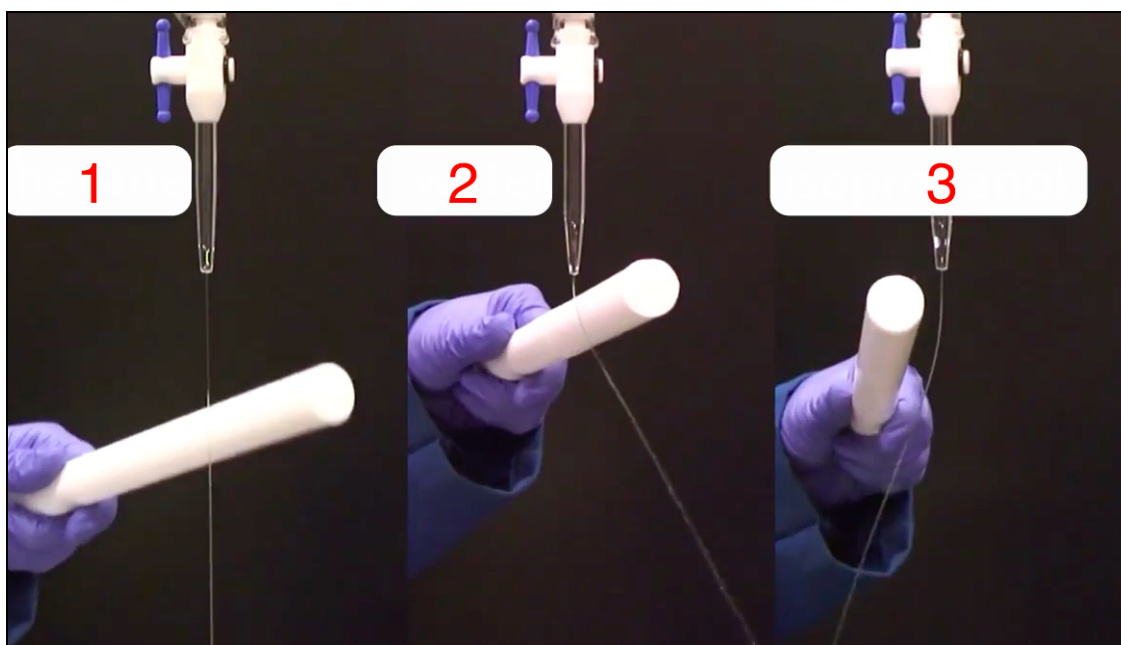
Pure Substance	Lewis Structure and Polarity	IMF Diagram	Boiling Point
H ₂ O	polar	dipole-dipole	high
CO ₂	non-polar	London Dispersion	Low

- If a substance is “non-polar” (see definition below) the dipoles (regions of electronegativity difference between atoms) cancel out and no “net charge” exists and only London Dispersion IMFs exist between particles, resulting in a low boiling point (see definition below). If a substance is “polar” (see definition below) the dipoles do not cancel and neighboring particles are attracted via coulomb’s law. When dipoles exist and are attracted to one another, the type of IMF forces is called, appropriately so, a “dipole-dipole” force. When they do cancel out the weaker type of force, as shown below between carbon dioxide molecules, is called a “London Dispersion Force”. It is important to note that because we are dealing with covalent compounds, a “dipole” is a separation of charge between two atoms that share

the electrons. Thus, a “partial” charge rather than a full charge (negative or positive) exists since there is no full transfer of electrons. The below image shows a “dipole-dipole” IMF force between two water molecules.



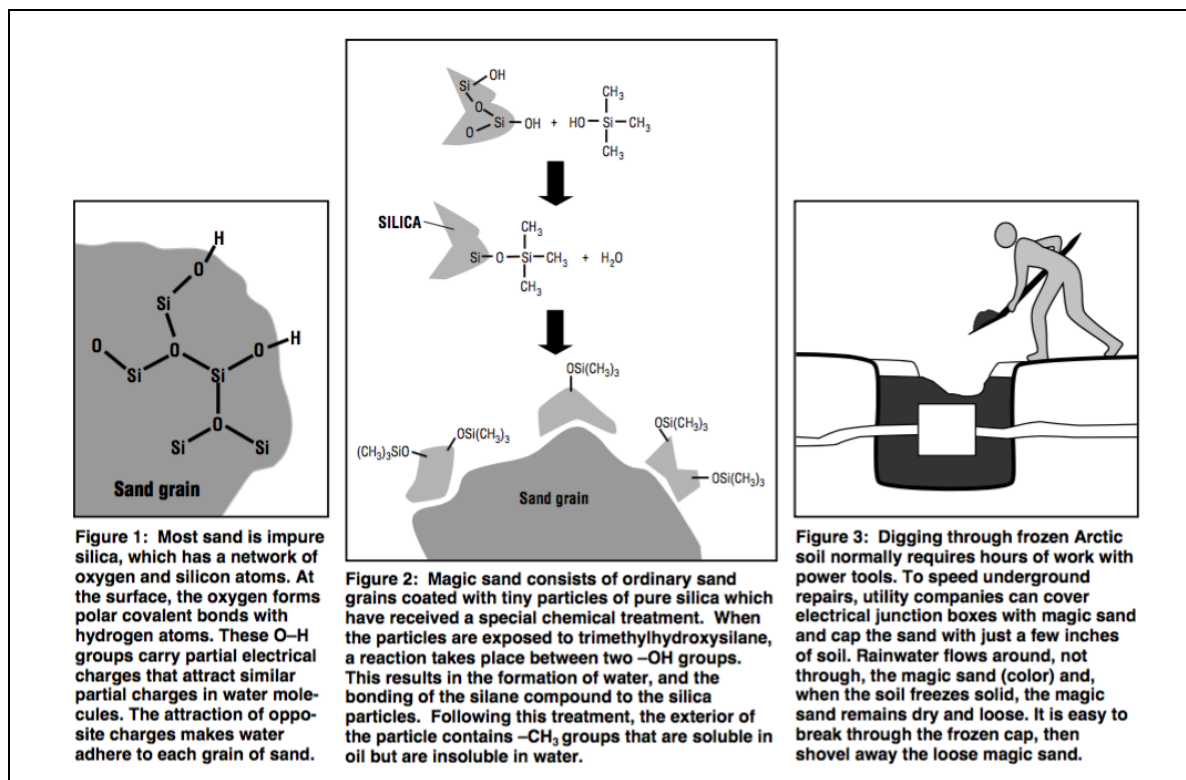
- We expanded on this model using a static rod and determined that polar substances, given their permanent dipoles, are subsequently attracted to a negatively charged rod. That is, the positive end of the dipole (the hydrogens in the case of water) are attracted to the negatively charged rod. The below diagram shows three different liquids with varying attraction to a negatively charged rod. The first liquid, hexane, has only C-H bonds and is thus non-polar, contain no dipoles and thus no attraction to the rod exists. The second substances is water, contains two O-H dipoles and thus both partial positive sides of the molecule are attracted to the rod. The last substance, ethanol, has only one O-H dipole and thus only one partially positive hydrogen is attracted to the rod causing a weaker attraction as compared to the oxygen. See image below.



Days 4 & 5: Mixtures

- To practice drawing IMF diagrams of pure substances we engaged in a group and individual practice activity. Click [here](#) for the individual problems and click [here](#) for the group problems. We then investigated the properties of “regular sand” and “magic sand” to gain an understanding of “mixtures” or

the interaction of different substances with different intramolecular characteristics. “Magic sand” has silicon atoms covered with CH_3 or “methyl” groups that are essentially non-polar and thus do not interact with water. “Regular Sand” has silicon atoms covered with OH or “hydroxyl” groups that interact with water via a strong Dipole-Dipole IMF. See the below diagram for more specifics on regular vs. magic sand.



- After the sand activity, we engaged in two different activities to model the behavior of food coloring and pepper when mixed with water. In both cases (although the “water” in the food coloring demonstration was milk), a small amount of detergent was mixed with the water. The positive and negative ends of the detergent molecule mixed with the water molecule and interacted via Coulomb’s Law with the partially negative and partially positive poles of the water molecule. This interaction essentially weakens the Dipole-Dipole IMFs between the water molecules causing them to scatter. The pepper and the food coloring model the “scattering of the water”. See images below.





Definitions

- *Intermolecular Forces (IMFs)*: forces of attraction or repulsion which act between neighboring particles (atoms, molecules or ions). They are weak compared to the intramolecular forces, the forces which keep a molecule together.
- *Dipole-Dipole IMFs*: are attractive forces between the positive end of one polar molecule and the negative end of another polar molecule.

Example Questions

1. Rank the following molecules from lowest to highest boiling point: SO_2 , CO_2 , H_2O . Explain your logic.
(answer = H_2O , SO_2 , CO_2 . Water and sulfur dioxide are both polar and thus exhibit Dipole-Dipole IMFs and thus have stronger IMFs than carbon dioxide which is non-polar and exhibits only London Dispersion IMFs. Water is stronger than SO_2 because the OH dipole is larger than the SO dipole due to the larger difference in electronegativity between H and O as compared to S and O. This difference leads to a stronger Dipole-Dipole force between water molecules and thus a higher boiling point.
2. Draw an IMF interaction diagram that shows the mixing of water with ethanol ($\text{CH}_3\text{CH}_2\text{OH}$)

