CHEM 1A

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Field(s) of Interest: General Chemistry

Brief Overview (1-3 sentences):
This lesson will give mentees a brief overview of chemistry! In particular, mentees will learn about bonds within molecules, forces between molecules, and acid-base interactions between molecules. After understanding the basics of what makes up a molecule, mentees will see firsthand some real-world effects of molecular properties.

Agenda:

- Introduction (5 min)
- Module 1: The Name's Bonds... Atomic Bonds (10-15 min)
- Module 2: Intermolecular Oranges (10-15 min)
- Module 3: How To Basic (15-20 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

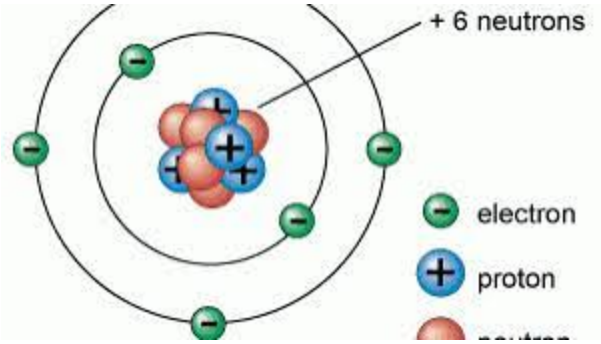
Key Terms	**MD Goals**
• **Electronegativity:** The tendency of an atom to pull electrons from another • **Nonpolar:** When there is an equal sharing of electronegativity between atoms or canceling of dipole moment • **Polar:** When one atom holds more of the electron charge on it. • **Dissolve:** When two molecules have similar polarities, they dissolve into each other.	

Background for Mentors

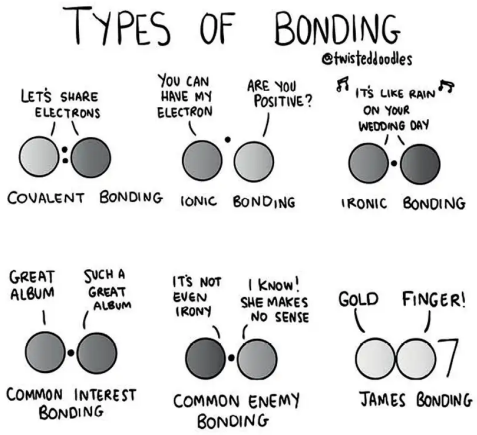
Module 1

- Elements
- Atoms
- Molecules
- Bonds

Atoms are tiny particles that are the basic building blocks of all matter, and can consist of protons, neutrons, and electrons. Everything in the universe is made up of a material called matter, and atoms are the smallest unit in which matter can be divided into. Atoms can be combined with other atoms to form **molecules**, but they cannot be divided into smaller parts normally. A **molecule** is two or more atoms joined/bonded tightly together to form a substance. The substance is determined by the number and kinds of atoms in a molecule, as well as the way they are arranged.



There are many ways that atoms can be formed; each of which correspond to a certain element on the periodic table. An **element** is a substance that is made from a single type of atom. You can think of elements as also being the building blocks of all matter in the universe, given that atoms are, and each formation of atoms pertains to a certain element. Atoms can come together and form a molecule through a process called **Chemical Bonding**, forming **bonds**. These bonds are usually created by the sharing or transfer of electrons between the atoms involved.



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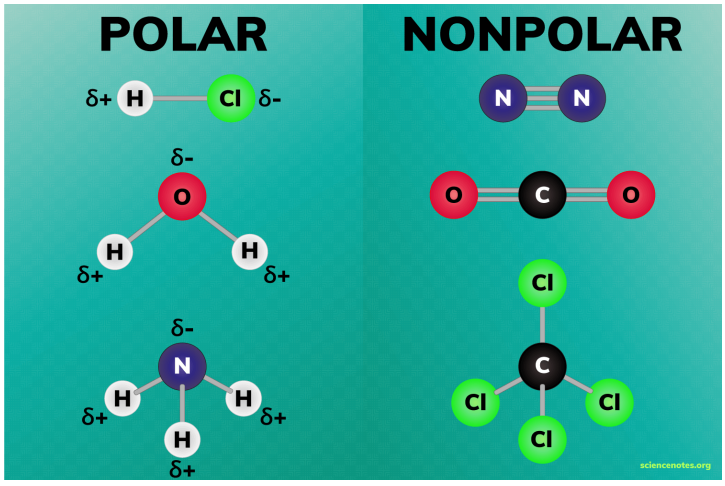
Module 2

- Electronegativity
- Nonpolar
- Polar
- Dissolves

All the molecules we observe have a certain electronegativity. **Electronegativity** is the overall sharing of electrons between atoms in a molecule. Some atoms such as fluorine like to hold electrons more than others. Some others such as hydrogen don't.

When we see an uneven distribution of electron density within a molecule we call it **Polar**. One caveat to remember when identifying a polar molecule is to check if its dipole moments cancel out each other. If there exist dipole moments that cancel out in opposite directions, it is actually considered **Non-Polar**. In the diagram below we can see how in CCl4 Carbon and Chlorine are very different in electronegativity, creating multiple dipole moments. However, based on its tetrahedral shape where all dipole moments head in separate directions, it is actually nonpolar. Some other ways to tell whether a molecule is nonpolar is if the connected atoms are very similar in electronegativity making the electron sharing difference negligible. Examples of these are molecules that are solely carbon and hydrogen-based such as methane, ethane, or even propyl.

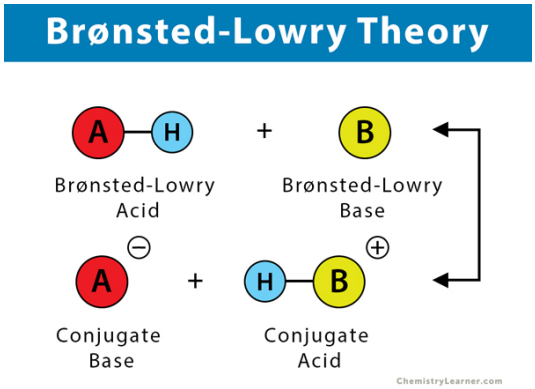


Something that highly depends on the polarity of molecules is **dissolving.** When molecules are very similar in polarity, it makes it very easy for the molecules to mix in with each other. A good example that shows the opposite of dissolving is water and oil. Oil is a very non-polar compound, while water is very polar. Due to their very contrasting polarity, we can observe how they also have a very hard time mixing and dissolving within each other.

Module 3

- Acids
- Bases
- pH

By brønsted-lowry theory, **acids** can be defined as proton donors and **bases** can be defined as proton acceptors. In the equilibrium expression shown below, a brønsted-lowry acid and base react to form the conjugate base and acid. The conjugate base is the acid without the hydrogen ion, while the conjugate acid is the base compound with the donated hydrogen from the brønsted-lowry acid. This reaction can occur in both the forward and backward directions, hence the double-headed arrow.



We can mix acids and bases to cancel out or neutralize their effects, a substance that is neither acidic nor basic is neutral.

pH is a measure of acidity/basicity, standing for the “potential of hydrogen.” Because pH is the negative log of the concentration of hydrogen ions over the molarity of the solution, each whole pH value below 7 is ten times more acidic than the next higher value.

The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. A pH greater than 7 is basic.

Introduction

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Concepts to Introduce

- **Chemical Bonding**
  - Ionic and covalent bonds hold atoms together, and intermolecular bonds hold molecules together
    - Bonding relies on “opposites attract”
- **Dissolving**
  - “Like dissolves like” concept
  - Connect how bonding relates to solubility (intermolecular forces etc.)
- **pH**
  - A measure of how strong an acid or a base is
  - Emphasize how it connects to bonding and solubility
    - Introduce that acids and bases are all around us!

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Questions to Pique Interest

- Have you ever noticed that salt disappears when you put it in water?
- Have you ever noticed that oil and water stay separate even after you mix them? Why do you think this is?
- What’s the smallest possible piece you can break something into?
- What do you think everything around us is made up of?
  - How do you think these things are held together?

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Scientists, Current and Past Events

- Jennifer Doudna and CRISPR is one very relevant example of chemistry in action at Cal!

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Careers and Applications

- Sustainable energy (biofuels)
- Medicine
- Food science
- Pharmaceuticals

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Module 1: The Name's Bonds... Atomic Bonds

In this module, mentees will learn about the basic building blocks of matter. Mentees will then be able to build their own molecules!

Teaching Goals	**Materials**
1. **Elements:** Substances that cannot be decomposed into simpler substances by ordinary chemical processes. 2. **Atoms:** The smallest component of matter that has the characteristic properties of a chemical element. 3. **Molecules:** A group of atoms bonded together, representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction. 4. **Bonds:** A link between two atoms that store energy.	• Toothpicks • Styrofoam balls (2 different sizes)

Procedure

1. Pass out 5 toothpicks and 10 styrofoam balls per mentee
2. First, instruct the mentees to build ethane, C2H6 (2 big styrofoam balls, 6 small ones and 7 bonds)
3. Then, instruct the mentees to build a water molecule (two small styrofoam balls, and one larger one and two toothpicks)
4. Then, carbon dioxide (4 toothpicks, 3 similarly sized balls)— expand a little on the double bond aspect of CO2.
5. Connect how the bonds in ethane rearrange to create water and carbon dioxide and release energy

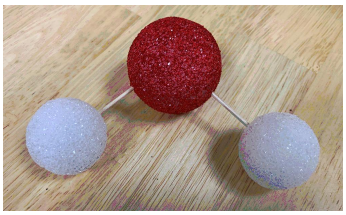

Figure 1: A model water molecule.

Classroom Notes

Module 2: Intermolecular Oranges

Mentees will learn about the polarity of molecules. Mentors will demonstrate polarity firsthand by popping a balloon with an orange peel.

Teaching Goals	**Materials**
1. **Electronegativity:** The tendency of an atom to pull electrons from another 2. **Nonpolar:** When there is an equal sharing of electronegativity between atoms or canceling of dipole moment 3. **Polar:** When one atom holds more of the electron charge on it. 4. **Dissolve:** When two molecules have similar polarities, they dissolve into each other.	● Orange ● Balloon ● Air pump

Procedure

1. Grab a balloon and blow it up with the air pump.
2. Peel an orange and tear a slice of the peel off.
3. Rub the inside of the peel on the balloon until it pops.
4. Explain how the inside of the orange is very non-polar and so is the outside of the balloon. Since they are both non-polar (similar in polarity) they dissolve within each other, causing the balloon to form a hole and pop!

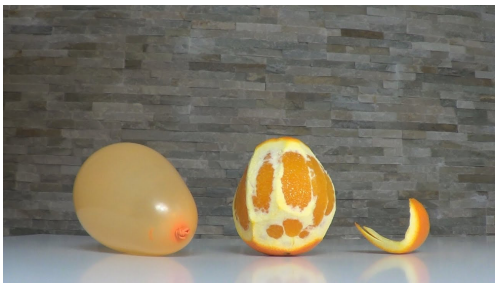

Figure 1: *A peeled orange with a blown up balloon*

Classroom Notes

Module 3: How To Basic

Mentees will gain a visual understanding of the difference between acids and bases by testing compounds of various acidity/basicity using pH paper.

Teaching Goals	**Materials**
5. Acid: A proton donor. pH of 1 - 6.99 **6. Base:** A proton acceptor. pH of 7.01 - 14 **7. pH:** indication of the concentration of H+ ions in a solution. **a.** 1 - 6.99 = acidic **b.** 7 = neutral **c.** 7.01 - 14 = basic	• Soap • Baking soda • Toothpaste • Pineapple juice • Vinegar • Water • pH paper

Procedure

1. Have students make predictions on whether the compounds (soap, baking soda, toothpaste, pineapple juice, vinegar, and water) will be acidic, basic, or neutral
2. Set up 6 stations around the room with one material at each station. All solid/thick compounds (soap, toothpaste, baking soda) can be mixed with water to make a liquid solution in order to test.
3. Divide students into six groups. Distribute one strip of pH paper per group.
4. Have groups rotate to each station and dip a little of their pH paper in the solution
5. Recap at the end of the demo, were the students' predictions right?

Figure 1. pH paper

Classroom Notes

Conclusion

Ask mentees what at home they think might be acidic and basic based on the experiments done in the modules. Talk with them about what parts were the most surprising, did any activity stand out? Ask them as a leading question if they think, or know of any other particles smaller than the atom that make up the world around us.