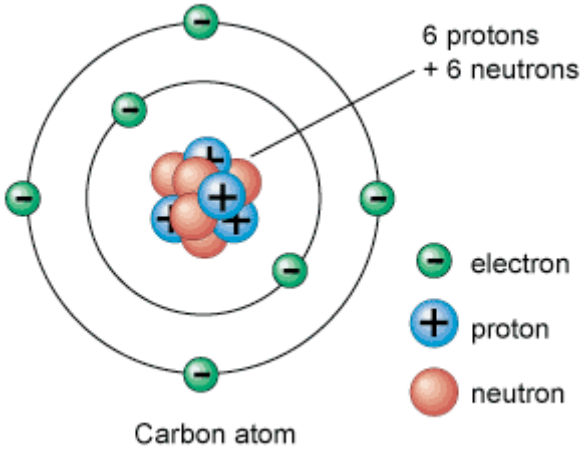
Colin Gould & Nihaal Mehta
29 October 2011
Brown Science Prep

Chemical forces lesson

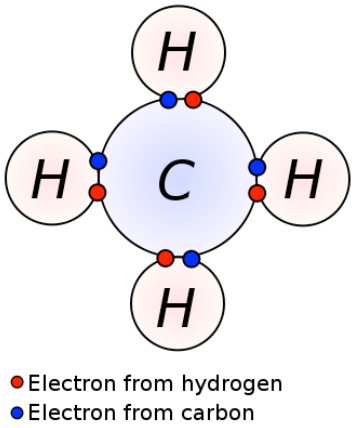
Objectives of lesson	• Identify the major subatomic particles, describe their basic properties, and provide a simplified model for atomic structure • Explain bonding in terms of following the octet rule, and identify the two major types of bonds • Demonstrate how bonding between different atoms of different elements creates bonds with unequal charge distribution (both ionic and polar covalent), and how molecules also have areas of partial positive/negative charges • Introduce the concept of intermolecular forces in order to provide an explanation for "like dissolves like" • Introduce paper chromatography as an application of solubility principles to a real-world problem
Relevant RI GSEs	***PS1 (5-8) INQ+POC –2*** *Given data about characteristic properties of matter (e.g., melting and boiling points, density, solubility) identify, compare, or classify different substances.* **Grade Span Expectations (5-8)** **PS1 (5-6) –2** **Students demonstrate an understanding of characteristic properties of matter by …** **2a** recognizing that different substances have properties, which allow them to be identified regardless of the size of the sample. **2b** classifying and comparing substances using characteristic properties (e.g., solid, liquid, gas). **PS1 (7-8) –2** **Students demonstrate an understanding of characteristic properties of matter by …** **2a** identifying an unknown substance given its characteristic properties. **2b** classifying and comparing substances using characteristic properties (e.g., solid, liquid, gas; metal, non-metal). ***PS1 (9-11) MAS+ FAF – 4*** *Model and explain the structure of an atom or explain how an atom's electron configuration, particularly the outermost electron(s), determines how that atom can interact with other atoms.* **Grade Span Expectations (HS)** **PS1 (9-11)– 4** **Students demonstrate an understanding of the structure of matter by …** **4a** comparing the three subatomic particles of atoms (protons, electrons, neutrons) and their location within an atom, their relative mass, and their charge. **4b** writing formulae for compounds and developing basic (excluding transition elements) models using electron structure. **4c** explaining or modeling how the electron configuration of atoms governs how atoms interact with one another (e.g. covalent, hydrogen and ionic bonding). **Example Extension(s)** **PS1 (Ext)– 4** **Students demonstrate an understanding of the structure of matter by …** **4aa** writing an electron configuration to include *s, p, d,* and *f* orbitals and relating to atomic interactions. **4bb given** specific reactants (e.g. $Ba + Cl_2$) write the balanced equation and determine the products, type of compound formed (ionic or molecular), and the properties of the compound (e.g. solubilities, electrolytic, etc).

1. Basic chemistry
    a. Atoms as constituents of matter
        i. Subatomic particles (*ask students to try to name them first*)
            1. **Nucleus** consists of positively charged **protons** and neutral **neutrons**
            2. Negatively charged **electrons** orbit nucleus (*draw oversimplified diagram like the one below*)
                a. Different "levels" or "shells"
                b. Outermost shell called **valence shell**, and those electrons are what determine bonding properties
            3. Emphasize positive-negative attraction within atom (*what two particles are attracting each other within the atom? can this also happen between atoms?*)

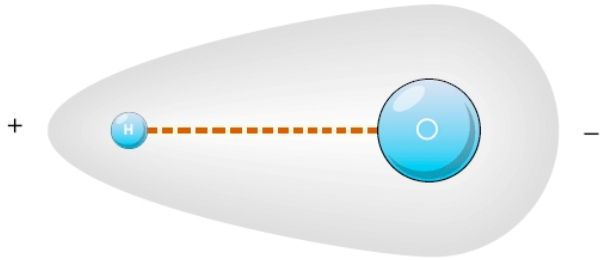


Carbon atom

        ii. Number of protons determines what element the atom is of, so organize elements by number of protons and you get the periodic table
    b. Bonding (*focus on diatomics. no need to get too fancy*)
        i. **Octet rule** – basic guideline for bonding that states elements want to have 8 electrons in valence shell (except for hydrogen which only wants 2 because it's small), either by sharing or by donating/receiving
        ii. **Covalent bond** – atoms share electrons (e.g. H_2O - water) to get to 8

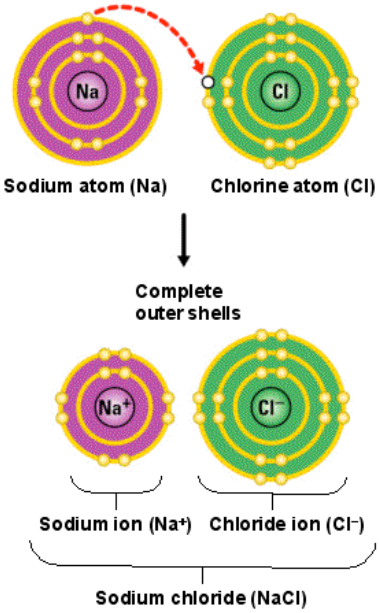


1. Sharing doesn't always happen equally; some atoms "like" electrons more and, as a result, the covalent bond is "unbalanced"–more negative on one side than the other (e.g. hydrogen-oxygen bond):



2. An unequal covalent bond is called a **polar covalent bond**, and molecules made up of polar bonds are called **polar molecules** while molecules without polar bonds are called **nonpolar molecules**

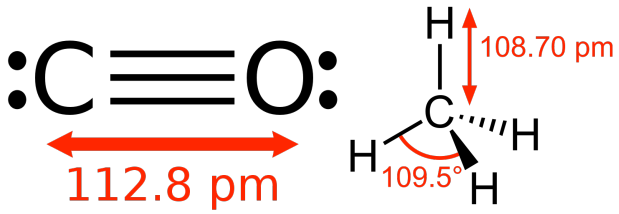
iii. **Ionic bond** – one atom donates electron(s) to the other (e.g. NaCl - table salt)



1. By its very nature, an ionic bond is always "unbalanced" in terms of the distribution of charge between atoms

2. **Intermolecular forces** – forces between molecules (*describe as the forces you see when you "zoom" out from bonds within molecules to see multiple molecules and how they interact. keep reminding them that now we're talking about molecules, not atoms)*
    a. Polar vs non-polar molecules

i. Based on the bonds inside a molecule, we either classify that molecule as **polar** or **non-polar** (definitions above) – a good quick way to tell if a molecule is polar or non-polar is to see if it looks symmetrical:

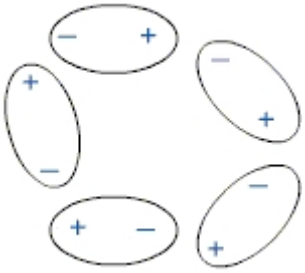


1. Carbon monoxide (on the left) definitely isn't symmetric and so is polar; methane (on the right) is symmetric (*draw both structures and explain tetrahedral molecular structure as being like a pyramid with a flag on top, or a tripod, or whatever analogy suggests itself)* and so isn't polar

b. **"Like dissolves like"** – polar substances like to mix with polar substances, and non-polar substances like to mix with non-polar substances

i. Interaction of polar molecules

1. Because polar molecules have some areas that are negativish and some that are positivish, they can form weak bonds with each other (*draw picture below, point out that each oval is a molecule*)



2. It's hard to break even these weak bonds unless they get replaced with new weak bonds, which is why substances made of polar molecules only like to dissolve in substances made of other polar molecules (*this is super important so go over it a few times and explain it thoroughly. use any necessary analogies but try not to get into thermodynamics or anything*)

ii. Interaction of non polar molecules

1. Unlike polar molecules, non-polar molecules do not have any weak bonds between them because there are no partial negative or partial positive regions (*this isn't totally true, but it's best not to bring up London dispersion/van der Waals interactions here. they aren't important for the purposes of this lesson and they're confusing anyway)*
2. So, as explained above, polar and non-polar won't want to mix

c. **Solubility** – we can often tell if something will dissolve in something else (like rubbing alcohol in water) or if it won't (like oil and vinegar) if we know whether the substances are polar or non-polar
    i. This is the basis of **paper chromatography** – a polar liquid solvent creeps up a strip of paper that has mixture on it and separates out the components of the mixture (*have them guess how this would work. remind them that there are multiple polar and non-polar components of the mixture in the paper, and that the polar solvent is moving through the mixture. which constituents will move with the solvent and which will stay stationary?)*