CHEM 1035 – Lecture 28

Chemical Bonding

The chemical and physical properties of elements are related to the electron configuration of the atoms. Things like Ionization Energy, Atomic Size, Electron Affinity follow trends that can be rationalized based on the atomic configuration. Other properties, such as the charge on monatomic ions can also be related to the atomic configuration of atoms. Finally, we will begin to explore the relationship between electron configuration and the formation of chemical bonds.

Ionic Bonds

- Bonds that form due to the electrostatic attraction between positively charged cations and negatively charged anions.

First we will consider ionic bonds – something that we've looked at previously.

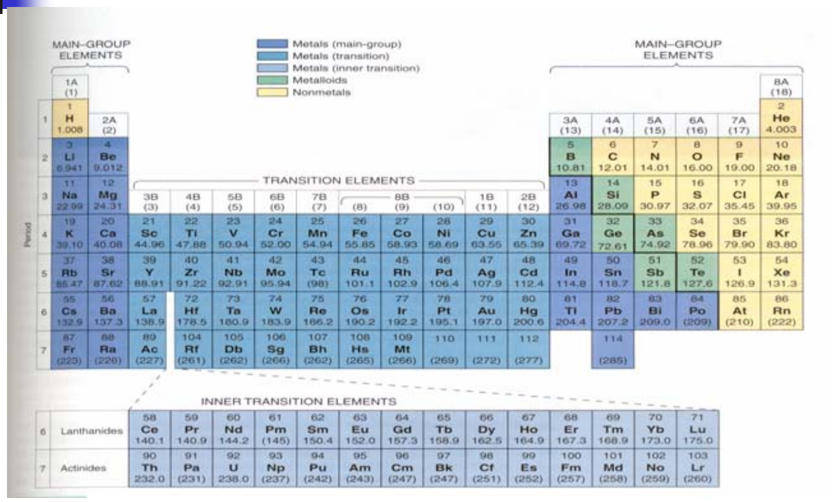
To simplify this process, we typically use something called a Lewis Dot structure to represent the high energy electrons available in each atom. This provides a visual representation of the "valence electrons", and provides clues as to how atoms will bond (if they will bond) with each other.

Lewis Dot Structure – main group elements

1. Write the atomic symbol – assume that the symbol is located within a square box.
2. Note the group number for the atom (this tells us how many valence electrons there are)
3. For each valence electron, draw a dot (one at a time) on each side of the symbol (on each side of the box).
4. Only pair the electron dots if there are more than 4 valence electrons

What are the valence electrons? These are the highest energy electrons that are involved in bonding interactions. Note that in drawing the Lewis dot structure, the “pairing of the dots” does not correspond with the pairing found in the electron configuration.

Periodic Chart



The existence of similar energy atomic orbitals (which contain the electrons) begins to tell us why some atoms have similar chemical and physical properties. Notice in the electron configuration that the pattern begins to repeat itself for each of the columns.

Consider the formation of an ionic bond between Na and Cl

Look at both the Lewis Dot structure for Na and Cl to see how the valence electrons satisfy the valence Octet rule

Octet rule – when atoms bond, they lose, gain, or share electrons to attain a filled outer shell of eight electrons.

If an atom loses its valence electrons when forming an ion, does it satisfy the octet rule?

Look at some other atoms: Ca + 2F, Mg + O, etc.

Lattice Energy

- The energy associated with the interaction between the cation and the anion.

Consider the reaction: Na + 1/2Cl_2 → NaCl What is the lattice energy of this?

We can begin to find the lattice energy by application of Hess' law of heat sumatino

Trends in Lattice Energy

- Relationship to ion size
- Relationship to ionic charge
- Relationship to properties of ionic compounds
  - Hard
  - Brittle
  - Rigid

What did we say previously about the strength of ionic bonds? Charge density? Can we rationalize this behavior, and then extend this rationalization so that we can relate it to the electron configuration

Covalent bonding

- Sharing of electrons between 2 atoms in order to achieve a favorable electron configuration in both
  - Shared electrons
  - “Lone pair” electrons

Show some Lewis dot structure of covalently bonded atoms: H_2, Cl_2, CH_4

Leonard-Jones Potential animation

Bond Order

- With many atoms, to satisfy the “octet rule” when forming a covalent bond, more than one pair of electrons must be shared between the atoms.
  - Single bonds – 1 pair of electrons shared
  - Double bonds – 2 pairs of electrons shared
  - Triple bonds – 3 pairs of electrons shared

Draw Lewis Dot structures of molecules that show this behavior.

Bond Energy

- Potential Energy of forming a covalent bond

Bond Length

- The distance between the nuclei of atoms involved in a covalent bond

There is a relationship between bond order, bond energy, and bond length. Generally, the higher the bond order, the shorter the bond length, and the greater the bond energy.

Provide some systematic relationships: eg. C-O, C=O, and C≡O; within a group, etc.

Properties of molecules composed of covalent bonds

Unlike molecules with ionic bonds, molecules composed of covalent bonds have a variety of properties (e.g. some are hard, some soft; some have high melting points, some low). Why is this?

Introduce the difference between bonding interactions, and intermolecular interactions. What is an "ionic molecule"?