Introduction to Physical Science

Ionic and Covalent Bonding

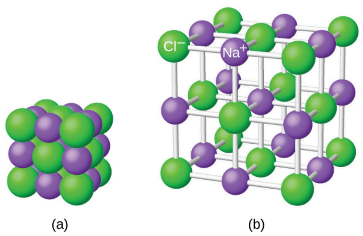
Presented by Robert Wagner

Ionic Bonding

- Ions are formed when an atoms gains or loses electrons
  - Cation - positive ion
  - Anion - negative ion
- Compounds composed of ions are held together by ionic bonds
  - Compounds tend to be brittle
  - Have high melting and boiling points
  - Easily dissolve in water
- Compounds are quite different than the materials that they are composed of
  - Ex: Sodium Chloride

Formation of Ionic Compounds

- Binary ionic compounds - formed from two elements
  - A metal - the cation
  - A nonmetal - the anion
- All substances will be electrically neutral
  - NaCl, Al_2O_3
- Formula does not represent the actual arrangement of ions



Electronic Structures of Cations

- Groups 1 & 2
  - Group number is equal to the number of valence electrons
- Groups 13-17
  - Group number exceeds the number of valence electrons by 10
- Transition and Inner Transition Metals
  - Transition metals generally form a 2+ or 3+ cation
  - Inner transition metals generally form a 3+ cation

Example

- What will the electronic configurations be for chromium (   ) and Zinc(   )?

$Cr : Z = 24 \,;\, Zn : Z = 30$

1s = 2 electrons ; 2s = 2 electrons
2p = 6 electrons ; 3s = 2 electrons
3p = 6 electrons ; 4s = 2 electrons
3d = 10 electrons

$Cr : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5 = [Ar]3d^5 4s^1$
$Zn : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} = [Ar]3d^{10} 4s^2$

$Zn^{2+} : [Ar]3d^{10}$
$Cr^{3+} : [Ar]3d^3$

Electronic Structures of Anions

- These will gain enough electrons to fill their outer s and p orbitals
  - Charge = number of electrons gained
- Oxygen:
  - Needs two elections to fill p shell
  - Charge: 2- or

Example

- What is the electron configuration for a the selenium and iodine anions?

$Se : Z = 34 \,;\, I = 53$

1s = 2 electrons ; 2s = 2 electrons
2p = 6 electrons ; 3s = 2 electrons
3p = 6 electrons ; 4s = 2 electrons
3d = 10 electrons ; 4p = 6 electrons
5s = 2 electrons ; 4d = 10 electrons
5p = 6 electrons

$Se = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$
$I = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^5$

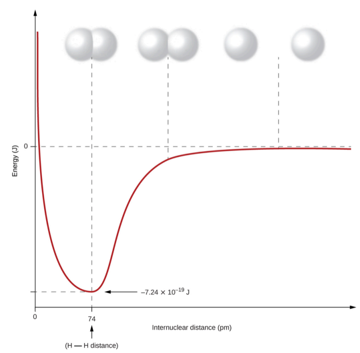
$Se^{2-} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
$I^- = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6$

Covalent Bonds

- Atoms share electrons
  - Form between atoms that have similar tendencies to attract electrons
- Covalent bonds
  - Compounds have lower melting and boiling points
  - Softer than ionic compounds (often gases or liquids)
  - Insoluble in water
  - Poor conductors of electricity

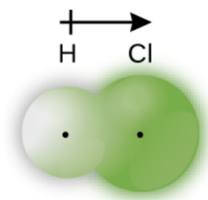
Formation of Covalent Bonds

- Covalent bonds between hydrogen atoms
  - As atoms approach, their 1s electrons will overlap
  - Electrons interact with both nuclei
- Bond length
  - Distance at which the lowest energy is achieved



Pure vs. Polar Covalent Bonds

- When the atoms are the same, electrons are shared equally
- Different atoms will have different affinities for the electrons
  - Sharing is unequal
  - Electron spends more time with one atom than the other
- Polar covalent bond: HCl



(a)

Electronegativity

- Electronegativity
  - A measure of the tendency of atoms to attract electrons
  - Larger value => More strongly the atoms attracts its electrons
- Periodic Table
  - Electronegativities increase to the right
  - Electronegativities decrease downward

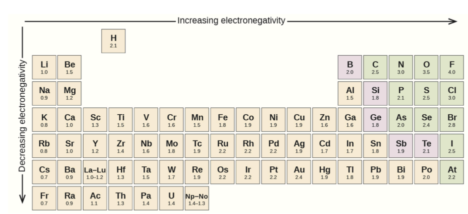
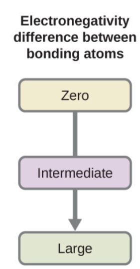
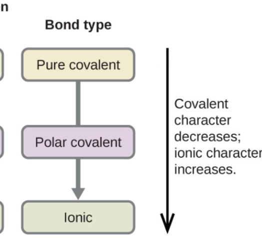


Figure 7.6 The electronegativity values derived by Pauling follow predictable periodic trends, with the higher electronegativities toward the upper right of the periodic table.

Electronegativity and Bond type

- Electronegativity Difference
  - The difference in negativity estimates the bond polarity and bond type
- Types of bonds
  - Large electronegativity difference = ionic
  - Small electronegativity difference = covalent





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Bond Type	Electronegativity Difference
pure covalent	< 0.4
polar covalent	between 0.4 and 1.8
ionic	> 1.8

Example

- Identify the type of bond in the following based on the electronegativities
  - C-C
  - N-H
  - H-F

Electronegativities: C: 2.5 ; N: 3.0 ; H: 2.1 ; F: 4.0

$$C - C: 2.5 - 2.5 = 0\ (Covalent)$$

$$N - H: 3.0 - 2.1 = 0.9\ (Polar\ Covalent)$$

$$H - F: 4.0 - 2.1 = 1.9\ (Ionic)$$

Summary

- In an ionic bond, electrons are transferred from one atom to another
- In a covalent bond, electrons are shared between atoms
- Electronegativities can help us determine the type of bond between two atoms