Chapter 8: Chemical Bonding

Nov 9, 2022

Chemistry Department, Cypress College

Class Announcements

Lab

- Experiment 17 Lewis Structures and Molecular Models
- Basic steps for lewis structures
- Reminder - Need 70% of laborator points to pass the course

Lecture

- Finish up Ch 7 and begin Ch 8
- Go over homework 9 (EC for students who present)
- Quiz and Homework assignment released Fri, Nov 11th at 3pm

Outline

Principles for Filling Atomic Orbitals

Aufbau principle - electrons fill an orbital starting with the lowest energy level

Pauli exclusion princple - No two electrons with the same spin can occupy the same orbital

Hund's Rule - Maximize the number of unpaired electrons

Electron Configurations of Ions

Cations - Remove electrons from the highest energy atomic orbitals

Anions - Follow the same Aufbau principle by filling orbitals with the lowest energy level

Electron Configurations of Ions

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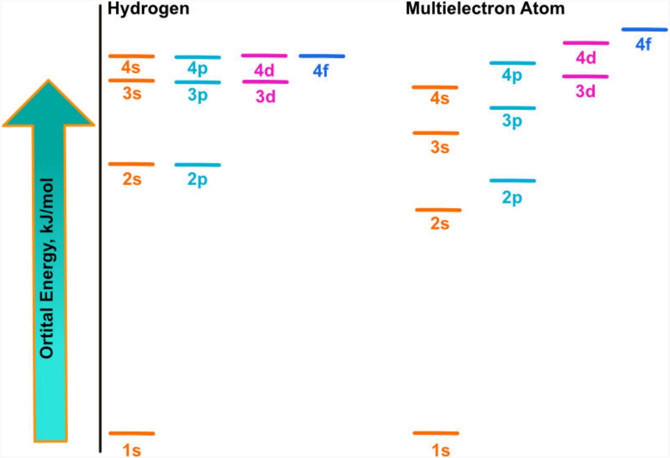
Q: For transition metals, which atomic orbitals, s or d, do you begin removing electrons from?

Orbital Diagram - Multielectron Element

Q: These diagrams show the relative energies of unfilled orbitals. Based on these orderings, do the relative energies of completely filled orbitals hold true?



Outline

Review: Electron Configuration of Ions

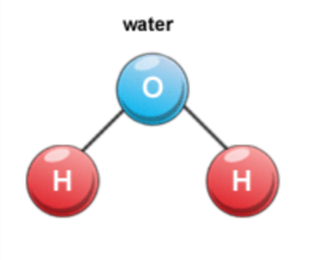
Types of Bonds

- Ionic and Covalent Bonds
- Electronegativity

Drawing Lewis Structures

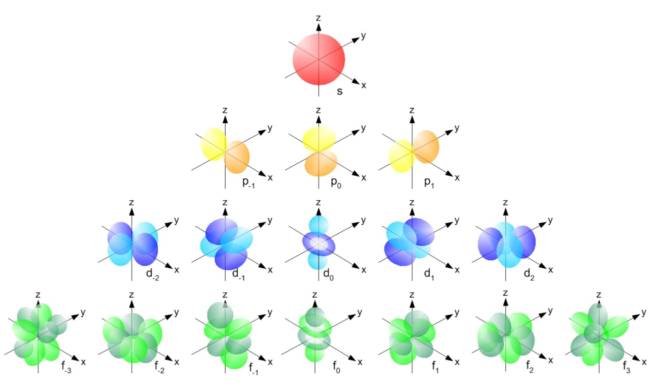
VSEPR Theory

Water is Life



- Liquid water made up of moles upon moles of water molecules
- Molecules are made up of atoms connected by "chemical bonds"

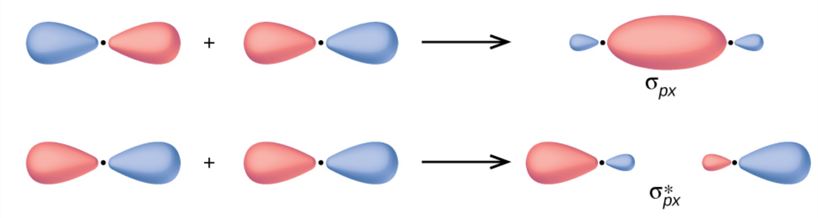
What are Chemical Bonds?



Bonds are made up of atomic orbitals

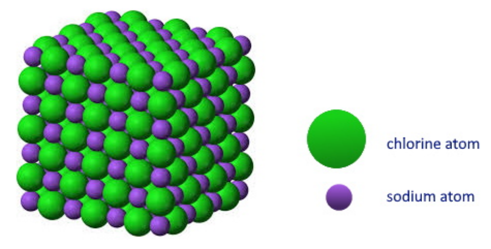
- Overlap of atomic orbitals lead to the formation of molecular orbitals (same energy and specific orientation)

Example of p-orbitals



- Depending on the orientation, p-orbitals will form a bond

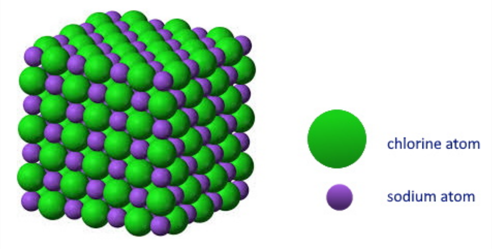
Ionic Bonds



Ionic Compounds - Made up of cation and anion

Ionic Bonds - Hold the cations and anions together; purely electrostatic interaction

Ionic Bonds

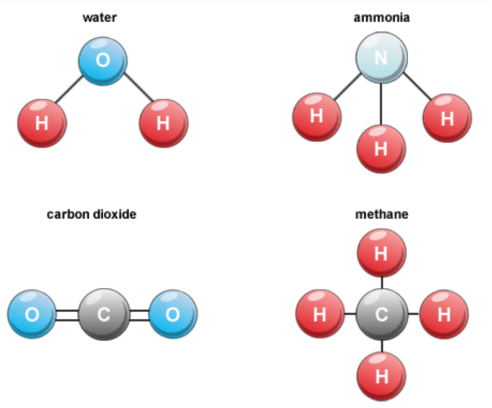


Ionic Compounds - Made up of cation and anion

Ionic Bonds - Hold the cations and anions together; purely electrostatic interaction

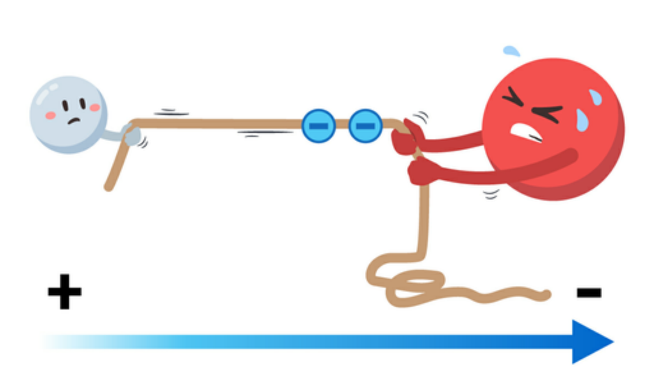
Q: For ionic bond, are the electrons shared between the cation and anion?

Covalent Bonds



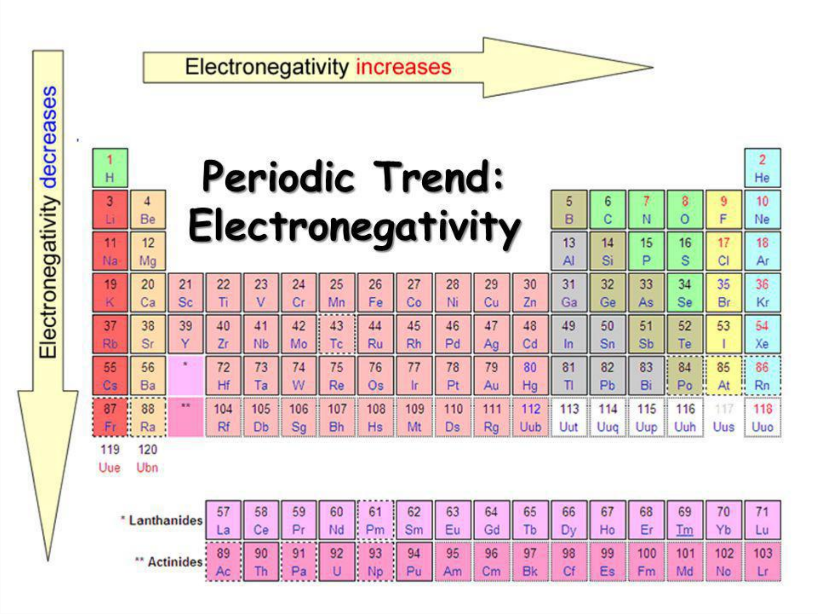
- Electrons are shared between atoms to achieve the octet rule
- *Note:* Octet rule can be broken for atoms after the 3rd row e.g. P, S, Cl, etc.

Electronegativity: Tug-of-War



- Sharing of electrons can lead to unequal pull (electronegativity)

Electronegativity Trends



Practice: Polarity

Which of the following is the most polar bond?

C–C; C–H; N–H; O–H; F–H; Se–H

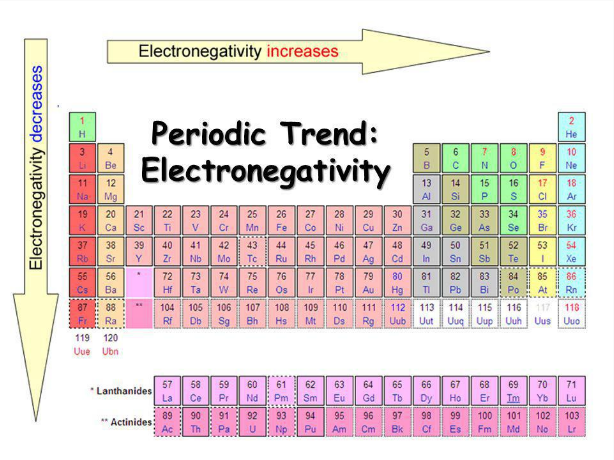
Outline

Octet Rule

Octet Rule - Atoms have a tendency to achieve an electron configuration having 8 valence electrons

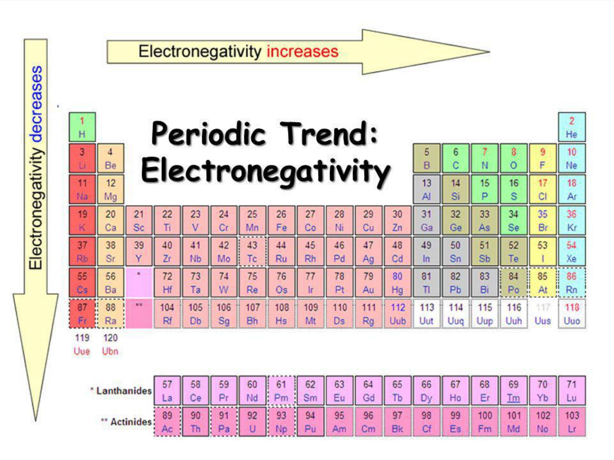
Q: How many electrons are needed for the following atoms to achieve the octet rule: C, N, O, F, Xe, and Ne

Exception to Octet Rule



Exceptions: Atoms starting in the 3rd row can break the octet rule

Exception to Octet Rule



Exceptions: Atoms starting in the 3rd row can break the octet rule

Q: Why are these atoms able to break the octet rule?

Drawing Lewis Structures

1. Count the total number of valence electrons
2. Draw the atomic skeleton by determining the central atoms (generally the one capable of making many bonds)
3. Add single bonds (each counts as 2 electrons) to atoms and add lone pairs if needed to satisfy the octet rule
4. Check that if the amount of valence electrons counted match the Lewis structure
5. Check formal charges on the atoms

Computing Formal Charges

$$\text{Formal Charge} = \text{VE - } \tfrac{1}{2} \text{ BE - NBE}$$

where VE is the number of valence electrons, BE is the bonding electron, and NBE is the nonbonding electron aka lone pairs

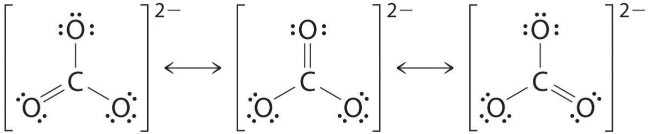
Practice: Draw Lewis Structures

Draw the Lewis structures and compute the formal charges for the following: CO_2, CN, HCl, O_3, CO_3^{2-}

Resonance Structures

As seen in the previous slide, O_3 and CO_3^{-2} have multiple structures that are valid

Resonance structures - the movement of electrons satisfying a valid Lewis Structure



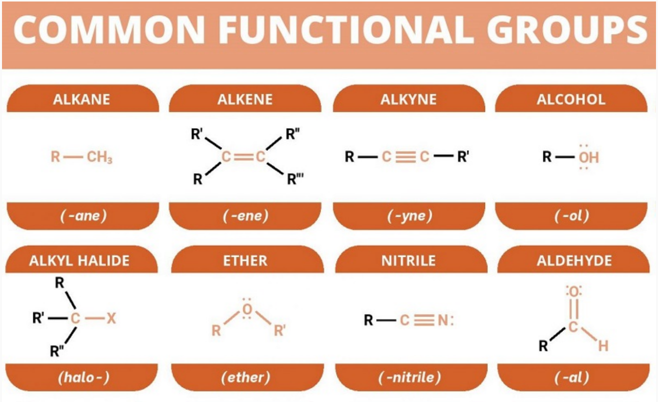
Practice: Drawing Resonance Structures

Draw the resonance structures and resonance hybrid for the following:

HCO_2^-, NO_2^-, SO_2, CNS^-, and N_2O

Functional Groups in Hydrocarbons

Functional Groups - derivatives of a hydrocarbon



where R represents hydrocarbon component

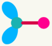
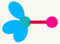
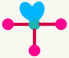
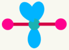
Practice: Drawing Hydrocarbons

Draw the lewis structures for the following hydrocarbons: CH_4, C_3H_8, CH_8, C_2H_2

Outline

VSEPR Theory

VSEPR Theory - predict the geometric shape of a molecule or an ion; minimizes the electronic repulsion of the lone pairs

Electron Pairs	L.P: 0	L.P: 1	L.P: 2	L.P: 3
2	 Linear	 Linear		
3	 Trigonal Planar	 Bent	 Linear	
4	 Tetrahedral	 Trigonal Pyramidal	 Bent	 Linear
5	 Trigonal Bipyramidal	 See-saw	 T-Shaped	 Linear
6	 Octahedral	 Square Pyramidal	 Square Planar	 T-Shaped
7	 Pentagonal Bipyramidal	 Pentagonal Pyramidal		

Practice: Determine the Geometry

CO_2, CN, HCl, O_3, CO_3^{2-}, CH_4, C_3H_8, CH_8, C_2H_2