Lesson Overview
Valence Bond Theory

Objective: The student will be able to apply the tenants of Valence Bond Theory (1) to draw comprehensive Lewis structures for difference chemicals and (2) to describe different properties of these molecules or compounds.

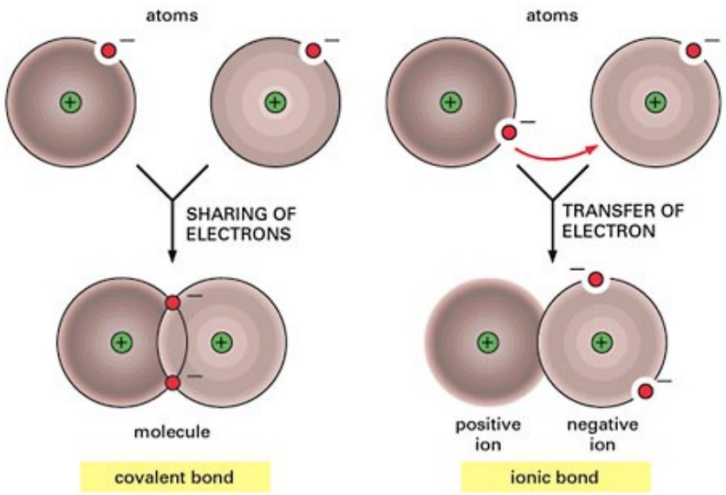
Pre-requisite Bonding Concepts:

- Calculating ΔEN using Pauling EN Scale
- Drawing Lewis structures for individual atoms
- Dative Bonds
- sigma and pi bonds
- Diatomic elements

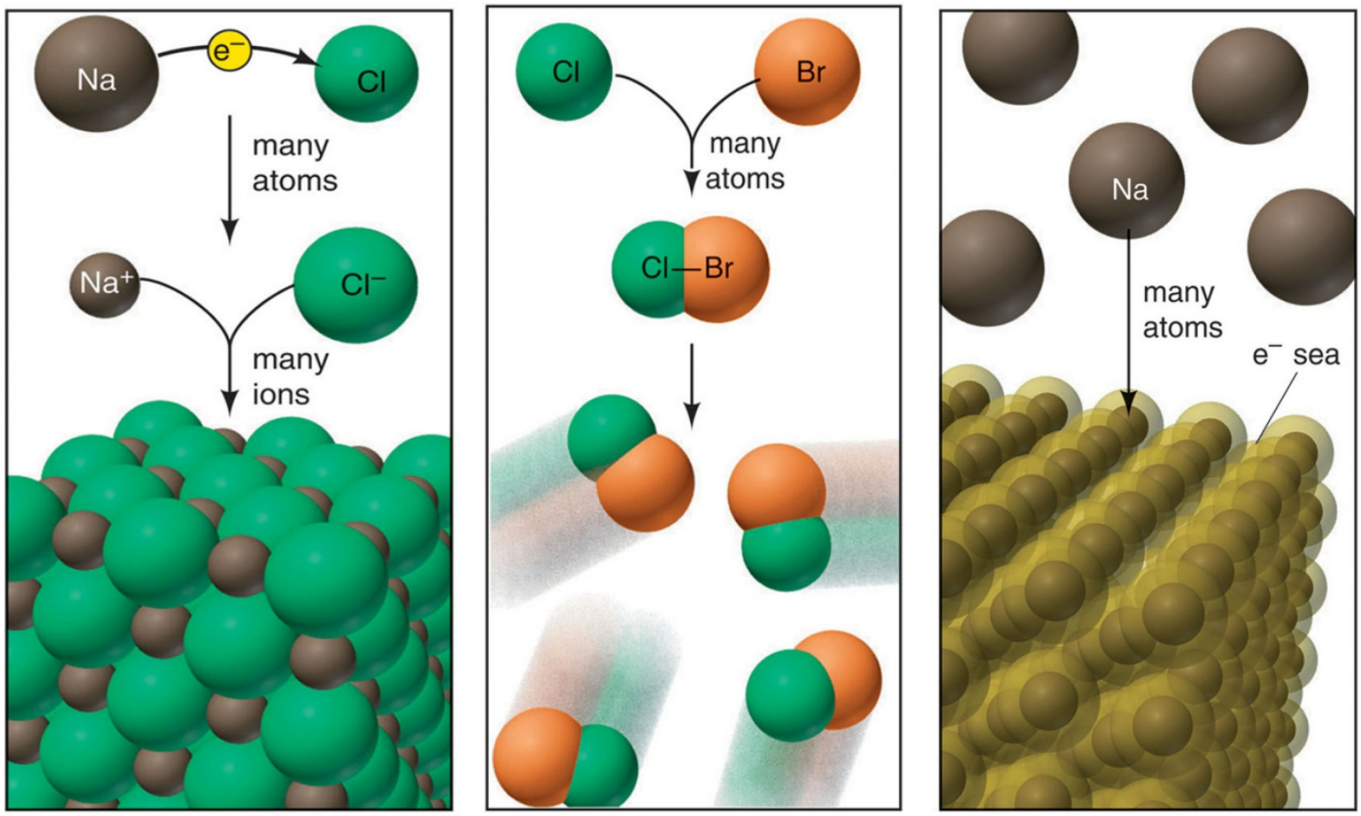
Introduction to Chemical Bonding

A chemical bond is the force that holds two atoms together in a molecule (or formula unit).

The three kinds of bonds are ionic, covalent, and metallic.



Three Models of Chemical Bonding



A Ionic bonding **B** Covalent bonding **C** Metallic bonding

Bonding Theories

I. Valence Bond (VB) Theory

II. Valence-Shell Electron-Pair Repulsion (VSEPR) Theory

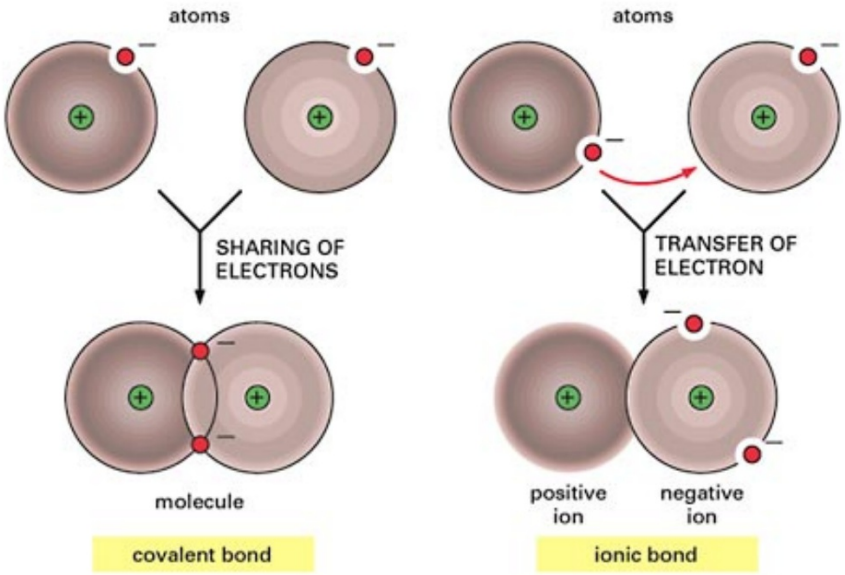
III. Molecular Orbital (MO) Theory

IV. Crystal Field (CF) Theory

V. Ligand Field (LF) Theory

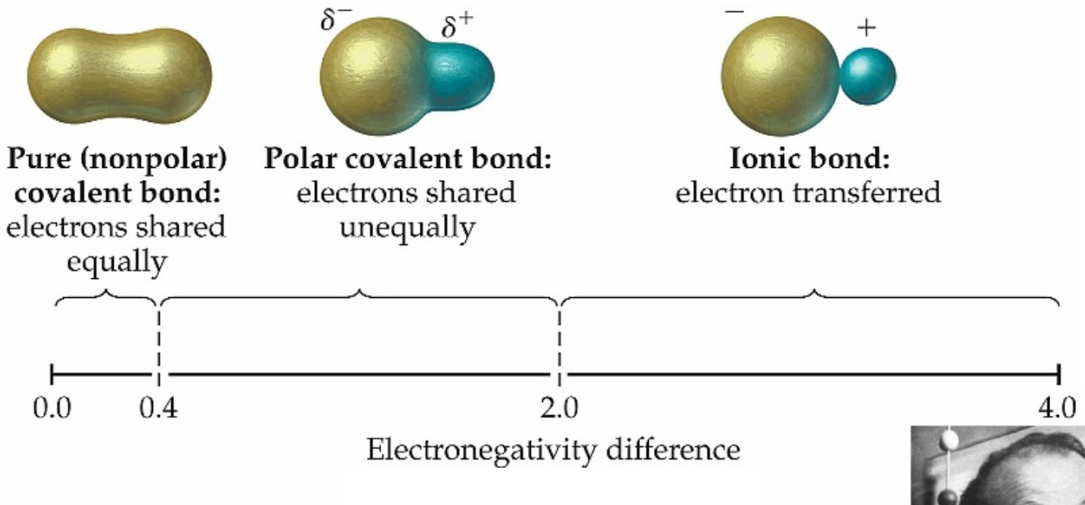
Covalent Bonding

Covalent bonds occur when electrons are shared by 2 atoms. If the electrons are shared equally, the bond is called nonpolar covalent, and if the electrons are shared unequally, the bond is called polar covalent.

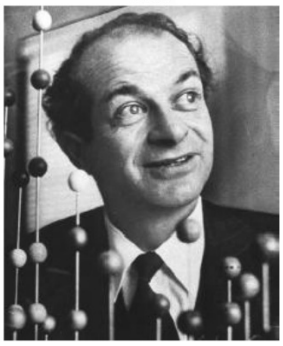


Classifying the Bond Type Mathematically

Pauling Electronegativity Scale:

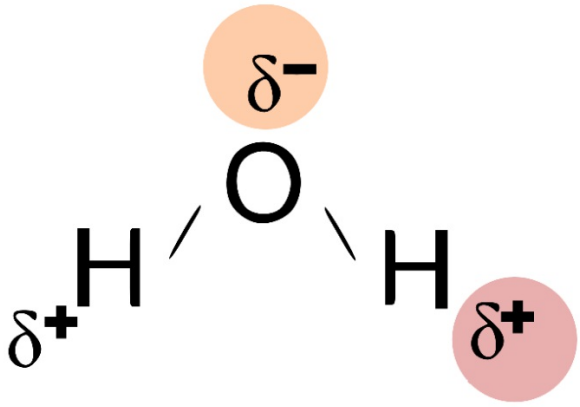


Subtraction, values found on good periodic table.



Introduction to the Dipole

In physics there are many variations of the dipole.



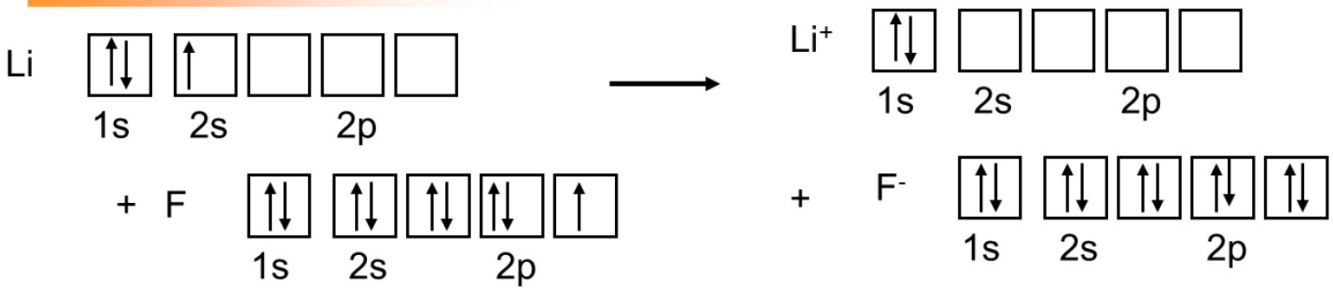
The version we study, a separation of positive and negative charges by some distance, is an electric dipole.

Dipoles are based on the bond polarity.

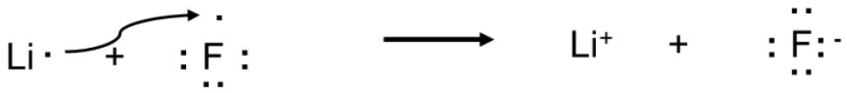
Three Ways to Depict Bonding

Electron configurations

Orbital diagrams



Lewis electron-dot symbols



Our focus will be the Lewis Model

How to Draw Lewis Structures

Step 1: Determine the total number of valence electrons.

Step 2: Place atom with lowest electronegativity in center.

Step 3: Draw single bonds.

Step 4: Obey the octet rule (or the Duet Rule, Hydrogen only). Give each atom 8 electrons.

Examples

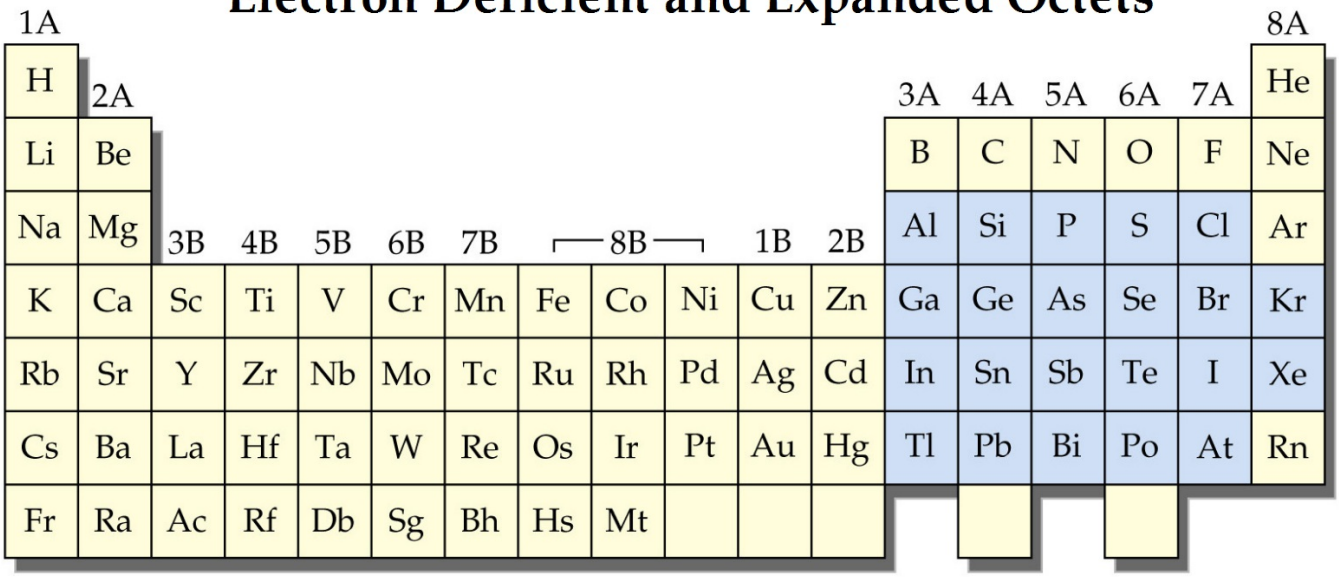
CF_4 NH_3 boron trifluoride

Structures with Multiple Bonds

Sometimes in order to get eight electrons around an atom I have to put multiple bonds (double and triple bonds) into the structure.

CO_2 **nitrogen gas** **sulfur dioxide**

Rule Breaking Structures
Electron Deficient and Expanded Octets

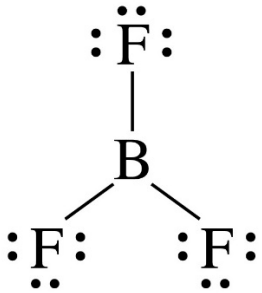


The octet rule occasionally fails for the shaded main-group elements. These elements, all of which are in the third row or lower, can use low-energy unfilled d orbitals to expand their valence shell beyond the normal octet.

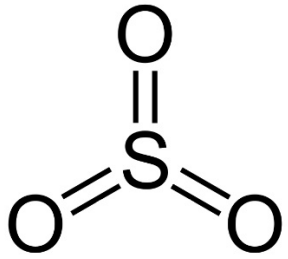
Structures that violate the Octet Rule

In some cases, structures will violate the octet rule

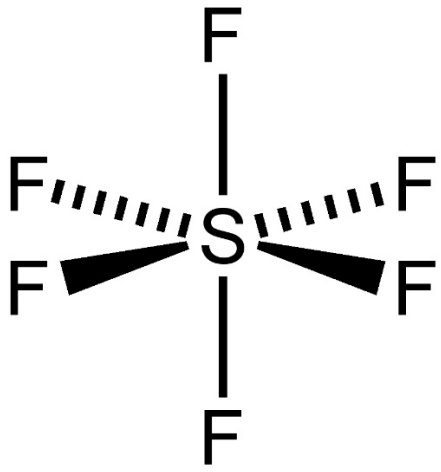
BF_3



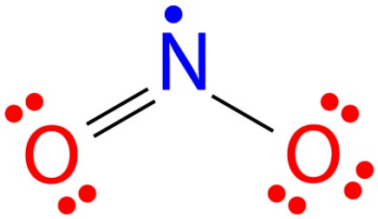
SO_3



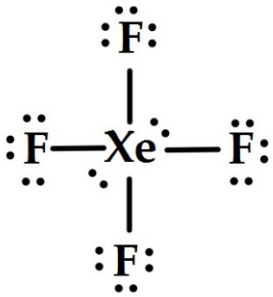
SF_6



NO_2



XeF_4



Generalized rules to Guide your Lewis Structures

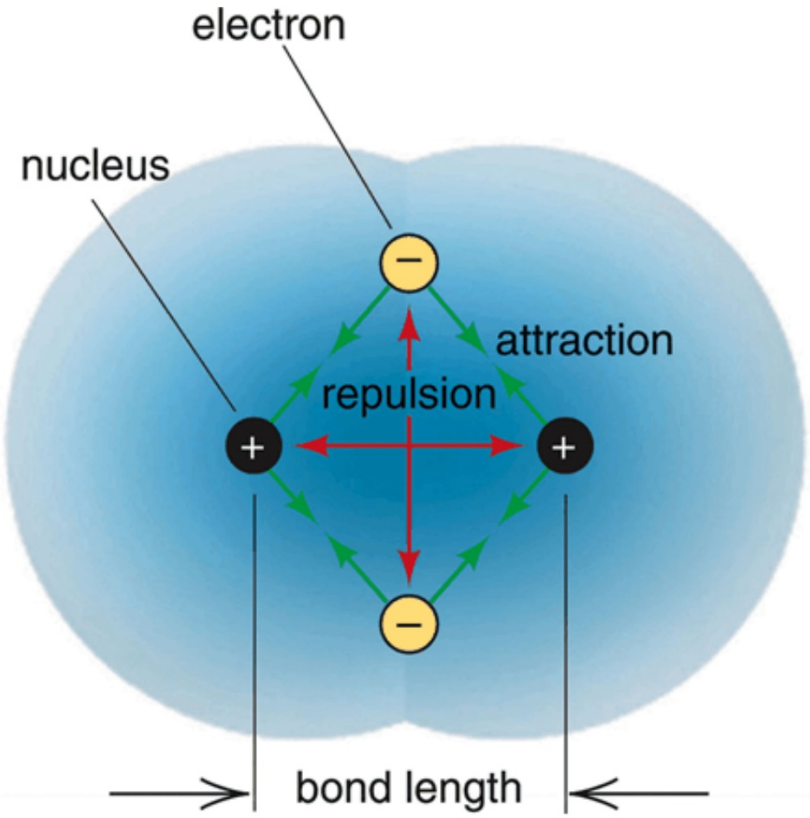
Central atom	# of bonds	# of lone pairs
Group 13	3	0
Group 14	4	0
Group 15	3	1
Group 16	2	2
Group 17	1	3

CO_2 **nitrogen gas** **sulfur dioxide**

Formal Charge

The charge an atom is assigned in a molecule in known as the atom's formal charge.

Bond Length and Bond Strength



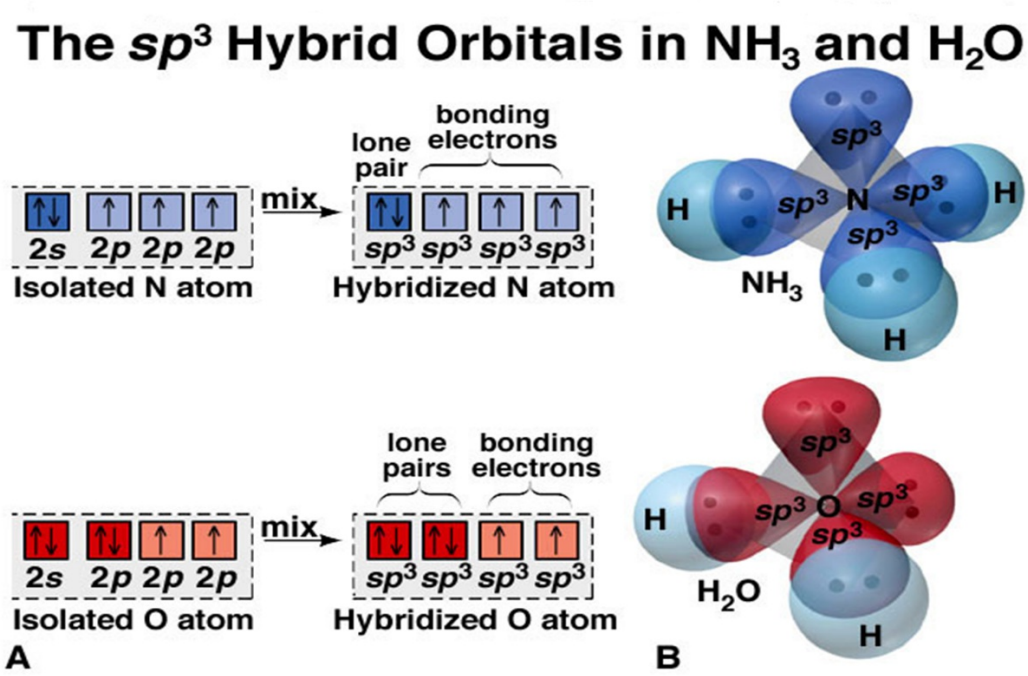
Bond Order

The number of bonds between a pair of atoms and indicates the stability of the bond.

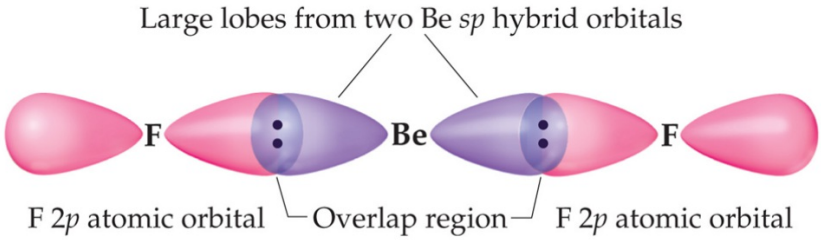
Consider the CO, CO_2, and CO_3^{2-}:

Hybridization

an atomic orbital postulated to form during bonding by the mathematical mixing of specific combinations of nonequivalent orbitals in a given atom.



sp hybrids



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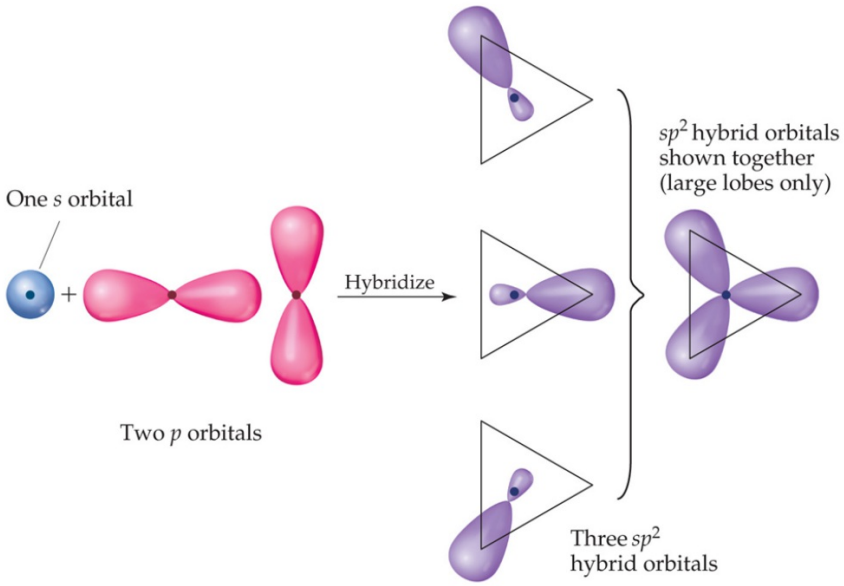
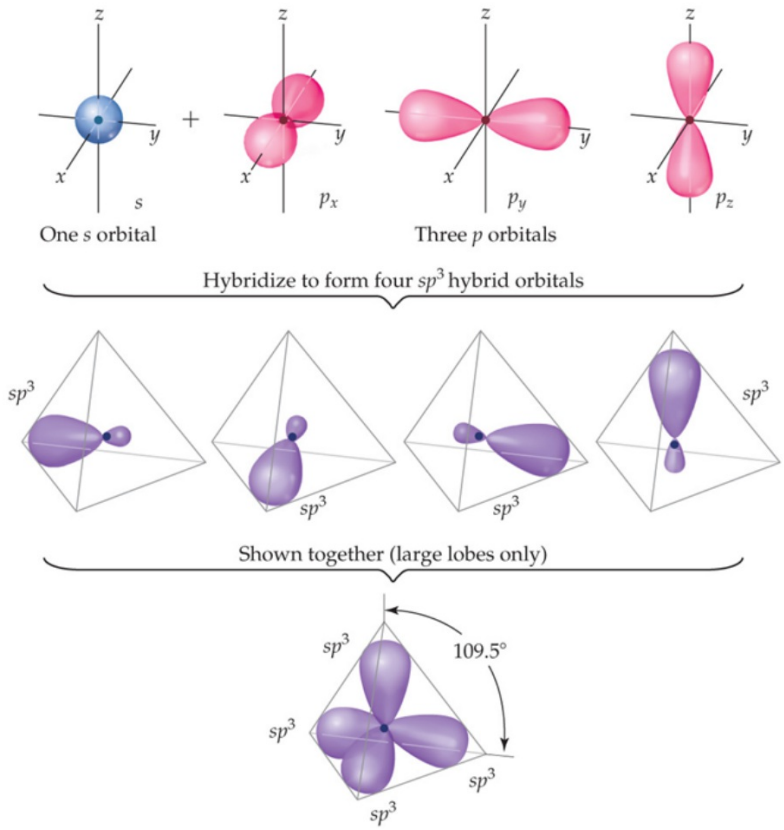
sp^2 hybrids

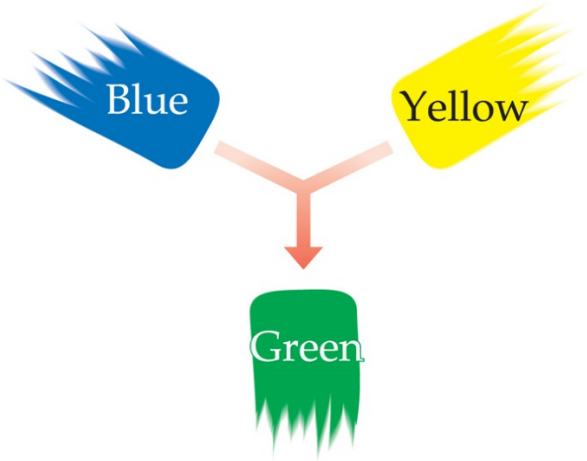


sp^3 Hybridization

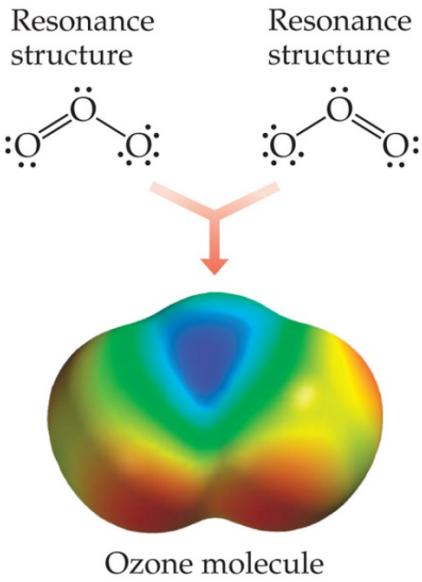


Resonance Structures

Resonance structures are a way of describing delocalized electrons within certain molecules or polyatomic ions where the bonding cannot be expressed by one single Lewis formula.



(a)



(b)

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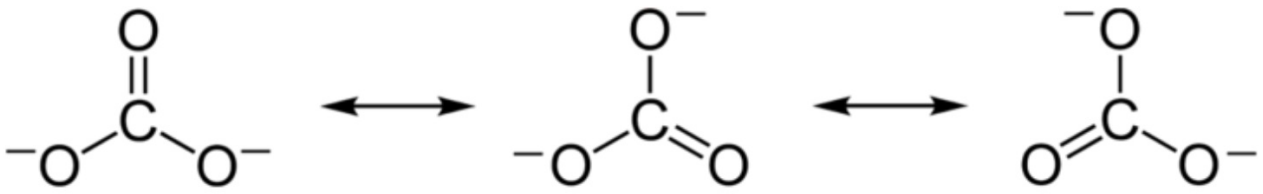

Example: SO_2

Diatomics and More

Group 1 / IA	2 / IIA		13 / IIIA	14 / IVA	15 / VA	16 / VIA	17 / VIIA	18 / VIII
H								He
Li	Be		B	C	N	O	F	Ne
Na	Mg		Al	Si	P	S	Cl	Ar
K	Ca		Ga	Ge	As	Se	Br	Kr
Rb	Sr		In	Sn	Sb	Te	I	Xe
Cs	Ba		Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Uut	Fl	Uup	Lv	Uus	Uuo

Diatomic **Tetratomic** **Octatomic**