Lewis Theory of Bonding

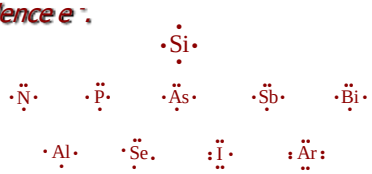
Chapter 4.1

Lewis Theory: An Overview

- Valence e^- play a fundamental role in chemical bonding.
- e^- transfer leads to *ionic bonds*.
- Sharing of e^- leads to *covalent bonds*.
- e^- are transferred or shared to give each atom a noble gas configuration – *the octet*.

Lewis Symbols

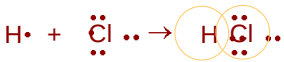
- A chemical symbol represents the nucleus and the *core* e^-.
- Dots around the symbol represent *valence* e^-.



Ionic and Molecular Compounds

- Formation of sodium chloride:

- Formation of hydrogen chloride:



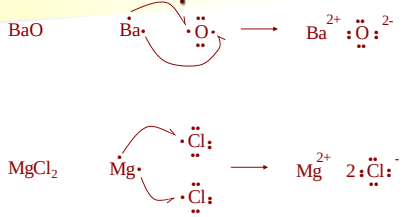
A metal and a nonmetal transfer electrons to form an ionic compound. Two nonmetals share electrons to form a molecular compound.

The Octet Rule

Atoms tend to gain, lose, or share electrons until they have eight valence electrons.

Hydrogen is an exception. It shares only one electron to reach an outer shell of two electrons

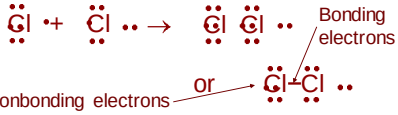
Lewis Structures for Ionic Compounds



Lewis Structures

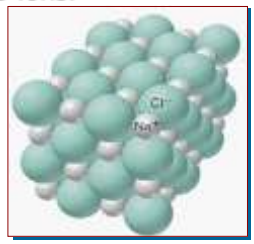
- Covalent bonding in a molecule is represented by a Lewis structure.
- A valid Lewis structure should have an octet for each atom except hydrogen.

H_2: $H\cdot + \cdot H \rightarrow H{:}H$ or H–H

Cl_2: 

Ionic Compounds

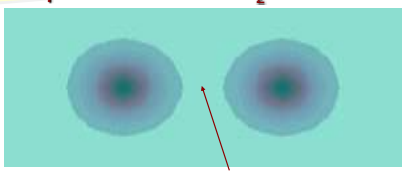
Ionic compounds consist of a lattice of positive and negative ions.

NaCl: 

Ionic Bonding in NaCl

Molecular Compounds

The simplest molecule is H_2:



Increased electron density draws nuclei together

The pair of shared electrons constitutes a covalent bond.

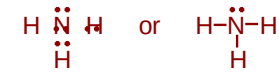
Chlorine - Cl_2

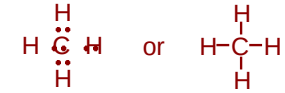
Lewis Structures

Draw Lewis structures for:

HF 

H_2O 

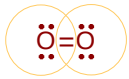
NH_3 

CH_4 

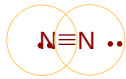
Double and Triple Bonds

- Atoms can share four electrons to form a double bond or six electrons to form a triple bond.

O_2:

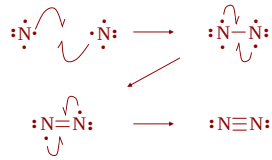


N_2:

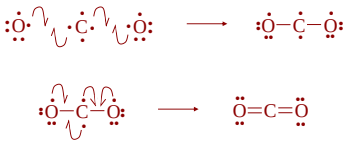


- The number of electron pairs is the bond order.

Multiple Covalent Bonds



Multiple Covalent Bonds

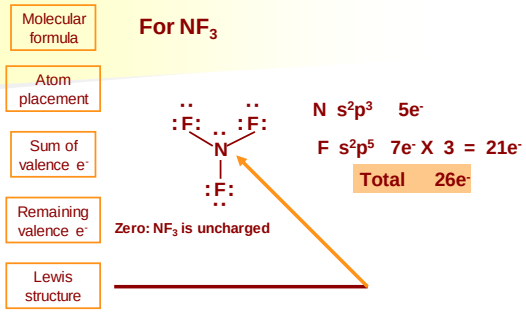


Writing Lewis Structures

- *All* the valence e^- of atoms must appear.
- *Usually,* the e^- are paired.
- *Usually,* each atom requires an octet.
  - H only requires 2 e^-.
- Multiple bonds may be needed.
  - Readily formed by C, N, O, S, and P.

Drawing Lewis Structures

- Sum the valence electrons from all atoms. Add one for each negative charge and subtract one for each positive charge.
- Draw a skeleton structure with atoms attached by single bonds.
- Complete the octets of atoms bound to the central atom.
- Place extra electrons on the central atom.
- If the central atom doesn't have an octet, try forming multiple bonds.



SAMPLE PROBLEM **Writing Lewis Structures for Molecules with One Central Atom**

PROBLEM: Write a Lewis structure for CCl_2F_2, one of the compounds responsible for the depletion of stratospheric ozone.

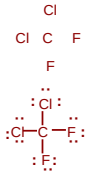
SOLUTION:

Step 1: Carbon has the lowest EN and is the central atom. The other atoms are placed around it.

Steps 2-4:

C has 4 valence e⁻, Cl and F each have 7. The sum is 4 + 4(7) = 32 valence e⁻.

Make bonds and fill in remaining valence electrons placing 8e⁻ around each atom.



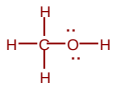
SAMPLE PROBLEM **Writing Lewis Structure for Molecules with More than One Central Atom**

PROBLEM: Write the Lewis structure for methanol (molecular formula CH_4O), an important industrial alcohol that is being used as a gasoline alternative in car engines.

SOLUTION: Hydrogen can have only one bond so C and O must be next to each other with H filling in the bonds.

There are 4(1) + 4 + 6 = 14 valence e⁻.

C has 4 bonds and O has 2. O has 2 pair of nonbonding e⁻.



SAMPLE PROBLEM **Writing Lewis Structures for Molecules with Multiple Bonds.**

PROBLEM: Write Lewis structures for the following:

(a) Ethylene (C_2H_4), the most important reactant in the manufacture of polymers

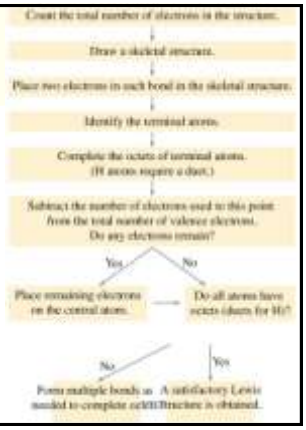
(b) Nitrogen (N_2), the most abundant atmospheric gas

PLAN: For molecules with multiple bonds, there is a ***Step 5*** which follows the other steps in Lewis structure construction. If a central atom does not have 8e⁻, an octet, then e⁻ can be moved in to form a multiple bond.

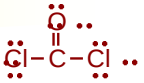
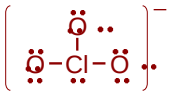
SOLUTION: **(a)** There are 2(4) + 4(1) = 12 valence e⁻. H can have only one bond per atom.

(b) N_2 has 2(5) = 10 valence e⁻. Therefore a triple bond is required to make the octet around each N.

Strategy for Writing Lewis Structures



Drawing Lewis Structures

$COCl_2$	24 ve's	
HOCl	14 ve's	
ClO_3^-	26 ve's	
CH_3OH	14 ve's