# Review of Lewis Structures

## Chem21, Introduction to Organic and Biochemistry

- **core electrons**: electrons in interior shells
- **valence electrons**: electrons in the highest filled n.

*Example:*

Phosphorous (P): $[Ne]3s^2 3p^3$
**5 valence** electrons (2 from 3s + 3 from 3p = 5)
15 total – 5 valence = **10 core** electrons

Zinc (Zn): $[Ar]4s^2 3d^{10}$
**2 valence** electrons (2 from 4s; 3d does *not* count since 3 < 4)
30 total – 2 valence = **28 core** electrons

Selenium (Se): $[Ar]4s^2 3d^{10} 4p^4$
**6 valence** electrons (2 from 4s + 4 from 4p = 6)
34 total – 6 valence = **28 core** electrons

For main group elements (groups with A's), the number of valence electrons equals the group number.
*Example*:

Al is in Group 3A = 3 valence electrons.
Br is in Group 7A = 7 valence electrons.

Valence electrons determine an atom's reactivity.

- **Lewis Theory:** model to explain why and how atoms form molecules
- **Lewis Dot Structures:** pictorial representation of an atom's valence shell

Each symbol (atom) is assumed to have 4 sides that can fit two electrons each.

- **Pauli Exclusion Principle:** Two electrons per orbital (i.e., side).
- **Hund's Rule:** Fill parallel (i.e., every side with one), then pair.

*Example:*

**Lithium** has 1 valence electron (Group 1A) and 2 core = 3 total.
Structure: Li• *Dot can be on <u>any</u> side*

**Sodium** has 1 valence electron (Group 1A) and 10 core = 11 total
Structure: Na• *Dot can be on <u>any</u> side*

**Sulfur** has 6 valence electrons (Group 6A) and 10 core = 16 total

Structure: 

*Fill all four sides first, THEN pair.*
*Unpaired electrons can be on ANY side.*

- **Octet Rule:** All atoms want 8 electrons in their valence shell (noble gas configuration).
  ***Exceptions***: hydrogen, helium (n=1) follow the **Duet Rule**: two $e^-$.

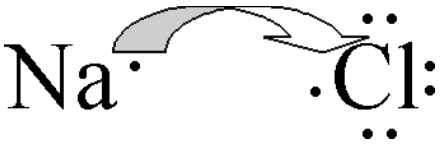
Atoms will satisfy the Octet/Duet Rules by bonding.

- **Ionic bond:** metal to nonmetal, electrons are exchanged
- **Covalent bond:** nonmetal to nonmetal, electrons are shared

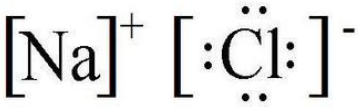
## IONIC BONDING

NOTE: Electrons are not shared; the electron transfer creates ions.

**Sodium chloride, NaCl**: Na ([Ne]$3s^1$) has 1 valence electron, Cl ([Ne]$3s^2 3p^5$) has 7 valence electrons

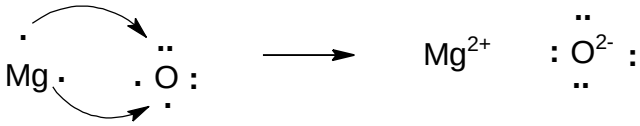


Na will transfer its one valence electron to Cl.



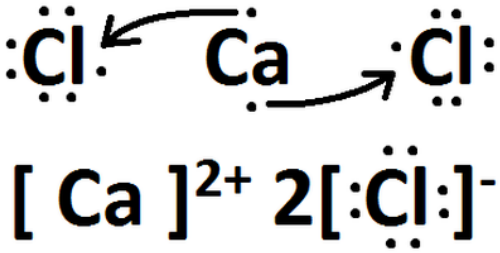
Na is now: [Ne] and Cl is now [Ne]$3s^2 3p^6$ or [Ar] – both are noble gases.
Na is now a **cation** (positive 1 charge having *lost* an electron) and Cl is now an **anion** (negative 1 charge having *gained* an electron). Ions are drawn surrounded by brackets with their charge in the top corner.
NaCl is held together by *attraction of charges*.

**Magnesium oxide, MgO**: Mg has 2 valence electrons, O has 6 valence electrons.



Mg will transfer two valence electrons to O.
Mg is now a 2+ cation and O is now a 2- anion.

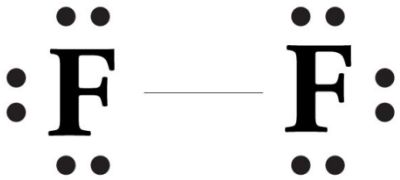
**Calcium chloride,** $CaCl_2$: Ca has 2 valence electrons, Cl has 7 valence electrons.
Each Cl can only take one valence electron before it hits 8. Therefore, two Cl will be needed to take both of Ca's valence electrons.



## COVALENT BONDING

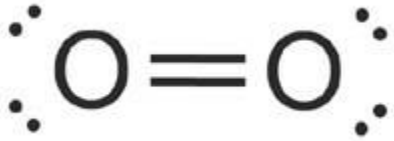
One electron from each atom combine to form a bonding pair.

**Diatomic fluorine, $F_2$**: F has 7 valence electrons, so both atoms want to gain one more electron.



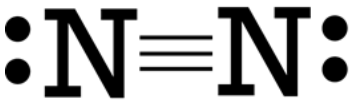
*Each F atom contributes one electron to make a bonding pair (**single** bond) where both electrons are shared and felt equally between the two atoms.*

**Diatomic oxygen, $O_2$**: O has 6 valence electrons, so both atoms want to gain two more electrons.



*Each O atom contributes one electron to each of the two bonds. There are two bonding pairs (**double** bond) between the atoms, representing 4 electrons being felt equally.*

**Diatomic nitrogen, $N_2$**: N has 5 valence electrons, so both atoms want to gain three more electrons.



*Each N atom contributes one electron to each of the three bonds. There are three bonding pairs (**triple** bond) between the atoms, representing 6 electrons felt equally.*

**Bond strength** increases going down (single < double < triple).
**Bond length** decreases going down (single > double > triple).

## How to Draw Lewis Structures: *·Draw $CO_2$.

(1) Count the total number of electrons available.
*Only count valence electrons from each atom.*
*Take into account charges:*
***cations (+), fewer $e^-$*** $\rightarrow$ *subtract from the total $e^-$*
***anions (-), extra $e^-$*** $\rightarrow$ *add to the total $e^-$*

(1)(4 $e^-$) + (2)(6 $e^-$) = 16 total $e^-$
Your structure must show exactly this many electrons, no more and no fewer.

(2) Draw a skeletal structure for the molecule.
*All atoms must be connected by at least one bond.*
*Count how many used $e^-$ to make bonds. (2 $e^-$ = 1 bond)*
*Guidelines*
*H is always terminal. (only **one** bond)*
*C is usually central.*
*O, halogens are usually central.*

(1) O—C—O vs. (2) O—O—C vs. (3) C—O—O

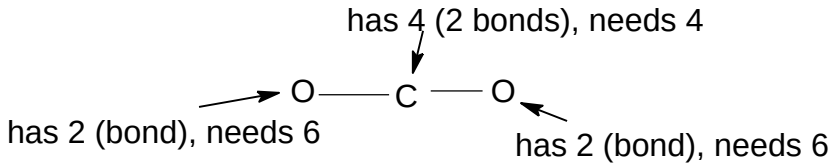
*Structures 2 and 3 are the <u>same</u> (rotated 180 degrees).*

*Structure 1 is the most likely: carbon is central (happy) and both oxygens are terminal (happy).*

2 bonds drawn x 2 $e^-$ each bond = 4 electrons used so far

(3) Calculated the needed $e^-$ to satisfy all the atoms' octets.

*Write in <u>temporary</u> dots on each atom to reach 8.*




6 needed + 4 needed + 6 needed = 16 needed $e^-$

(4) Subtract total – used – needed.

*(-): used too many, need to add multiple bonds*

*zero: used just enough, structure is correct*

*(+): used too few, expanded octet*

16 total – 4 used – 16 needed = -4/2 → add 2 more bonds