Chapter 9
Bonding - 1

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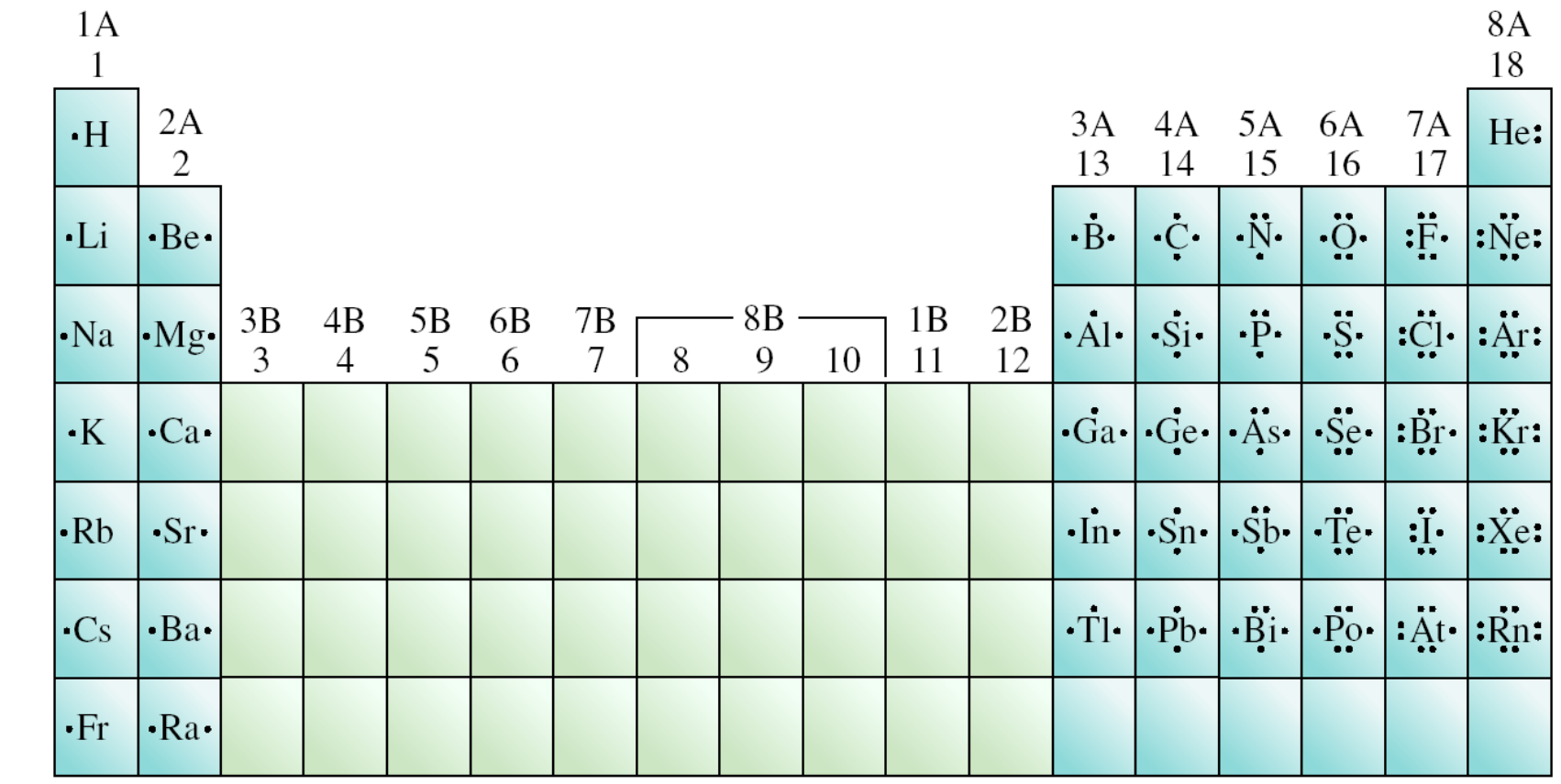
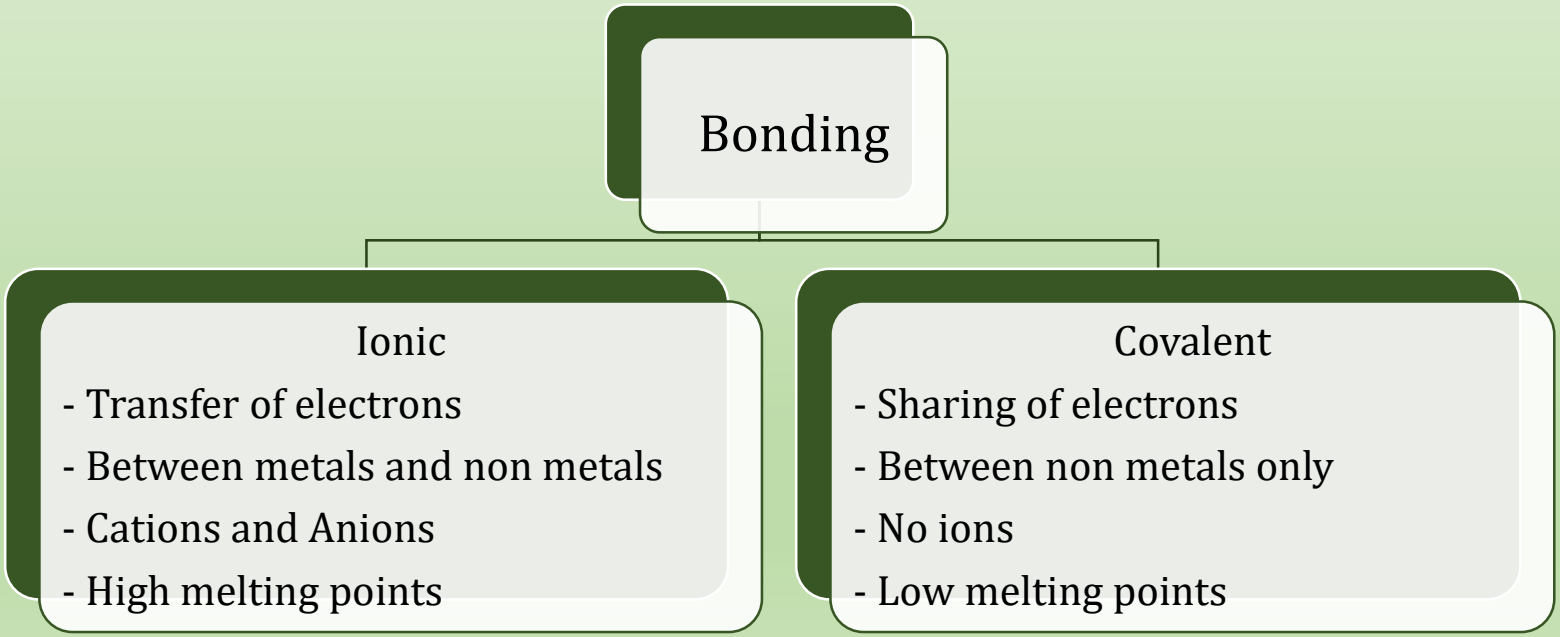
Lewis Dot Symbol

- Lewis dot symbols is a notation where valence electrons are shown as dots.
- Draw the electrons symmetrically around the sides (top, bottom, left and right)



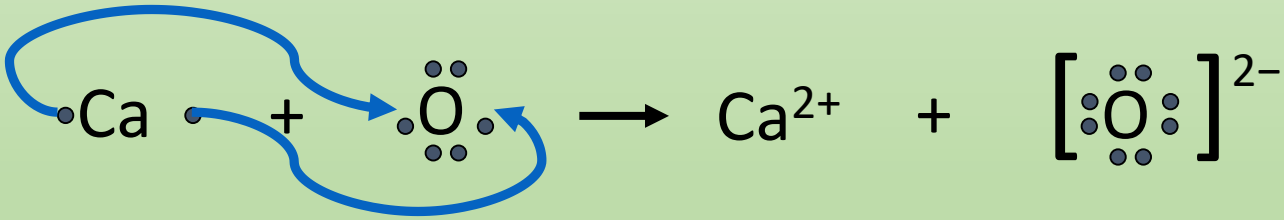
Why Bonding? And Types?

- Bonding occurs to make elements more stable.
- Noble gases are stable, non reactive – it must be the electronic configuration.
- All elements try to have the noble gas configuration
- OCTET RULE: have 8 e- in the valence shell.



Ionic Bond

- Made from transfer of electrons
- Metals lose electrons and become cations (metals have low ionization energy so lose electrons easily)
- Non metals gain electrons and become anions (non metals have high electron affinity so they gain electrons)
- Metals give electrons to non metals
- (Writing Lewis dot structures of ions)
- Below is a representation of transfer of electrons.



Lewis Structure – Ionic Compounds

- Sodium and Chlorine

  Na – needs to give one electron becomes Na^+

  Cl – needs to gain one electrons becomes Cl^-

  $Na\cdot + |\underline{\overline{Cl}}\cdot \qquad Na^+ [\ |\underline{\overline{Cl}}|\ ]^-$

- Calcium and Fluorine

  Ca – needs to give two electron becomes Ca^{2+}

  F – needs to gain one electrons becomes F^-

  $Ca: + |\underline{\overline{F}}\cdot + |\underline{\overline{F}}\cdot \qquad Ca^{2+}\ 2[\ |\underline{\overline{F}}|\ ]^-$

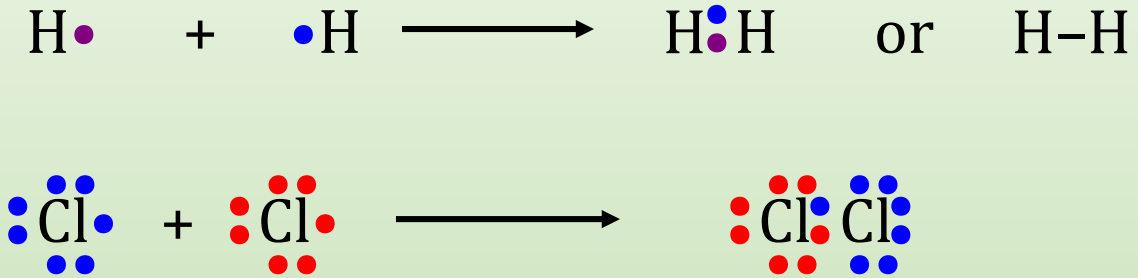
- Aluminum and Oxygen

  $\cdot Al\cdot + |\underline{\underline{O}} \qquad 2Al^{3+}\ 3\ [\ |\underline{\underline{O}}|\ ]^{2-}$

  $\cdot$

Covalent Compounds – Lewis Structures

- Atoms share electrons to form covalent bonds.



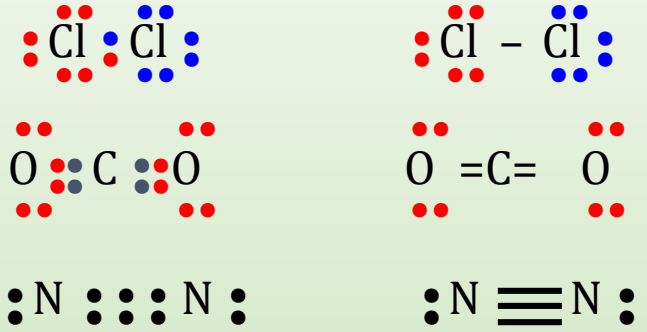
Covalent Bonds

A **single bond** is a covalent bond in which one pair of electrons is shared by two atoms.

A **double bond** is a covalent bond in which two pairs of electrons are shared by two atoms.

A **triple bond** is a covalent bond in which three pairs of electrons are shared by two atoms.

Double bonds form primarily with C, N, and O.
Triple bonds form primarily with C and N.



Bond strength and bond length

bond strength single < double < triple

bond length single > double > triple

	N–N	N=N	N≡N
Bond Strength	163 kJ/mol	418 kJ/mol	941 kJ/mol
Bond Length	1.47 Å	1.24 Å	1.10 Å

Writing Lewis Structures

1. Draw the skeleton structure of the molecule or ion by placing the lowest electronegative element in the center.
2. Add the total number of valence electrons. Subtract electron(s) if is a cation and add electron(s) if anion
3. Share one pair of electrons between each atom, and subtract those from the total number of electrons.
4. Distribute electrons to the atoms surrounding the central atom or atoms to satisfy the octet rule.
5. Distribute the remaining electrons as pairs to the central atom or atoms.
6. Add multiple bonds if atoms don't have the octet.

Hint:

H and halogens have single bonds (unless halogen is in the center)

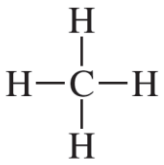
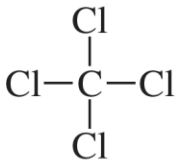
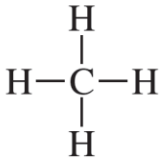
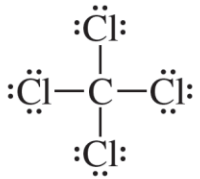
O and S has two bonds (two single or one double)

N and P has three bonds (three single, one double one single or triple)

C has four bonds (different combination)

Steps for Writing Lewis Structure

Steps for Drawing Lewis Structures

Step	CH_4	CCl_4	H_2O	O_2	CN^-
1					
2	8	32	8	12	10
3	8 – 8 = 0	32 – 8 = 24	8 – 4 = 4	12 – 2 = 10	10 – 2 = 8
4					
5	—	—		—	—
6	—	—	—		

Exceptions to the Octet Rule

- Exceptions to the octet rule fall into three categories:
  - Molecules with an incomplete octet
  - Molecules with an expanded octet
  - Molecules with an odd number of electrons

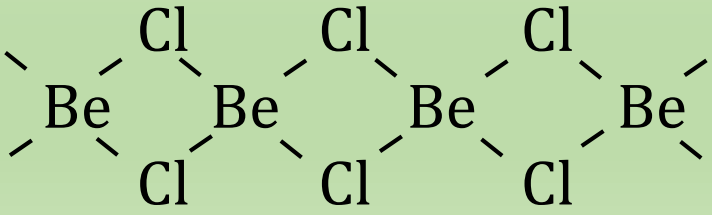
Incomplete Octets

Example: BF_3 (boron trifluoride)

$$BF_3 \Rightarrow (1 \times 3) + (3 \times 7) = 24 \text{ val. } e^-$$

- Common with Be, B and Al compounds, but they often dimerize or polymerize.

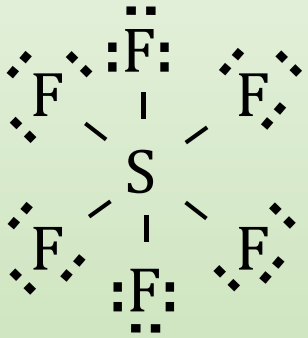
Example:



Expanded Octet

Elements of the 3rd period and beyond have *d*-orbitals that allow more than 8 valence electrons.

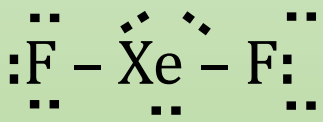
SF_6 =



48 valence e^-

(S has 12 valence electrons)

XeF_2 =



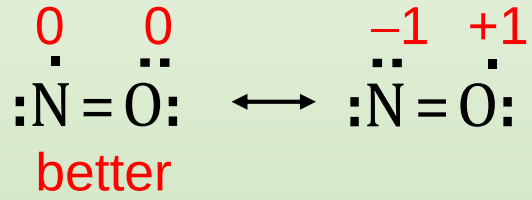
22 valence e^-

(Xe has 10 valence electrons)

Odd Numbers of Electrons

Example: NO (nitrogen monoxide or nitric oxide)

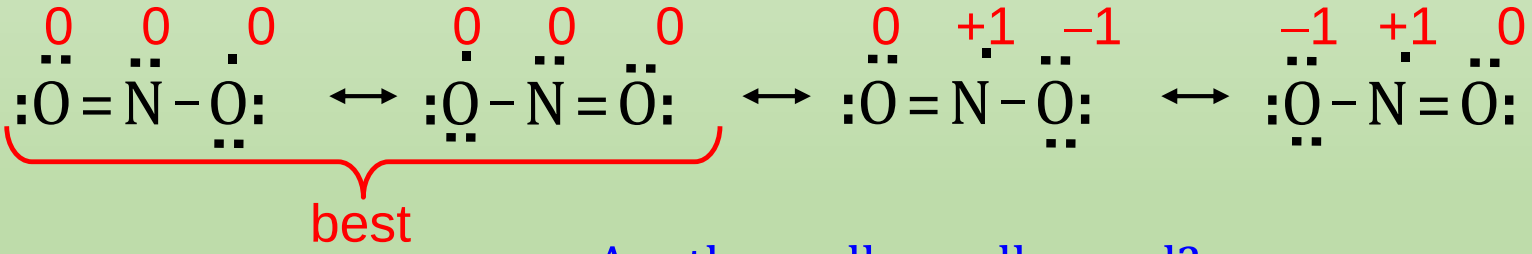
$$NO \Rightarrow (1 \times 5) + (1 \times 6) = 11 \text{ valence } e^-$$



Are these both equally good?

Example: NO_2 (nitrogen dioxide)

$$NO_2 \Rightarrow (1 \times 5) + (2 \times 6) = 17 \text{ val. } e^-$$



Are these all equally good?

Key Points

- Lewis dot symbols
- Ionic bonding
- Covalent bonding
- Octet rule
- Lewis structures
- Exceptions to the Octet Rule
  - Incomplete octets
  - Expanded octets
  - Odd numbers of electrons