Bonding

-**Chemical Bond**

-attractive force between atoms or ions that binds them together as a unit

-bonds form in order to…

-decrease potential energy (PE)

-increase stability

Ionic Bonding

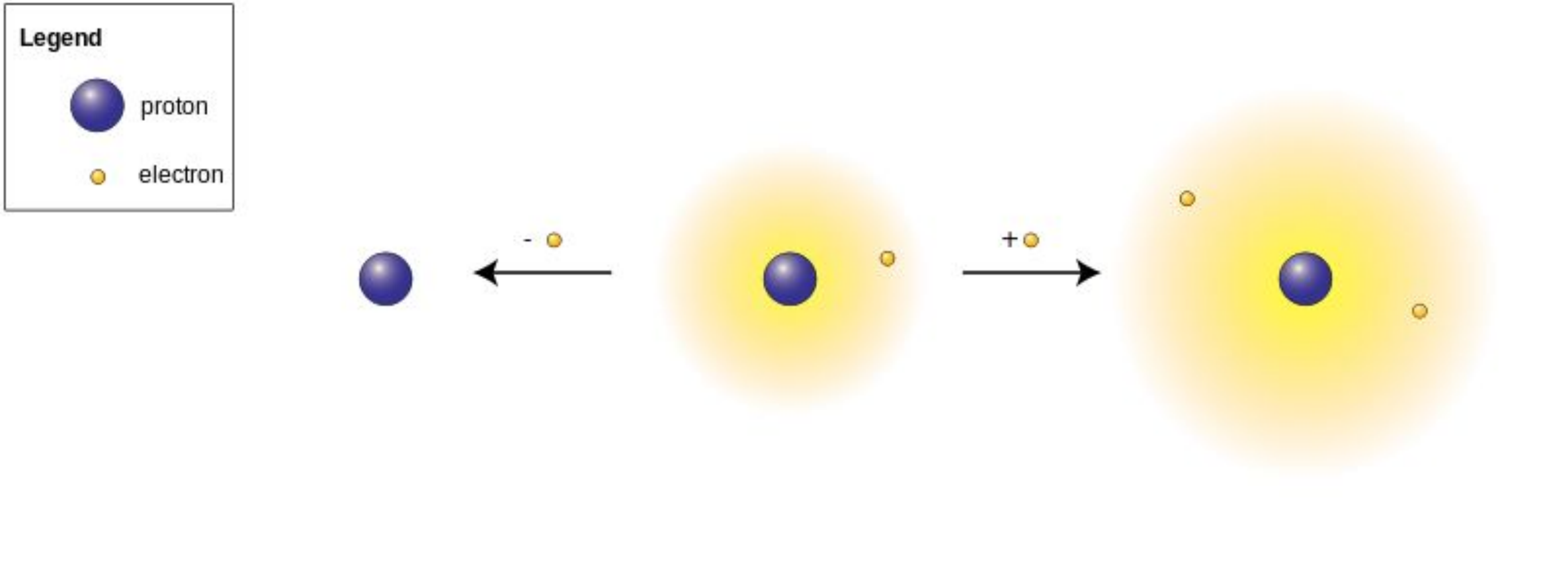
<u>Ion</u>- Atom's which either **gain** or **lose** ***electrons***

- \- They do this to become more stable

  \- They become ***<u>ISOELECTRONIC</u>*** - same number of electrons as the noble gases.

  \- This is called the ***<u>OCTET RULE</u>***: atoms will gain or lose electrons to have full shells

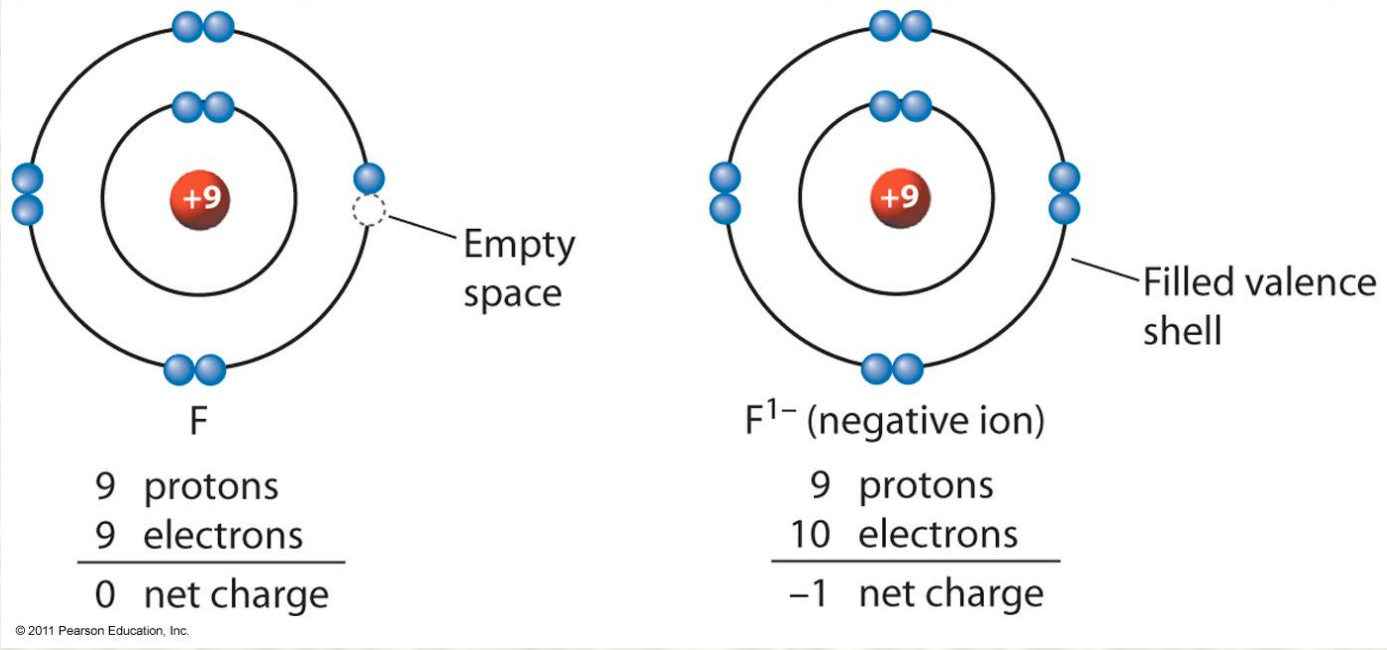
Ionic Bonding



Ionic Bonding

- -Fluorine gains an electron and becomes negatively charged

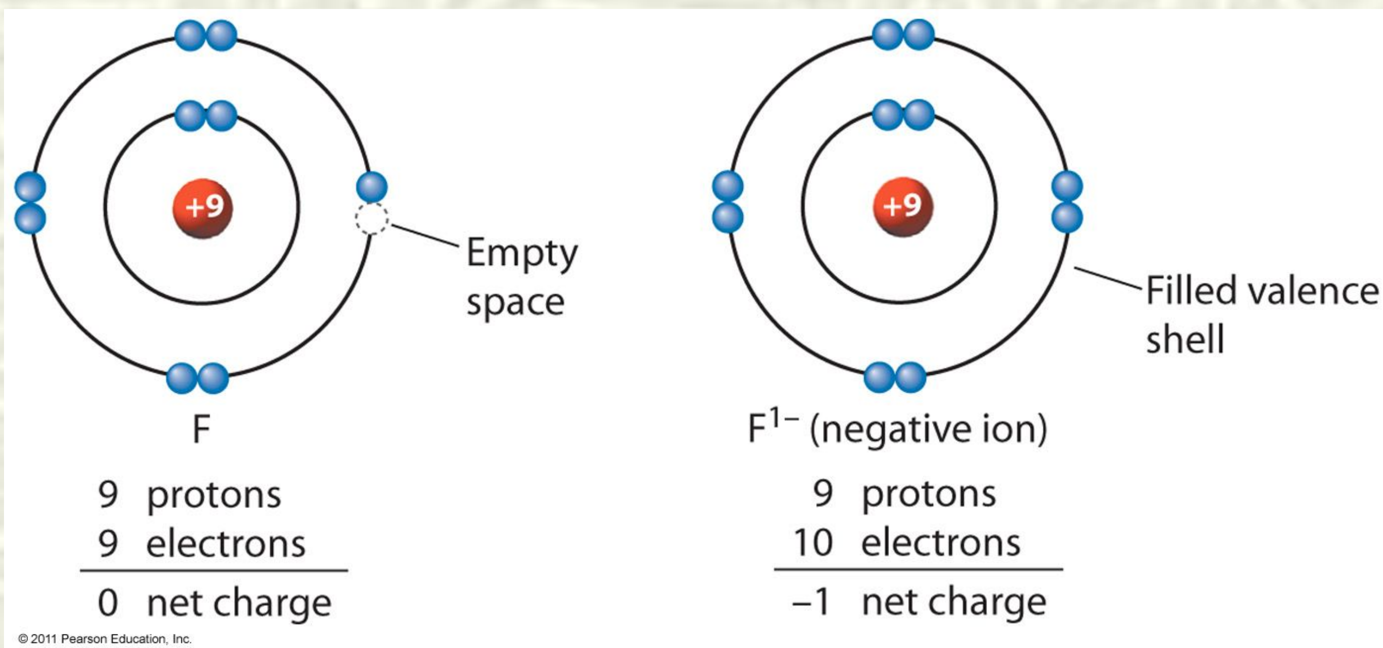
$F + e^{-}$ □ F^{-}



Ionic Bonding

-Fluorine gains an electron and becomes negatively charged

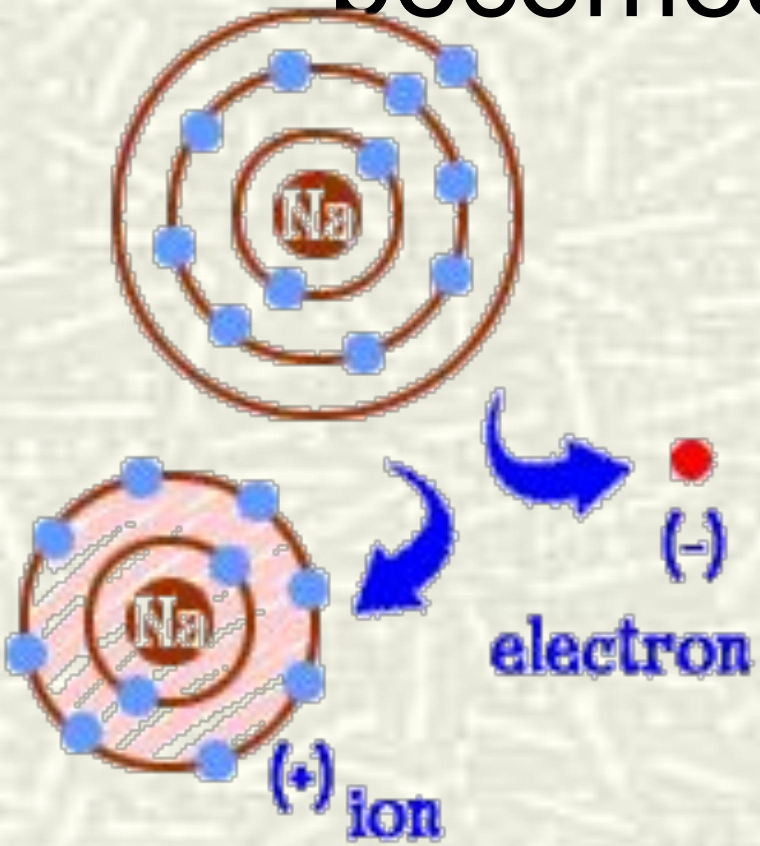
$F + e^- \rightarrow F^-$



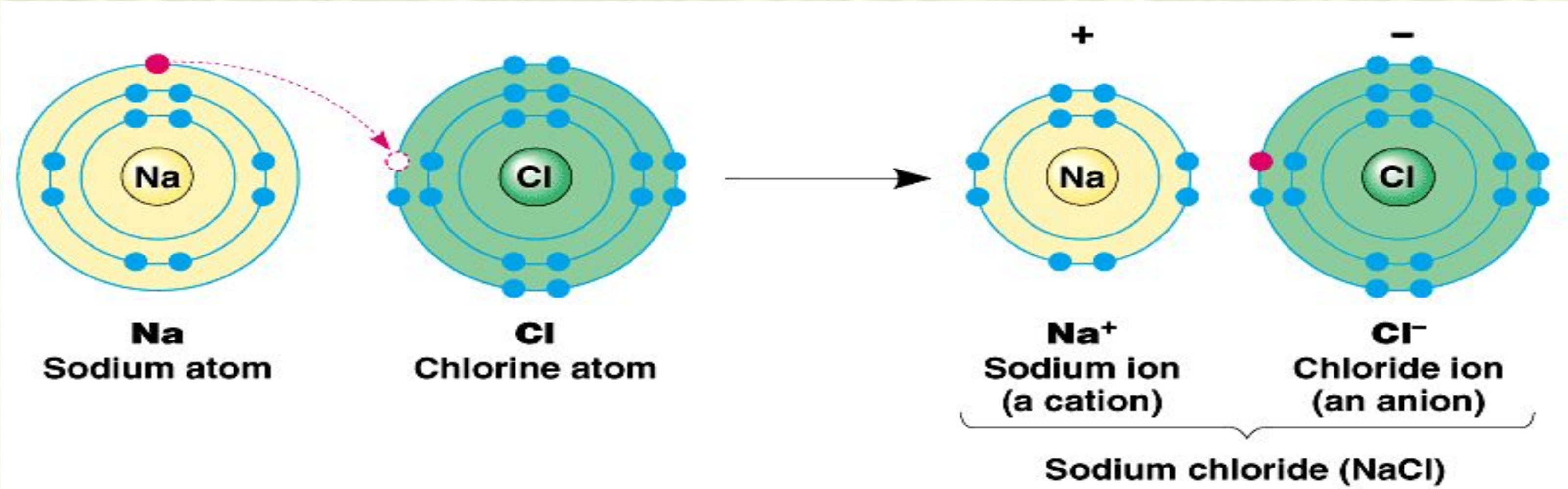
Ionic Bonding

Sodium loses an electron and becomes positively charged

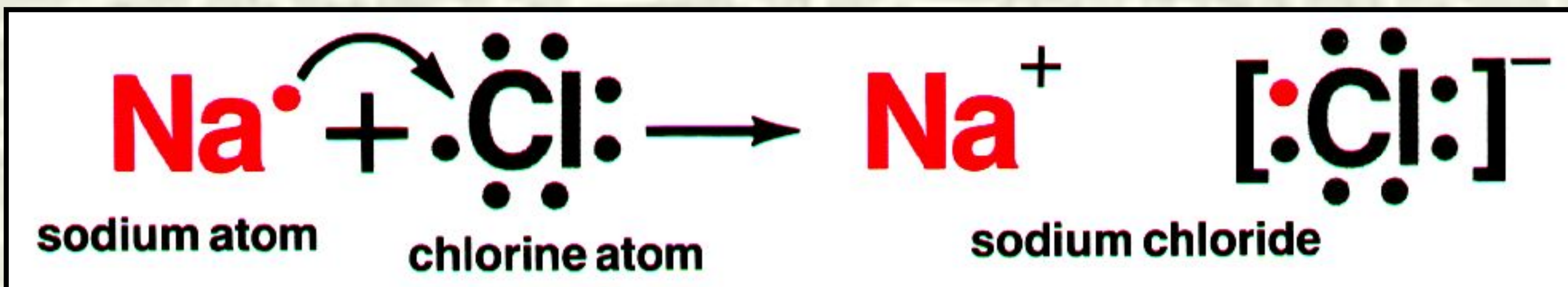
$Na \rightarrow Na^+ + e^-$

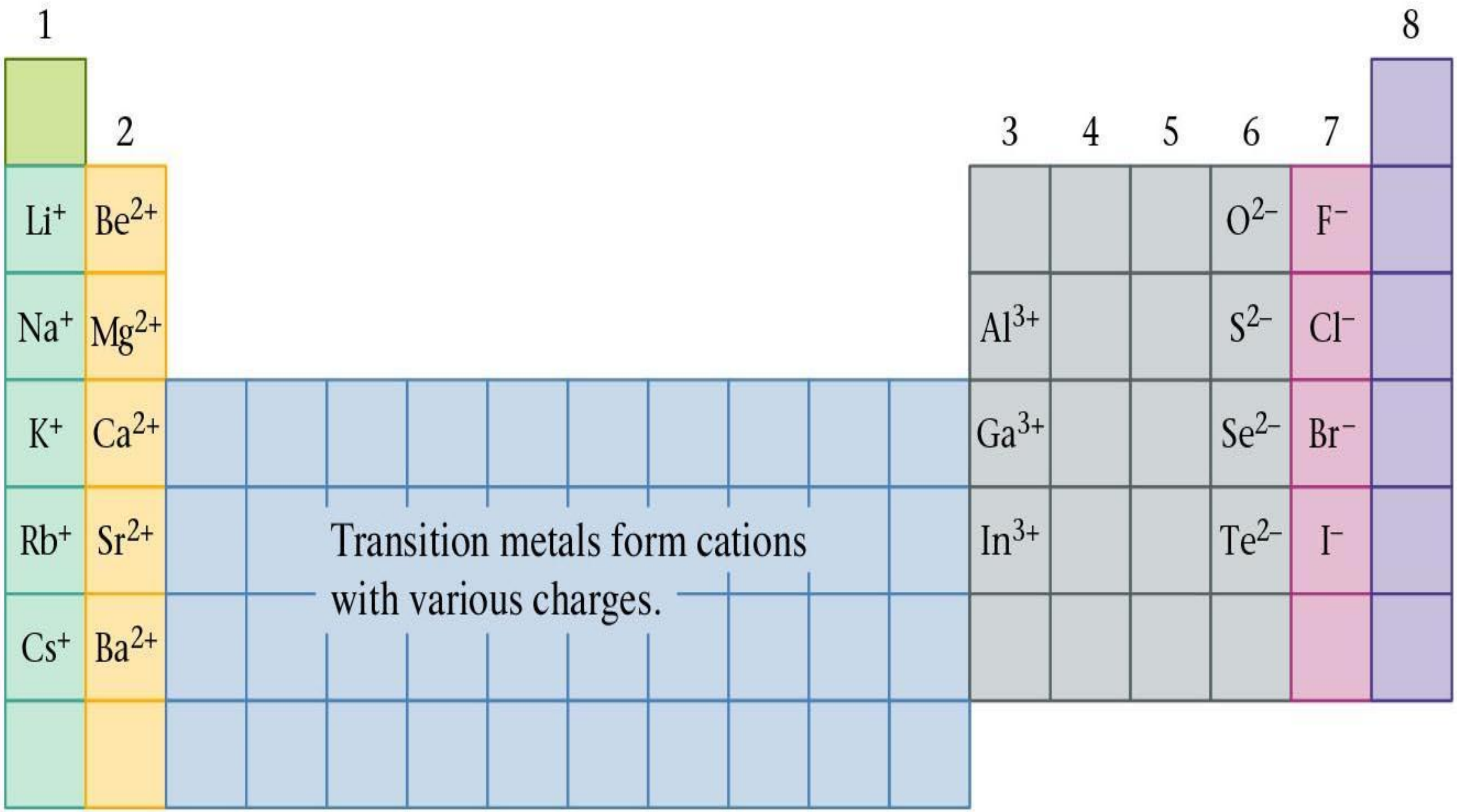


- Electrons are transferred (“given up” or “stolen away”).
- This type of “tug of war” between a *METAL* and *NONMETAL* is called an *IONIC BOND*, which results in a *SALT* being formed



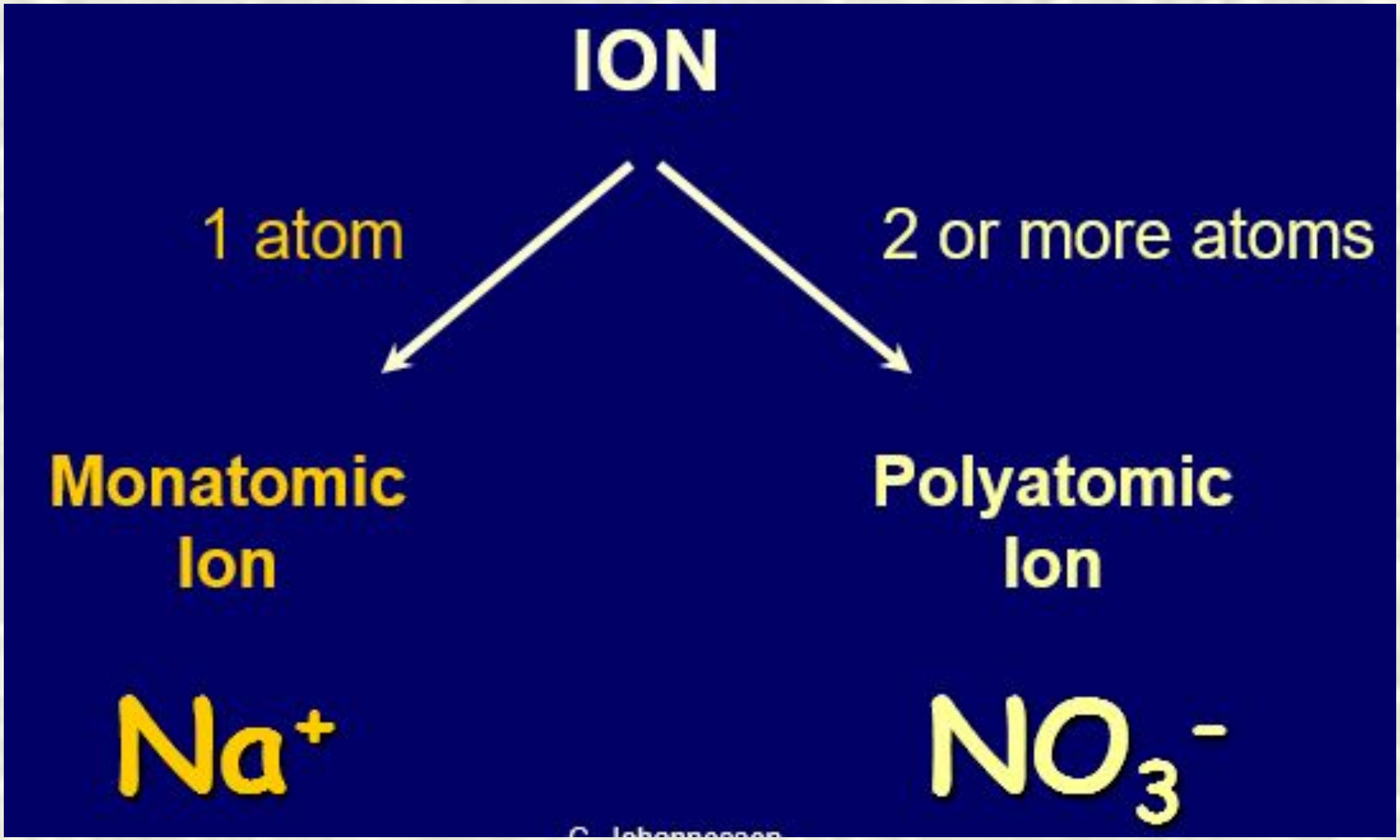
- Electrons are transferred ("given up" or "stolen away").
- This type of "tug of war" between a *METAL* and *NONMETAL* is called an *IONIC BOND*, which results in a *SALT* being formed




1
2
3
4
5
6
7
8
Li+
Be2+
O2–
F–
Na+
Mg2+
Al3+
S2–
Cl–
K+
Ca2+
Ga3+
Se2–
Br–
Rb+
Sr2+
In3+
Te2–
I–
Cs+
Ba2+
Transition metals form cations with various charges.

Cation	Anion
Positive ion	Negative ion
Lose their valence electrons	Gain valence electrons
From atoms with less than 4 valence electrons	From atoms with more than 4 valence electrons
Example: Mg $Mg \Rightarrow Mg^{2+} + 2e^-$	Example: Cl $Cl + e^- \Rightarrow Cl^-$
Smaller than parent element (less electrons, same protons)	Larger than parent element(more electrons, same protons)

You can ions with one atom or multiple atoms.



- Binary compounds are those that contain only two different elements. The names for binary ionic compounds containing a metal that forms only one type of ion have the following form:

$\boxed{\textbf{Name of Cation}}$ **+** $\boxed{\textbf{Base Name of Anion + } \textbf{\textit{ide}}}$

TABLE 5.4 Metals Whose Charge Is Invariant from One Compound to Another

Metal	Ion	Name	Group Number
Li	Li^+	lithium	1A
Na	Na^+	sodium	1A
K	K^+	potassium	1A
Rb	Rb^+	rubidium	1A
Cs	Cs^+	cesium	1A
Mg	Mg^{2+}	magnesium	2A
Ca	Ca^{2+}	calcium	2A
Sr	Sr^{2+}	strontium	2A
Ba	Ba^{2+}	barium	2A
Al	Al^{3+}	aluminum	3A
Zn	Zn^{2+}	zinc	*
Ag	Ag^+	silver	*

*The charge of these metals cannot be inferred from their group number.

TABLE 5.5 Some Metals That Form More Than One Type of Ion and Their Common Charges

Metal	Symbol Ion	Name	Older Name*
chromium	Cr^{2+}	chromium(II)	chromous
	Cr^{3+}	chromium(III)	chromic
iron	Fe^{2+}	iron(II)	ferrous
	Fe^{3+}	iron(III)	ferric
cobalt	Co^{2+}	cobalt(II)	cobaltous
	Co^{3+}	cobalt(III)	cobaltic
copper	Cu^{+}	copper(I)	cuprous
	Cu^{2+}	copper(II)	cupric
tin	Sn^{2+}	tin(II)	stannous
	Sn^{4+}	tin(IV)	stannic
mercury	Hg_2^{2+}	mercury(I)	mercurous
	Hg^{2+}	mercury(II)	mercuric
lead	Pb^{2+}	lead(II)	plumbous
	Pb^{4+}	lead(IV)	plumbic

* An older naming system substitutes the names found in this column for the name of the metal and its charge. Under this system, chromium(II) oxide is named chromous oxide. We do *not* use this older system in this text.

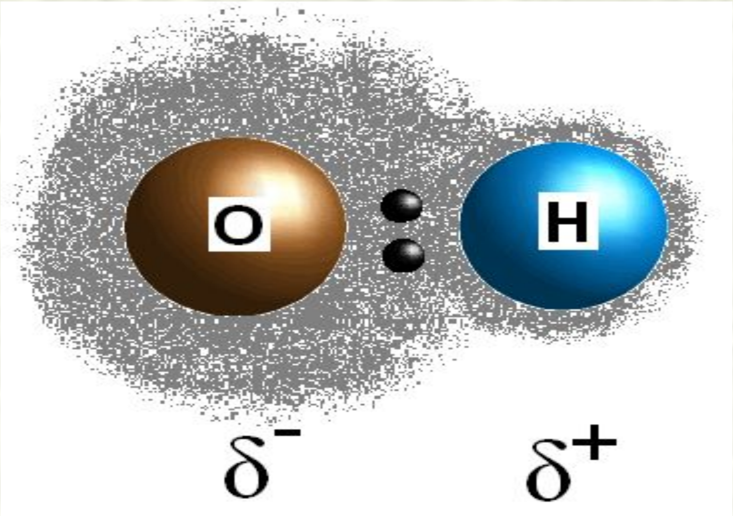
TABLE 5.6 Some Common Anions

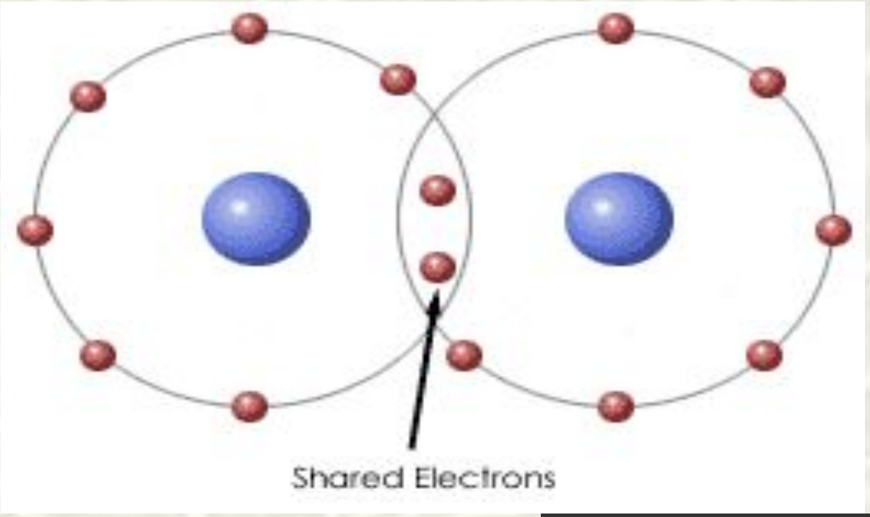
Nonmetal	Symbol for Ion	Base Name	Anion Name
fluorine	F^-	fluor-	fluoride
chlorine	Cl^-	chlor-	chloride
bromine	Br^-	brom-	bromide
iodine	I^-	iod-	iodide
oxygen	O^{2-}	ox-	oxide
sulfur	S^{2-}	sulf-	sulfide
nitrogen	N^{3-}	nitr-	nitride

Molecular Compounds

- Now, you will learn about another type of bond in which electrons are shared

- <u>Covalent Bonds are atoms held together by *SHARING* electrons between *NONMETALS*</u>





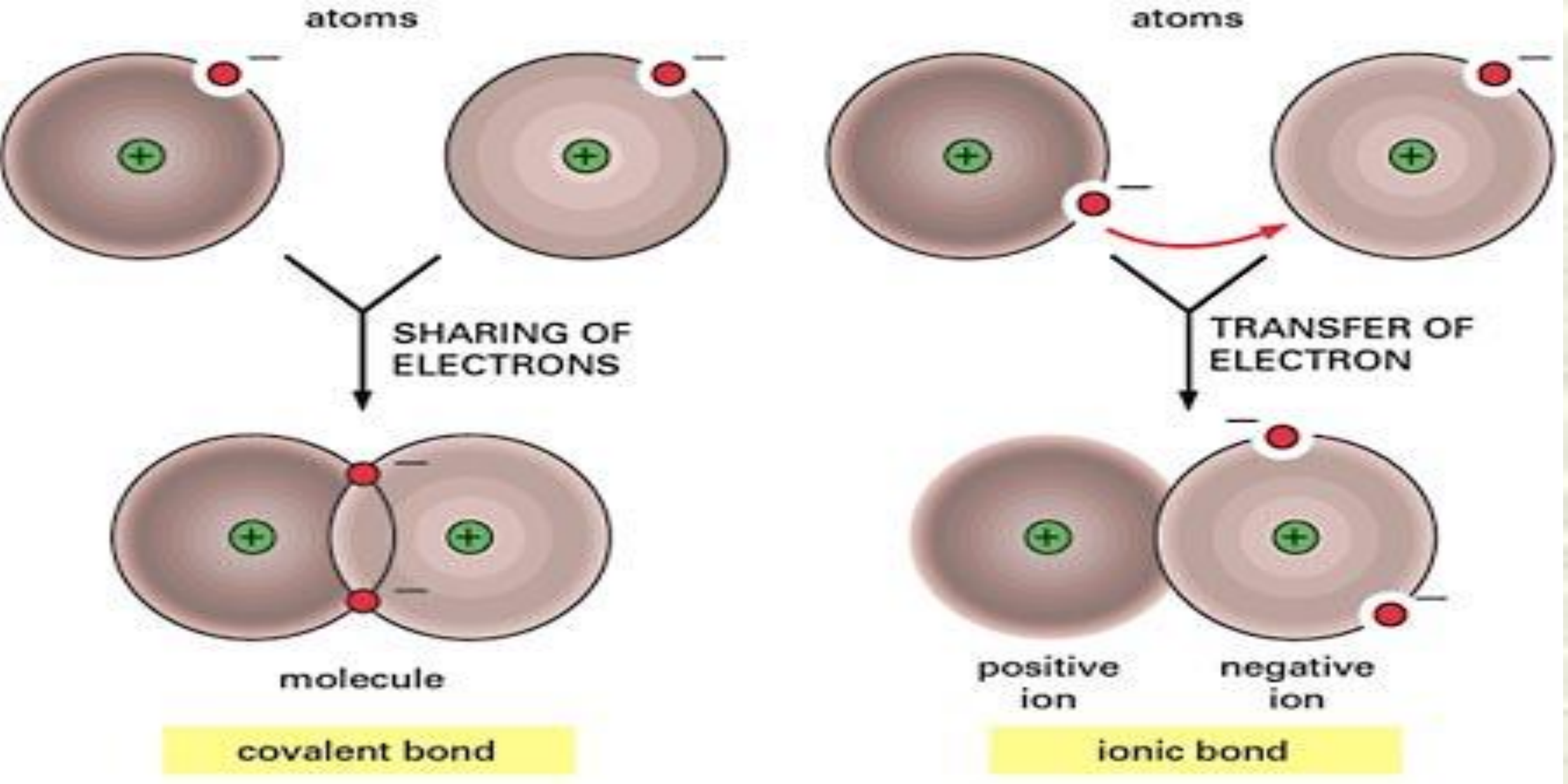
Salt versus Molecules

- A metal cation and nonmetal anion are joined together by an ionic bond called SALT

- A group of atoms joined together by a covalent bond is called a MOLECULE

- A Compound is a group of two or more elements bonded together (Ionic or Covalent).

Covalent vs Ionic



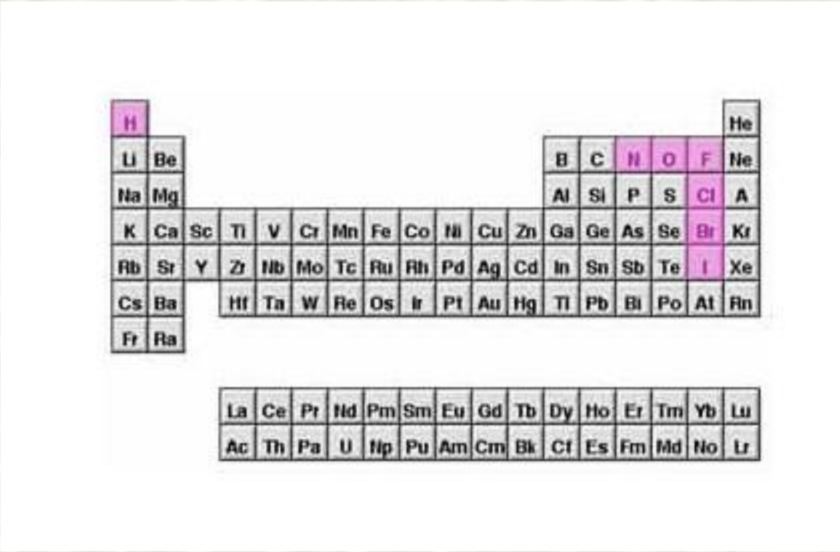
Monatomic vs. Diatomic Molecules

- Most molecules can be monatomic or diatomic

- Diatomic Molecule is a molecule consisting of two atoms

- <u>There are 7 diatomic molecules (SUPER 7) – N_2, O_2, F_2, Cl_2, Br_2, I_2, H_2</u>

- You can also remember them as: $H_2O_2F_2Br_2I_2N_2Cl_2$



Properties of Molecular Compounds

- Liquids or gases at room temperature

- Lower Melting Points than Ionic Compounds (which means that they are weaker than ionic)

Molecular Formulas

- The Molecular Formula is the formula of a molecular compound

- It shows how many atoms of each element a molecule contains

- Example
  - H_2O contains 3 atoms (2 atoms of H, 1 atom of O)
  - C_2H_6 contains 8 atoms (2 atoms of C, 6 atoms of H)

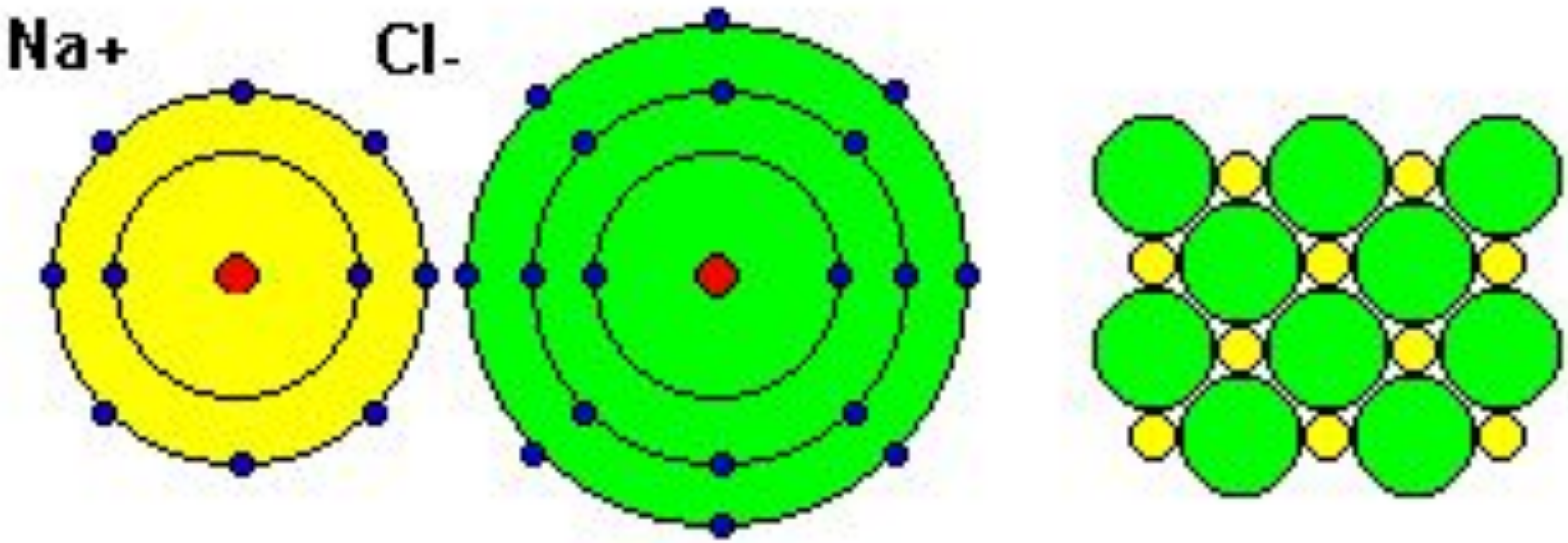
Practice

How many atoms total and of each do the following molecular compounds contain?

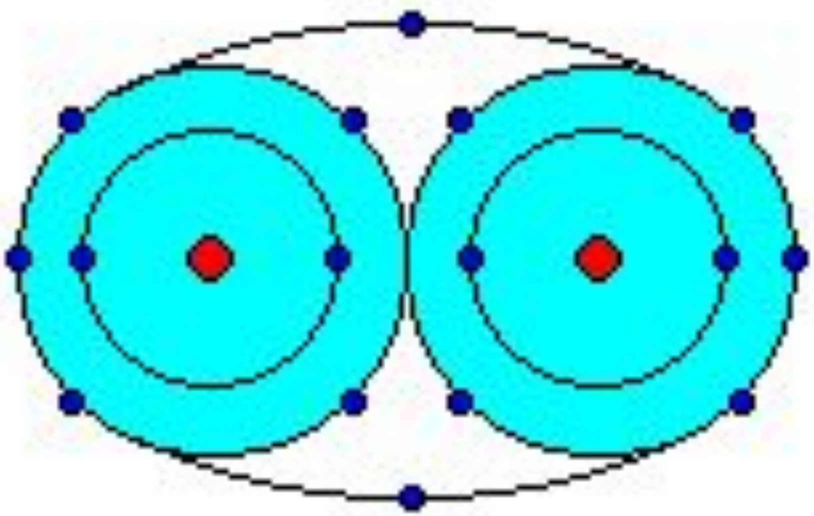
1. H_2
2. CO
3. CO_2
4. NH_3
5. C_2H_6O

Practice: True or False

1. All molecular compounds are composed of atoms of two or more elements. TRUE
2. All compounds are molecules. FALSE
3. Molecular compounds are composed of two or more nonmetals. TRUE
4. Atoms in molecular compounds exchange electrons. FALSE
5. Molecular compounds have higher melting and boiling points than ionic compounds. FALSE



NaCl - Ionic Bonding



Oxygen-
Covalent Bonding

Ionic versus Covalent

	IONIC	COVALENT
Bonded Name	Salt	Molecule
Bonding Type	Transfer e^-	Share e^-
Types of Elements	Metal & Nonmetal	Nonmetals
Physical State	Solid	Solid, Liquid, or Gas
Melting Point	High (above 300ºC)	Low (below 300 ºC)
Solubility	Dissolves in Water	Varies
Conductivity	Good	Poor

Covalent Bonding

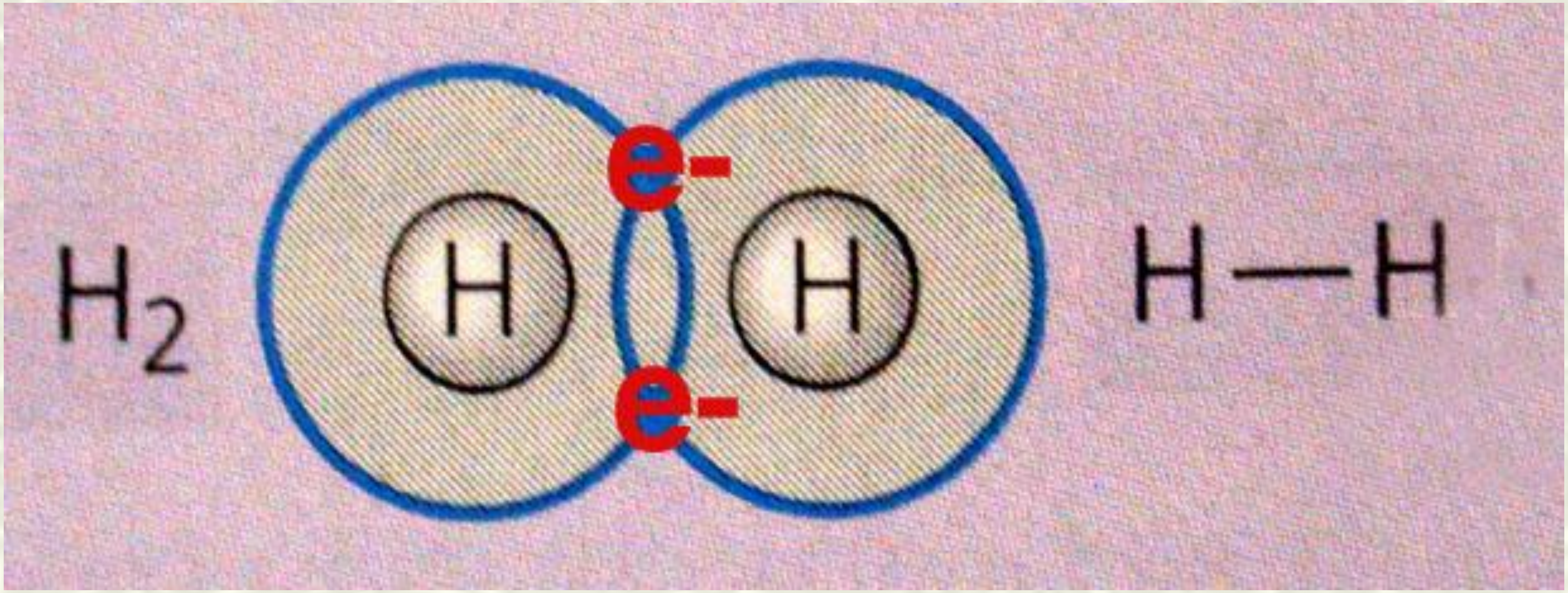
- Remember that ionic compounds *transfer electrons* in order to attain a noble gas electron configuration

- Covalent compounds form by *sharing electrons* to attain a noble gas electron configuration

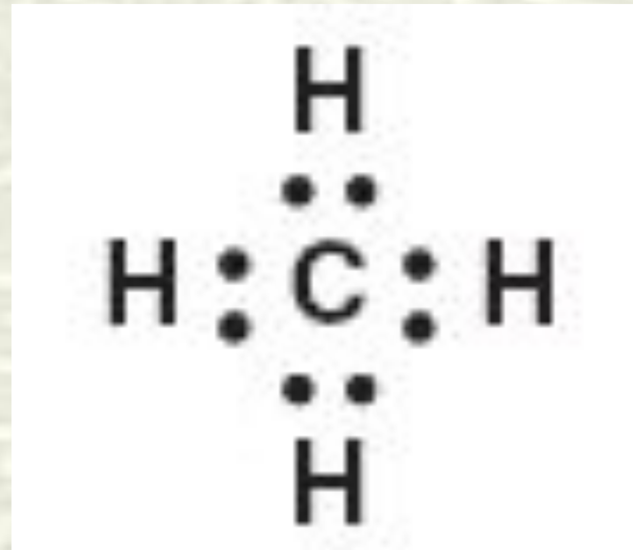
- Regardless of the type of bond, the Octet Rule still must be obeyed (8 valence electrons)

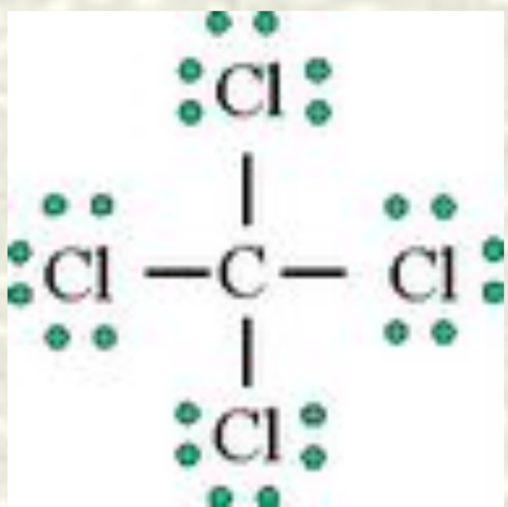
Single Covalent Bond

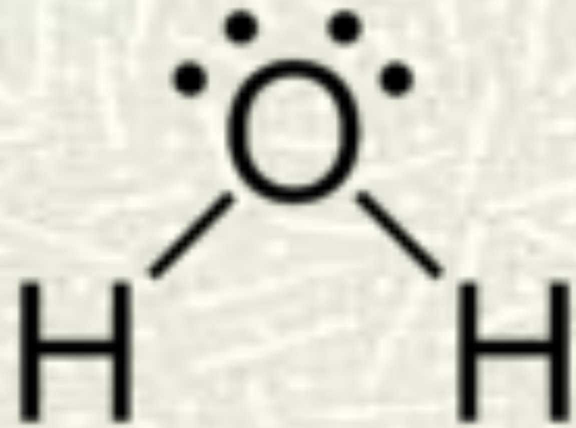
- A Single Covalent Bond consists of two atoms held together by sharing 1 pair of electrons (2 e^-)



Electron Dot Structure

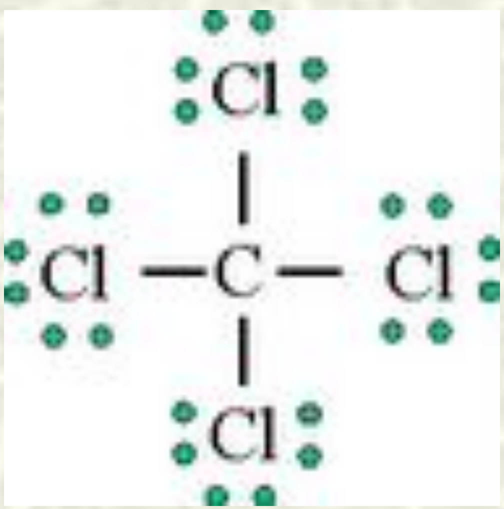


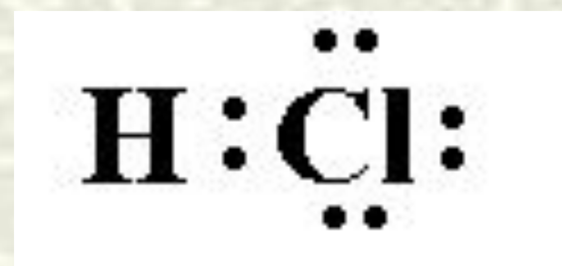




Shared versus Unshared Electrons

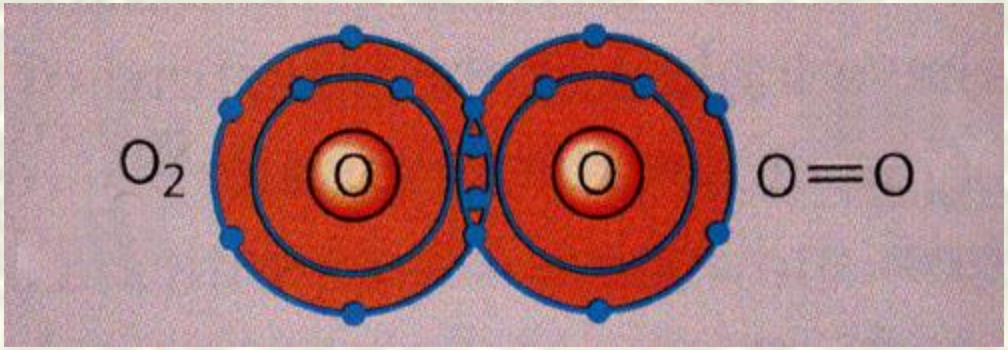
- A Shared Pair is a pair of valence electrons that is shared between atoms
- <u>An Unshared Pair is a pair of valence electrons that is not shared between atoms</u>

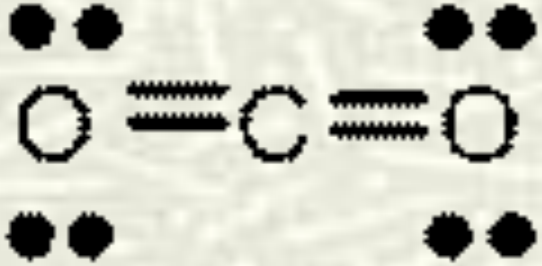




Double Covalent Bonds

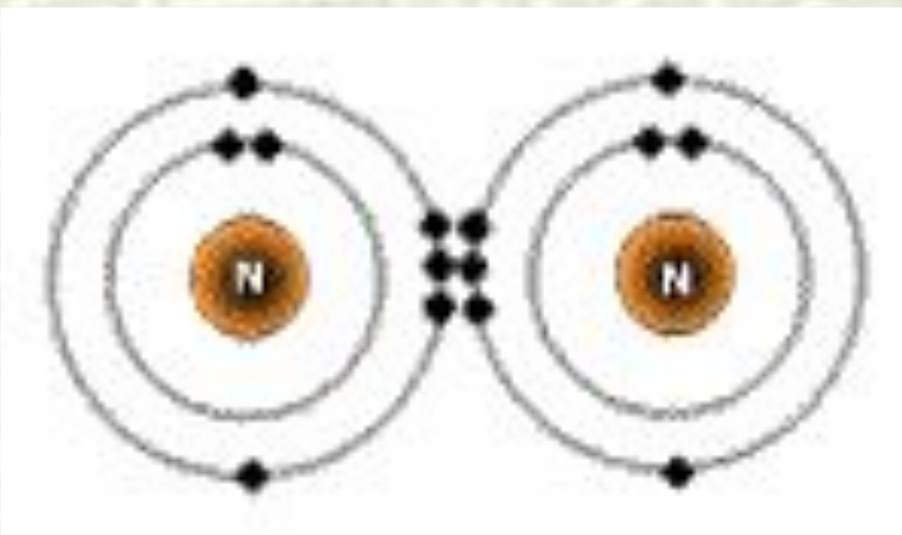
- Sometimes atoms attain noble gas configuration by sharing 2 or 3 pairs of electrons
  - A Double Covalent Bond is a bond that involves 2 shared pairs of electrons (4 e^-)





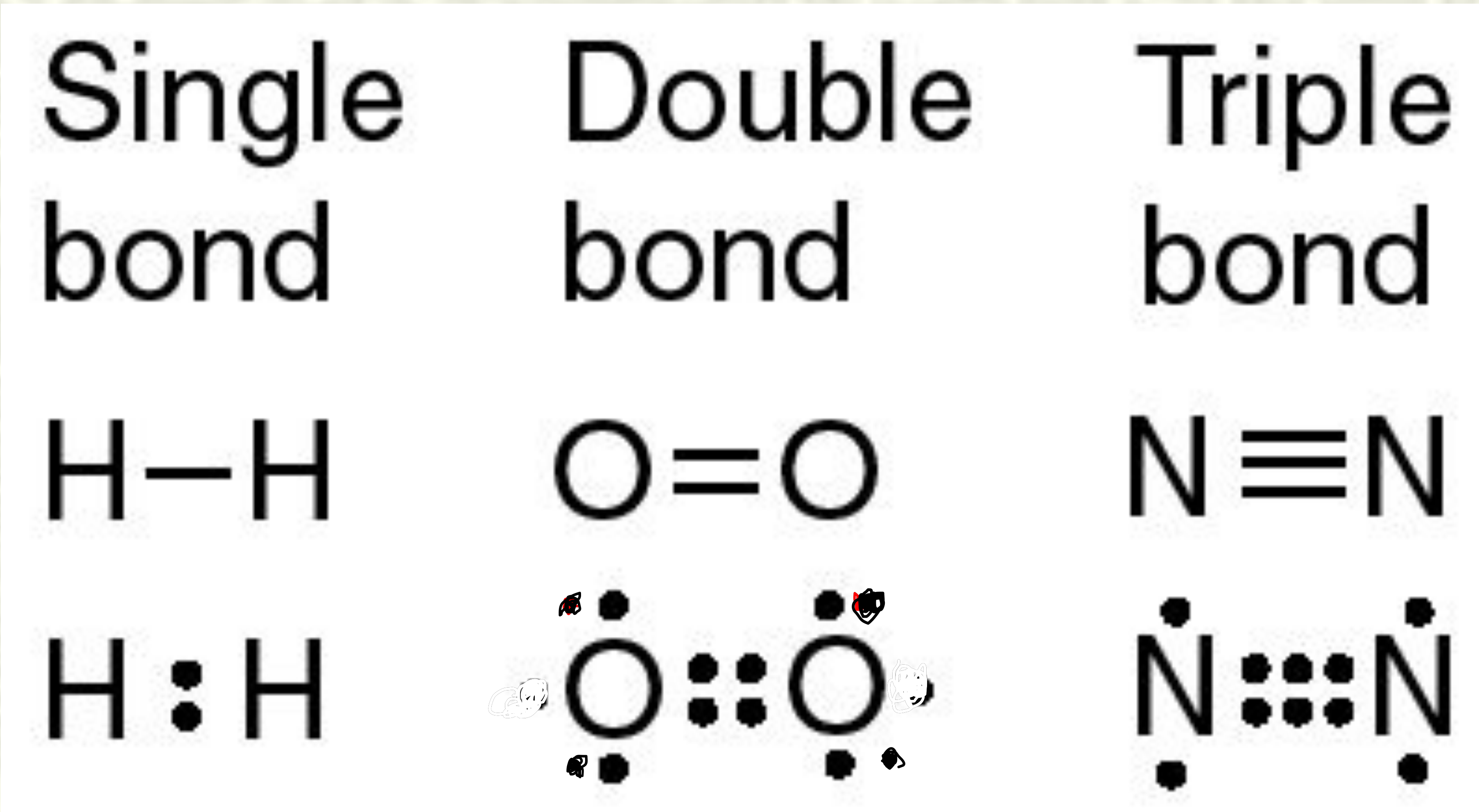
Triple Covalent Bond

- A Triple Covalent Bond is a bond that involves 3 shared pairs of electrons (6 e^-)



$:N\equiv N:$

Covalent Bonds



covalent compounds:

- They are the majority of nature's bonds
- they are also considered molecules
- Can form Hydrocarbons: compounds of hydrogen and carbon   ex. (CH, C_2H_4 ,C_4H_8)
  - Many are used as fuels
- Can form Polymers: a long chained molecule made up of smaller molecules (monomers)

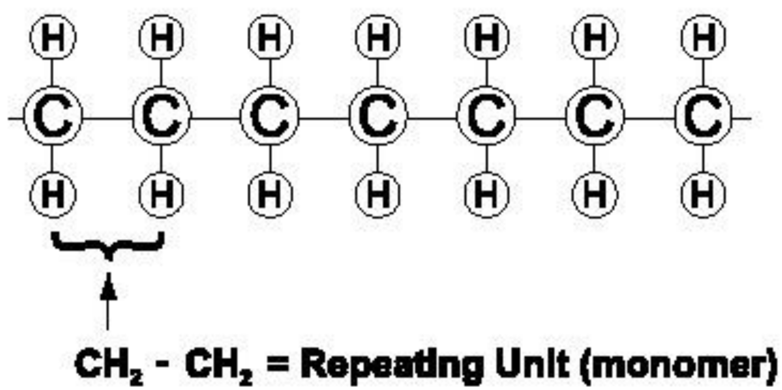


Figure 1 Portion of a polyethylene molecule made of repeating units of carbon and hydrogen

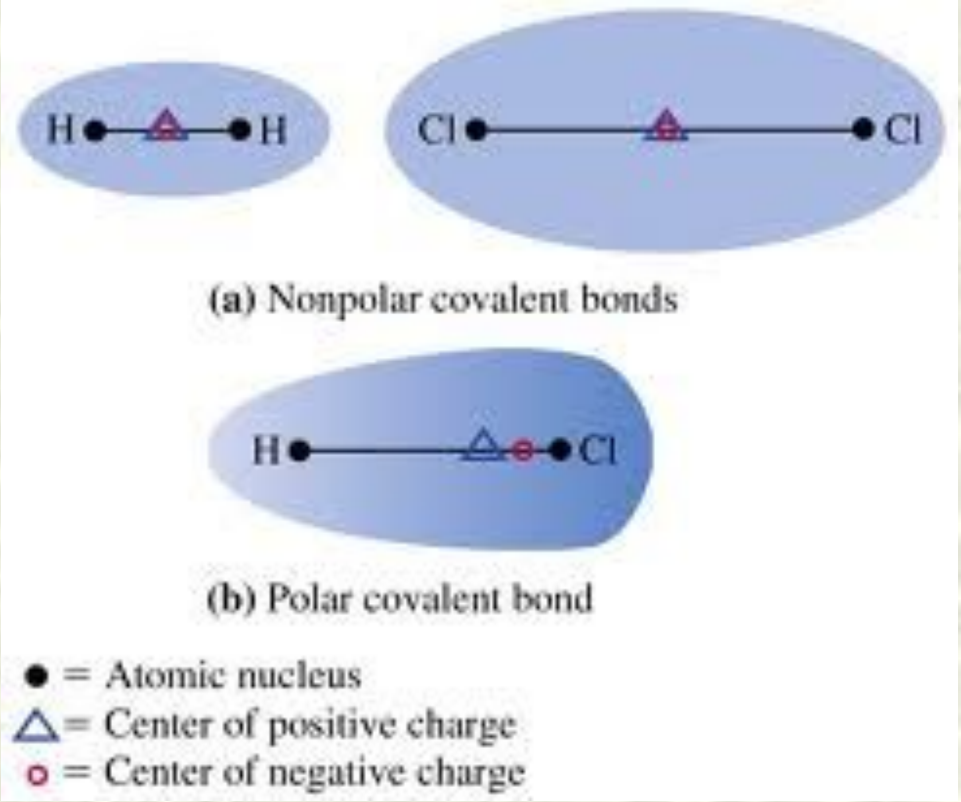
Covalent Bonds and Polarity

- Covalent bonds share electrons

This can be equal sharing (non-polar)

This can be unequal sharing (polar)

Polar covalent bonds have dipoles (one atom attracts shared electrons more than the other atom)



Electronegativity: The ability of an atom to attract electrons

- Difference in electronegativity values can determine if a bond is nonpolar covalent, polar covalent or ionic.

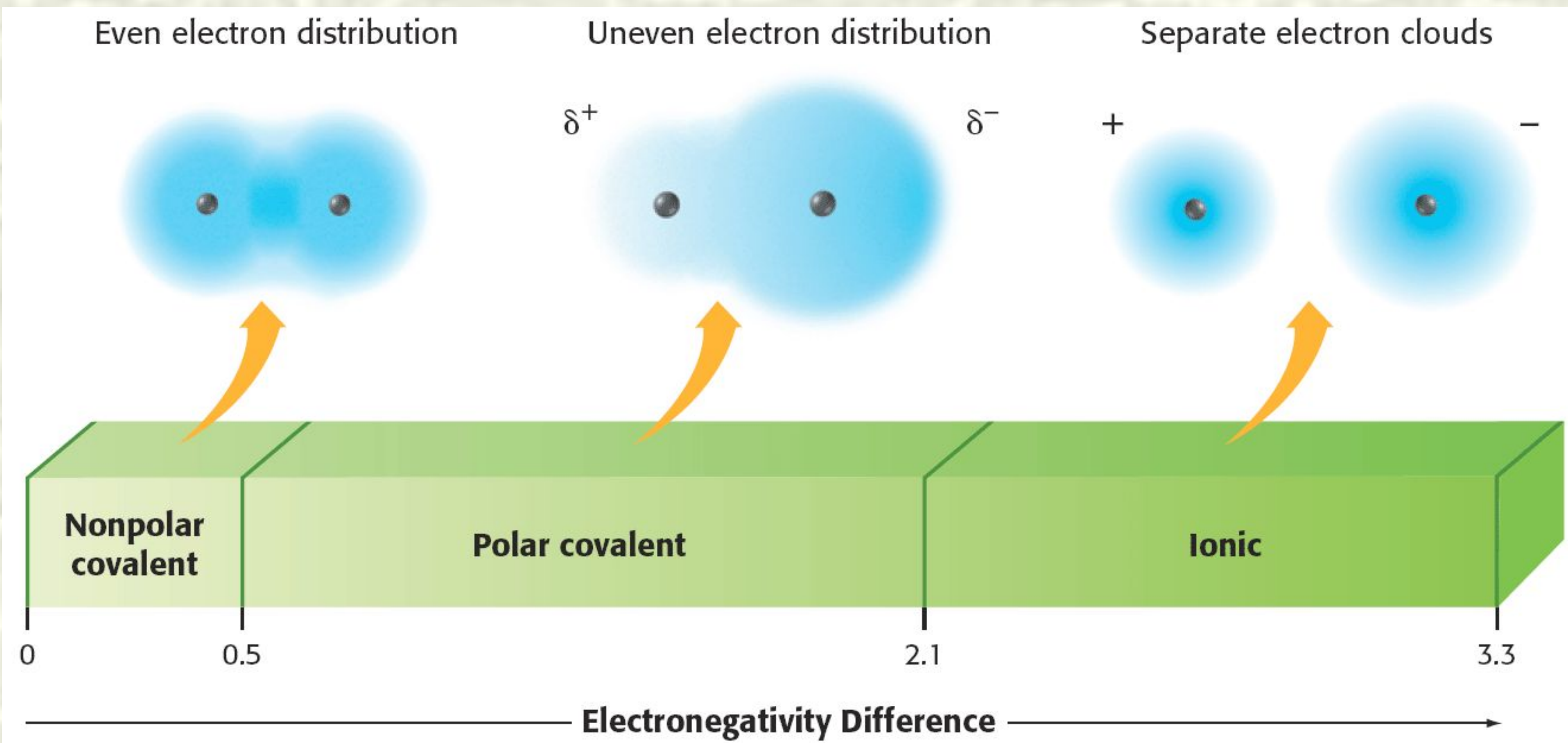


Table of Electronegativity values

		H 2.2					He
Li 1.0	Be 1.6	B 2.0	C 2.6	N 3.0	O 3.4	F 4.0	Ne
Na 0.93	Mg 1.3	Al 1.6	Si 1.9	P 2.2	S 2.6	Cl 3.2	Ar
K 0.82	Ca 1.3	Ga 1.6	Ge 2.0	As 2.2	Se 2.6	Br 3.0	Kr
Rb 0.82	Sr 0.95	In 1.8	Sn 2.0	Sb 2.1	Te 2.1	I 2.7	Xe
Cs 0.79	Ba 0.89	Tl 2.0	Pb 2.3	Bi 2.0	Po 2.0	At	Rn

Electronegativity

4.0–   3.0–3.9   2.0–2.9   1.0–1.9   0–0.99

Table of Electronegativity values

Electronegativity increases

Electronegativity increases

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
H 2.20						H 2.20	He —
Li 0.98	Be 1.57	B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne —
Na 0.93	Mg 1.31	Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar —
K 0.82	Ca 1.00	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	Kr —
Rb 0.82	Sr 0.95	In 1.78	Sn 1.96	Sb 2.05	Te 2.1	I 2.66	Xe —
Cs 0.79	Ba 0.89	Tl 2.04	Pb 2.33	Bi 2.02	Po 2.0	At 2.2	Rn —
Fr 0.7	Ra 0.9						

Non-polar covalent bonds	Polar Covalent bonds	Ionic bonds
- Electrons shared equally -Lots of covalent character -Little if any difference in electronegativity -Very close to each other on periodic table		

Non-polar covalent bonds	Polar Covalent bonds	Ionic bonds
- Electrons shared equally -Lots of covalent character -Little or no difference in electronegativity -Close to each other on periodic table	-Electrons shared unequally - both ionic & covalent character -Small difference in electronegativity - little bit away from each other on periodic table	

Non-polar covalent	Polar Covalent bonds	Ionic bonds
- Electrons shard equally -Lots of covalent character -Little or no difference in electronegativity -Close to each other on periodic table	-Electrons shared unequally - both ionic & covalent character -Small difference in electronegativity - little bit away to each other on periodic table	-Electrons are transferred -lots of ionic character -large difference in electronegativity -Very far from each other on periodic table (metal and non-metal)

Decide if these atoms will form ionic, polar covalent, or non-polar covalent bonds.

1.) O with I

2.) H with Cl

3.) Ba with I

4.) N with O

5.) As with P

Names and Formulas of Binary Covalent Compounds

- Composed of covalent bonds (2 non-metals).

Rules:

1. First element (the one with lower electronegativity= farthest to the left or lowest in the group) is written first with the full name.
2. The second element has the ending –ide
3. Greek prefixes are used to indicate the number of atoms for each element.

EXCEPT: *Mono-* is not used on the first element

(ex. C_2O_2 is dicarbon dioxide while CO_2 is carbon dioxide)

TABLE 2.6 Prefixes Used in Naming Binary Compounds Formed Between Nonmetals

Prefix	Meaning
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

Prefixes show the number of each atom

P_2S_5

Prefix needed if there is more than one atom of the less-electronegative element	+	Name of less-electronegative element		Prefix that shows the number of atoms of the more-electronegative element	+	Root name of more electronegative element + *ide*
diphosphorus				**pentasulfide**		

Some examples with the first 5 prefixes

Prefix	Number of atoms	Example	Name
mono-	1	CO	carbon monoxide
di-	2	SiO_2	silicon dioxide
tri-	3	SO_3	sulfur trioxide
tetra-	4	SCl_4	sulfur tetrachloride
penta-	5	$SbCl_5$	antimony pentachloride

Name the following molecules:

1. CO_2
2. PCl_3
3. BrF

1. Carbon dioxide
2. Phosphorous trichloride
3. Bromine monoflouride

Examples:

4. NO_2
5. N_2O
6. N_2O_5
7. SF_6
8. P_4O_{10}

4. nitrogen dioxide
5.dinitrogen monoxide
6. dinitrogen pentoxide
7. sulfur hexaflouride
8. Tetraphosphorous decoxide