

previously

### Valence Electrons in Yellow

H	1s <sup>1</sup>		
He	1s <sup>2</sup>	full	Noble (inert) gas
Li	1s <sup>2</sup> ,2s <sup>1</sup>		
Be	1s <sup>2</sup> ,2s <sup>2</sup>		
B	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>1</sup>		
C	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>2</sup>		
N	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>3</sup>		
O	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>4</sup>		
F	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>5</sup>		
Ne	1s <sup>2</sup> ,2s <sup>2</sup> p <sup>6</sup>	full	Noble (inert) gas

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### Stable Electron Structures: 8 (and 2) as a Special Number

Octet Rule- atoms tend to lose, gain, or share electrons to achieve the electron configuration of the nearest noble gas in the periodic table.

Special Case- He has only two electrons (first principle energy level full) and thus H is "happy" just having two electrons.

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### Three Types of Bonds

Ionic bonds- metal-nonmetal

Metallic- metal-metal

Covalent- nonmetal-nonmetal

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### Ionic Bonds

Ionization Energy-

Electronegativity-

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### Ions and Ionic Bonds

Ions- atoms that have either lost (*cations*) or gained (*anions*) electrons

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### Ion Sizes are Different than Their Parent Atom Sizes

Anions are larger than parent atom

Cations are smaller than parent atom

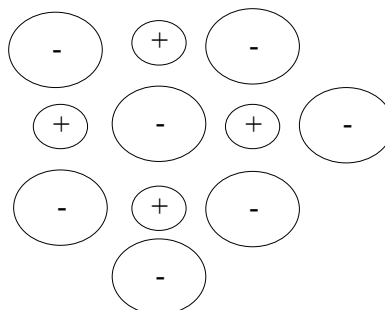
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### Ionic Bonds are Electrostatic

The cation and anion are attracted to each other.

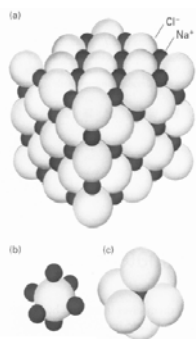
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### Crystal Lattice's Form to Stabilize Electrical Charge



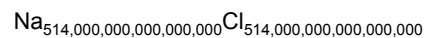
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### Crystal Lattice's Form to Stabilize Electrical Charge



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### Formula Units



Formula unit- the simplest whole number ratio of elements which describes the crystal.

Use "criss-cross" method to determine formula.

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### Sample Test Questions

What is the formula unit of the compound which forms when  $\text{Fe}^{2+}$  interacts with  $\text{O}^{2-}$ ?

What is the formula unit of the compound which forms when magnesium reacts with bromine?

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### Oxidation State

Do not forget how to determine oxidation state by looking at the periodic table!

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## Nomenclature of Ionic Compounds

Binary ionic compounds- exactly two elements

Named: metal nonmetal root + ide

Sodium *chloride*

Other examples

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## Sample Test Question

What is the name of the ionic compound,  $\text{AlCl}_3$ ?

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## Nomenclature of Ionic Compounds Containing Transition Elements

Common name of transition elements:

$\text{Fe}^{2+}/\text{Fe}^{3+}$  Ferrous                  Ferric

$\text{Sn}^{2+}/\text{Sn}^{4+}$     Stannous              Stannic

Systematic name easier.

$\text{Fe}^{2+}/\text{Fe}^{3+}$     Iron (II)                      Iron (III)

$\text{FeCl}_2$

iron (II) chloride

$\text{SnCl}_4$

tin (IV) chloride

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## Polyatomic Ions

<u>Polyatomic ionic compounds</u>	<u>Formula/Charge</u>	<u>Name</u>
- two or more atoms can combine to act as a unit (two or more elements)	$\text{NH}_4^+$	ammonium
	$\text{CO}_3^{2-}$	carbonate
	$\text{NO}_3^-$	nitrate
Formula unit is determined by criss-cross method, using the polyatomic ion as a unit.	$\text{SO}_4^{2-}$	sulfate
	$\text{PO}_4^{3-}$	phosphate
	$\text{SO}_3^{2-}$	sulfite
	$\text{HCO}_3^-$	bicarbonate

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## Nomenclature Involving Polyatomic Ions

Cation is always named first

Named differently depending on possible combination

if monoatomic anion                  cation anion root + *ide*

EX:  $\text{NH}_4\text{F}$     ammonium fluoride

or, if two polyatomic ions

polyatomic cation polyatomic anion

EX:  $\text{NH}_4\text{NO}_3$  ammonium nitrate

or, if polyatomic anion                  cation polyatomic anion

EX:  $\text{Ca}_3(\text{PO}_4)_2$     calcium phosphate

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## Sample Test Questions

What is the formula unit for the interaction of  $\text{NH}_4^+$  and  $\text{F}^-$ ?

What is the formula unit for the interaction of ammonium and carbonate?

What is the name of  $\text{NH}_4\text{Br}$ ?

What is the name of  $\text{Ca}_3(\text{PO}_4)_2$ ?

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## Covalent Bonds

Covalent bonding- valence electrons are *shared* between atoms

2 shared e<sup>-</sup> equals one bond

Can have single, double, even triple covalent bonds

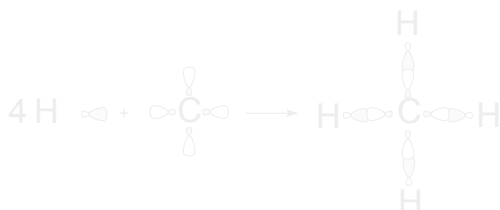
Number of unpaired valence e<sup>-</sup> is perfect indicator of how many bonds an atom needs to form to become stable.

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Group	Name	valence e <sup>-</sup>
IA	Alkali metals	1
IIA	Alkaline earth metals	2
IIIA		3
IVA		4
VA		5
VIA	Chalcogens	6
VIIA	Halogens	7
VIIIA	Noble gases	8
	Transition Elements	2*

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## Covalent Bond Formation



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## Lewis Dot Structures

- Represent valence e<sup>-</sup> as dot around the element symbol
- Two shared e<sup>-</sup> equals one bond
- Shared e<sup>-</sup> are counted towards both atoms in seeing if the octet rule is satisfied
- e<sup>-</sup> not used to form a bond are called "lone pairs" or "nonbonding pairs"

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## Electron Dot Structures

1. Add the number of valence e<sup>-</sup> from each atom in the formula.
2. Join atoms with covalent bonds.
3. For each bond, subtract 2 from the total e<sup>-</sup> to account for. Use the leftover e<sup>-</sup> to give each atom 8 e<sup>-</sup> (or 2).
4. Repeat as necessary.

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## Some of the Ways Molecules Trick Us

Multiple Covalent Bonds- double and triple bonds can form between two atoms

CO<sub>2</sub>N<sub>2</sub>

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## Some of the Ways Molecules Trick Us

Coordinate Covalent Bond- one atom contributes both electrons to a bond

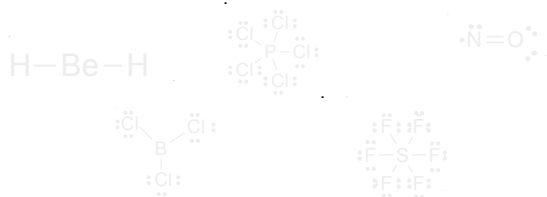


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## Some of the Ways Molecules Trick Us

Exceptions- Be, B, P, S, N

BeH<sub>2</sub> BCl<sub>3</sub> PCl<sub>5</sub> SF<sub>6</sub> NO



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## Guidelines

1. H is always terminal (because it can only form one bond).
2. Halogens are usually terminal.
3. Oxygen is often terminal (many exceptions).
4. Central atom has the lowest subscript and is usually listed first.

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## Nomenclature of Covalent Compounds

Binary molecular compounds- exactly two elements

Named: nonmetal 1 + nonmetal 2 root + ide  
except, we have to say how many of each there are

1	mono-	7	hepta-
2	di-	8	octa-
3	tri-	9	nona-
4	tetra-	10	deca-
5	penta-		
6	hexa-		

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## Sample Test Questions

Classify the following bond as metallic, ionic or covalent: C-O

What is the name of N<sub>2</sub>O<sub>4</sub>?

What is the formula of dihydrogen monoxide?

Draw the Lewis dot structure for a molecule of boron trichloride. Include all lone pairs in the diagram.

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## Shapes of Molecules

VSEPR theory is used to predict the shape of a molecule.

VSEPR- Valence-Shell Electron-Pair Repulsion

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## 1. Electron pairs in four locations.

109° separation of e<sup>-</sup>

Linear

Bent

Pyramidal

Tetrahedral

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## 2. Electron pairs in three locations.

120° separation of e<sup>-</sup>

Triangular molecules result

Bent molecules rarely result

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## 3. Electron pairs in two locations.

180° separation of e<sup>-</sup>

Only linear molecules result

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## 4. Electron pairs in one location.

no separation of e<sup>-</sup>

Linear molecule

only example is H<sub>2</sub>

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## Predicting the Shape of Molecules

electron-pair geometry- geometry, around a central atom, of both bonding and nonbonding electron pairs.

molecular geometry- describes the shape only of atoms around a central atom.

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## Predicting the Shape of Molecules

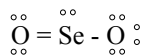
1. Draw the Lewis structure.
2. Determine the total number of bonding and nonbonding pairs of electrons attached to the central atom.
3. Determine the molecular geometry, remembering that nonbonding electron pairs will repel the bonding pairs just as they will other nonbonding pairs.

Linear      Bent or angular      Pyramidal  
Tetrahedral      Triangular

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### Sample Test Question

What is the molecular shape of the following compound, for which the correct Lewis dot structure is given?



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### Sample Test Question

What is the molecular shape of  $\text{PF}_3$ ?

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### Polar and Nonpolar Bonding

The difficulty that ensues because of how some atoms pull electrons away from other atoms.

When two atoms of different electronegativity bond, a dipole is the result

dipole moment- a molecule has separated centers of partial positive ( $\delta^+$ ) and partial negative ( $\delta^-$ ) charge.

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### Determining if a Bond is Polar

- Determine the difference in electronegativity of the two atoms involved (given in chart form)
- |            |                   |
|------------|-------------------|
| Difference | Type of bond      |
| < 0.5      | Nonpolar Covalent |
| 0.5- 2.0   | Polar Covalent    |
| > 2.0      | Ionic             |

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### Sample Test Question

Using chart 1, determine the type of bond involved between the following pairs of elements.

C-H \_\_\_\_\_  
 C-Cl \_\_\_\_\_  
 N-H \_\_\_\_\_  
 Ca-Cl \_\_\_\_\_

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### Determining if a Molecule is Polar

- Determine electronegativity of atoms bonded.
- Determine which way the electrons would be pulled, if any.
- Determine the symmetry of the pulls

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### Sample Test Question

Classify the following molecules as polar or nonpolar.

OFH \_\_\_\_\_

CH<sub>2</sub>Cl<sub>2</sub> \_\_\_\_\_

CF<sub>4</sub> \_\_\_\_\_

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### Properties of Covalent and Ionic Compounds (Table)

Ionic	Covalent
• metal-nonmetal	nonmetal-nonmetal
• Solid	solid, liquid or gas
• hard and brittle (salt)	brittle and weak (sugar) or soft and waxy (butter)
• high mp and bp	low mp and bp
• soluble in water	solubility varies widely
• nonconductor if solid or conductor if liquid	insulators

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### The Two Faces of Ammonia

