Unit 4

Bonding and Naming

Review

Ions are created when atoms LOSE or GAIN valence electrons.

How do you determine valence electrons?

Look at the group number. Ex. Group 3 has 3 valence electrons. Group 17 has 7 valence electrons.

What about transition metals?

Look at the electron configuration.

Ex. Cu - [Ar] $5s^1$ $4d^{10}$

Valence Electrons

Review - **Ions**

- Two types of ions:
  - **<u>Cations</u>** - formed when an atom loses its valence electrons
    - Positively charged ion
      - (more protons than electrons)
  - **<u>Anions</u>** - formed when an atom gains valence electrons
    - Negatively charged ion
      - (more electrons than protons)

Naming Ions

- <u>Cations</u>:
  - Metals are always cations
  - The name of a cation is the same as that of the original atom
    - EXAMPLE: Na - sodium atom; Na^{1+} - sodium ion
- <u>Anions</u>:
  - Nonmetals are always anions
  - The name of an anion always ends in -ide
    - EXAMPLE: F - fluorine atom; F^{1-} - fluor***ide*** ion

Ion Formation Equation

- Equations to show the transfer of electrons:
  - $Na - 1\ e^- \rightarrow Na^{1+}$
    - Sodium atom yields sodium ion plus one electron.
  - $O + 2\ e^- \rightarrow O^{2-}$
    - Oxygen atom plus two electrons yields an oxide ion.

Ion Formation Practice

Write an equation for the formation of an ion for the following atoms:

- $P + 3e^- \rightarrow P^{3-}$
- $Ba - 2e^- \rightarrow Ba^{2+}$
- $Zn - 2e^- \rightarrow Zn^{2+}$
- $Br + 1e^- \rightarrow Br^-$
- $Xe \rightarrow Xe$

Ionic Bonds & Ionic Compounds

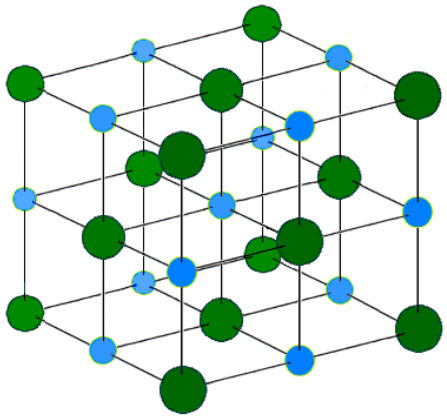
- **Ionic bonds**:
  - Electrostatic forces that hold ions together in ionic compounds

- **Ionic compounds**:
  - Compounds composed of cations & anions
    - *Metal* is bonded to a *nonmetal*
  - total positive charge = total negative charge
    - Electrically neutral compound
      - *CHEMICALLY* combined

Ionic Bonding

- Ionic Bonds form a crystal lattice structure.

In the picture, which “dots” would be the cations, and which are the anions? How do you know?



The CATIONS are the smaller BLUE DOTS.
The ANIONS are the larger GREEN DOTS.
Anions are larger, and cations are smaller.

Examples of Ionic Compounds

- NaCl – sodium chloride (salt)

- Fe_2O_3 – iron (III) oxide (rust)

Compounds With Ionic Bonds

1. Have high melting points and boiling points
2. Can conduct an electric current when melted or dissolved in water.
3. Many are soluble in water - Ions free to move in solution
4. Nonconductors in solid state - Ions are in a fixed position in solid

Ionic Compounds

- A **<u>Chemical Formula</u>** represents the composition of substances by showing the kinds and numbers of atoms in the ***smallest representative unit of a substance***.
- $Ca + Br \rightarrow Ca^{2+} + Br^{1-} \rightarrow CaBr_2$
- $Mg + O \rightarrow Mg^{2+} + O^{2-} \rightarrow Mg_2O_2 \rightarrow MgO$

Forming Ionic Compounds

- 1. Determine the oxidation number for each element or ion in the compound.
- 2. Cross the numbers to become the subscripts and drop the + or – sign.
- 3. Reduce subscripts if possible.

- Beryllium + Sulfur
- $Be \longrightarrow Be^{2+}$
- $S \longrightarrow S^{2-}$
- $Be^{2+}\ S^{2-} \longrightarrow Be_2S_2$
- Be_2S_2 reduces to Be_1S_1
- Compound: **BeS**

Practice:

1. Write the formula for combining the following elements:
2. Write the name of the compound formed.

- Lithium + Selenium $Li^{1+}\ Se^{2-} \longrightarrow Li_2Se$ Lithium Selenide
- Potassium + Fluorine $K^{1+}\ F^{1-} \longrightarrow KF$ Potassium Fluoride
- Calcium + Nitrogen $Ca^{2+}\ N^{3-} \longrightarrow Ca_3N_2$ Calcium Nitride
- Strontium + Oxygen $Sr^{2+}\ O^{2-} \longrightarrow Sr_2O_2 \longrightarrow SrO$ Strontium Oxide

Transition Metals

- Transition metals can have more than one oxidation number.
- Therefore, we use Roman Numbers to indicate the charge of the metal.
  - Ex. Iron(II) Oxide

    $Fe^{2+} + O^{2-} \longrightarrow FeO$

I - 1	VI - 6
II - 2	VII - 7
III - 3	VIII - 8
IV - 4	IX - 9
V - 5	X - 10

Transition Metals cont.

- Silver (Ag) - always 1+
- Zinc (Zn) - always 2+
- Cadmium (Cd) - always 2+

- Therefore, you **DO NOT** have to write the roman numeral to represent their charges.

Transition Metal Practice

1. Chromium (III) Sulfide Cr_2S_3
2. Mercury (I) Chloride $HgCl$
3. Zinc Nitride Zn_3N_2

Transition Metal Practice cont.

Name the compound. Note: You need to find the charge of each cation.

1. $NiCl_2$

Nickel (II) Chloride

2. Cu_2O

Copper (I) Oxide

3. $SnBr_4$

Tin (IV) Bromide

Bell Work – 10/5/16

Write the formula and name the following Ionic Compounds:

1. Lithium + Bromine
2. Calcium + Oxygen
3. Cesium + Iodine
4. Gold (II) + Oxygen

Today we will be discussing polyatomic ions. What do you think a polyatomic ion is?

Polyatomic Ions

- Polyatomic Ions are a group of atoms bonded together that act as a unit.
  - They have a charge, and they stay together during reactions.
  - See your reference table for a list of Polyatomic ions.
  - The name of the Polyatomic ion doesn't change in the compound name.
- When creating bonds, put the Polyatomic ion in parentheses!!

Ex. Calcium + Hydroxide

Polyatomic Ion Practice

Write the formula for the following compounds:

1. Magnesium + Hydroxide $Mg(OH)_2$
2. Aluminum + Sulfate $Al_2(SO_4)_3$
3. Copper (II) + Chlorate $Cu(ClO_3)_2$
4. Potassium Permanganate $KMnO_4$

Bell Work - 10/10/16

Molecular Compounds...

Are compounds composed of molecules

Are also known as *Covalent Compounds*

Are held together by covalent bonds

Covalent Bond :

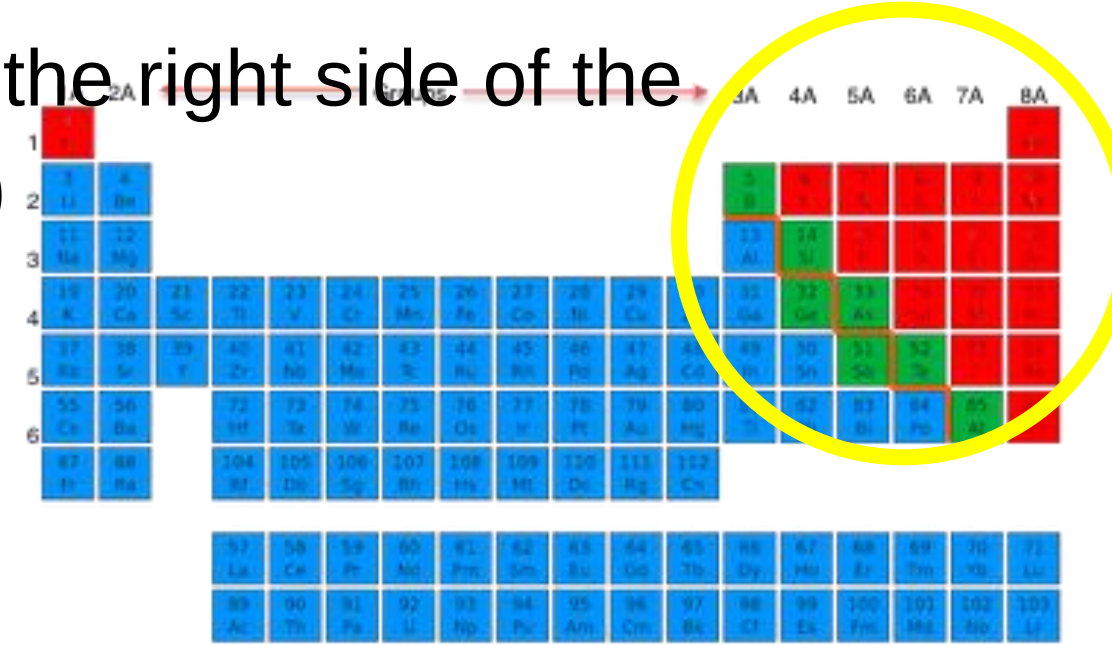
atoms held together by the ***SHARING*** of electrons they share so they each can have 8 electrons (octet rule!)

Molecular Compounds

Molecular compounds are formed between a nonmetal and a nonmetal.

(All elements from the right side of the Periodic Table!!)

NO METALS!!



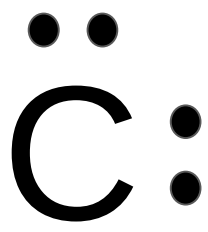
Properties of Covalent Bonds

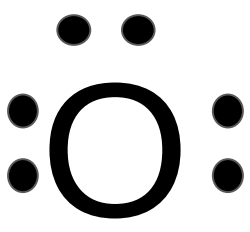
- ***Electrons are shared*** so that the atoms can attain the electron configuration of noble gases. (Remember the Octet Rule)
- ***Weak inter-particle forces*** in contrast to ionic compounds.
- Many are ***liquids or gases at room temperature***, but some are solids (i.e. sugar).
- Have ***low melting and boiling points*** compared to ionic compounds.
- ***Do not conduct electricity***.
- ***Less soluble in water*** than ionic compounds, in general.

Covalent Bonds

To show covalent bonds, we draw the Lewis Dot Structure of the entire molecule.

Review:Draw the Lewis Dot structure of Carbon and Oxygen.





Drawing Lewis Diagrams

Find total # of valence e^-.

Arrange atoms - singular atom is usually in the middle.

Form bonds between atoms. (2 e-)

Distribute remaining e^- to give each atom an octet.

If there aren't enough e^- to go around, double and triple bonds will be formed.

Drawing Lewis Structures

Ex. CF_4

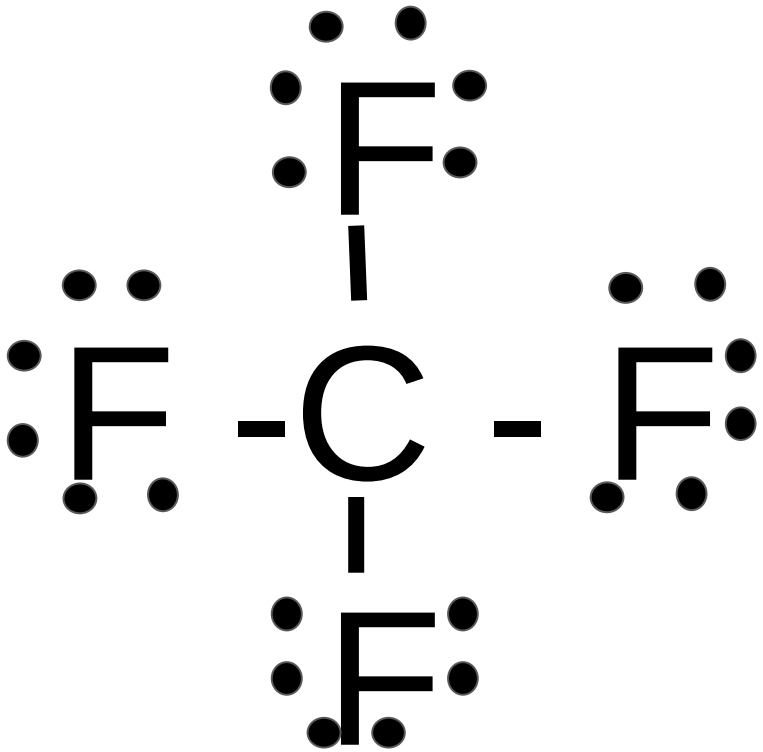
1 C x 4 e^- = 4 e^-

4 F x 7 e^- = <u>28 e^-</u>

32 e^- - <u>8 e^-</u>

= 24 e^-

EACH ELEMENT MUST OBEY THE OCTET RULE!!



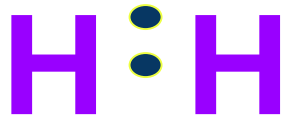
Practice with Lewis Structures

PF_3

H_2O

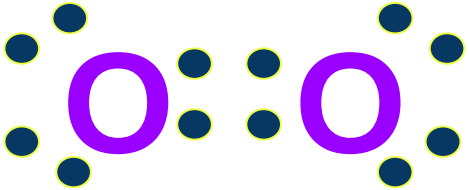
SHARING OF ELECTRONS

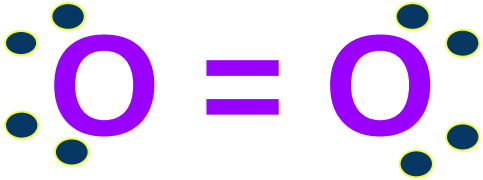
- **<u>Single Covalent Bond</u>**
  - *<u>One shared pair</u>* of e^-
  - Represented by two dots or one line
  - **Longest bond - weakest**



SHARING OF ELECTRONS

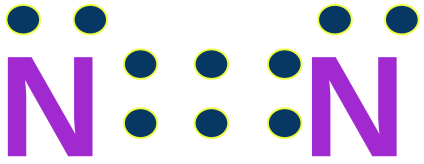
- **Double Covalent Bond**
  - *Two shared pairs* of e^-
  - Represented by four dots or two lines
  - Notice each atom STILL obeys the Octet Rule





SHARING OF ELECTRONS

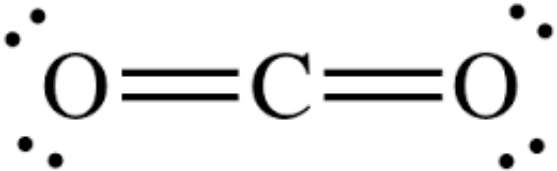
- **Triple Covalent Bond**
  - *Three shared pairs* of e^-
  - Represented by six dots or three lines
  - **Shortest bond - strongest**



Practice Drawing Lewis Dot Structures

PCl_3

CO_2



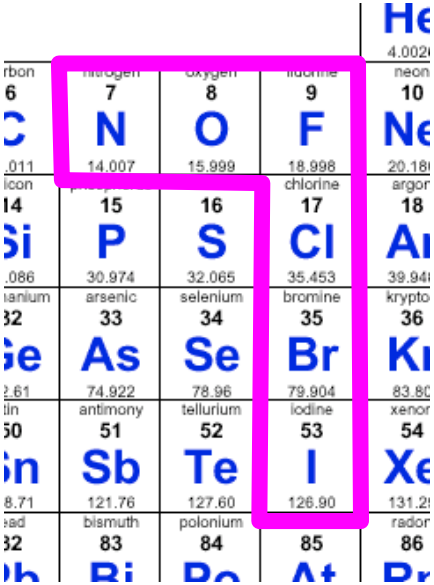
More Practice Drawing Lewis Structures

Remember each element MUST obey the Octet Rule!!

1. HCN
2. NH_3
3. N_2
4. H_2

Diatomic Molecules

- Molecules that contain 2 of the same atom
- There are <u>7</u> diatomic molecules:
  - H_2, O_2, F_2, Br_2, I_2, N_2, Cl_2
  - <u>*Ways to remember:*</u>
    - Make the shape of a seven on the periodic table
    - Excluding *HYDROGEN*!
    - Name: H-O-F Br-I-N-Cl



Bell Work - 10/11/16

Practice with Covalent Bonds. Draw the Lewis Dot Structures for the following Compounds.

1. $POCl_3$
2. NO_2
3. C_2H_6

Comparing Ionic & Covalent Compounds

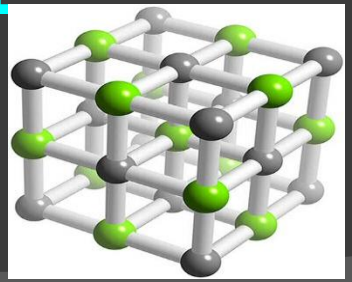
IONIC COMPOUNDS

- Complete ***transfer of electrons***
- Cation + Anion
- Metal present
- Have to look at ***charges***

Example:

$K^{1+}Cl^{1-}$

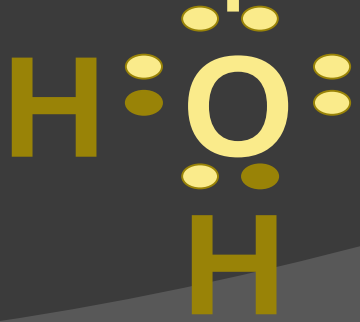
KCl

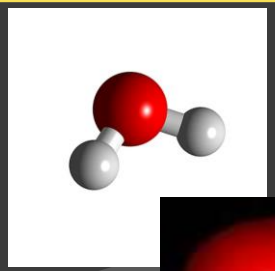


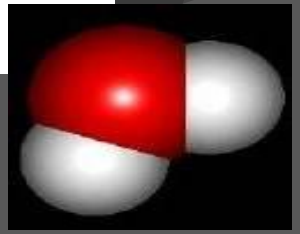
COVALENT COMPOUNDS

- Electrons ***shared***
- Nonmetal + Nonmetal
- No metals! No ions!
- Have to look at ***valence electrons***

Example:







Exceptions to the Octet Rule

- The octet rule **cannot** be satisfied in

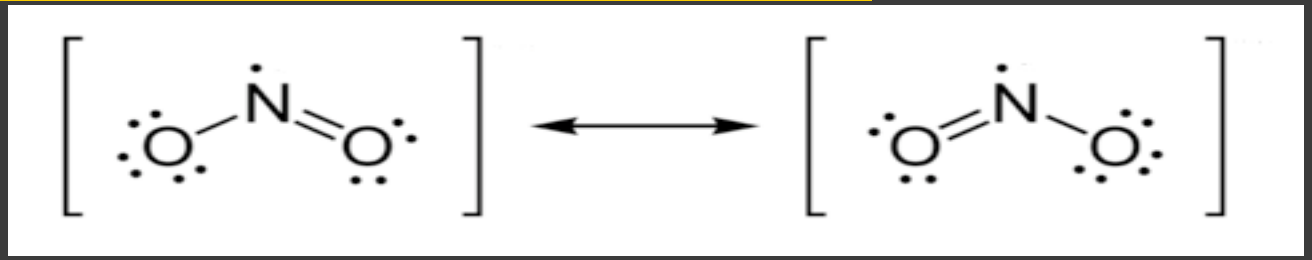
What does this mean?! Let's take a closer look…

- molecules in which an *atom has fewer, or more than a complete octet* of valence electrons.

1. ODD NUMBER OF *TOTAL* VALENCE ELECTRONS…

- NO_2 – ***17*** total electrons
  - N – 5 valence electrons
  - O – 6 valence electrons (x 2) = 12 valence electrons

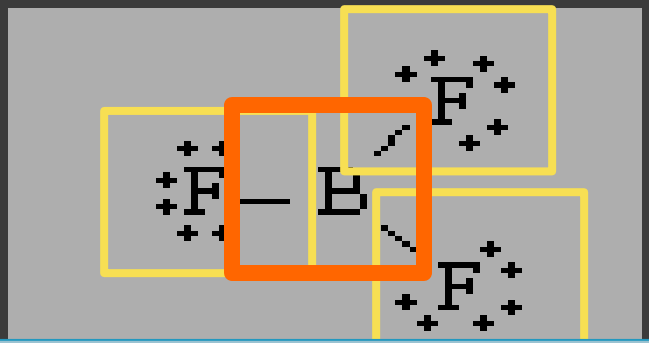
Count the total electrons around each atom…



***Resonance Structure*: structure that occurs when it is possible to draw two or more valid electron dot structures that have the same number of electron pairs for a molecule or ion.**

2. *LESS* THAN A COMPLETE OCTET…

- BF_3

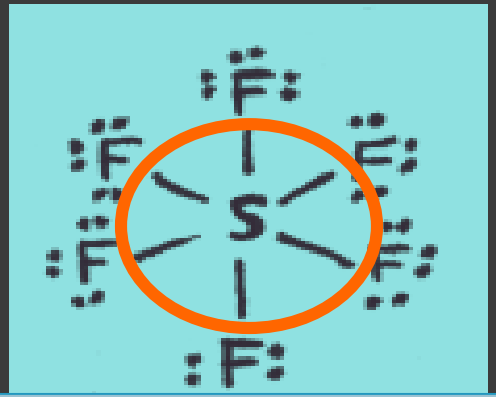


Count the valence electrons around each atom…

- **Boron is the exception**
  - **It is missing 2 electrons**
- **Why? Because it only has 3 electrons to share!**

2. *MORE* THAN A COMPLETE OCTET…

- SF_6



Count the valence electrons around each atom…

Original Lewis Structure

- **Sulfur has more than 8 valence**
- **This is an *expanded* octet**
- **Each of sulfur's unshared pairs were split apart**

Naming Covalent Compounds

- In order to name molecular compounds, a ***different*** naming system is required.
  - ***WHY***?
    - How else would we differentiate between CO & CO_2?
- Still follow the same naming rules, but add **PREFIXES** to distinguish how many atoms of each element are in the compound.

Prefixes – **need to memorize**

1 = mono

2 = di

3 = tri

4 = tetra

5 = penta

6 = hexa

7 = hepta

8 = octa

9 = nona

10 = deca

Naming Covalent Compounds

- Write the name of the first element.
- Add a prefix if there is **more than one** of that first atom.
- Write the name of the second element and change the ending to ***–ide***
- Add a prefix to the second atom <u>even if</u> there is only one!

Naming Covalent Compounds

- If you have an “oo” or “ao” in the name, drop the “o” or “a”.

- Ex.
  - Monooxide becomes Monoxide

  - Pentaoxide becomes Pentoxide

Examples:

- H_2O – **di**hydrogen **mon<u>o</u>**xide
- N_2O_3 – **di**nitrogen **tri**oxide
- BI_3 – boron **tr<u>ii</u>**odide

Practice:

1) N_2O Dinitrogen monoxide
2) NO Nitrogen monoxide
3) P_3N_2 Triphosphorus dinitride
4) P_2S_5 Diphosphorus pentasulfide
5) SO_3 Sulfur trioxide

Naming Diatomic Molecules

- 7 diatomic elements:
  - H_2, O_2, F_2, Br_2, I_2, N_2, Cl_2
- You will name the molecule the same as the element!
  - H_2 = hydrogen or hydrogen gas

Bell Work - 10/12/16

1. Have out HW (p.2 of packet) to be checked.
2. Draw the Lewis Dot Structure for: CH_4
3. Draw the Lewis Dot Structure for: CO_2
4. Write the name for the following:
   a. CF4
   b. PCl3
5. Write the chemical formula for:
   a. Dinitrogen Triiodide
   b. Tetraphosphorus Decoxide

Bonding in Metals

- Metals can bond in two different ways:
  - 1. **Ionic Bonding**
    - bond between a metal (cation) and a nonmetal (anion)
    - *CHEMICAL* combination of ions
  - 2. **Metallic Bonding**
    - The attraction of free-floating valence electrons for the positively charged metal ions.
    - Occurs between two metal atoms.
    - *PHYSICAL* combination of atoms

Metallic Bonding

- Metallic bonding explains why metals are…
  - **<u>Good Conductors</u>**
    - Transfers heat or electricity easily.
  - **<u>Ductile</u>**
    - Can easily be drawn into wires.
  - **<u>Malleable</u>**
    - Can be hammered or forced into shapes.

Why do metals have these properties?

- Their valence electrons are mobile and drift freely from one part of the metal to another.

- Valence electrons of metal atoms are loosely held by the positively charged nucleus.

- Valence electrons are released into a “SEA OF ELECTRONS” shared by all of the metal atoms.

Metals are...

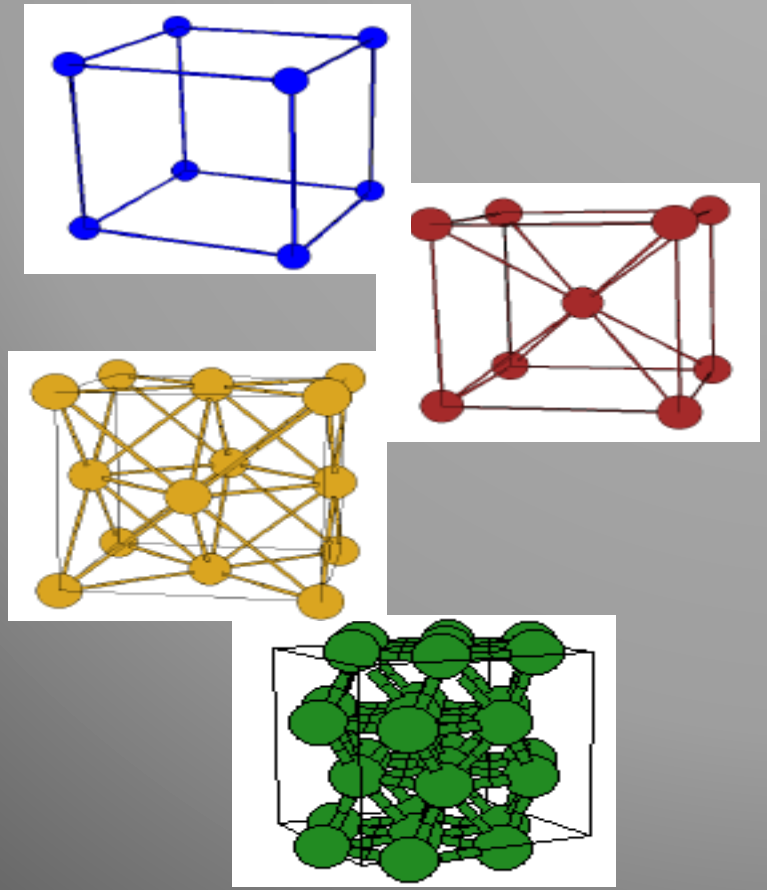
- Crystalline solids
  - Atoms arranged in very compact and orderly patterns
- Crystal
  - Regular, repeating arrangements of atoms, ions, or molecules

Because...

- This arrangement helps save space while allowing as many atoms to be stacked as possible.

Shapes of Metals

- Simple Cube
- Body-centered cubic
- Face-centered cubic
- Hexagonal close-packed



Alloys

- Alloys are *MIXTURES* composed of two or more elements, at least one of which is a metal.
- They are important because their properties are often superior to those of their component elements.
- Alloys are *PHYSICALLY* combined, meaning that they can be separated by physical means (i.e. melting).

Examples of Alloys

Brass
–copper & zinc

Stainless Steel
–iron, chromium, carbon, & nickel

Cast Iron
–iron & carbon

Sterling Silver
–silver & copper

Surgical Steel
–iron, chromium, nickel, & molybdenum

REVIEW:

- What is an ionic compound?
- What are the two types of ions?
- What are the characteristics of ionic compounds?
- How do metallic bonds differ from ionic bonds?

- Cation + Anion
- Cation (Metals) – lose electrons
- Anion (Nonmetals) – gain electrons
- High melting points
- Soluble in water
- Conduct electricity when melted or dissolved in water
- Crystalline solids at room temp.
- Metallic bonds are physically combined; Ionic bonds are chemically combined.

Ionic, Metallic, or Covalent?

1. Two non metals
2. Transfer of electrons
3. Metal and nonmetal
4. Two metals
5. Crystal Structure
6. Sharing of electrons
7. Conducts electricity without being melted
8. High melting point
9. Solid at room temperature
10. Sea of electrons

1. Covalent
2. Ionic
3. Ionic
4. Metallic
5. Ionic
6. Covalent
7. Metallic

1. Ionic
2. Ionic & Metallic
3. Metallic

Ionic, Metallic, or Covalent?

1. Brittle
2. Conducts electricity after being melted or dissolved in water
3. Strong inter-particle forces
4. Forms molecules
5. Low melting point
6. Does not conduct electricity
7. Liquid or gas at room temperature

1. Ionic
2. Ionic

1. Ionic
2. Covalent
3. Covalent
4. Covalent
5. Covalent