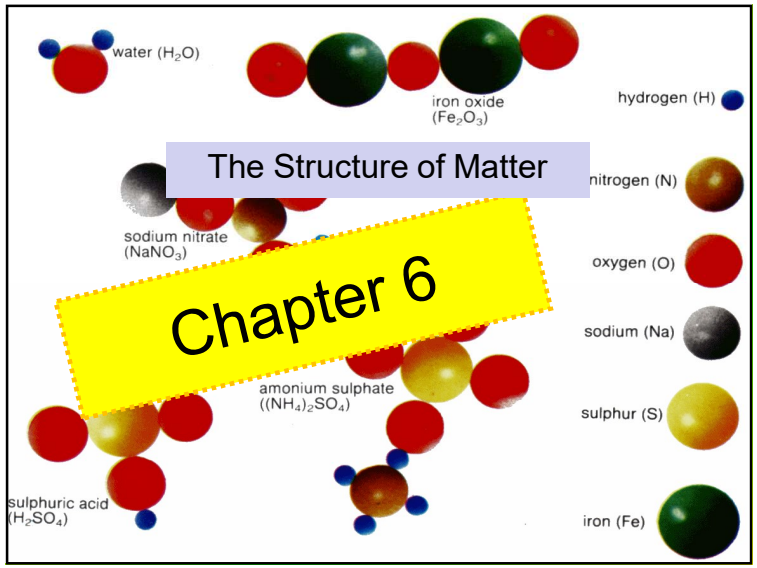


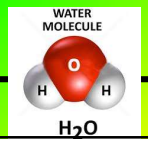
The Structure of Matter

Chapter 6

Compounds

- What is a compound?
  - Result from way atoms or ions are joined
- When elements combine, the resulting compound has properties very different from those of elements that make it
- Always have same chemical formula

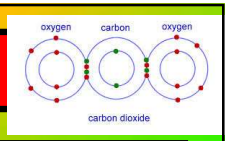
Types of Chemical Bonds Video



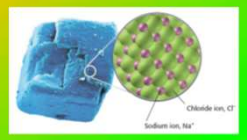
Formulas of Familiar Compounds

Compound	Formula
Water	H_2O
Carbon dioxide	CO_2
Methane	CH_4
Propane	C_3H_8
Sugar (sucrose)	$C_{12}H_{22}O_{11}$
Rubbing alcohol	C_3H_8O
Ammonia	NH_3
Sodium chloride	NaCl
Baking soda	$NaHCO_3$

What are bonds?



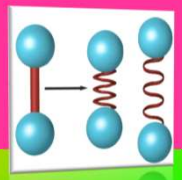
- A **Chemical Bond** is an attractive force that holds atoms or ions together.
- Atoms bond when their valence electrons interact.
  - This way, the outermost energy level of the atom is full. (Octet Rule)

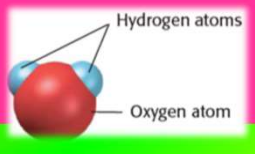


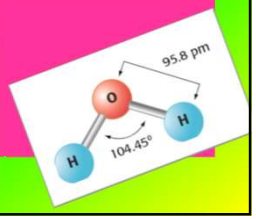
Wannabe Noble Gases

Bonds are Flexible…

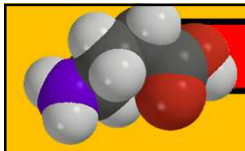
- **Bonds are NOT like toothpicks, they ARE like springs ☺**
- **There are many models of molecules, but the atoms are not stuck in place.**
  - **Atoms move back and forth.**



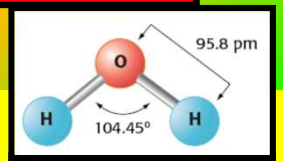




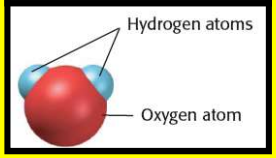
Models



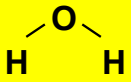
- **Ball-and-stick**
  Ball represents atoms, stick represents bonds

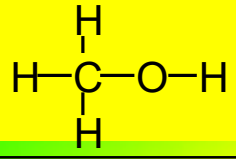


- **Space-filling**
  Shows that atoms the right size and in the right place.



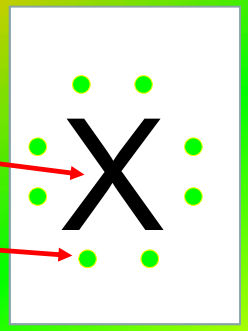
- **Structural**
  Uses chemical symbols to represent atoms.





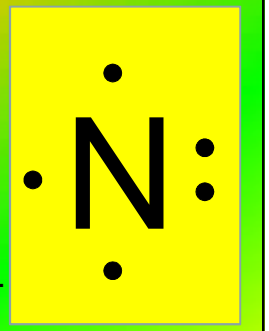
Electron Dot diagram

- A way of keeping track of valence electrons.
- How to write them –**RTLB**
- Write the symbol.
- Put one dot for each valence electron
- Don't pair up until they have to



Electron Dot diagram

- Nitrogen has 5 valence electrons.
- First we write the symbol.
- Then add 1 electron at a time to each side.
- Until they are forced to pair up.



Write the electron dot diagram for the following elements.

Na

F

Mg

Ne

C

He

O

Lewis Structures **Name:**

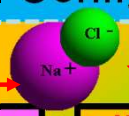
- Lewis structures, or dot diagrams, are a simplified way to show how the valence electrons are arranged in the outer shell. This is where the chemical reactions take place. Atoms will either share or give away these electrons to form bonds.
- Using your periodic table, determine the number of valence electrons for each element.
- Draw a dot to represent each valence electron around the element symbol.
- Follow the pattern below starting with position number 1.

Examples: Ba In Se

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca						

Electron Configuration

Cations → ← **Anions**



- **Metals** lose electrons to fill their outer levels
- They make positive ions.

Ca

Ca^{2+}

- **Nonmetals** gain electrons to fill their outer levels
- They make negative ions.

P

P^{3-}

What are 3 ways that atoms can form bonds?

1. Ionic bonds

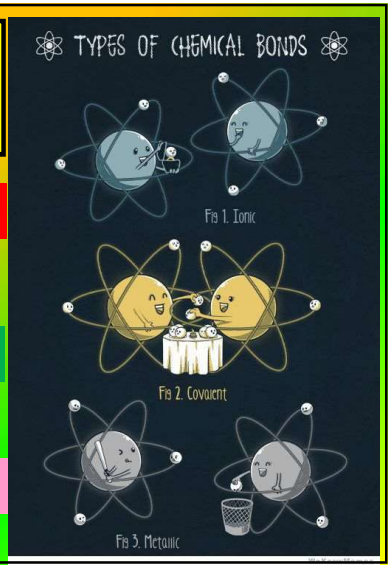
Transferring electrons

2. Covalent bonds

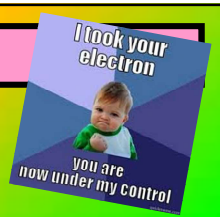
Sharing electrons

3. Metallic bonds

Many free electrons

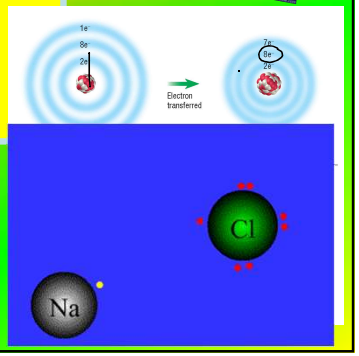


Binary Ionic Bonds



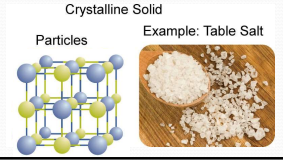
- bond formed between two ions by the transfer of valence electrons
- Net charge is zero
- Chemically stable

- Ionic compounds result when metals react with nonmetals



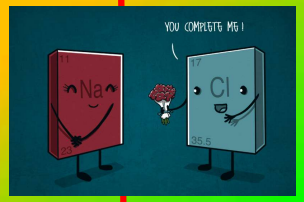
Properties of Ionic Compounds

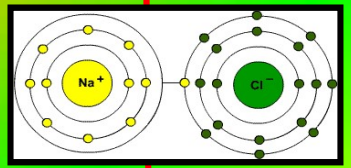
- Stronger bonds
- High melting points
- Conduct electricity when in solution or in a molten state
  - Generally dissolve in water
- Generally crystalline solid at room temp.



Example

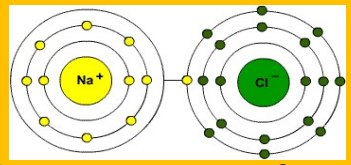
- Sodium (Na) (Explosive metal)!
- Chlorine (Cl) (toxic gas!)



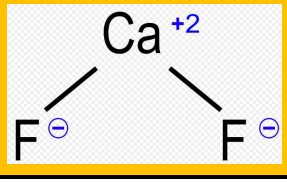


Ionic Compounds

- Sodium Chloride: NaCl, or 1 Na+ for every 1 Cl- ion.



- Calcium Fluoride: CaF_2, or 1 Ca_2+ for every 2 F- ions.



Ionic Bonds

Sodium Chlorine

Ionic Bonds

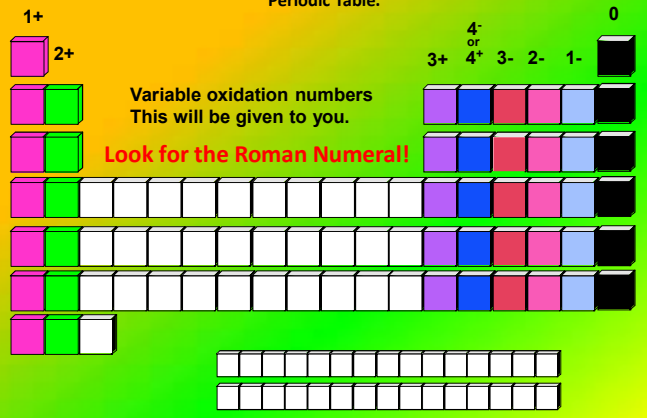
Ionic Bonds

Magnesium Oxygen

Ionic Bonds

Oxidation Numbers

Remember that the charge of an ion can be determined by its place on the Periodic Table.



For each elements on your notes, predict the charge of its most common ion using the periodic table.

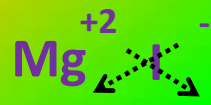
P -3	Ne 0	Ca +2	Be +2	I -1	He 0
Na +1	Mg +2	Br -1	O -2	Li +1	F -1
S -2	K +1	N -3	Cs +1	Cl -1	Xe 0

Writing Binary Ionic Formulas

Steps for writing chemical formulas using oxidation numbers

- 1. Write the chemical symbols for the *cation* (first) and *anion* (second). *Metal 1st Nonmetal 2nd*
- 2. Write the oxidation number on top of the Chemical Symbols for the cation and anion. The 1 is understood.
- 3. Kris cross the oxidation numbers writing each number as a subscript for the other atom or polyatomic ion.
- 4.Reduce Subscripts if they can be reduced

Example



MgI_2

magnesium iodide

$Ca_2O_2 = Ca_{2/2}O_{2/2} = CaO$

$Pb_2O_4 = Pb_{2/2}O_{4/2} = PbO_2$

Writing Binary Ionic Formulas

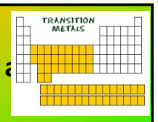
1. sodium chloride 2. magnesium oxide 3. potassium sulfide

	1. sodium chloride	2. magnesium oxide	3. potassium sulfide
1.	Na Cl	Mg O	K S
2.	Na^{+1} Cl^{-1}	Mg^{+2} O^{-2}	K^{+} S^{-2}
3.	Na^{+1} Cl^{-1}	Mg^{+2} O^{-2}	K^{+} S^{-2}
4.	Na Cl	Mg_2 O_2	K_2 S
5.	**NaCl**	**MgO**	**K_2S**

Use the Criss-Cross Method to find the formulas for the following compounds. ***Circle your answers!***

1. calcium oxide	2. hydrogen bromide	3. magnesium sulfide	4. sodium bromide
5. hydrogen chloride	6. potassium oxide	7. potassium chloride	8. lithium nitride
9. sodium oxide	10. aluminum oxide	11. aluminum fluoride	12. lithium oxide
13. barium oxide	14. barium nitride	iron (II) oxide	16. copper (II) sulfide

- **Transition metals are less predictable.**
  - **Form positive ions (cation) because they a metals.**
  - **The charges are important in determining the formula of an ionic compound.**
  - **They use Roman Numerals to determine charge**



What are the charges of the transition metals below:

Iron (II) ___+2___ Iron (III) ___+3___

Copper (II) ___+2___ Copper (I) ___+1___

Tin (IV) ___+4___ Tin (II) ___+2___

Lead (II) ___+2___ Lead (IV) ___+4___

iron (III) oxide

$Fe^{+3}\ O^{-2}$

Commonly Used Roman Numerals In Transition Metals

Ionic Charge	Roman Numeral
1+	I
2+	II
3+	III
4+	IV

Examples: transition metals

1) iron(I)chloride: $Fe^{+}\ Cl^{-}$

formula: $FeCl$

2) copper(II)chloride: $Cu^{2+}\ Cl^{-}$

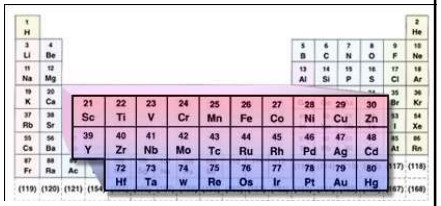
formula: $CuCl_2$

3) tin(IV)oxide: $Sn^{4+}\ O^{2-}$

formula: SnO_2

Naming Ionic Compounds Containing a Transition Metal

- **Transition Metals** usually have **more than one** charge listed on the periodic table (i.e. can lose different number of electrons)
- Therefore you must use a Roman Numeral to indicate the charge.



Write the formula (transitional Metals)

1. Copper (I) chloride — CuCl
2. Lead (IV) Oxide — PbO_2
3. Chromium (I) Sulfide — Cr_2S
4. Nickel (II) Oxide — NiO
5. Silver (II) Fluoride — AgF_2
6. Manganese (II) Nitride — Mn_3N_2

Rules for Naming Binary Ions

1. The names of metals do not change.
2. Changing the name of nonmetals:
   - Root of element name + *-ide* = name of ion

Examples:

The name of chlorine's ion:

chlor- + -ide = chloride

The name of nitrogen's ion:

nitr- + -ide = nitride

Common Anions

Charge	Formula	Name
1−	H^-	Hydride ion
	F^-	Fluoride ion
	Cl^-	Chloride ion
	Br^-	Bromide ion
	I^-	Iodide ion
	CN^-	Cyanide ion
	OH^-	Hydroxide ion
2−	O^{2-}	Oxide ion
	O_2^{2-}	Peroxide ion
	S^{2-}	Sulfide ion
3−	N^{3-}	Nitride ion

Rules for Naming Ions

Examples of naming ions:

The name of calcium's ion:

calcium

(The names of metals don't change!)

The name of oxygen's ion:

ox- + -ide = oxide

The name of aluminum's ion:

aluminum

(The names of metals don't change!)

Common Anions

Charge	Formula	Name
1−	H^-	Hydride ion
	F^-	Fluoride ion
	Cl^-	Chloride ion
	Br^-	Bromide ion
	I^-	Iodide ion
	CN^-	Cyanide ion
	OH^-	Hydroxide ion
2−	O^{2-}	Oxide ion
	O_2^{2-}	Peroxide ion
	S^{2-}	Sulfide ion
3−	N^{3-}	Nitride ion

Rules for Naming Ions

Write the name of each of the ions.

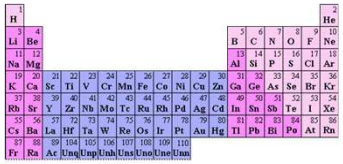
sulfur: sulfide	lithium: lithium
nitrogen: nitride	bromine: bromide
potassium: potassium	chlorine: chloride
oxygen: oxide	hydrogen: hydrogen (+), hydride (-)

Name the following Ions

1. NaF — sodium fluoride
2. MgO — magnesium oxide
3. $SrCl_2$ — strontium chloride
4. Li_2S — lithium sulfide
5. CaO — calcium oxide
6. KI — potassium iodide

Rules for Naming Ionic Compounds Containing a Transition Metal

- Use same steps as previously learned (binary ionic compounds)
- Roman Numeral indicates the charge of the transition metal
- Include a Roman Numeral in name
- Use the Roman Numeral in the name to help determine the chemical formula



Naming Ionic Compounds with Transition Metal

- Go backwards.
- Criss cross back up to form you oxidation charges.
- Check your charge for the nonmetal to ensure it is correct.
- If it isn't correct, then it was reduce.
- Multiple both charges by the number it was reduce to give you the correct charges for both the metal and nonmetal.

Therefore to balance out the charges…
(ionic compounds are neutral)

Example: PbO

Step 1:

Step 2:

Step 3:

Name: lead (II) oxide

Naming Ionic Compounds with Transition Metal

- Go backwards.
- Criss cross back up to form you oxidation charges.
- Check your charge for the nonmetal to ensure it is correct.
- If it isn't correct, then it was reduce.
- Multiple both charges by the number it was reduce to give you the correct charges for both the metal and nonmetal.

Therefore to balance out the charges…
(ionic compounds are neutral)

Example: PbO_2

Step 1:

Step 2:

Step 3:

Name lead (IV) oxide

Name the Ions (transitional Metals)

1. **CuCl** — Copper (I) chloride
2. **PdO_2** — Palladium (IV) oxide
3. **ZnS** — Zinc (II) sulfide
4. **Ni_2O_3** — Nickel (III) oxide
5. **NiO** — Nickel (II) oxide
6. **$MnBr_4$** — Manganese (IV) bromide

Binary Ionic Compound Pracitice

6) $SnBr_4$ tin (IV) bromide

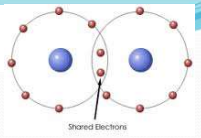
7) $SnBr_2$ tin (II) bromide

8) Cu_3N copper (I) nitride

9) iron (III) oxide Fe_2O_3

10) nickel (II) phosphide Ni_3P_2

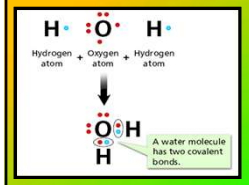
Covalent Bonds



- Occur between two nonmetals.
- Formed when two atoms **share** electrons with one another.
- Nonmetals hold onto their valence electrons, but want a full outer shell
- A bond formed when two atoms share electrons.
  - Bond formed by 2 valence electrons

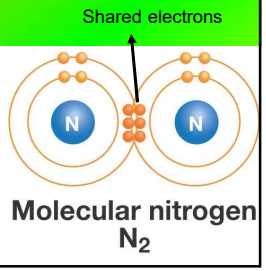
Covalent Bonds

- Can be between two different atoms, or between two atoms of the same element
- They actually form *molecules*. (Molecular compounds)
- Atoms may share more than one pair of electrons.



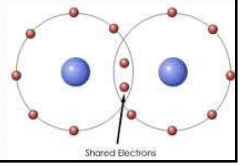
(c) Triple bonds

- A double bond is when atoms share two pair (4) of electrons.
- A triple bond is when atoms share three pair (6) of electrons.



Chemical Properties of Covalent Compounds

- Weaker bonds
- Low melting and boiling points
- Do NOT conduct electricity when in solution
  - Generally don't dissolve in water.
- Generally gases or liquids at room temperature

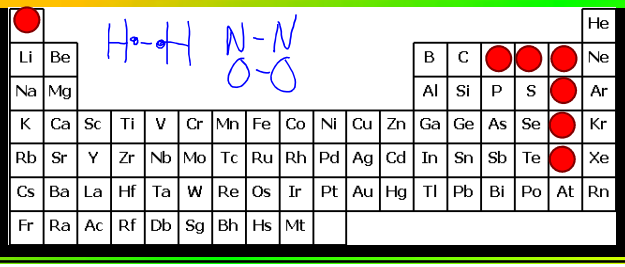


Covalent Bonds

There are 7 elements that exist in nature as *diatomic* molecules.

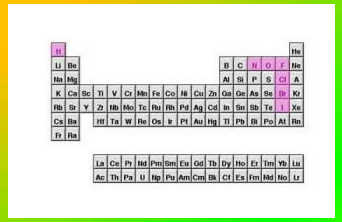
What elements exist as diatomic molecules?

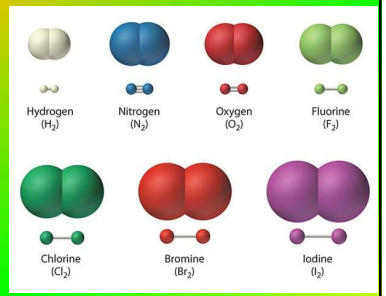
H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2



Diatomic Molecules

I Iodine, I_2
Bring Bromine, Br_2
Cookies Chlorine, Cl_2
For Fluorine, F_2
Our Oxygen, O_2
New Nitrogen, N_2
Home Hydrogen, H_2





Covalent Bonds

- There are millions of covalent compounds.
- You will be learning about the easiest type of covalent compound to name:

Binary Covalent Compounds

What does binary mean? Binary means 2.

Binary covalent compounds are between 2 different nonmetals.

Covalent Bonds

- Nonmetals can share electrons in many different ways.
- Two nonmetals can create multiple compounds together.

carbon and oxygen

CO CO_2

phosphorous and chlorine

PCl_3 PCl_5

nitrogen and oxygen

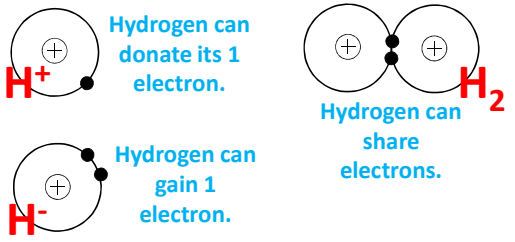
N_2O_4 N_2O_3

Covalent Bonds

Important Facts:

Hydrogen only has 1 proton and 1 electron
Behaves differently than any other element on the PT

1
H
1.008
Hydrogen



This means that hydrogen can act as either a metal or a nonmetal!

Covalent Bonds

- To show the correct ratio of elements, we use prefixes.
- Remove the -o or a from a prefix before adding it element. Leave -i alone.

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

Covalent Bonds

How would you write each of the prefixes in front of oxide?

mono-	monoxide	di-	dioxide
tri-	trioxide	tetra-	tetroxide
penta-	pentoxide	hexa-	hexoxide
hepta-	heptoxide	octa-	octoxide
nona-	nonoxide	deca-	decoxide

Naming Binary Covalent Bonds

Step 1: Write the name of the first nonmetal.

Step 2: Write the name of the second nonmetal changing its ending to *-ide*.

Step 3: Add prefixes to specify how many of each element are present.

dinitrogen tetroxide

N_2O_4

Covalent Bonds

Rules for Using Prefixes

Rule 1: Prefixes are only for BINARY COVALENT compounds.

Rule 2: The prefix *mono-* is never used on the first element of a binary covalent compound. It is assumed that there is only 1.

Example: CO_2 is carbon dioxide, and not ~~monocarbon dioxide.~~

Rule 3: Remove the -o or -a from a prefix before adding it to oxide.

Example: CO is carbon monoxide, and not ~~carbon monooxide.~~

Name the binary covalent compounds

CO_2:	carbon dioxide
CS_2:	carbon disulfide
PBr_3:	phosphorous tribromide
PBr_5:	phosphorous pentabromide
P_2S_5:	diphosphorous pentasulfide
N_2S:	dinitrogen monosulfide
SiS_2:	silicon disulfide
NBr_3:	nitrogen tribromide
N_2Cl_4:	dinitrogen tetrachloride

Writing Covalent Bonds formulas

Because of the prefixes, it is very easy to go from the name of a binary covalent compound to its formula.

Step 1: Write the symbol of the first nonmetal and the subscript that matches the prefix.

Step 2: Write the symbol of the second nonmetal and the subscript that matches the prefix.

dinitrogen tetrafluoride

N F

N_2F_4

Covalent Bonds

Write the formulas of the binary covalent compounds

What is the formula of each of the binary covalent compounds named below.

carbon tetrachloride	CCl_4	iodine heptafluoride	IF_7
phosphorous pentachloride	PCl_5	dinitrogen tetroxide	N_2O_4
dinitrogen monoxide	N_2O	phosphorous trichloride	PCl_3
carbon monosulfide	CS	carbon monoxide	CO
boron trihydride	BH_3	iodine monochloride	ICl
disulfur hexabromide	S_2Br_6	tetrasulfur tetranitride	S_4N_4
silicon disulfide	SiS_2	dihydrogen monoxide	H_2O
phosphorous triiodide	PI_3	chlorine pentafluoride	ClF_5
nitrogen trichloride	NCl_3	nitrogen dioxide	NO_2

What is it?

BAN
DIHYDROGEN MONOXIDE
The Invisible Killer
NO DHMO
DHMO.org

DANGER

0 2 1 Oxy

Dihydrogen monoxide is colorless and odorless.

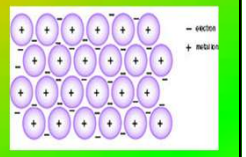
Accidental inhalation of DHMO may be fatal.

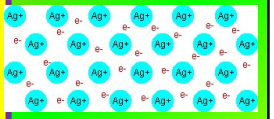
Prolonged exposure to its solid form causes severe tissue damage.

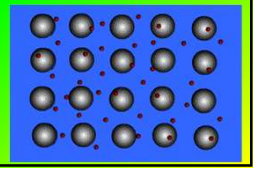
Symptoms of DHMO ingestion can include excessive sweating and urination, and possibly a bloated feeling, nausea, vomiting and body electrolyte imbalance.

Metallic Bonds

- **The bonding between atoms within metals.**
- **The sharing of many free electrons.**
  - **Sea of electrons**
- **Metals are flexible and conduct electric current well**
  - **Their atoms and electrons can move freely throughout a metal's packed structure.**







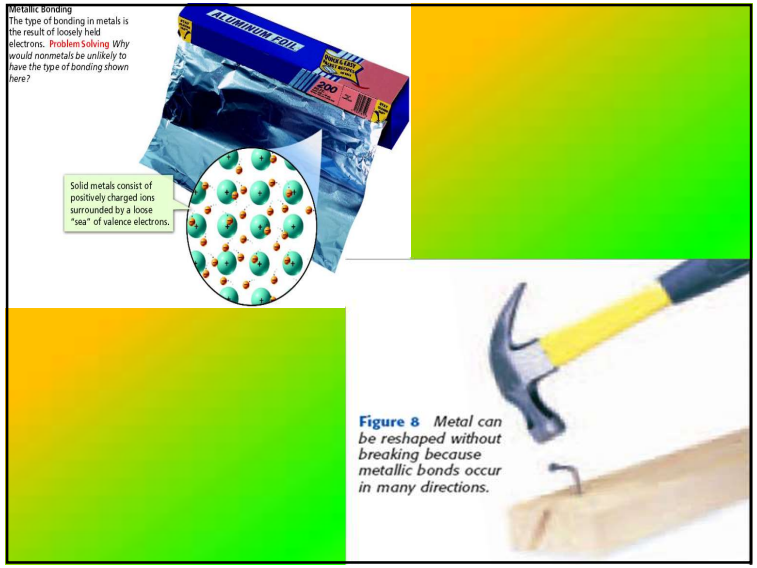
Chemical Properties of Metallic Compounds

- High melting and boiling points
- Not soluble in water.
- Good conductors of Electricity
- Malleable

Comparing Chemical Properties

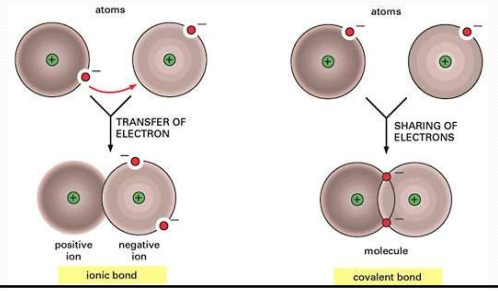
Use the data table below to classify the following substances.

Type	Example	Melting Point	Solubility in water	Electric properties	Mechanical properties
Ionic	NaCl	High	Yes	Conductor when melted or dissolved	Brittle
Covalent	O2	Low	Only polar molecules	Insulator	None
Metallic	Fe	High	No	Conductor	Malleable and Ductile



How do you know which type of bond is formed?

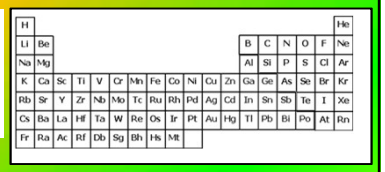
IONIC	COVALENT
- Metal and Nonmetal	- Two Non Metals
- Transfer Electrons	- Share Electrons



Review

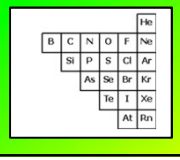
What elements do ionic compounds contain?

Ionic compounds contain a metal and a nonmetal.



What elements do covalent compounds contain?

Covalent compounds contain only nonmetals.



Review

Decide whether the compounds are ionic or covalent.

SrO I	NCl_3 C	KF I	AgCl I
N_2O_4 C	CBr_3 C	$AlCl_3$ I	$NaNO_3$ I
CaF_2 I	IF_7 C	CO C	Fe_2O_3 I

Review

Name the following compounds

SrO Strontium Oxide	NCl_3 Nitrogen trichloride
N_2O_4 Dinitrogen tetroxide	CBr_3 Carbon tribromide
CaF_2 Calcium fluoride	IF_7 Iodine heptaflouride
KF Potassium fluoride	AgCl Silver (I) Chloride
$AlCl_3$ Aluminum chloride	$NaNO_3$ Sodium nitrate
CO Carbon monoxide	Fe_2O_3 Iron (III) oxide

Review

Write the formulas of the compounds.

hydrogen monochloride: HCl

barium fluoride BaF_2

tin (II) sulfide SnS

dinitrogen monoxide N_2O

carbon disulfide CS_2

disulfur hexachloride S_2Cl_6

sodium phosphate Na_3PO_4

platinum (II) chloride $PtCl_2$