Note Packet # 10 I love chemistry

Chemical Bonding

A **chemical bond** is the force of attraction that holds groups of atoms or ions together resulting in the formation of compounds, diatomic elements, or metallic solids.

Remember! A compound is 2 or more different elements chemically bonded (combined).
Remember! A diatomic element has 2 atoms of the same element bonded together.

Chemical bonding is the result of mutual attractions between positive nuclei and negative electrons of different atoms or ions (species).

Chemical bonding results in the formation of compounds, diatomic elements, or metallic solids.

The type of bonding between atoms determines the type of compound formed and its chemical and physical properties.

Forces of Nature: The forces of nature are driven by two simple concepts.
Natural processes happen spontaneously (by themselves) if;
a) stability increases

b) energy is released (exothermic)

When a bond is formed energy is released (exothermic).

Therefore; nature favors the formation of chemical bonds.

A + B --> AB + Energy

This represents element A bonding with element B to form compound AB.
A chemical bond is formed.
Energy is released, therefore, it appears on the product side of the equation.

Place energy where it belongs in the following equation.

_________ H + Cl --> HCl _________

When a bond is broken energy is absorbed (endothermic).

AB + Energy --> A + B

This represents compound AB decomposing to elements A and B.
A chemical bond is broken.
Energy is absorbed, therefore, it appears on the reactant side of the equation.

Place energy where it belongs in the following equation.

_________ KBr --> K + Br _________

Note Packet # 10

I love chemistry

Noble gases (Group 18 elements) have 8 valence electrons (except Helium has 2). This is a very stable electron configuration and is known as a **stable octet**. Therefore; atoms become more stable by attaining a Noble gas electron configuration (a stable octet).

List all the noble gas electron configurations.

He _______________

Ne _______________

Ar _______________

Kr _______________

Xe _______________

Rn _______________

Atoms attain a stable electron configuration by bonding with other atoms. Noble gases have stable electron configurations and tend not to bond.

The 3 types of chemical bonding we will study are: *ionic bonding*, *covalent bonding*, and *metallic bonding*.

Chemical bonds form when valence electrons are: transferred from one atom to another **(ionic bonding)**; shared between atoms **(covalent bonding)**; molile within a metal **(metallic bonding)**.

Electronegativity is an atom's attraction for electrons during chemical bonding. It indicates how strongly an atom of an element attracts electrons in a chemical bond.

Electronegativity indicates how strongly an atom of an element attracts electrons in a chemical bond. Electronegativity values are assigned according to an arbitrary scale based on a maximum value of "4.0" for Fluorine.

List the electronegativities for the following elements.

H ____ Br ____ Li ____ Ca ____ O ____

Note Packet # 10 I love chemistry

Ionic Bonding results from a **transfer of electrons**. This occurs between metal and non-metal atoms or between **atoms with an electronegativity difference greater than 1.7.**
Remember! Electronegativity values are found in the reference table on pages 10 & 11.

All atoms are neutral. Atoms become ions by gaining or losing electrons.
When an atom gains one or more electrons, it becomes a negative ion (anion) and its radius (size) increases.
When an atom loses one or more electrons, it becomes a positive ion (cation) and its radius (size) decreases.
Metal atoms transfer electrons to non-metal atoms.
As a result, + metal ions (cations) and - non-metal ions (anions) are formed.
Opposite electric charges attract.
The force of attraction that holds the + metal ions and - non-metal ions together is called an **ionic bond.** An ionic bond is a bond between + and - ions
Ionic bonding results in ionic compounds.

The greater the electronegativity difference between the elements, the more ionic the bond.

Example question: Which compound is more ionic? NaCl or MgS
To solve compare the electronegativity difference between the atoms of each compound.
The electronegativity difference between Na and Cl is 2.3, for MgS it is 1.3.
The difference is greater for NaCl. Therefore, NaCl is more ionic.

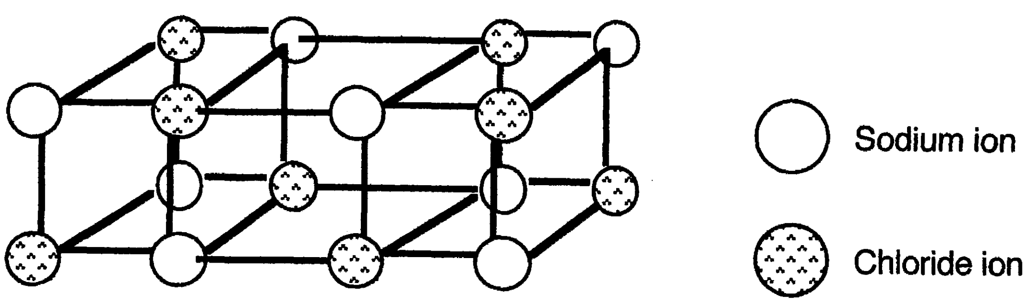
Properties of Ionic Compounds

a) Ionic compounds have high melting and boiling points.
Why? Because there is a very strong force of attraction between the ions.

b) Solid ionic compounds are poor conductors of electricity.
Why? Because ions are locked in place and can't move around.

c) Liquid (melted) or dissolved (aqueous) ionic compounds are good conductors of electricity. Why? Because the ions are free to move about.

d) Solid ionic compounds exist as rigid crystal structures consisting of a repeating 3 dimensional pattern.
Example: sodium chloride



e) Most ionic compounds dissolve in polar liquids such as water.
Example: Sodium chloride (table salt) dissolves in water (water is very polar).

Note Packet # 10

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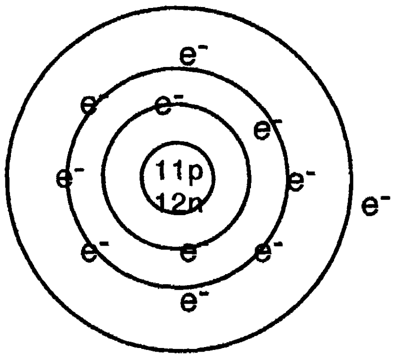
When a metal atom becomes an ion it becomes smaller since it loses valence electrons.

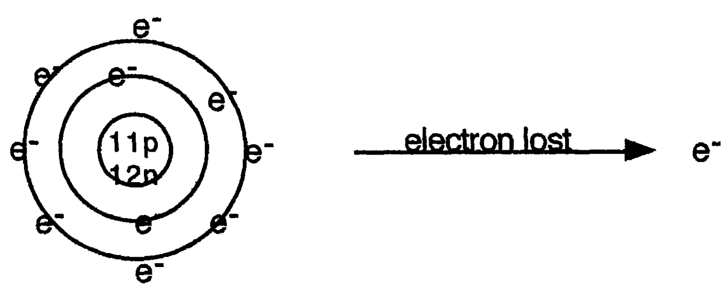
Metal ions are simply named ions.
Example: sodium ion, calcium ion, lithium ion,& magnesium ion.

Bohr model of a sodium atom. **NEUTRAL!**



A sodium atom becomes an ion by losing its 1 valence electron.
This results in an ion which is smaller than the atom.

Bohr model of a sodium ion.**+ 1 CHARGE!**



Non-metal ion names end in "**ide**".

Examples:
A chlorine atom becomes a chlor**ide** ion.

An oxygen atom becomes an ox**ide** ion.

A nitrogen atom becomes a nitr**ide** ion.

Complete the following:

A fluorine atom gains an electron to become a _______________ ion.

A bromine atom gains an electron to become a _______________ ion.

An iodine atom gains an electron to become an ________________ ion.

A phosphorous atom gains an electron to become a _______________ ion.

A sulfur atom becomes a ___________________ion.

A carbon atom becomes a __________________ ion.

Note Packet # 10

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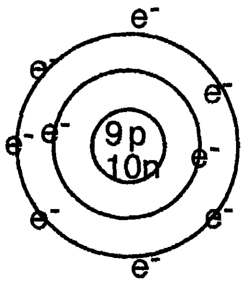
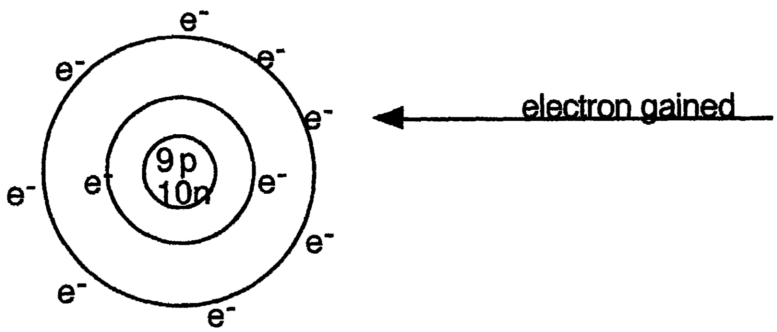
Bohr model of a fluorine atom. **NEUTRAL !**



When a fluorine atom becomes an ion it gains a valence electron and becomes larger.

Bohr model of a fluoride ion. - **1 CHARGE!**



Note Packet # 10 I love chemistry

Lewis Structures (Dot Diagrams) are a way of representing the valence electrons of elements, compounds or ions. Remember! Valence electrons are the electrons in the outer-most shell of an atom. It is the last entry of an electron configuration.
Examples:
2-8-5 has 5 valence electrons.

2-7 has 7 valence electrons.

2-1 has 1 valence electron.

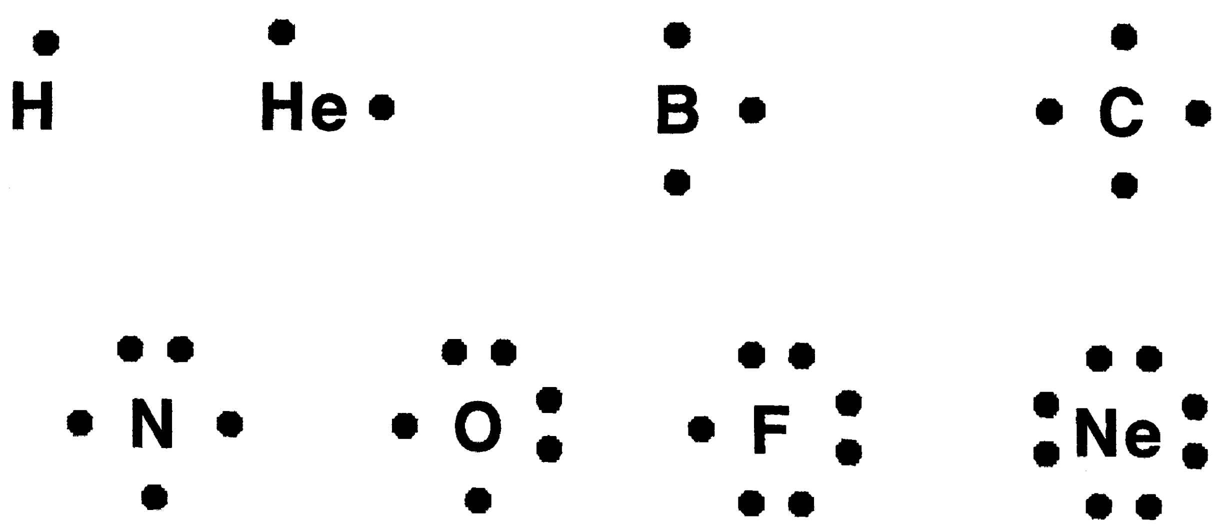
2-8-18-18-8 has 8 valence electrons.

Dot symbols are a simple and convenient way of showing valence electrons and keeping track of them in the course of chemical bonding.

Valence electrons are represented as dots. Dots are placed around the element's atomic symbol one at a time starting at the 12 O' clock position and working around every 3 hrs.
The maximum # of valence electrons is 8.

Remember you can find the electron configuration for any atom on the periodic table.

Dot symbols for atoms



Note Packet # 10

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During ionic bonding, **metal atoms lose their valence electrons** to aquire a noble gas electron configuration (stable octet).

How many valence electrons do metals lose?

For this chemistry class it will be the **same as the element's top oxidation # on the periodic table.**

Examples: Lithium has a + 1 oxidation #. It loses 1 electron.

Magnesium has a + 2 oxidation #. It loses 2 electrons.

Aluminum has a + 3 oxidation #. It loses 3 electrons.

Calcium has a + 2 oxidation #. It loses 2 electrons.

electron configurations:			**electron configurations:**	
Metal atom			**Metal ion**	
Li	2-1	loses 1 electron	Li^{+1}	2
Mg	2-8-2	loses 2 electrons	Mg^{+2}	2-8
Al	2-8-3	loses 3 electrons	Al^{+3}	2-8
Ca	2-8-8-2	loses 2 electrons	Ca^{+2}	2-8-8

Notice! all the metals aquired Noble gas electron configurations!

During ionic bonding **non-metals gain valence electrons** to attain a Noble gas electron configuration (stable octet).

How many?

For this chemistry class it will be the same as the element's top oxidation #.

Examples: Fluorine has a - 1 oxidation #. It gains 1 electron.

Oxygen has a - 2 oxidation #. It gains 2 electrons.

Chlorine has a - 1 oxidation #. It gains 1 electron.

electron configurations:		**electron configurations:**
Non-metal atom		**Non-metal ion**
F	2-7	2-8
O	2-6	2-8
Cl	2-8-7	2-8-8

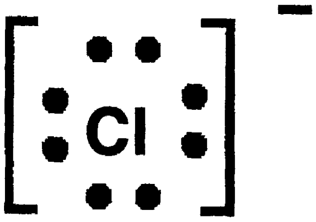
Notice! all the non-metals aquired Noble gas electron configurations!

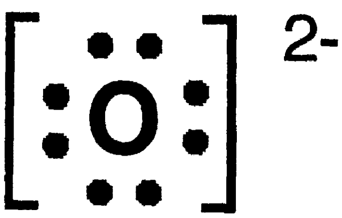
Note Packet # 10

I love chemistry

How to represent **ions** using Lewis structures (Dot diagrams).

a) All ions must show charges.
b) No dots are shown for metal ions.
c) Non-metals always show 8 dots. (except hydrogen will show 2 dots)
d) Non-metal dots must be in brackets.

metal	non-metal
Sodium ion	Chloride ion
Na^{+}	

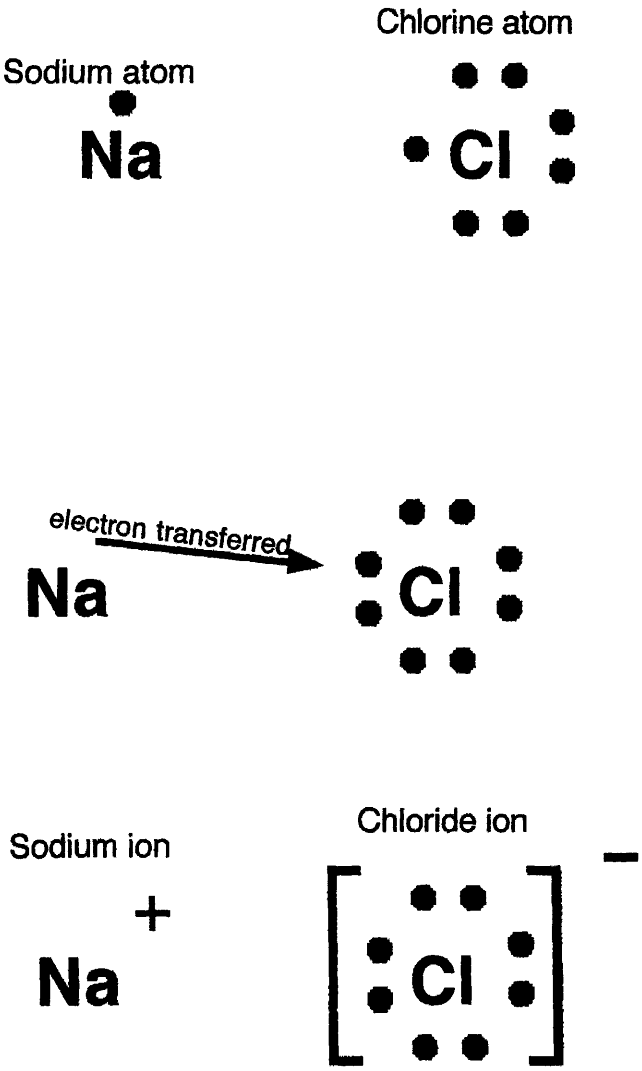
metal	non-metal
Magnesium ion	Oxide ion
Mg^{2+}	

Note Packet # 10

How to represent ionic bonding using Lewis structures (Dot diagrams).

a) All ions must show charges.
b) No dots are shown for metal ions.
c) Non-metals always show 8 dots.
d) Non-metal dots must be in brackets.
e) The sum of the oxidation #s in a compound must be zero. This will determine the ratio of ions in the ionic compound.

Sodium bonds with chlorine as follows.



These ions in a 1:1 ratio form the compound sodium chloride.

The sum of the oxidation #s in a compound must be zero.

Note Packet # 10

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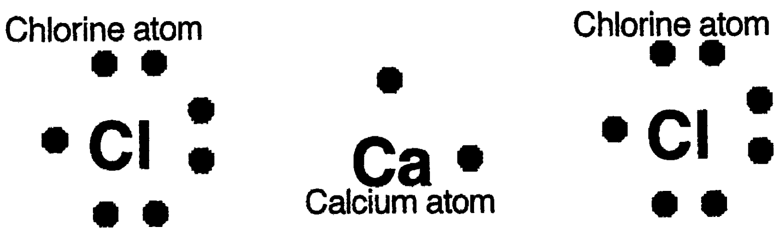
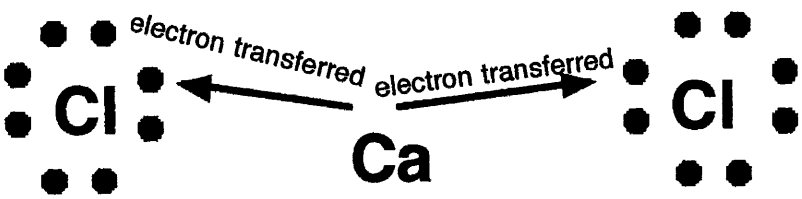
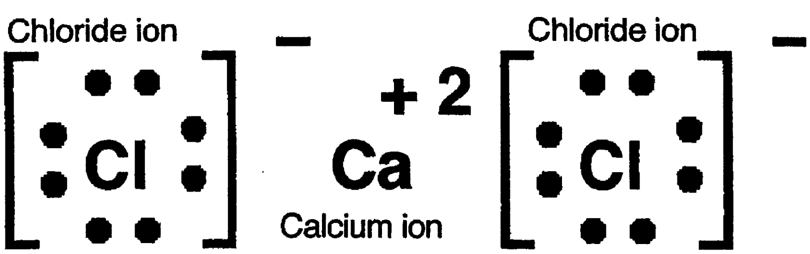
Calcium bonds with chlorine as follows.





The compound calcium chloride consists of one + 2 calcium ion and two - 1 chloride ions.



Notice the Ca^{+2} and Cl^{-1} are in a 1 : 2 ratio. The sum of the oxidation #s in a compound must be zero.

Note Packet # 10

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Draw the Lewis Structures for the following **ionic** compounds.
You know if you are looking at an ionic compound if a metal and a non-metal are present.
Remember! The sum of the oxidation #s must be zero!

LiBr

CaO

NaF

$MgCl_2$

$AlCl_3$

Li_2O

Note Packet # 10

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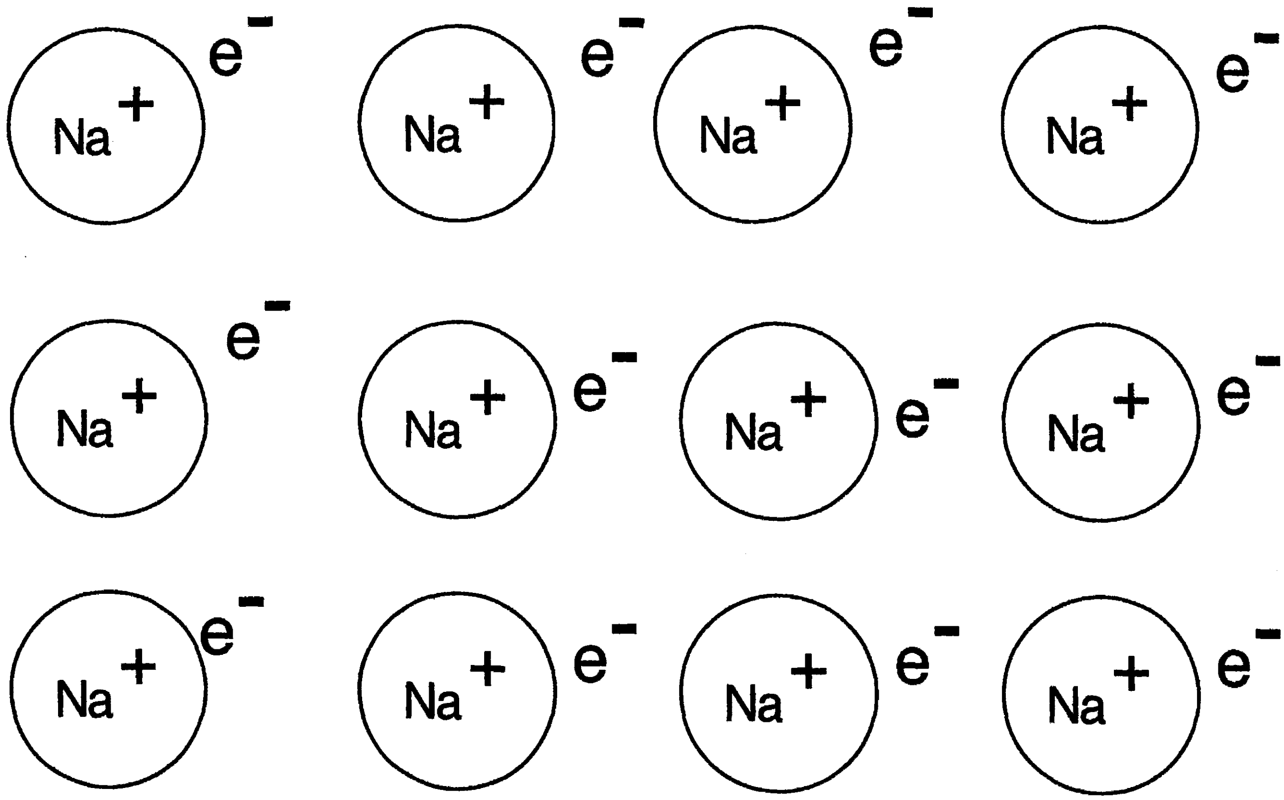
Metallic Bonding occurs between atoms of metals. Metal atoms lose their valence electrons to become + metal ions. The valence electrons are free to move between the metallic ions.

Metallic bonding is referred to as **+ metal ions surrounded by a "sea of mobile electrons"**.

The mobile electrons make metals good conductors of heat and electricity.

For this example, sodium "Na" loses its one valence electron to become a + sodium ion "Na^+". Its valence electrons freely circulate throughout.



Note Packet # 10 I love chemistry

Covalent Bonding is a **sharing of electrons** between non-metal atoms. The **electronegativity difference between covalently bonded atoms is less than 1.7** As a result of covalent bonding, atoms aquire noble gas electron configurations (a stable octet).

Covalent bonding results in **molecules.**

Molecule - a group of covalently bonded atoms that act as an independent unit.

Example: H_2O (water) is a molecule composed of 2 hydrogen atoms covalently bonded to 1 oxygen atom.

Properties of Molecular (covalent) Substances

a) Molecular solids are soft.

Why? Because the force that holds the molecules together is weak.

b) Molecular substances are poor conductors of heat and electricity.

Why? Because there are no free ions or electrons to carry an electric current.

c) Molecular substances have low melting and boiling points.

Why? Because the force that holds the molecules together is weak.

How to represent Lewis structures (dot diagrams) for covalent (molecular) compounds.

a) All bonded atoms must have 8 dots (valence electrons). Exception: Hydrogen will only have 2 dots(hydrogen aquires helium's electron configuration).

b) The number of valence electrons in a compound must = the number of the valence electrons in the individual atoms.

c) If there are more than 2 atoms present use the atom that there is only one of as the central atom.

d) All unshared electrons must be in pairs (not alone).

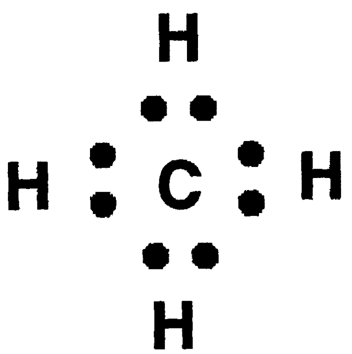
1 shared pair of electrons between atoms represents a **single** covalent bond.

2 shared pairs of electrons between atoms represents a **double** covalent bond.

3 shared pairs of electrons between atoms represents a **triple** covalent bond.

Examples:

Methane CH_4



Hydrogen H_2

Note Packet # 10

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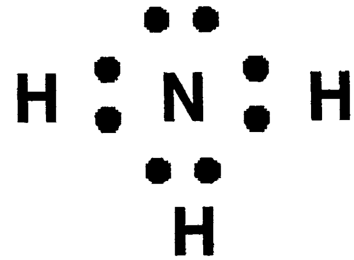
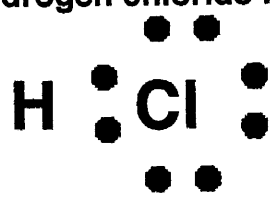
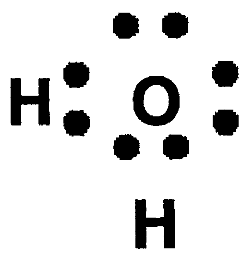
Ammonia NH_3



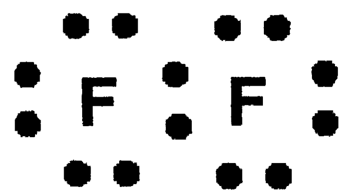
Hydrogen chloride HCl



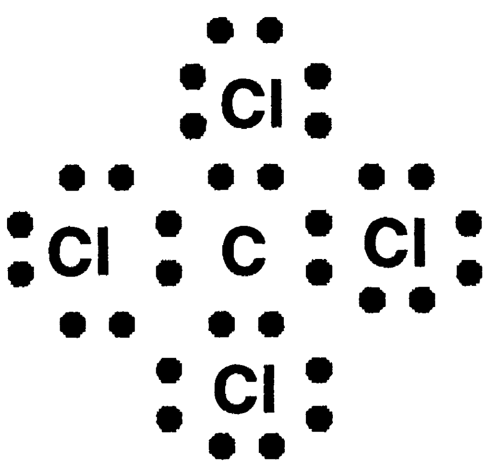
Water H_2O



Fluorine F_2



Carbon tetrachloride CCl_4



Notice! In all these examples, all the atoms, except hydrogen, have 8 dots (valence electrons) **This is a Noble gas electron configuration.** The total # of valence electrons in the compound is equal to the sum of the valence electrons of the individual atoms.

Note Packet # 10

I love chemistry

Draw the Lewis structures for the following **covalent** (molecular) compounds. You know the compound is covalent if only non-metals are present.

Cl_2

CBr_4

HBr

H_2S

CF_3Br

I_2

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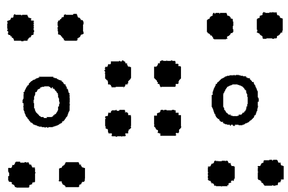
Special Lewis Structures (Dot diagrams)

There are some special Lewis structures that would be very hard to construct following the regular rules.

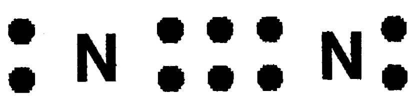
These must be memorized!

Oxygen O_2

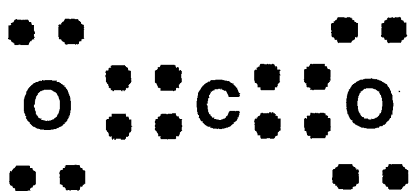


A diatomic molecule of oxygen is an example of a double covalent bond

Nitrogen N_2



A diatomic molecule of nitrogen is an example of a triple covalent bond.



Carbon dioxide is an example of a molecule with 2 double covalent bonds.

Notice! All the atoms have 8 dots (valence electrons). This is a Noble gas electron configuration).

Note Packet # 10

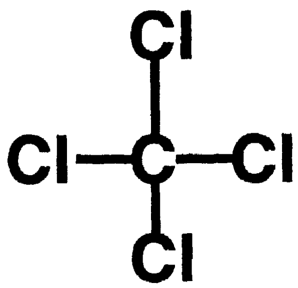
I love chemistry

A **structural formula** represents the covalent bonds and the shape of molecules. **Molecules** are nonmetal atoms that are covalently bonded.

Covalent bonds can be represented as lines. —

H—H

This represents the single covalent bond in a diatomic hydrogen molecule. H_2



This represents the 4 single bonds in carbon tetrachloride CCl_4.

N≡N

This represents the triple covalent bond in a diatomic nitrogen molecule N_2.

O=O

This represents the double covalent bond in a diatomic oxygen molecule O_2.

Note Packet # 10

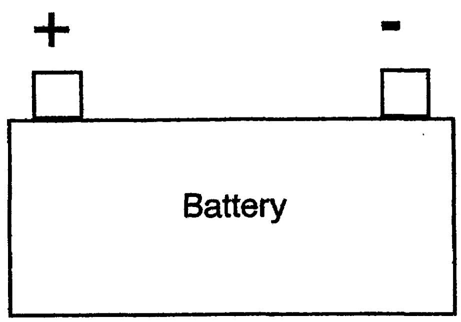
I love chemistry

Polarity refers to an object having different ends.

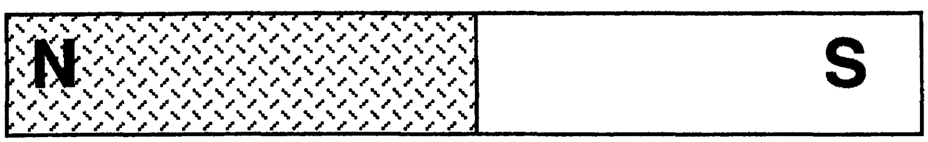
You may be familiar with some things that are polar.

These objects are called **polar**.

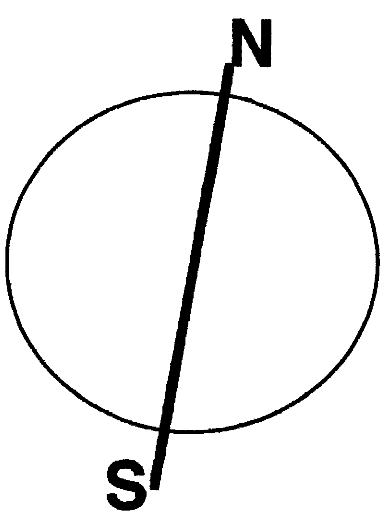
Batteries are polar. They have a + and a - terminal.



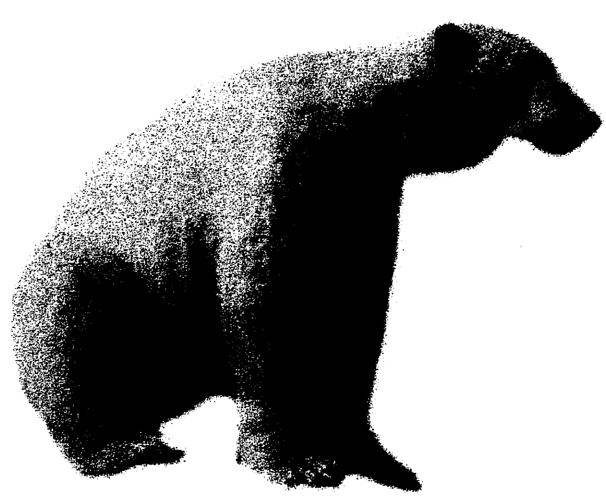
Magnets are polar they have a North and South pole.



Earth is polar. It has a North and a South pole.



Yes, a polar bear has different ends too.



Note Packet # 10 I love chemistry

Polar Covalent Bonds

A **covalent bond** is a chemical connection between atoms resulting from the **sharing** of electrons.
If a covalent bond has a different atom on each end it is polar (different ends).

When atoms of different elements are covalently bonded, a polar bond results.

The element with the greater electronegativity will cause the bond to be negative on that end of the bond due to unequal sharing of electrons. The atom with the greater electronegativity will pull the shared electron closer to itself causing an unbalanced charge.

The electronegativity difference between two bonded atoms is used to determine the degree of polarity of a bond. **The greater the electronegativity difference the more polar the bond.**

Hydrogen's electronegativity is 2.1, chlorine's electronegativity is 3.2. Chlorine has the greater electronegativity.

The shared electron is pulled closer to the chlorine atom resulting in a polar bond.

$$H \overset{e^-}{\text{———}} Cl$$

The chlorine end of the bond is slightly- and the hydrogen end is slightly +.

Non-polar Covalent Bonds

A **covalent bond** is a chemical connection between atoms resulting from the **sharing** of electrons.
If a covalent bond has the same atoms on each end it is non-polar (same ends).

Determine if the following bonds are polar or non-polar and indicate which end is negative and which end is positive.

H -H

H - Br

H - I

O$=$C$=$O

Note Packet # 10

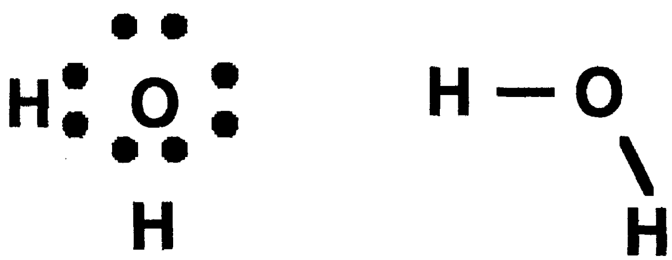
Polarity of Molecules
Polar Molecules are called Dipoles.

Symmetry means sameness or balance. Any molecule that has electrostatic symmetry is non-polar.
Asymmetrical (no symmetry) molecules are polar (dipoles).

Symmetrical molecules are non-polar.
If a molecule has only non-polar bonds it imust be non-polar

Molecules with polar bonds may or may not be polar (asymmetrical).
What does that mean?
If a molecule with polar bonds has symmetry it is non-polar.
To deternine if a molecule with polar bonds is polar examine its shape and see if it has different ends based on electronegativity.

Water H_2O

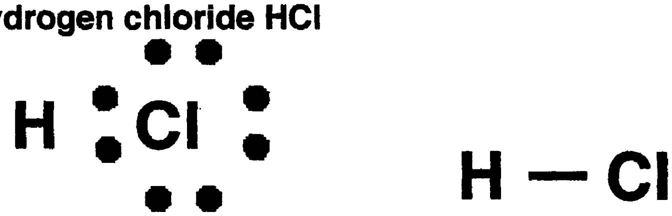


Water is polar. You can see it has different ends. There is an oxygen side and a hydrogen side. Oxygen has a higher electronegativity than hydrogen. The oxygen end is negative and the hydrogen side is positive.
The polarity of water is important to remember. Remember! "Polar bears love water".

Hydrogen H_2

Hydrogen is non-polar. It only has non-polar bonds. It must be non-polar.

Hydrogen chloride HCl



Hydrogen chloride is polar. It has a chlorine end and a hydrogen end. Chlorine has a higher electronegativity than hydrogen. The chlorine end is negative and the hydrogen side is positive.

Note Packet # 10

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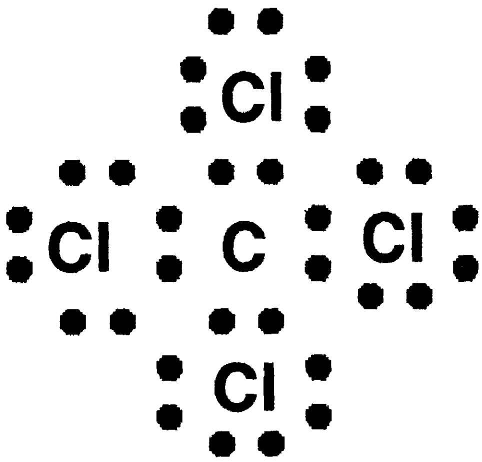
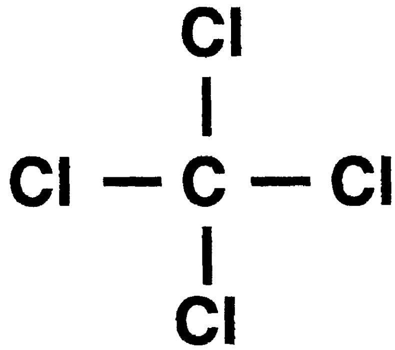
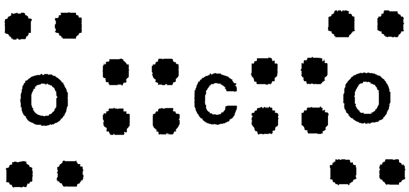
Carbon tetrachloride CCl_4





Carbon tetrachloride is a non-polar molecule even though it has polar bonds. This molecule has symmetry. It does not have different ends.



Carbon dioxide is a non-polar molecule even though it has polar bonds. This molecule has symmetry. It does not have different ends.

Note Packet # 10 I love chemistry

Describe the bond polarity and the molecular polarity of the following:

		bond polarity	molecular polarity
a)	HCl		
b)	Cl_2		
c)	CBr_4		
d)	H_2S		

Molecular Polarity and Solubility

Solubility means dissolvability.
The expression **"Like dissolves Like"** refers to the fact that polar substances dissolve well in other polar substances.
Non-polar substances dissolve well in other non-polar substances.
Water is the usual example for a polar liquid. Remember! Polar bears like water!
Oil is the usual example for a non-polar liquid.
Oil and water don't mix.
Ammonia (NH_3) is polar. It dissolves well in water which is polar.
Oil is non-polar. It does not dissolve in water.
Carbon tetrachloride (CCl_4) is non-polar. It dissolves easily in oil.

If you ever tried to clean up an oily mess with water, you probably found it did not work very well.
Water consists of very polar molecules. Oil consists of very non-polar molecules. "Like dissolves like" tells us that oil and water do not dissolve in each other. If you try to clean up an oily mess with just water, you will probably just smear it around.

Solubility is a physical property which can be used to separate components of mixtures.

Example question:

How can a mixture of ammonia gas and helium gas be separated ?
To solve:
Ammonia (NH_3) gas is polar. Helium gas is non-polar.
Like dissolves like. Therefore; ammonia gas will dissolve in water (water is very polar), helium gas will not dissolve in water.
If the gas mixture is placed over water, the ammonia will dissolve in the water and the hydrogen gas will remain above the water.

Note Packet # 10 I love chemistry

Polyatomic Ions

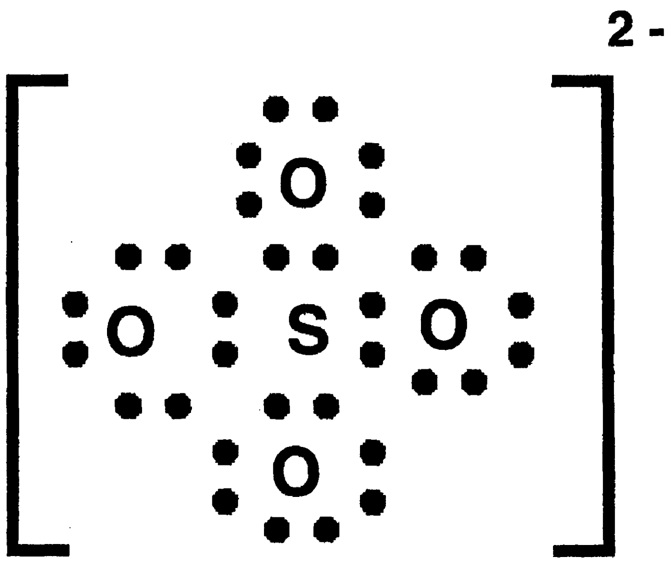
You learned that ions are charged particles. Polyatomic ions are groups of chemically bonded atoms that behave as a normal ion.

Table E contains the names, formulas and charges of many polyatomic ions.

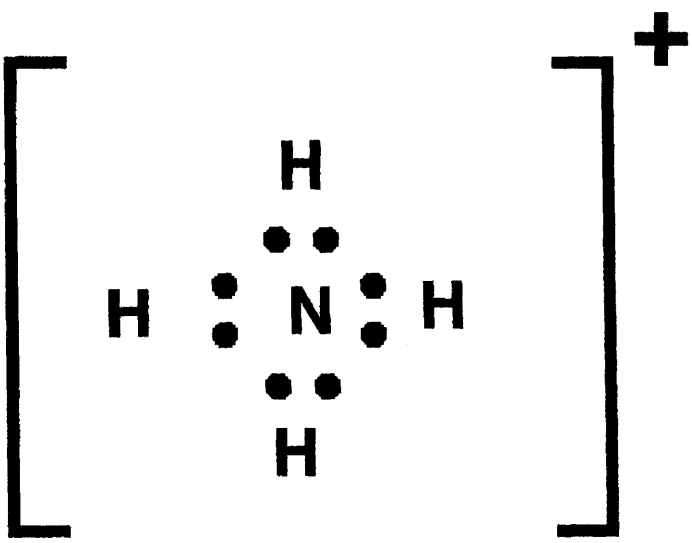
Polyatomic ions contain both ionic and covalent bonding.

Example:

This is the polyatomic ion "**Sulfate**". It has covalent bonding between the sulfur and oxygen atoms. It also has a charge making it ionic.



Below is the polyatomic ion "ammonium". It has covalent bonding between the nitrogen and hydrogen atoms. It also has a charge making it ionic.

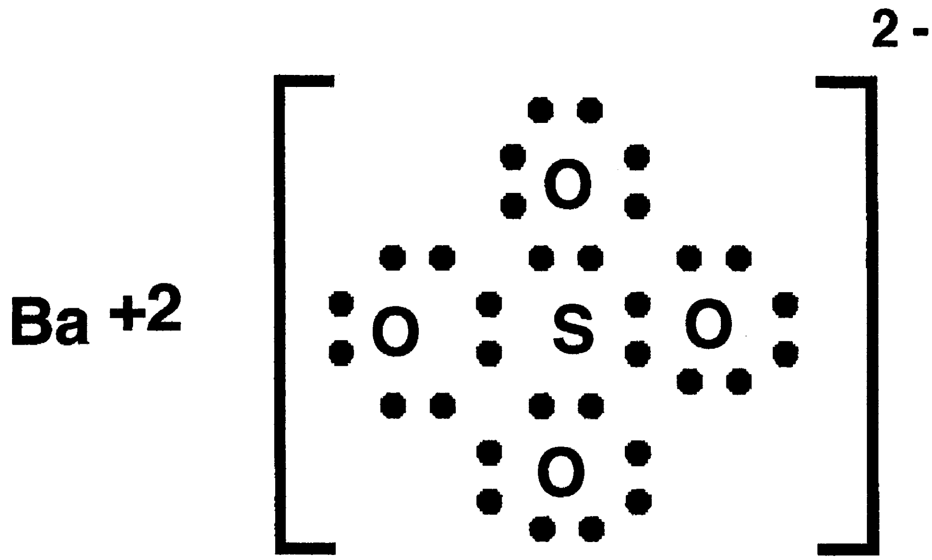


Note Packet # 10

I love chemistry

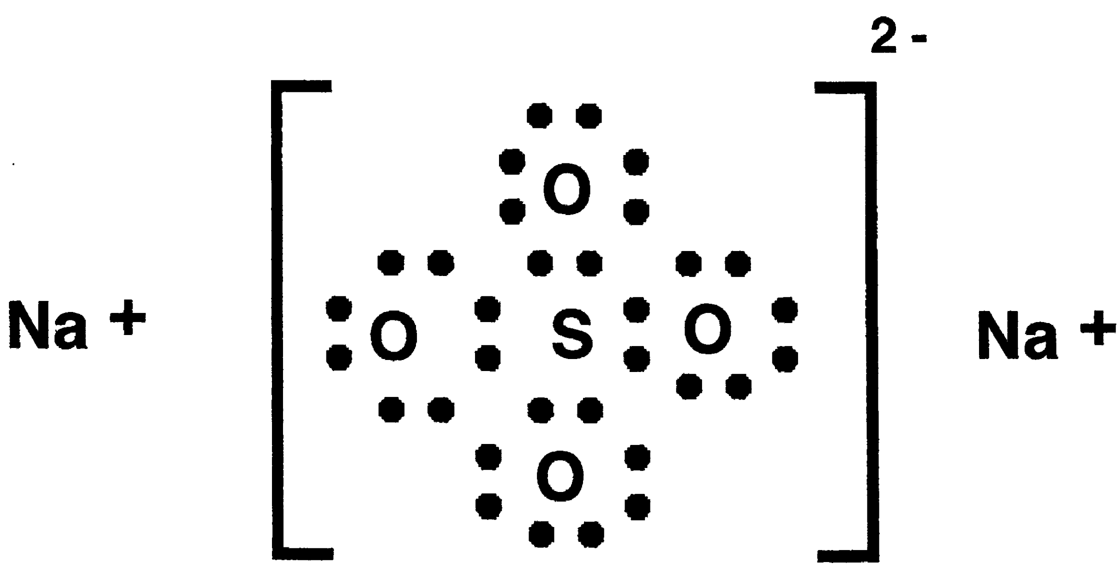
Compounds with polyatomic ions

This is the compound **barium sulfate**. Notice it contains both covalent and ionic bonding



Notice the sum of the charges in the compounds is equal to zero.

This is the compound **sodium sulfate**. Notice it contains both covalent and ionic bonding



Note Packet # 10
Important bonding concept!

Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases (Group 18) have stable electron configurations and tend not to bond.
All noble gases have 8 valence electrons except helium. Helium is a Noble gas with 2 valence electrons.
You must be able to determine which Noble gas configuration an atom will attain during bonding.

Determine the Noble gas electron configuration before and after bonding for the following atoms and state which Noble gas electron configuration it becomes the same as.

	Electron configuration before bonding	**Electron configuration** after bonding	**Noble gas** same as
a) Li			
b) Mg			
c) Al			
d) Ba			
e) N			
f) O			
g) Br			
h) Cl			
i) S			
j) K			
k) P			

Note Packet # 10

Electricity

You will learn a lot about electricity when you take physics. For now, you need to know that electricity is a moving electrical charge. Electrical charge must travel through a material (medium).

Conduction (conductivity) is the movement of electrically charged particles through a transmission medium (electrical conductor). The movement of charge constitutes an electric current.

An **electrical conductor** is a material capable of conducting an electric current
Electrons are electrically charged particles (-).

Ions are electrically charged particles (+ or -).

Metals are good conductors of electricity since metals have freely moving electrons.

Electrolytes are aqueous mixtures that contain ions. Electrolytes are good conductors of electricity since they have freely moving ions.

All materials contain electrons or ions.

Material will only conduct an electric current if its electrons or ions are free to freely circulate.

Therefore: when considering whether a material can conduct electricity, ask yourself, "does it have electrons or ions that can move from one place to another?"

Metals are good conductors of electricity because they have freely moving electrons.

Liqiud (melted) ionic compounds are good conductors of electricity because they have freely moving ions.

Aqueous ionic compounds (dissolved in water) are good conductors of electricity since they contain freely moving ions.

Solid ionic compounds are poor conductors of electricity because their ions are locked in place and can not move around.

Covalent (molecular) compounds are poor conductors of electricity because their electrons can not circulate freely through the material.