Name: Answers Period: iPad #:

CHEMICAL BONDING LAB BOOK

_____ Never trust an atom they make up everything~ Chemical Bonding Activity (3)

_____ Conductivity Lab (1)

_____ 3- Dimensional Models of Covalent Molecules ~ "Building a Molecule" (2)

_____Bonding in Common Minerals Activity (1)

QUIZ POINTS BONUS!

- COMIC STRIP - Choose one type of bonding and write a comic strip with 3+ frames. The comic should incorporate at least 3 properties from your Bonding Comparison Chart .
- SINGLE-FRAME CARTOON - Draw a single-frame cartoon for each type of bonding. Each cartoon should incorporate at least one key property from your Bonding Comparison Chart .

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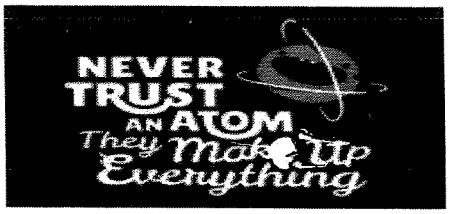
JHS Regents Chemistry Department



Chemical Bonding of Atoms

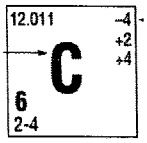
Bonding Basics:

Atoms combine to become more stable by completing their valence shell. Completing each atoms valence shell requires eight valence electrons referred to as an octet. The exception to this is Hydrogen and Helium that only requires 2 valence electrons to complete their outer principal energy level. When an atom loses or gains electrons it becomes an ion. This loss or gain of electrons indicates the electrons exchanged or shared during a chemical bond. The determination of whether an atom will lose or gain electron is dependent on 3 factors:

- electronegativity of an element ~ its ability to gain electrons from other atoms
- ionization energy ~ energy needed to remove an atoms most loosely bound (valence) electrons
- number of valence electrons an atom has.

The loss or gain of electrons during a chemical bond is indicated by an oxidation state. The most commonly used oxidation states of each element are indicated on the periodic table of elements in the upper right hand corner of each elements box.

Element symbol



← selected oxidation states

Section A: Complete the chart using a periodic table to help you.

Element	Atomic Symbol	Total # of Electrons	# of Valence Electrons	# of Electrons Needed to Fill Outer Shell	Oxidation Number
Chlorine	Cl	17	7	1	-1
Potassium	K	19	1	7	+1
Magnesium	Mg	12	2	6	+2
Fluorine	F	9	7	1	-1
Aluminum	Al	13	3	5	+3
Sodium	Na	11	1	7	+1
Nitrogen	N	7	5	3	-3
Oxygen	O	8	6	2	-2
Hydrogen	H	1	1	7	+1/-1
Carbon	C	6	4	4	+4/-4
Iodine	I	53	7	1	-1

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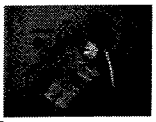
Answer the following questions:

1. Atoms of non-metals, tend to gain one or more electrons and will have a ___(−)___ charge.
2. Atoms of metals, tend to lose one or more electrons and will have a ___(+)___ charge.
3. An atom that gains or loses one or more electrons is called an ___ion___.
4. A positive ion is called a ___cation___ and a negative ion is called an ___anion___.

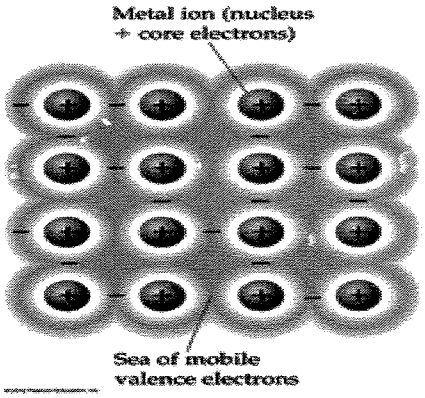
Atoms are basic building blocks that can combine with one another in a variety of patterns & combinations to form Chemical Compounds. Chemical compounds are represented by a chemical formula which contains the elements symbols and subscripts that indicate the number of atoms of each element is present. They combine in ***definite proportions*** (remember Dalton's theory) through ionic, metallic & covalent bonds.



METALLIC BONDS:

Metallic bonding is the availability of **mobile electrons** among the structure (lattice) of all one type of metal atom. Metallic bonding accounts for many physical properties of metals, such as strength, malleability, ductility, thermal and electrical conductivity (ALWAYS) and luster. Metals are solids except mercury which is liquid.

A metallic bond is a bond **within ONE type of Metal**. Electrons are delocalized among the entire metal lattice. They are a **MOBILE**, "sea of electrons" that belong to the entire metal sample. These mobile electrons allow heat and electricity to be carried throughout the metal and are responsible for metals conductivity of heat and electricity in all phases.

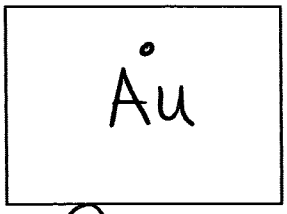


Lewis Dot Diagram for a sample of sodium

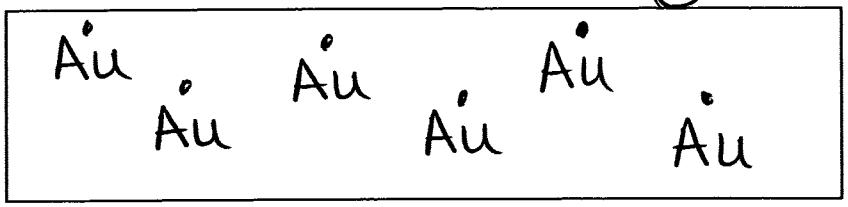
Na Na Na Na
Na Na Na Na
Na Na Na Na

1. What type of elements or atoms is involved in metallic bonds? ___metals___

2. Draw the Lewis electron dot structure for **ONE** Gold atom



3. Sketch a Lewis dot structure of a sample of Gold metal. Include at least 6 atoms of Gold.



4. List 5 properties of metals
   - conductor of heat & electricity
   - malleable
   - ductile
   - luster

5. Use a textbook or online resource define alloy? Explain why alloys are **not** formed by metallic bonds.

Alloy - mixture of metals. Not within one metal

LET'S COMPARE ELEMENTS

Column One and Column Two both show different compounds made by bonding different elements together. There are two types of bonding shown in these two groupings. Let's take a closer look at the elements in each compound to see what makes a compound IONIC or COVALENT.

IONIC BONDS	COVALENT BONDS
NaCl (Sodium Chloride)	H_2O (Dihydrogen Monoxide)
MgO (Magnesium Oxide)	CH_4 (Methane)
Li_2O (Lithium Oxide)	CO_2 (Carbon Dioxide)
KF (Potassium Fluoride)	HF (Hydrofluoric Acid)
$FeBr_3$ (Iron III Bromide)	NH_3 (Ammonia)
$CaCl_2$ (Calcium Chloride)	NO_2 (Nitrogen Dioxide)
NiI_2 (Nickel Iodide)	$C_6H_{12}O_6$ (Glucose)
BaS (Barium Sulfide)	CF_4 (Carbon Tetraflouride)

1. What do you notice about the FIRST element that makes up each compound in COLUMN ONE?
   metal

2. What side of the periodic table do you find these FIRST elements on?
   left of steps

3. What do you notice about the SECOND element that makes up each compound in COLUMN ONE?
   non-metal

4. What side of the periodic table do you find these SECOND elements on?
   right of steps

BIG IDEA: When a metal **transfers electrons to** non metal **to form an IONIC BOND.**

5. What do you notice about ALL of the elements in Column TWO?
   non-metals

6. What side of the periodic table do you find ALL of these elements on?

right of steps

BIG IDEA: When a non-metal and another non-metal come together, they make a COVALENT BOND.

IONIC BONDS

Chemical compounds in which ions are held together in a lattice structure by the electrostatic forces between oppositely charged bodies are classified as ***Ionic*** bonds. Usually, the ***positively charged*** portion consists of ***metal cations*** and the ***negatively charged*** portion is a ***non-metallic anion***. The electrons are **TRANSFERRED** from the metal to the non-metal. What happens in **IONIC BONDING**? The **METALS** have a small amount of electrons in their last shell so it is easier for them to get rid of them than try to gain a bunch. The **NONMETALS** almost have a full shell of eight (or 2 Hydrogen & Helium) so it is easier for them to get a few then get rid of all of theirs. This is why the **METALS TRANSFER ELECTRONS TO NONMETALS IN IONIC BONDING.**

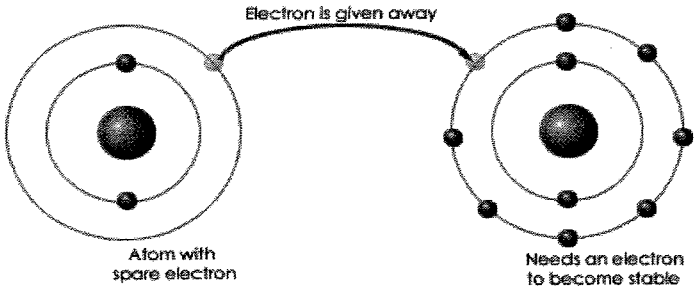
PROPERTIES:

Ionic compounds have high melting points, and they are hard, solid and very brittle. ***Solid ionic*** compounds ***cannot conduct electricity*** because there are no free ions present in the lattice. When an ***ionic compound is dissolved in a liquid (aqueous) or molten (melted),*** they ***can conduct*** electricity due to presence of **FREE ions** that allowed the electricity passed through it.

Ionic Bonds

An Ionic bond will occur between metals and nonmetals when electrons are transferred from metal atoms to non-metal atoms causing each of these atoms to become charged (ions).

1. Atoms will transfer one or more e⁻ to another atom to form an ionic bond.
2. Each atom is left with a full outer shell.
3. An ionic bond forms between a metal that will become a cation with a positive charge and a nonmetal that will become an anion with a negative charge.



Lithium (Li) atom Fluorine (F) atom

BIG IDEA: In IONIC BONDING, the metal *TRANSFERS* it's electron(s) to the non-metal.

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The diagram below indicates how a metal and nonmetal will bond to form an Ionic compound. Use the Lewis Dot diagram and your understanding of **ionic bonds** to answer the following questions.

LEWIS DOT DIAGRAM

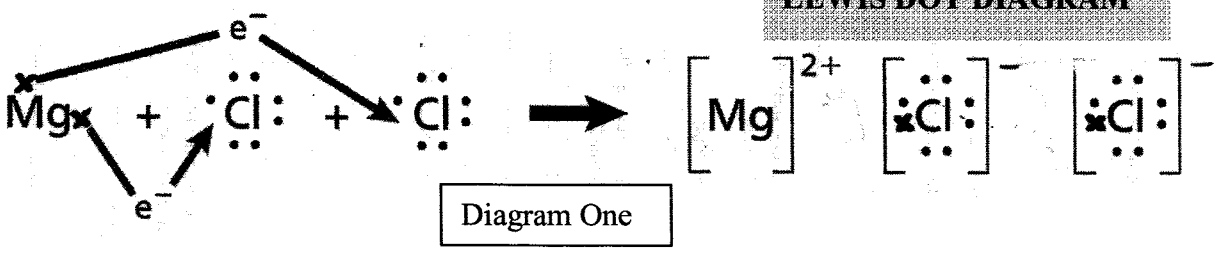

Diagram One

Name: Magnesium Chloride **Formula**: $MgCl_2$

1. What are the names of the elements (Mg & Cl) shown in the diagram?

magnesium & chlorine

2. How many valence electrons does a neutral Mg atom have? How are they represented in the diagram?

2; 2 dots

3. What is the charge on the Mg ion (pictured to the right of the arrow in the diagram)? What does Mg have to do to form such an ion? Why does Mg form such an ion?

Mg^{+2} — lose 2e⁻; full next lower shell (stability)

4. How many valence electrons does a single neutral Cl atom have? How are the valence electrons of the Cl atoms represented in the diagram?

7; 7 dots

5. What is the charge on a single Cl ion (pictured to the right of the arrow in the diagram)? What does Cl have to do to form such an ion? Why does Cl form such an ion?

Cl^{-1}; gains e⁻; fill its valence shell (become stable)

6. When there is a balance between how many electrons are given and how many are taken (in a reaction like that pictured in the diagram), a formula unit of an Ionic Compound is formed. How many Mg atoms and how many Cl atoms are needed to create a formula unit of the Ionic Compound Magnesium Chloride (pictured to the right of the arrow in the diagram)? In other words, what is the ratio of Mg to Cl needed to achieve a neutral charge overall?

1 : 2
Mg Cl

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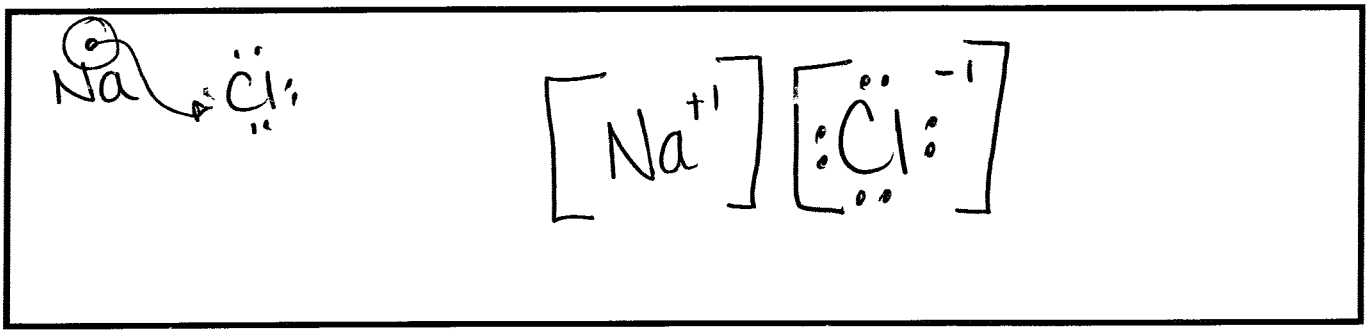
7. In an ionic compound electrons are transferred from an atom or atoms that tend to donate electrons, and then these electrons are taken by an atom or atoms that tend to steal electrons. Does the diagram seem to represent the formation of an ionic compound? Why or why not?

Yes! Mg - donates e- & Cl - takes e-

Using the diagram above as a guide TRY THESE:

#1: Sodium + Chlorine



a) How many valance electrons does Sodium have? 1

b) How many valence electrons does Chlorine have? 7

c) How many electrons does Chlorine need to complete its outer shell? 1

d) How many electrons does Sodium need to lose to be left with a complete shell? 1

e) What will the overall net charge of chlorine when the electrons are transferred from sodium to chlorine. -1

f) What will occur to the size of the Chlorine atom when electrons are transferred? larger

g) What will occur to the size of the sodium atom when electrons are transferred? Smaller

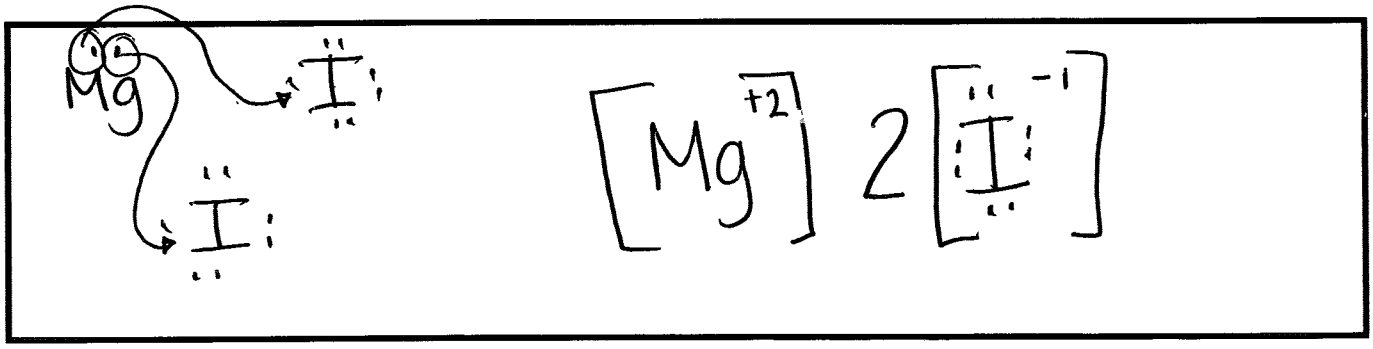
h) What will the overall net charge of sodium when the electrons are transferred from sodium to chlorine. +1

i) What is the overall net charge of the compound formed between the sodium and chlorine atoms? 0

j) How many atoms of sodium are needed to form this bond 1

k) How many atoms of chlorine are needed to form this bond 1

 # 2: Magnesium + Iodine



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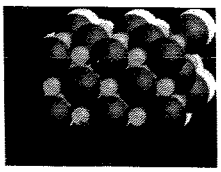
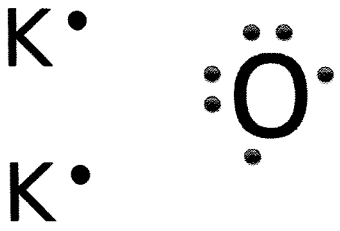


NOW….. let's create models of ionic compounds and observe the chemical formula of the binary compounds you have created. Using the Ion cards given to your group create 5 different ionic compounds. Your data will be recorded in a data table found on the next page. ***NOTE:*** Binary Ionic compounds are composed of ions of two different elements - one of which is a metal, and the other a nonmetal. For example, sodium iodide, NaI, is composed of sodium ions, Na^+ (elemental sodium is a metal), and iodide ions, I^- (elemental iodine is a nonmetal). Using the rules below predict the name and formulas for all the compounds on your chart.

Rule 1. The cation is written first in the name; the anion is written second in the name.
Rule 2. The name of the cation is the same as the (neutral) element from which it is derived (e.g., Na^+ = "sodium").
Rule 3. The anion is named by adding the suffix *-ide* to the root of the element name (e.g., I^- = "**iod***ide*").
Rule 4. the total charge of the cations must EQUAL the toatal charge of the anions so the compound is neutral

Hints:
Non-metals need the metals to lose its electrons. Therefore, in formula writing …the metal is always listed first. More than one atom of the same element can react with another element. For example, potassium has an oxidation number of +1 (loses 1 valence electron). In order for potassium to react with oxygen (oxidation number of -2), 2 atoms of potassium must react with one atom of oxygen.



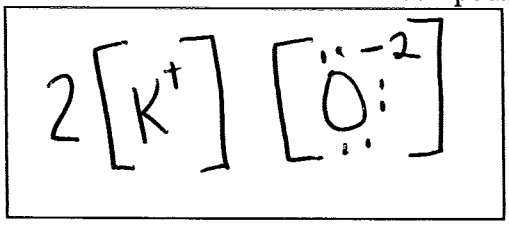
See rules

1. The chemical formula for this compound is:

K_2O

2. The name of this compound is: potassium oxide

3. The Lewis Structure for this compound would be:



4. Explain, in terms of electrons, why the bonding in Potassium Iodide is ionic.

transfer e⁻ from K → I

4. List 4 properties of ionic compounds.

- hard, solids
- high melting point
- lattice structure
- poor conductors as solid but can conduct as liquids or in water due to FREE IONS

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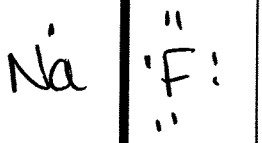
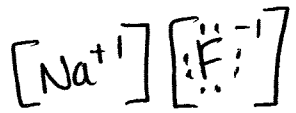
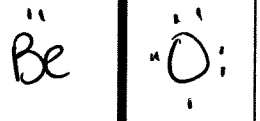
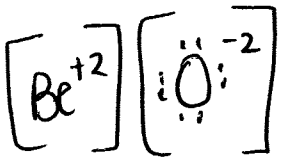
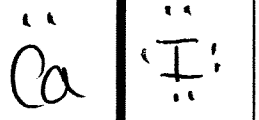
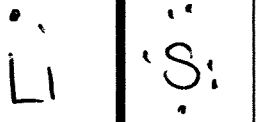
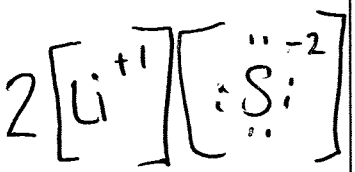
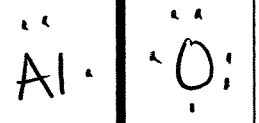
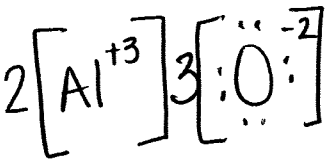
ATOM e- Dot Structures Metal / Non-Metal	Oxidation State Metal	Oxidation State Non – Metal	Lewis dot diagram of compound	Predicted Chemical Formula and compound name
Sodium / Fluorine 	+1	−1		Formula: : NaF Name: Sodium Flouride
Beryllium / Oxygen 	+2	−2		Formula: : BeO Name: Beryllium Oxide
Calcium / Iodine 	+2	−1		Formula: : CaI_2 Name: Calcium Iodide
Lithium / Sulfur 	+1	−2		Formula: : Li_2S Name: Lithium Sulfide
Aluminum / Oxygen 	+3	−2		Formula: : Al_2O_3 Name: Aluminum Oxide

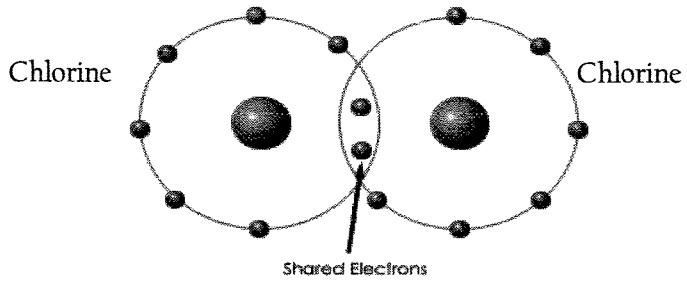
COVALENT COMPOUNDS

Chemical compounds in which atoms are bonded through ***sharing electrons*** between atoms is classified as ***Covalent*** bonds. A **molecule** by definition contains more than one non metal atom **covalently bonded**. Molecules may contain one or more kinds of atoms and may be solids, liquids, or gases at room temperature. Molecules are typically soft substances, with low melting points and poor conductivity. Covalent bonds are affected by the electronegativity of the connected atoms. Two atoms with ***equal (or very close to) electronegativity*** will make **nonpolar covalent** bonds and an ***unequal electronegativity*** relationship creates a **polar covalent** bond. What happens in COVALENT BONDING? Both NONMETALS are almost a full valence shell reaching an octet,so neither wants to give anything away. This is why NONMETALS SHARE ELECTRONS IN COVALENT BONDING.

In this activity, we will use the modeling approach to reinforce our understanding of bonding and compound structures. In a covalent bond electrons are shared either equally (non polar) or unequally (polar) between non metallic atoms. The equality of the electrons shared between atoms is dependent on 2 factors:

- Electronegativity difference between the elements
- number of valence electrons in each element

1. Atoms share one or more e- with each other to form the bond.
2. Each atom is left with a full outer shell.
3. A covalent bond forms between two nonmetals.
4. When electrons are shared equally between atoms that is referred to as a non-polar bond.
5. When electrons are shared unequally that is referred to as a polar bond.



6. What TYPE of element is element one? Element two?

non-metal & non-metal

7. Therefore, bonding picture two must show the process for which type of bonding; ionic or covalent?

covalent

BIG IDEA: In COVALENT BONDING, the nonmetal and the other nonmetal *SHARE* their electrons.

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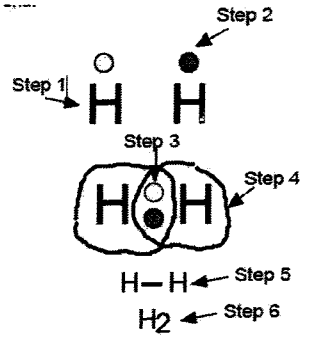
Creating Lewis Dot Diagrams for Covalent molecules.
Follow the directions below to complete each of covalent combinations. See diagram below.

EXAMPLE: Hydrogen + Hydrogen

- *Write the symbols for each element.*
- *Use cereal pieces to create the e- dot diagram for each atom.*
- *Decide how many of each atom would be needed to create a neutral covalent compound.*
- *Rearrange the electrons (or cereal pieces) to pair up any single (unpaired) electrons as needed from each atom.*
- *Circle the shared electrons.*
- *Draw the bond structure using symbols and lines. Use **<u>one line for each pair</u>** of electrons that is shared. Each pair of electrons shared represents one bond*
- *Between nonmetallic atoms. This "bond" is represented by a dash between the element symbols*
- *Write the chemical formula for each molecule.*
- *Use a pencil or crayon to draw the electrons as you remove the pieces of cereal.*



Elements to Bond	***e- dot diagram for each atom***	***Circle paired electrons***	***Bond structure***	***Chemical formula***
Hydrogen & Hydrogen	H H	H H	H—H	H_2

a) How many valance electrons does each Hydrogen have? 1

b) How many electrons does each Hydrogen need to complete its outer shell? 1

c) What is the overall net charge of the compound formed between the Hydrogen atoms? ∅

d) How many atoms of Hydrogen are needed to form this bond 2

<u>NOW YOU TRY THESE!</u>

Elements to Bond	***e- dot diagram for each atom***	***Circle paired electrons***	***Bond structure***	***Chemical formula***
Hydrogen & Oxygen	H O	H O H	H - O - H	H_2O

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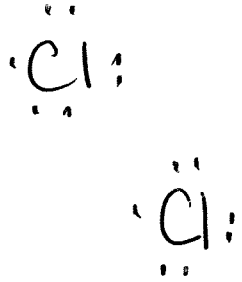
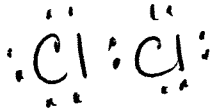
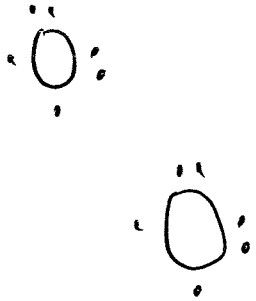
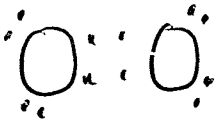
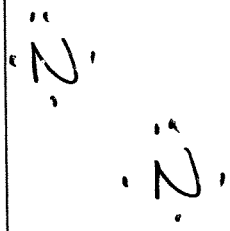
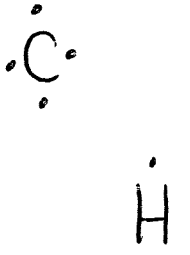
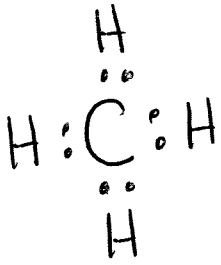
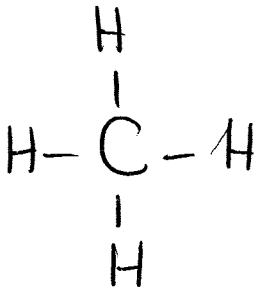
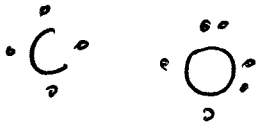
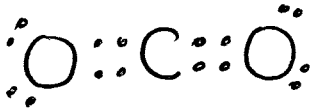
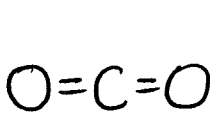
Chlorine & Chlorine			Cl - Cl	Cl_2
Oxygen & Oxygen			O=O	O_2
Nitrogen & Nitrogen			N≡N	N_2
Carbon & Hydrogen				CH_4

**Carbon & Oxygen				CO_2

NOW.....

Let's use the molecule kits to model covalent bonding. Each colored ball represents an atom that can become part of a covalent molecule. The wood links are to be used when bonding two atoms together with one covalent bond. The spring links are to be used when bonding the same two atoms together with multiple covalent bonds.

Coloring Key for atoms

- ○ Carbon ~ black
- ○ Oxygen ~ red
- ○ Hydrogen ~ yellow
- ○ Nitrogen ~ blue
- ○ Fluorine ~ orange
- ○ Chlorine ~ green
- ○ Bromine ~ maroon

Each atom has a certain number of valence electrons to help attach or bond with other atoms. Notice that each atom model contains a certain number of "holes" which corresponds to the number of bonding sites that atom has based on its valence electrons. Each pair of shared electrons represents 1 bond.

- One covalent bond is formed by one pair of shared electrons, one electron from one atom and the other electron from the other atom.
- Any pair of atoms may form multiple covalent bonds between them sharing multiple pairs of electrons (
  - 4 electrons between atoms = double bond
  - 6 electrons between atoms = triple bond

Fill in the information below based on the atom models in your kit.

○ Hydrogen (H) has 1 hole(s) in the atom which represents 1 potential bond(s) and 2 shared electrons

○ Chlorine (Cl) has 1 hole(s) in the atom which represents 1 potential bond(s) and 2 shared electrons

○ Oxygen (O) has 2 hole(s) in the atom which represents 2 potential bond(s) and 4 shared electrons

○ Nitrogen (N) has 3 hole(s) in the atom which represents 3 potential bond(s) and 6 shared electrons

○ Carbon (C) has 4 hole(s) in the atom which represents 4 potential bond(s) and 8 shared electrons

TRY THIS:

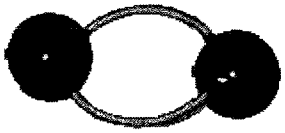
Part I: A carbon atom is very versatile and can bond to another carbon atom with a single, double, or triple bond. To see how, take out 6 black carbon atoms and connect them in pairs as follows:

A. connect one pair of carbon atoms together with one covalent bond (use one **wooden** link)

Carbon - carbon single bond 

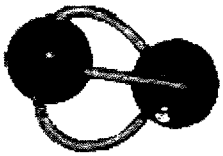
How many pairs of electrons are shared between the carbon atoms? 1

B. connect the second pair of carbon atoms together with two covalent bonds (use **two spring** links)

Carbon - carbon double bond 

How many pairs of electrons are shared between the carbon atoms? 2

C. connect the third pair of carbon atoms together with three covalent bonds (use **three spring** links)

Carbon - carbon triple bond 

How many pairs of electrons are shared between the carbon atoms? 3

For each bonded pair, try ***twist or rotating the atoms*** around their bonds and also wiggling the atoms with respect to each other.

1. Which arrangement, A, B or C shared covalent bonds, places the **least** constraint on the free motion of atoms?

A

2. Which arrangement, A, B or C shared covalent bonds, places the **greatest** constraint on the free motion of atoms?

C

The *greater the constraints* on free motion, the *less stable* the bonds are and the more likely it will break.

3. Which of these bond situations produces the most constrained, least stable, most reactive molecule?

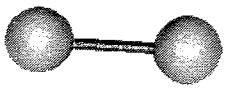
A) a single bond B) a double bond) C) a triple bond

Explain why you chose your answer: (C) more bonds, less stable more likely to break (greater "potential" to break) (React)

Name: Period: iPad #:

Part II:

Make a model of hydrogen gas, H_2. It consists of two hydrogen atoms connected by a single covalent bond. Take two hydrogen atoms and connect them together with a wooden link.



Hydrogen gas

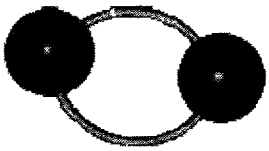
1. What does the link between the two atoms represent? Describe in terms of the structure of the atoms and their shared parts.

1 bond - 2 shared e -

2. Could you connect more than two hydrogen atoms together? Explain, in terms of the structure of the atoms and their shared parts, why or why not.

no; each only has 1 e- to share only needs 2 e- to fill its valence shell

Another simple molecule is oxygen gas, O_2. To model oxygen, take two oxygen atoms and covalently bond them together in such a manner that nothing else could be attached to either atom.



Oxygen gas

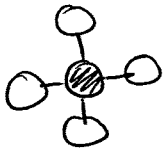
1. How many covalent bonds are required to connect two oxygen atoms together? 2

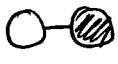
2. How many electrons are being shared by the two atoms? 4e-

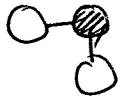
3. How many pairs of electrons are being shared by the two atoms? 2 pairs

<u>Using your model kit build the following molecules</u>

NH_3 CCl_4 HCl H_2O

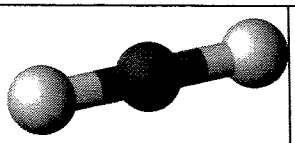
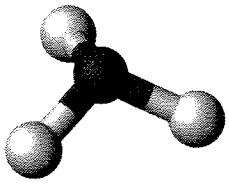
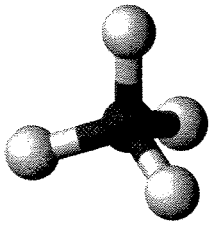






Name: Period: iPad #:

Match each of the covalent compounds created at the bottom of page 15 to the corresponding molecule shape below. Draw the model and write the chemical formula of the compound that belongs in the correct molecular shape.

LINEAR  HCl	**BENT**  H_2O
PYRAMIDAL  NH_3	**TETRAHEDRAL**  CCl_4

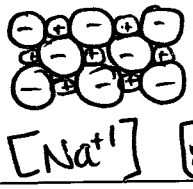
CONCLUSION QUESTIONS:

1. What is a chemical bond? Simultaneous attraction for e- btwn atoms
2. Why do most atoms form chemical bonds?
to stabilize + fill their valence shell (PEL)
3. What types of atoms are involved and how are Ionic Bonds formed?
metal + nonmetal metal transfers e- to n-metals
4. What types of atoms are involved and how are covalent Bonds formed?
shared e- between non-metals
5. In the 19th century, Dmitri Mendeleev predicted the existence of a then unknown element X with a mass of 68. He also predicted that an oxide of X would have the formula X_2O_3. On the modern Periodic Table, what is the group number and period number of element X?
group # 13 period # 4
6. Element X is a solid metal that reacts with chlorine to form a water-soluble binary compound.
   a. State one physical property of element X that makes it a good material for making pots and pans.
   mobile e-
   b. The binary compound consists of element X and chlorine in a 1:2 molar ratio. XY_2
   What is the oxidation number of element X in this compound? +2

Name: Period: iPad #:

7. A metal, M, was obtained from a compound in a rock sample. Experiments have determined that the element is a member of Group 2 on the Periodic Table of the Elements.
   a. What is the phase of element M at STP? Solid
   b. Explain, in terms of electrons, why element M is a good conductor of electricity.
   mobile e−
   c. Explain why the radius of a positive ion of element M is smaller than the radius of an atom of element M.
   element M will lose e− + become smaller (lose outer PEL)
   d. Using the symbol M for the element, write the chemical formula for the compound that forms when element M reacts with iodine. MI_2

Bonding Comparison Chart

	IONIC	COVALENT	METALLIC
Types of Atoms Involved	metal + nonmetal	non-metal + nonmetal	one metal only
Method of Bond Formation	transfer e−	share e−	mobile sea of e−
Type of structure /substance	crystalline lattice	soft	lattice
Physical State	solid	solid, L, G	solid (except Hg)
Melting Point	high	low	high
Electrical Conductivity	only as liquid or in water FREE IONS!	NEVER	always mobile e−
Sample/ example Lewis diagram Image	 [Na+] [:Cl:−]	H:Ö:H	Mg Mg Mg

FINALLY... ***Based on what you just learned, identify each compound as*** **IONIC (I) or COVALENT (C).**

KCl I Rb_2S I Cl_2 C PH_3 C CH_3Cl C SO_2 C $MgCl_2$ I

Fe_2O_3 I $NaBr$ I CaF_2 I SCl_6 C N_2O_5 I CuF_2 I CS_2 C