Honors Chemistry Chapter 6 Section 1 and 4, Chapter 7 Section 1

Chapter 6 Section 1: Introduction to Chemical Bonding pgs. 175-177.
Objectives:
1. **Define chemical bond.**
2. **Explain why most atoms form chemical bonds.**
3. **Describe ionic and covalent bonding.**
3. **Explain why most chemical bonding is neither purely ionic nor purely covalent.**
4. **Classify bonding type according to electronegativity differences.**

Vocabulary: Define the following.
1. **chemical bond--**

2. **ionic bonding--**

3. **covalent bonding--**

4. **nonpolar-covalent bond--**

5. **polar--**

6. **polar-covalent bond--**

Most atoms are not found as free elements in nature but rather form combinations with other atoms by means of a chemical bond in which there is an attraction between nuclei and valence electrons of the different atoms. ***A bond lowers the potential energy of each atom making the combination of atoms more stable.

Types of Bonds

Ionic Bonds
Ionic bonds generally are formed between ions. A metal often combines with a nonmetal. In an ionic bond electrons are completely lost from atom(s) and given to other atom(s) which take these electrons. The loss or gain of electrons make these atoms become ions.

Covalent Bonds
In a covalent bond electrons are shared between groups of atoms. Covalent bonds often form between nonmetals and nonmetals.
There are two different types of covalent bonds, those that are polar covalent bonds and those that are nonpolar. In both types of bonds electrons are shared but the degree of sharing determines the type of covalent bond. If one atom attracts the shared electrons more strongly than the other atom as in water, one end may be slightly positive and the other end slightly negative. This results in two differently charged ends or poles, and as such is called a polar covalent bond. If the sharing is more equal there are no slightly charged ends so there are no poles and as such is called nonpolar.

Difference in Electronegativities

Subtracting electronegativities from each other will determine the type of bond formed.
When atoms with different electronegativities share electrons the shared electrons are more strongly attracted to the atom that has the greater electronegativity. This type of bond is called a polar covalent bond.
In a polar bond, the more electronegative atom is slightly negative and the other atom is slightly positive. This is signified by the Greek letter delta (δ).
When the electronegativities are equal or nearly equal the bond is said to be nonpolar.

Diagram a group of water molecules from class lecture here in your notes.

Diagram **Polar Bonds in H_2O**

Electronegativities differences predict whether a bond is polar, nonpolar, or ionic. In general the following applies. If the electronegativity difference is:

$\leq$ 0.3 ---- nonpolar covalent
between 0.3 and 1.7----polar covalent
$\geq$ 1.7 ----ionic

Copy the above electronegativity differences onto your periodic table.
Use pg. 161 in your text to answer the following.
What type of bond is formed between:
(Show Work)

1. **Beryllium and oxygen?**

2. **Copper and sulfur?**

3. **Chlorine and chlorine?**

4. **Germanium (Ge) and arsenic (As)?**

5. **Iodine and bromine?**

6. **Calcium and oxygen?**

Section 4: Metallic Bonding pgs. 195-196

Metallic bonding is a small topic in chemistry. In brief, metallic bonding occurs between metal atoms in what is called a "sea of electrons" that surrounds each group of metal atoms. This

"sea" results from the fact that only the s orbitals are filled in the metals. The p orbitals contain no electrons at all and the d orbitals have only a few electrons. These unfilled orbitals allow electrons to move between adjacent atoms easily and results in high thermal and electrical conductivity. Since the outer electrons absorb light easily these electrons are constantly moving between higher and lower energy levels, continuously dropping back to the lower levels emitting the light most often associated with the luster seen in metals.
Two properties closely associated with metals are malleability and ductility. Malleability is the ability of a metal to be hammered into sheets. Ductility is a metal's ability to be able to be drawn into a thin wire.
The "vacancies" found in the orbitals also explains malleability and ductility in that electrons can slide past each other without the entire structure fracturing or breaking.

Chapter 7 Section 1: Chemical Names and Formulas pgs. 219-231.
Objectives:
1. **Explain the significance of a chemical formula.**
2. **Determine the formula of an ionic compound formed between two given ions.**
3. **Name an ionic compound given its formula.**
4. **Using prefixes, name a binary molecular compound from its formula.**
5. **Write the formula of a binary molecular compound given its name.**

Vocabulary: Define the following.
1. **monatomic ion**

2. **binary compound--**

3. **nomenclature--**

4. **oxyanion--**

5. **salt--**

A chemical formula shows the number of atoms of each kind in a chemical compound.
Ionic Bonds and Ionic Compounds-Formula Units
In an ionic bond, a positively charged ion is attracted to a negatively charged ion.
*****Ionic bonds are formed between metals and nonmetals and when polyatomic ions are involved.**
*****Ionic bonds form formula units.**
Ionic compounds are substances entirely composed of ions.
Positive ions are called cations.
Negative ions are called anions.
In ionic compounds the metallic element loses electron(s), while the nonmetallic element gains electron(s).

Monatomic Ions

Monatomic cations are formed from one atom. These ions have the same name as the element name with the word ion afterwards. For instance a magnesium atom that loses 2 electrons is called the magnesium ion and is written as Mg^{2+}.

Transition metals often form more than one ion and do not always follow the octet rule. Iron for instance can lose 2 or 3 electrons and can be written as $Fe^{2+,3+}$. The particular charge being used will be communicated to the reader by its name, (to be discussed shortly). Some of the more common transition metals with more than one valence need to be memorized. *****These include the following which need to be memorized tonight.

Memorize the following:

Chromium, $Cr^{2+,3+}$; Manganese, $Mn^{2+,3+}$; Iron $Fe^{2+,3+}$; Cobalt, $Co^{2+,3+}$; Copper, $Cu^{1+,2+}$; Tin, $Sn^{2+,4+}$; and Lead $Pb^{2+,4+}$.

Chemists use the Stock System to identify the particular ion. In the Stock System chemists use the English name for the element followed by the ion charge written in Roman numerals enclosed in parenthesis. The iron ion showing a 2+ charge is written as iron (II), and the iron showing the 3+ charge is written as iron (III).

Try writing the following in the Stock System:

Cr^{+2} _____ **and Cr^{+3}** _____

Mn^{+2} _____ **and Mn^{+3}** _____

Fe^{+2} _____ **and Fe^{+3}** _____

Co^{+2} _____ **and Co^{+3}** _____

Cu^{+1} _____ **and Cu^{+2}** _____

Sn^{+2} _____ **and Sn^{+4}** _____

Pb^{+2} _____ **and Pb^{+4}** _____

An older system of naming these 7 transition metal ions is called the Classical System. This system is gradually being phased out in favor of the Stock System, but still appears in the literature and in chemical supplies.

Therefore the student should familiarize themselves with this system.

The drawbacks of this older system are that Latin names must be memorized and the ion charge is not given but is found in the name. Here the lower of the two charges is written with the Latin ending changed to ous and the higher charge changed to ic.

Please commit the following to memory tonight.

Cr^{2+}--- chromous	**Cr^{3+}---chromic**
Mn^{2+}---manganous	**Mn^{3+}----manganic**
Fe^{2+}----ferrous	**Fe^{3+}-----ferric**
Co^{2+}----cobaltous	**Co^{3+}----cobaltic**
Cu^{1+}----cuprous	**Cu^{2+}----cupric**
Sn^{2+}-----stannous	**Sn^{4+}----stannic**
Pb^{2+}----plumbous	**Pb^{4+}----plumbic**

Monatomic Anions

Nonmetals form negative anions easily. Monatomic anions have their ending changed to ide. There is no set rule on what part of the ending to change, rather it depends on how the name looks and sounds. Thus the chlorine atom becomes the chloride ion, the fluorine atom becomes the fluoride ion, the sulfur atom becomes the sulfide ion, etc.
Write the following anion name.

Oxygen	_____	**Nitrogen**	_____
Carbon	_____	**Bromine**	_____
Phosphorus	_____	**Iodine**	_____
Fluorine	_____	**Sulfur**	_____

Remember the ending is only changed on the negative nonmetal anion, while the positive metal cation name is written as it appears on the periodic table.

Binary Ionic Compounds

Binary ionic compounds contain only 2 elements; a positive metal cation and a negative nonmetal anion. To show the ratio of one ion to another a subscript is used. Ones (1) are not used but are assumed to be there (as in math).
Crisscross Method of Writing Binary Ionic Compounds.
If the ratio of the ions is different, swap their ion charges and then write these charges as subscripts using the lowest common denominator.
The positive ion is always written first and the negative next. No ion charges should appear in the final formula. For instance, Na^{1+} combines with Cl^{1-} to form NaCl. No subscripts are written because the subscript for both is 1.
Na^{1+} combines with O^{2-} to form Na_2O. The ion charge 2^- of the O becomes the subscript of the Na and the ion charge 1^+ of the Na becomes the subscript of the O but is not written because it is 1.
Remember the ratios must be in the smallest whole number, so that Mg^{2+} and O^{2-} result in the compound Mg_2O_2 but both subscripts of 2 are reduced and the formula is written as MgO.
Examples: Write the formula of the compound formed from:

1. **sodium and sulfur Answer: Na_2S**
2. **magnesium and fluorine Answer: MgF_2**
3. **bromine and lithium Answer: LiBr (Positive ion first).**
4. **calcium and oxygen Answer: CaO (The crisscross method gives Ca_2O_2 and must be reduced to CaO).**

(Note: You will find that reducing to the lowest ratio does not apply in covalent compounds). The smallest whole number ratio is called the empirical formula and is referred to often as a formula unit. In binary ionic compounds this is the chemical formula. This is not the case in molecular compounds.

Try writing the chemical formulas of the following.

1. sodium and bromine _____ 2. lithium and fluorine _____

3. potassium and chlorine _____ 4. cesium and oxygen _____

5. magnesium and iodine _____ 6. sodium and sulfur _____

7. oxygen and potassium _____ 8. calcium and oxygen _____

9. sodium and nitrogen _____ 10. calcium and phosphorus _____

Naming Binary Ionic Compounds (2 elements)

For a metal and nonmetal binary ionic compound in which the metal has only one ion charge (columns IA and IIA) do the following:
1. Write the metal name as given in the periodic table.
2. Change the nonmetal name ending to ide.
Example:
Magnesium and chlorine combine to form magnesium chloride--- $MgCl_2$.
Lithium and sulfur combine to form lithium sulfide---Li_2S.
Write the following binary ionic names given the formula.

1. NaI _____ 2. CaO _____

2. K_2S _____ 4. $MgCl_2$ _____

5. $AlCl_3$ _____ 6. $SrBr_2$ _____

7. Li_3N _____ 8. Be_3P_2 _____

9. Ca_2C _____ 10. GaF_3 _____

Metals With More Than One Ion Charge

If the metal part of the compound forms more than one ion (the memorized 7) do the following using the Stock System.

1. **Write the name of the metal from the periodic table unchanged followed by the ion charge in Roman numerals.**
2. **Add the name of the anion whose ending is changed to ide.**
   Example: Fe_2O_3--iron (II) oxide. Pronounced iron 2 oxide.
   SnF_4-- tin(IV) fluoride. Pronounced tin 4 fluoride.

Write the Stock and Classical names for the following:

Formula	Stock Name	Classical Name
Cu_2O	_____	_____
CuO	_____	_____
$PbCl_2$	_____	_____
$PbCl_4$	_____	_____
SnO	_____	_____
SnF_2	_____	_____

Compounds Containing Polyatomic Ions

Polyatomic ions are a charged group of covalently bonded atoms. The polyatomic ions act as if they are a single ion when forming compounds. Trying to discover why these ions show a particular charge is beyond the scope of this course and instead should be memorized. These polyatomic ions appear very often in chemistry courses so it is essential that the student spend a good deal of time memorizing the most common polyatomic ion formulas, names, and their charges.

Most polyatomic ions are negative and contain oxygen. Those that contain oxygen are called oxyanions. Different elements can form many types of oxyanions. Some such as chlorine can form up to 4 oxyanions. The following combinations of prefixes and suffixes are used to show the different number of oxygens. The suffix ite is lower than ate in the number of oxygens but does not tell exactly how many oxygens and therefore must be memorized instead. If there is another oxyanion of the same element with less oxygen than the ite form than the prefix hypo is used. If there is an additional form with more oxygens than the ate form then the prefix per is used.

Example:

hypochlorite--ClO^{-1}
chlorite--ClO_2^{-1}
chlorate--ClO_3^{-1}
perchlorate--ClO_4^{-1}

*******Memorize the following from pg. 226 of your text tonight tonight!!!!!**

1^-	2^-	3^-
OH^{1-} ----hydroxide	CO_3^{2-} ---carbonate	PO_4^{3-} ---phosphate
NO_2^{1-} ---nitrite	SO_3^{2-} ---sulfite	
NO_3^{1-} ---nitrate	SO_4^{2-} ---sulfate	
CN^{1-} ---cyanide		
$C_2H_3O_2^{1-}$---acetate		

1^+

NH_4^{1+}---ammonium

The crisscross or swapping method of trading ion charges for subscripts also works in polyatomic ions. If only one polyatomic ion is needed a parenthesis is not used. A parenthesis encloses the entire polyatomic ion if more than one is needed to balance the other ion's charge. Example: sodium hydroxide ---NaOH; sodium carbonate--Na_2CO, calcium nitrite----$Ca(NO_2)_2$

Try writing the <u>formula</u> of the following polyatomic compound names.

1. magnesium hydroxide _____

2. calcium phosphate _____

3. ammonium sulfate _____

4. hydrogen cyanide _____

5. ammonium oxide _____

6. strontium nitrate _____

<u>Polyatomic Compound Names (More than 2 elements)</u>

Most of the common polyatomic names have a negative charge. Most are quite easy to name as long as you have memorized the polyatomic name.

Just write the name of the metal and add the polyatomic name. For instance Na_2SO_4 is sodium sulfate, and $Ca(OH)_2$ is calcium hydroxide.

Be careful always to check that the metal is not one of the 7 metals with more than one charge. When you encounter this be sure and add the Roman numeral name to the name. For instance, CuOH is copper (I) hydroxide, and Cu_2SO_4 is copper (II) sulfate. Try the following:

1. LiOH _____ 2. $Ca(OH)_2$ _____

3. $NaNO_2$ _____ 4. Na_3PO_4 _____

5. $SnCO_3$ _____ 6. $Pb(NO_3)_4$ _____

Write the formula given the name for the following:

7. beryllium sulfite _____ 8. calcium phosphate _____

9. copper (II) oxide _____ 10. stannic fluoride _____

11. ammonium hydroxide _____ 12. potassium nitrate _____

Covalent (Molecular) Bonding

Covalent bonds form molecules. Ionic bonds form formula units. In ionic bonds electrons are completely given and taken away. In covalent bonds electrons are shared. Covalent bonds form between nonmetals and nonmetals.

A molecular formula is used to describe covalent compounds.

Naming Molecular (Covalent) Compounds

Binary molecular compounds follow the same rules for naming as binary ionic compounds in that the ending of the last element's name is changed to ide. The difference is that prefixes are used to identify the subscripts of the both atoms. It is necessary to memorize the following prefixes.

one---- mono* **	**six---- hexa**
two---- di	**seven-----hepta**
three----tri	**eight--- -octa**
four---- tetra	**nine---- nona**
five---- penta	**ten---- deca**

*****mono is not used as a prefix for the first element of the compound.**

Examples: CO---carbon monoxide
CO_2---carbon dioxide
N_2O_4---dinitrogen tetroxide
PCl_3---phosphorus trichloride

If the element to which a prefix is attached begins in a vowel the i or a of the prefix is dropped, so N_2O_5 would be named dinitrogen pentoxide.

Try the following:

1. NO_2 _____ **2. BF_3 _____**

3. P_2O_5 _____ **4. CCl_4 _____**

5. ICl_3 _____ **6. SO_3 _____**

Acids

An acid is a molecular substance that dissolves in water to produce hydrogen ions (H^+). The formulas for acids are easily recognized because they begin with H such as: HCl, hydrochloric acid; HF, hydrofluoric acid.

The names for most binary acids are obtained by using hydro for the H and changing the ending of its anion to ic followed by the word acid as shown above.

What is the name of HI?

HI Answer: _____

What is the formula of hydrobromic acid? Answer: _____

For acids that are formed from polyatomic ions it is easier for now to memorize the names of these types of common acids. The common acids to be memorized are:

HNO_3--nitric acid
H_2CO_3--carbonic acid
H_2SO_4--sulfuric acid
H_3PO_4--phosphoric acid
$HC_2H_3O_2$--acetic acid

An ionic compound formed from a cation and an anion from an acid is called a salt.

Summary of Naming Chemical Compounds

I. The compound has only 2 elements ----Go to 1a and 1b.

1a. Made of a metal and a nonmetal---ionic -----Go to 2a and 2b.
1b. Made of a nonmetal and a nonmetal ---molecular -----Go to 3a and 3b.

2a. The metal is not one of the 7 memorized metals with more than one ion. Leave the metal name alone and change the nonmetal ending to ide. ex: NaF, sodium fluoride.
2b. The metal is one of the 7 metals with more than one ion charge. Write the ion charge as a Roman numeral enclosed in parenthesis. Change the ending of the metal to ide. ex. copper (II) sulfide CuS.
3a. The compound does not begin with H -----Go to 4a.
3b. The compound begins with H---an acid - ----Go to 4b.

4a. Use prefixes to identify the subscripts in both elements, (do not use mono for the first element), change the ending of the second element to ide. ex: N_2O_4, dinitrogen tetroxide.
4b. The compound begins with H and is an acid. Use hydro to represent the hydrogen. Change the ending of the second element to ic and add the word acid. ex: HCl, hydro-chloric acid.

II. The compound has 3 elements -----Go to 5a and 5b.

5a. The first element is a metal -----Go to 6a and 6b.
5b. The first element is H -----Go to 7a.

6a. The metal is one of the 7 metals with more than one ion charge. Write the metal with the Roman numeral of its charge in parenthesis. Add the polyatomic name. ex: $Fe(OH)_2$, iron (II) hydroxide.
6b. The metal is from column IA or IIA. Write the name of the metal unchanged and add polyatomic name. ex: $CaSO_4$, calcium sulfate.
7a. The compound is an acid. Write the memorized name. ex: H_2SO_4, sulfuric acid.

III. The compound has 4 or more elements -----Go to 8a and 8b.

8a. The compound has water molecules added---a hydrate. Write the name of the compound to which the water has been added using the above steps. Use prefixes to identify the number of water molecules. Add the word hydrate.
ex: $CuSO_4 \cdot 5\ H_2O$, Copper (II) sulfate pentahydrate.
8b. The compound does not have water attached. The only compound studied with 4 elements has the polyatomic ion ammonium as a beginning, bonded to another polyatomic ion . Write ammonium followed by the name of the second polyatomic ion. ex: NH_4NO_3, ammonium nitrate.