Chemical Formulas and Equations

I. Handout: Condensed Notes
II. Elements
    I. Metals
        i. Form large crystals of many atoms. See large version of image at right. (This image, used with permission, was created by C.H. Mak at Virginia Tech. University)
        ii. Share electrons among all atoms in the crystal.
        iii. Bond is formed by common attraction of each nucleus for all nearby electrons and ease of electron mobility. This is why many metals are ductile. As one bends or shapes a metal bonds can break and reform fairly easily.
        iv. See video clip on metal structure.
        v. See video clip on steel structure.
    II. Nonmetals
        i. Exist as monatomic or diatomic gasses or larger crystals formed through covalent bonds think of these as forming small molecular units. See large version of image at right. (This image, used with permission, was created by C.H. Mak at Virginia Tech. Universit
        ii. Covalent bonds are formed when one or more electrons are shared between two specific atoms.
    III. Metalloids - these are somewhere between metals and nonmetals, possessing bonding patterns as well as other properties in common with both groups.
III. Compounds
    I. Ionic compounds - See large version of image at right. (This image, used with permission, was by C.H. Mak at Virginia Tech. University)
        i. Forms large crystals consisting of metals and nonmetals.
        ii. An ionic bond is formed between oppositely charged metals and nonmetals (oppositely charged ions).
        iii. The ionic bond is formed by the attraction between opposite charges.
        iv. See video clip on ion formation

iii.A covalent bond or the sharing of electrons between specific atoms is what bonds these nonmetals together.
iv.See video clip on covalent bond formation.
v.When dissolved in solution the molecules stay whole retaining the covalent bonds between the atoms. The atoms don't separate from each other when dissolved.

III.Acids
i.These compounds fall somewhere in-between.
ii.Many acids are molecular in pure form, but ionic when dissolved.
iii.The trademark quality of an acid is that it will produce H^{+1} ions when dissolved.
iv.For example, HCl in pure form is a gas formed of diatomic molecules. When dissolve breaks up into separate ions: H^{+1} and Cl^{-1}.

i.Demo: Conductivity of various compounds.
ii.Flash illustration of Dissolving Compounds
iii.**Homework:Discriminating between Substances sheet**

IV.Naming Substances and Writing Formulas
i.Elements
a.The names of the elements are given on the periodic table.
b.Formulas are written differently depending on the element.
1.The formula for most elements is just its symbol. For example, Na for sodium or Xe fo
2.Some elements naturally come in diatomic molecules. When expressing this element we would write a formula indicating this state. There are seven diatomic elements: H_2 Br_2, and I_2. You should memorize these.

ii.Compounds
a.Ionic Compounds
I.Ionic compounds are formed between oppositely charged ions.
II.An ion can be a single charged atom or a small group of atoms (molecule) with a cha
III.Binary Ionic Compounds (compounds composed of two single atom ions)

adding -ide.

ii.Formula writing

a.To write the correct formula you must know the charges present on each ion you would look on the periodic table or your common ion sheet.

b.The positive and negative charges must exactly balance each other in order t ratio of ions to form a neutral compound.

c.Sodium can form a +1 charged ion and is written: Na^{+1}

d.Sulfur can form a -2 charged ion and is written: S^{-2}

e.The formula for Sodium Sulfide is Na_2S

f.Some other common ions that you should memorize: K^{+1}, Ag^{+1},Mg^{+2}, Zn^{+} O^{-2}, Cl^{-1}

g.Try some examples below:

Calcium Fluoride =

Potassium Chloride =

Lithium Oxide =

Aluminum Sulfide =

IV.Polyatomic Ionic Compounds

i.Sometimes a group of atoms can have a charge. This is called a poly atomic ion.

ii.Some common poly atomic ions which you should memorize are: nitrate NO_3^{-} carbonate CO_3^{-2}, bicarbonate (or hydrogen carbonate) HCO_3^{-1}, and hydroxide OH

iii.Notice that the names of these ions end in -ate.

iv.When you see a name ending in -ate it probably implies that it is a polyatomic i

v.The groups of atoms can be thought of as a single entity with a charge, just like a

a

charge. For example, Sodium Nitrate needs one +1 sodium ion to neutralize one

Sodium Sulfate =

Zinc Phosphate =

Barium Hydroxide =

Ammonium Sulfate =

V.Ions with multiple charges

i.Some atoms can commonly form 2 or 3 different charges. These atoms are typica elements.

ii.Copper, for example, usually forms +1 or +2 charged ions.

iii.This can cause problems if a compound is named Copper Oxide. This could hav Cu_2O depending on the charge of the copper atom.

iv.To clear up this ambiguity we can name the ions by specifically adding on a nu Cu+1 is Copper(I) and Cu+2 is Copper(II). So the names of the copper compounds liste Copper(II)Oxide for CuO and Copper(I)Oxide for Cu_2O.

v.Try some examples below:

Iron(II)Oxide =

=CuSO4

Iron(III)Oxide =

= $Cr(NO_3)_3$

b.Handout: Solubility Rules and Common Ions

c.Homework: Read pp. 166-174; Binary Ionic Naming Sheet

d.Homework: Binary Ionic With Roman Numerals.

e.Homework: Polyatomic Ion Sheet.

f.Molecular Compounds

I.Molecular naming falls into two groups - organic and inorganic. We will talk about ino now. Later this year an entire unit will be dedicated to the study of organic molecules

II.Prefixes which indicate the number of atoms of each element are used in the namin

hepta- = 7

octa- = 8

nona- = 9

deca- = 10

III. When given a formula the prefixes above are applied to the words that would be us
the compound as if it were ionic. For example, P_2O_3 would be named Phosphorous C
were ionic, but it consists of two nonmetals, so it would be named Diphosphorous Tr

IV. Whenever there is only one atom of the first element in a formula we drop the ter
example CO is Carbon Monoxide, not Monocarbon Monoxide.

V. To write formulas you just interpret the prefixes on the names and write the approp
symbolic representation. For example, Sulfur Dioxide is SO_2.

VI. Try some of the following examples:

Carbon Tetrachloride =

$=N_2O$

Trinitrogen Pentoxide =

$= CO_2$

VII. There are special cases where we use common names for molecular compounds. T
two that I want you to memorize are: Water = H_2O and Ammonia = NH_3 (not to be
with the amonium ion = NH_4^{+1}

g. Ban dihydrogen monoxide! DMHO Fact Sheet- Join the movement by clicking here.

h. Acids

I. Binary Acids

i. As a general rule the formula for an acid starts with hydrogen.

ii. If acid consists of just two elements, then it is named Hydro-_____-ic Acid.

iii. For example HCl is Hydrochloric Acid

b.HNO_3 = Nitric Acid

c.$HC_2H_3O_2$ = acetic acid

i.Homework: Naming Various Chemicals Sheet

j.Get some extra practice on naming substances at the ChemTeam website.

iii.General naming and formula writing strategy

I.General naming strategy

i.Determine if the formula depicts an ionic compound (metal and nonmetal), a m
compound (two nonmetals), or an acid (begins with hydrogen).

ii.If ionic, determine the names of the ions and write the name putting the metal f

iii.If molecular, determine the names of the nonmetals and add the appropriate pr
before writing the name.

iv.If an acid, it is either in the form hydro-_____-ic acid or it is one of the ones y
memorized.

II.General formula writing strategy

i.Determine if the name depicts an ionic compound (metal and nonmetal), a mol
compound (two nonmetals), or an acid (has the word acid in its name).

ii.If ionic, determine the charges on the ions and write a formula that will yield a n
compound.

iii.If molecular, write a formula using the prefixes in the name to determine the su
in the formula.

iv.If an acid, then it is either one of the ones you memorized or it's H__. (hydroge
followed by some single element)

V.Writing Chemical Equations

I.A chemical equation is a symbolic representation of what happens during a chemical reaction

II.To describe the reaction you did between baking soda and hydrochloric acid in words you would write: Sodium Bicarbonate reacts with Hydrochloric Acid to produce Carbon Dioxide Water, and Sodium Chloride.

III.In symbolic form we would write: $NaHCO_3 + HCl \rightarrow CO_2 + H_2O + NaCl$

i. Typically ionic compounds won't react with each other unless they are dissolved in water. Therefore, most of our reactions with ionic compounds will be in the aqueous phase.

ii. A reaction only occurs if one of the products formed would be insoluble in water. Whe an insoluble compound is formed from a reaction between two aqueous solutions, we call this compound a precipitate. See the Precipitation Rules Sheet to learn if an insoluble compound would form.

iii. When combining two aqueous ionic compounds you basically have four different ion floating around in solution. The positive and negative ions from each compound have the opportunity to come in contact and react. If the new compound formed is insoluble then a precipitate forms.

iv. We can write the reaction between Sodium Chloride and Lead(II)Nitrate in several ways.

a. In words it would be:

Sodium Chloride + Lead(II) Nitrate --> Sodium Nitrate + Lead(II) Chloride

b. In formulas it would be

$NaCl_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow NaNO_{3(aq)} + PbCl_{2(s)}$ (see an illustration of this below)

c. Notice that the $NaNO_3$ is still dissolved. Basically, the sodium and nitrate ions did not really do anything. They were floating around dissolved in solution before and after the reaction. So, we have another way of writing this equation which is called the net ionic equation:

$Pb^{+2}_{(aq)} + Cl^{-1}_{(aq)} \rightarrow PbCl_{2(s)}$

VII. Reactions with all other substances utilize the "In formulas" method listed above.

II. Let's recall the reaction between Sodium Chloride and Lead(II) Nitrate:

$NaCl_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow NaNO_{3(aq)} + PbCl_{2(s)}$

Where did the second chloride ion come from, and where did the other nitrate ion go?

III. Every atom that appears on the left side of the arrow must also appear on the right side. It might be tempting to fix this problem by rewriting $PbCl_2$ as PbCl, but that would be the incc formula for Lead(II) Chloride. Pb^{+2} must pair up with two Cl^{-1}s.

IV. We resolve this by placing coefficients in front of the formulas indicating that you can ha different ratios of the substances reacting to form different ratios of products. To fix the abo reaction we would rewrite it as:

$2\ NaCl_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow 2\ NaNO_{3(aq)} + PbCl_{2(s)}$

V. The 2 in front of NaCl give you 2 Nas and 2 Cls. The 2 in front of the $NaNO_3$ gives you 2 N N, and 6 O. If you count up all the atoms on the left and right of the arrows you will have t same number of each element. The equation is now balanced.

VI. An unbalanced equation is like having a recipe with no quantities for each ingredient.

VII. Click here to see a visual representation of balancing equations by C.H. Mak at Virginia T

i. Homework: Read pp. 238-244 and pp. 248-249; Balance Practice

ii. If you want even more practice on balance equations click here to see the ChemTeam's set of

iii. Lab: Seven Solution Lab

VII. Types of Reactions

I. Reactions can placed in broad categories.

i. Synthesis

a. This occurs when the number of products is fewer than the number of reactants.

b. In symbolic form: A + B --> AB

b.In symbolic form: A + BC --> AC + B or A + BC --> BA + C

c.Concrete example: $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

iv.Double Replacement (or Displacement)

a.This occurs when two sets of elements switch places in a reaction.

b.In symbolic form: AB + CD --> AD + CB

c.Concrete example: $2\ NaCl_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow 2\ NaNO_{3(aq)} + PbCl_{2(s)}$

d.There are two special cases which have specific names given to them

1.When the reaction is between two ionic compounds and they form a precipitate, this reaction is also called a Precipitation. The example given above shows this.

2.When the reaction is between an acid and a base (any compound that forms hydroxide ions), water is formed as one of the products. This is called Neutralization. For example:

$H_2SO_{4(aq)} + 2\ NaOH_{(aq)} \rightarrow 2\ H_2O_{(l)} + Na_2SO_{4(aq)}$

v.Combustion

a.Typically combustion occurs when a hydrocarbon reacts with oxygen to produce carbon dioxide and water. Hydrocarbons are a class of compounds that primarily consist of hydrogen and carbon.

b.In symbolic form: $CxHy + O_2 \rightarrow CO_2 + H_2O$

c.Concrete example: $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$

II.Some common chemical reactions that you should be familiar with:

a.acid + base ----> water + ionic compound

b.metal + oxygen ---> ionic compound

c.metal + acid ---> hydrogen gas + ionic compound

d.ionic compound1 + ionic compound2 ---> ionic compound3 + ionic compound4

e.acid + carbonate ---> carbon dioxide + water + ionic compound

f.metal1 + ionic compound1 ---> metal2 + ionic compound2