High School
Honors Chemistry
Eytcheson

4TH QUARTER CURRICULUM PACKET

Hayward Community School District
715-634-2619

#HurricaneStrong

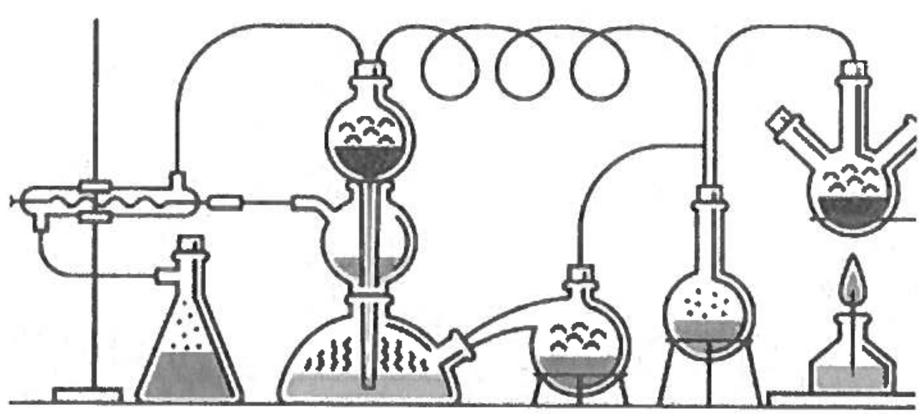
Honors Chemistry Materials

For

the rest of the school year

Spring 2020

*As always – check Google Classroom & email for updates and changes to curriculum and schedule.



Chemistry

Unit 5: Counting Particles Too Small To See

Activities and Assignments

- ✓ Relative Mass Lab
- ✓ WS 5-1: Molar Masses of the Elements
- ✓ WS 5-2: The Mole
- ✓ WS 5-3: Molar Mass Conversions & Numbers of Particles
- ✓ Empirical Formula Lab
- ✓ Quiz
- ✓ WS 5-4: Empirical & Molecular Formulas
- ✓ Unit Review WS
- ✓ Unit 5 Exam

Standards

24. I am able to calculate the relative mass of substances, based upon a set of data.
25. I am able to define molar mass and determine the molar mass of a pure substance, based on a chemical formula.
26. I am able to convert between mass, moles and particle numbers in a sample of a pure substance.
27. I am able to relate mass data about a compound to the percent composition and the empirical & molecular formulas of the substance.

Study Guide

- State evidence for Avogadro's Hypothesis.
- Use Avogadro's Hypothesis and experimental data to determine the relative mass of molecules.
- Use experimental data to determine the relative mass of two objects.
- Use experimental data to determine the number of items in a sample without actually counting them.
- Given the chemical formula of a substance, determine the molar mass.

- Given the mass of a substance, determine the number of moles of the sample and the number of atoms or molecules in the sample.
- Given the number of moles of a substance, find the mass of the sample and the number of atoms or molecules in the sample.
- Given the formula of a compound, determine its percent composition.
- Given data about the percent composition of a sample, determine the empirical formula of the compound.
- Given the empirical formula and information about the molar mass of the compound, determine the molecular formula.
- Define Avogadro's Hypothesis, relative mass, mole, percent composition, empirical formula, and Avogadro's number.

Counting Particles Too Small To See

Unit 5

Relative Atomic Masses

- Since masses of atoms are extremely small, scientists use relative masses when referring to the mass of an atom.
- Relative masses are the mass of an atom in comparison to some standard.
- Scientists have chosen Carbon-12 as the standard and given it the arbitrary mass of 12 atomic mass units (amus).

Relative Atomic Masses

- One atomic mass unit, or 1 amu, is exactly 1/12th the mass of a carbon-12 atom, or 1.660 540 x 10^{-27} kg.
- The atomic masses of all other atoms is determined by comparing it to the carbon-12 atom.
- Isotopes of different masses do not differ very much in their chemical behavior.

Average Atomic Mass

- Most elements occur naturally as a mixture of isotopes.
- Scientists need to account for the % of occurrence when calculating the average atomic mass of the element.
- Average atomic mass is the weighted average of the atomic masses of the naturally occurring isotopes of an element.

Calculating Average Atomic Mass

(amu isotope 1)(% occurrence) +
(amu isotope 2)(% occurrence) +
(amu isotope 3)(% occurrence).....=
Average atomic mass in amus

Relating Mass to Numbers of Atoms

- The relative atomic mass scale makes it possible to know how many atoms of an element are present in a sample of the element with a measurable mass.

The Mole

- SI unit of amount of substance.
- A mole (mol) is the amount of a substance that contains as many particles as there are atoms in exactly 12 g of carbon-12.
- The mole is a counting unit.

Avogadro's Number

- The number of particles in a mole has been experimentally determined to be 6.022×10^{23}.
- 12 g of carbon-12 contains 6.022×10^{23} atoms C.
- Particles = atoms = ions = molecules

Molar Mass

- The mass of Avogadro's number of atoms of a substance.
- The mass of 1 mol of a pure substance is called the molar mass (MM) of that substance.
- Molar mass is numerically equal to the atomic mass of that substance.
- Units are g/mol.
- H has molar mass of 1.00794 g/mol.

Gram/Mole Conversions

- Molar mass is used as a conversion factor in mass-mole problems.
- 1 mol A = atomic mass A in g.

g A	1 mol A	= mol A
	At. Mass A g	

mol A	At. Mass A g	= g A
	1 mol A	

Mole/Particles Conversions

- Avogadro's number is used as a conversion factor in mole-particles problems.
- 1 mol A = 6.022×10^{23} particles A

$$\text{mol A} \times \frac{6.022 \times 10^{23} \text{ particles A}}{1 \text{ mol A}} = \text{particles A}$$

$$\text{particles A} \times \frac{1 \text{ mole A}}{6.022 \times 10^{23} \text{ particles A}} = \text{moles A}$$

Gram/Particles Conversions

- Use both conversion factors in these problems.

$$\text{g A} \times \frac{1 \text{ mol A}}{\text{At. Mass A g}} \times \frac{6.022 \times 10^{23} \text{ particles A}}{1 \text{ mol A}} = \text{particles A}$$

$$\text{particles A} \times \frac{1 \text{ mol A}}{6.022 \times 10^{23} \text{ particles A}} \times \frac{\text{At. Mass A g}}{1 \text{ mol A}} = \text{g A}$$

Using Chemical Formulas

Formula Mass

- FM = sum of atomic masses in g or amu.
- Example: Sodium
- FM of Na = 22.99 g Na
  - This is the atomic mass from the periodic table for sodium.
  - Remember, rule is to take atomic masses off the Periodic Table rounded to 2 decimal places.

Example: H_2O

- FM of H_2O is

2 H x 1.01g = 2.02g
1 O x 16.00g = 16.00g
18.02 g

- FM is aka molecular mass or molecular weight.

Percentage Composition

- It is useful to know the percentage by mass of an element in a compound.
- If we needed a source of oxygen you would want to choose a compound that has a lot in it in order to be efficient.
- Formula used to calculate % comp.:

$$\%comp = \frac{\text{FM of element in cmpd}}{\text{FM of cmpd}} \times 100\%$$

Example: % Comp. of Cu_2S

1. FM of compound
   2Cu x 63.55g = 127.10g
   1S x 32.07g = 32.07g
   159.17 g Cu_2S
2. % Cu
   $\frac{127.10\text{ g}}{159.17\text{ g}} \times 100\% = 79.85\%$ Cu
3. % S
   $\frac{32.07\text{ g}}{159.17\text{ g}} \times 100\% = 20.15\%$ S

You can subtract one from 100% to get 2nd answer, but….
What if you are wrong?!?!?

Determining Chemical Formulas

What Is an Empirical Formula?

- An empirical formula consists of the symbols for the elements combined in a compound, with subscripts showing the smallest whole-number mole ratio of the different atoms in the compound.
- aka: simplest formula

Diborane

EF = BH_3

Molecular formula = B_2H_6

Calculation of Empirical Formula

A. Need composition data. This can be given in mass or % composition in the problem.

78% boron

22% hydrogen

Calculation of Empirical Formula

1. If given in % comp., change it to grams. You may assume you have 100g of the cmpd.

   78% B = 78g B

   22% H = 22 g H
2. If given in mass - begin with that data.

Calculation of Empirical Formula

B. Convert the mass data to moles.

$$78 \text{ g B} \times \frac{1 \text{ mol B}}{10.81 \text{ g B}} = 7.216 \text{ mol B}$$

$$22 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 21.78 \text{ mol H}$$

Calculation of Empirical Formula

C. Calculate the ratio of the elements in the cmpd.

7.216 mol B : 21.78 mol H

*Must be a simple whole number ratio.

$$\frac{7.216 \text{ mol B}}{7.216} : \frac{21.78 \text{ mol H}}{7.216}$$

1 mol B : 3.01 mol H or 1 mol B : 3 mol H

Calculation of Empirical Formula

D. Write the empirical formula.

1 mol B : 3 mol H

BH_3

EF Summary of Steps

1. Composition Data
2. Composition in g
3. Convert to moles
4. Calculate mole ratio
5. Write EF

Calculation of Molecular Formula

- The relationship between the EF and its MF is

X(EF) = MF

X = whole number multiplier

- Once the X is known, it can be used to calculate the MF.
- To calculate X

X(EF FM) = MF FM

Calculation of Molecular Formula

A. Calculate FM of EF

BH_3 = 1 B x 10.81 g = 10.81 g
3H x 1.01 g = 3.03 g
13.84 g BH_3

Calculation of Molecular Formula

B. Need FM of MF

- This will be given in the problem.

MF FM = 27.67 g

Calculation of Molecular Formula

C. Calculate X

X(EF FM) = MF FM

X(13.84 g) = 27.67 g

X = 2

Calculation of Molecular Formula

D. Determine MF

X(EF) = MF

$2(BH_3) = B_2H_6$

MF Summary of Steps

1. Calculate FM of EF
2. FM of MF (given)
3. Calculate X
4. Determine MF

Chemistry Name____________________
Unit 5: Counting Particles Too Small To See
Mrs. Eytcheson Due Date:
WS 5-1

Molar Masses of the Elements

Relative Mass From Gases

We have established that the combining ratio of gases can be explained if two assumptions are made:

1. Equal volumes of gases contain the same number of molecules at the same pressure and temperature.
2. Some pure elemental gases are clustered into pairs to form diatomic molecules.

Use these assumptions and particle diagrams to explain the fact that the density of oxygen gas at standard temperature and pressure is 1.43 g/liter, whereas the density of hydrogen gas under these conditions is 0.089 g/liter. How many times more massive is one molecule of oxygen than one molecule of hydrogen?

You shouldn't conclude that chemists were able to determine the molar masses of all the elements using this technique. Measurements of the density of the gaseous phase of many of the elements are difficult, if not impossible. However, we are going to see that chemists could use another tool – the *percent composition of compounds* to determine molar masses.

Relative Mass From Compounds

Many substances combine with oxygen to form a type of compound called an oxide. In the previous unit we saw that such combinations often occur in multiple proportions.

John Dalton made the assumption that the lowest ratio was a 1:1 combination of elements. For now, we will make a similar assumption. *We may have to re-examine this assumption later.*

In Unit 4 you examined % composition data of several compounds. For example, 100 g of the simplest oxide of carbon contains 42.9g of C and 57.1 g of O. To be able to compare masses of elements to the mass of oxygen, it is important to use the same mass of oxygen in all of the ratios. Using a proportion, one can show that 75.0 g of C combines with 100 g of oxygen.

$$\frac{42.9gC}{57.1gO} = \frac{75.0gC}{100gO}$$

In like manner, the masses of the elements in various oxides were calculated and shown in the table below.

Element	Mass of element that combines with 100 g of oxygen	Dalton's relative mass Question 1	Adjusted relative mass Question 3
Hydrogen	12.5 g	1.0	1.0
Carbon	75.0		
Nitrogen	87.5		
Oxygen	100 g		
Iron	349		
Mercury	1250		
Silver	1349		

1. If these elements combine in a 1:1 ratio, then the values in the 2nd column could be used to compare the masses of these elements. As you did in the relative mass lab, divide these values by the mass of hydrogen to obtain relative masses of the elements. Record these values in the 3rd column. These are the values Dalton reported for the relative masses of these elements.

2. Compare the value for the mass of oxygen you obtained this way with the value you calculated earlier. Sketch particle diagrams for both Dalton's and our current model of water. Use these to explain why Dalton's mass for oxygen is too low.

3. Since the mass Dalton obtained for oxygen was half of the accepted value, adjust the values you obtained for the other elements and record them in the 4th column. How do these values compare to the molar masses in the Periodic Table? Are there any other elements that do not combine in a 1:1 ratio? Explain.

Chemistry

Unit 5: Counting Particles Too Small To See

Mrs. Eytcheson

WS 5-2

Name ______________________________

The Mole

To help you better visualize the enormous size of Avogadro's number, 6.022×10^{23}, consider the following analogies:

1. If we had a mole of rice grains, all the land area of the earth would be covered with rice to a depth of about 75 meters!

2. One mole of rice grains is more grain than the number of **all** grain grown since the beginning of time.

3. One mole of marshmallows (standard 1 in^3 size) would cover the United States to a depth of 650 miles.

4. If the Mount St. Helens eruption had released a mole of particles the size of sand grains, the entire state of Washington would have been buried to a depth equal to the height of a 10-story building.

5. A mole of basketballs would just about fit perfectly into a ball bag the size of the earth.

Your turn

NOTE: To earn credit for these problems, you MUST show your work using dimensional analysis, scientific notation, significant figures and labels.

6. Assuming that each human being has 60 trillion body cells (6×10^{13}) and that the earth's population is 6 billion (6×10^{9}), calculate the total number of living human body cells on this planet. Is this number smaller or larger than a mole?

7. A supercomputer, nicknamed Roadrunner, built by IBM for the Los Alamos National Labs can perform about 1.03 petaflop/s (1 petaflop is 1×10^{15} calculations). Determine how many seconds it would take this computer to count a mole of things. Convert this figure into years.

8. If you started counting when you first learned how to count and then counted by ones, eight hours a day, 5 days a week for 50 weeks a year, you would be judged a 'good counter' if you could reach 4 billion by the time you retired at age 65. If every human on earth (about 7×10^{9}) were to count this way until retirement, what fraction of a mole would they count?

Chemistry
Unit 5: Counting Particles Too Small To See
Mrs. Eytcheson
WS 5-3

Name ____________________

Due Date:

Mass-Mole-Particle Conversions

1. An old (pre-1987) penny is nearly pure copper. If such a penny has a mass of 3.3 g, how many moles of copper atoms would be in one penny?

2. Four nails have a total mass of 4.42 grams. How many moles of iron atoms do they contain?

3. A raindrop has a mass of 0.050 g. How many moles of water does a raindrop contain?

4. What mass of water would you need to have 15.0 moles of H_2O?

5. One box of Morton's Salt contains 737 grams. How many moles of sodium chloride ($NaCl$) is this?

6. A chocolate chip cookie recipe calls for 0.050 moles of baking soda (sodium bicarbonate, $NaHCO_3$). How many grams should the chef mass out?

7. Rust is iron (III) oxide (Fe_2O_3). The owner of a 1959 Cadillac convertible wants to restore it by removing the rust with oxalic acid, but he needs to know how many moles of rust will be involved in the reaction. How many moles of iron (III) oxide are contained in 2.50 kg of rust?

8. First-century Roman doctors believed that urine whitened teeth and also kept them firmly in place. As gross as that sounds, it must have worked because it was used as an active ingredient in toothpaste and mouthwash well into the 18th century. Would you believe it's still used today? Thankfully, not in its original form! Modern dentists recognized that it was the ammonia that cleaned the teeth, and they still use that. The formula for ammonia is NH_3. How many moles are in 0.75 g of ammonia? How many molecules?

9. Lead (II) chromate, $PbCrO_4$, was used as a pigment in paints. How many moles of lead chromate are in 75.0 g of lead (II) chromate? How many atoms of oxygen are present?

10. The diameter of the tungsten wire in a light bulb filament is very small, less than two thousandths of an inch, or about 1/20 mm. The mass of the filament is so very small – 0.0176 grams – that it would take 1,600 filaments to weigh an ounce! How many tungsten atoms are in a typical light bulb filament?

11. Two popular antacids tablets are Tums and Maalox. The active ingredient in both of these antacids is calcium carbonate, $CaCO_3$. Tums Regular Strength tablets contain 0.747 g and Maalox tablets contain 0.600 g of calcium carbonate. Compare the number of formula units of calcium carbonate in both Tums and Maalox.

Chemistry | Name ______________________
Unit 5: Counting Particles Too Small To See
Mrs. Eytcheson | Due Date:
WS 5-4

Empirical and Molecular Formulas

Use dimensional analysis including units, significant figures, and scientific notation. Be sure to show all mathematical work and reasoning and use complete sentences in explanations where necessary.

1. Find the empirical formula of a compound containing 32.0 g of bromine and 4.9 g of magnesium.

2. What is the empirical formula of a carbon-oxygen compound, given that a 95.2 g sample of the compound contains 40.8 g of carbon and the rest oxygen?

3. A compound was analyzed and found to contain 9.8 g of nitrogen, 0.70 g of hydrogen, and 33.6 g of oxygen. What is the empirical formula of the compound?

4. A compound composed of hydrogen and oxygen is found to contain 0.59 g of hydrogen and 9.40 g of oxygen. The molar mass of this compound is 34.0 g/mol. Find the empirical and molecular formulas.

5. A sample of iron oxide was found to contain 1.116 g of iron and 0.480 g of oxygen. Its molar mass is roughly 5 x as great as that of oxygen gas. Find the empirical formula and the molecular formula of this compound.

6. Find the percentage composition of a compound that contains 17.6 g of iron and 10.3 g of sulfur. The total mass of the compound is 27.9 g.

7. Find the percentage composition of a compound that contains 1.94 g of carbon, 0.48 g of hydrogen, and 2.58 g of sulfur in a 5.00 g sample of the compound.

8. What is the % by mass of oxygen in $Mg(NO_3)_2$?

Chemistry
Unit 5: Counting Particles Too Small To See
Mrs. Eytcheson
Review WS

Name______________________________

In Class Activity

Unit 5 Review

1. Define the following terms:

   a. mole

   b. molar mass

   c. Avogadro's number

   d. empirical formula

   e. molecular formula

2. Find the molar mass of the following:

   a. KNO_3

   b. oxygen gas

   c. $(NH_4)_2CO_3$

   d. $Ca(NO_3)_2$

   e. Ag_2CrO_4

   f. $PbSO_4$

3. Consider the mass of the various hardware listed below.

Type	Mass (g)	Relative mass
Washer	1.74	
Hex nut	3.16	
Anchor		3.00
Bolt	7.64	

a. Do the calculations necessary to complete the table.

b. Explain the connection between these calculations and the atomic masses in the Periodic Table.

4. Convert the following:

a. 12.0 g Fe to moles

b. 25.0 g of Cl_2 gas to moles

c. 0.476 g of $(NH_4)_2SO_4$ to moles

d. 0.15 moles $NaNO_3$ to grams

e. 0.0280 moles NO_2 to grams

f. 0.64 moles $AlCl_3$ to grams

5. Use Avogadro's number to do the following:

a. How many atoms are there in 0.00150 moles Zn?

b. If you had 2.50 moles of oxygen gas, what mass of the gas would be in the sample?

c. A 4.07 g sample of NaI contains how many atoms of Na?

d. How many atoms of chlorine are there in 16.5 g of iron (III) chloride, $FeCl_3$?

*e. What is the mass of 100 million atoms of gold? Could you mass this on a balance?

6. Calculate the empirical formula of a compound that contains 4.20 g of nitrogen and 12.0 g of oxygen.

7. When 20.16 g of magnesium oxide reacts with carbon, carbon monoxide forms and 12.16 g of Mg metal remains. What is the empirical formula of magnesium oxide?

8. Determine the molecular formula of each compound:

a. EF = CH; MM = 78 g/mol

b. EF = NO_2; MM = 92 g/mol

9. A compound is composed of 7.20 g of carbon, 1.20 g of hydrogen and 9.60 g of oxygen. The molar mass of the compound is 180 g/mole. Determine the empirical and molecular formulas of this compound.

10. What is the % by mass of oxygen in water?

11. A compound of iron and oxygen is found to contain 28 g of Fe and 8.0 g of O. What is the % by mass of each element in the compound?

Honors Chemistry

Unit 6: Particles with Internal Structure

Activities and Assignments

- ✓ Sticky Tape Lab
- ✓ WS 6-1: Thomson Model of the Atom
- ✓ WS 6-2: Thomson Model and Sticky Tape
- ✓ Conductivity of Substances and Solutions Activity
- ✓ Electrolysis of Copper (II) chloride Activity
- ✓ WS 6-3: Patterns of Charge in the Periodic Table
- ✓ Structures of Solids Activity
- ✓ WS 6-4: Why Structure Is Important
- ✓ WS 6-5: Ionic Compounds
- ✓ Quiz
- ✓ WS 6-6: Representing Ions and Empirical Formulas
- ✓ Unit Review WS
- ✓ Unit 6 Exam

Standards

28. I am able to describe the Thomson model of the atom and cite evidence for the mobile charge in atoms being negative.
29. I am able to able to explain the differences between the properties of ionic, molecular and atomic solids using models of the crystal structures.
30. I am able to differentiate between ionic and molecular compounds from a name or a formula.
31. I am able to state the correct name or formula of a binary molecular compound, given its formula or name.
32. I am able to state the correct name or formula of an ionic compound, given its formula or name.

Study Guide

- Describe evidence that supports the idea that particles have a property we call charge.

- Use the Thomson model of the atom to account for the fact that neutral atoms can become either positively or negatively charged by the loss or gain of electrons.
- List properties that distinguish metals from nonmetals.
- Describe the evidence that distinguishes ionic from molecular or atomic solids.
- Given the formula of an ionic or molecular substance, state its name.
- Given the name of an ionic or molecular substance, write its formula.
- From the name or formula of a substance determine whether that substance is molecular or ionic.

Chemical Formulas & Chemical Compounds

Unit 6

Chemical Names & Formulas

The Significance of a Chemical Formula

2 Examples

- C_8H_{18}
  - Molecular Compound
- $Al_2(SO_4)_3$
  - Ionic Compound
  - Formula unit
  - Sulfate ion
    - Use parentheses to indicate how many of the ion.
    - 2 Al, 3 S, 12 O

What does a formula tell you?

- It represents known facts about the compound.
- Can represent how much of a substance.

H_2O

  - 1 molecule of water
  - 1 mole of water
  - 6.022×10^{23} molecules of water
  - 1 molar mass of water

Monatomic Ions

- Ions formed from a single atom.
- Na^+, Mg^{+2}, Al^{+3}
- Cl^-, S^{-2}, N^{-3}

Naming Positive Monatomic Ions

1. Write element name.
2. Add the word "ion".

K^{+}
Potassium ion

Naming Negative Monatomic Ions

1. Drop the ending of the element name.
2. Add "-ide" ending.
3. Add the word "ion".

F^{-}
fluoride ion

Binary Ionic Compounds

- Contain 2 different elements.
- In ionic compounds, charges must be equal so compound is neutral.

Mg^{+2} and Br^{-}
$MgBr_2$

Basic Naming & Formula Writing Rules

- Always write the positive ion first.
- Don't write "1" as a subscript.
- Don't write charges in the chemical formula of a compound.

The Cross-Over Method

- Useful in determining the subscripts to be used in a chemical formula.

1. Write the symbols with their charge.
2. Cross over the charge numerical values to give the subscripts.
3. Check the subscripts & write the formula.

Example

Al^{+3} and O^{-2}

Al^{+3} O^{-2}

$2Al \times +3 = +6$
$3O \times -2 = \underline{-6}$
0

Al_2O_3

Example

Al^{+3} and O^{-2}

Al^{+3} ⨯ O^{-2}

$2Al \times +3 = +6$
$3O \times -2 = \underline{-6}$
0

Al_2O_3

Naming Binary Ionic Compounds

1. Name positive ion.
2. Name negative ion.
3. Combine names and drop "ion"s.

Al_2O_3
Aluminum ion
oxide ion
Aluminum oxide

The Stock System of Naming

- Used when the positive ion has more than one possible charge.
- A Roman numeral is included in the name to indicate which ion is in the compound.

Copper (I) ion
Copper (II) ion

How to use the Stock System

1. Identify the positive ion's charge.
2. Write the name of the positive ion including a Roman numeral for the charge.
3. Write the name of the negative ion.
4. Drop the words "ion".
5. Write the compound name.

Example

- Fe^{+3} and Cl^{-}

- Iron (III) ion
- chloride ion

- Iron (III) chloride

<u>Nomenclature</u>

- A naming system.
- The Stock system is a type of nomenclature.

Polyatomic Ions

- Most are negative.
- Most are oxyanions.
  - A negative ion that contains oxygen.
- Many are formed from the same two elements.

NO_2 and NO_3

- So we need a way to designate the difference when naming.

Designating Oxyanions

- The one with the most oxygen atoms gets an -ate ending.
- The one with the least oxygen atoms gets an -ite ending.

NO_2^- = nitrite

NO_3 = nitrate

- So how do you know??????

LOOK IT UP!!!

Binary Molecular Compounds

- Are compounds that contain 2 different elements but are bonded covalently.
- These are named using a prefix system.

Dihydrogen monoxide

H_2O

Using the Prefix System of Naming

1. First element
   a. Write the element name.
   b. Use a prefix if there is more than one.
2. Second element
   a. Write the prefix that indicates how many atoms there are.
   b. Add the root of the element name.
   c. Add -ide ending.

Examples

- SO_3 = Sulfur trioxide
- P_2O_5 = Diphosphorous pentoxide
- Phosphorous trichloride = PCl_3
- Carbon tetrachloride = CCl_4

Acids

- Usually are binary compounds or an oxyacid.
- Binary acids (HCl)
  - Contain 2 different elements.
  - Cation is always H.
- Oxyacids (H_3PO_4)
  - Contain H, O and a third element.
  - Cation is always H.

Salts

- An ionic compound composed of a cation and the anion from an acid.
- NaCl
  - Cl^- from hydrochloric acid.
- $CaSO_4$
  - SO_4^{-2} from sulfuric acid.

HWQ 7-1

- You should be able to:
  - Determine the formula of an ionic compound, molecular compound, and acid.
  - Given a chemical formula, determine the name of an ionic compound, also using the Stock System when necessary
  - Given a chemical formula, determine the name of a binary molecular compound using the prefix system of naming.
  - Given a chemical formula, determine the name of an acid.

Oxidation Numbers

What is an oxidation number?

- Aka: oxidation state
- An oxidation number is similar in meaning to "ionic charge".
- It can be used with molecular compounds to determine formulas, too.
  - Remember, molecular compounds are covalently bonded so there is no transfer of electrons (no ions formed).

How to determine oxidation numbers

- $FeCl_2$

1Fe x +2 = +2
2Cl x -1 = <u>-2</u>
0

So, Fe^{+2} and Cl^-

HWQ 7-2

- You should be able to:
  - Determine the oxidation number of an element within a compound.
  - Determine the oxidation number of an element within a polyatomic ion.

Using Chemical Formulas

Formula Mass

- FM = sum of atomic masses in g or amu.
- Example: Sodium
- FM of Na = 22.99 g Na
  - This is the atomic mass from the periodic table for sodium.
  - Remember, rule is to take atomic masses off the Periodic Table rounded to 2 decimal places.

Example: H_2O

- FM of H_2O is

2 H x 1.01g = 2.02g
1 O x 16.00g = 16.00g
18.02 g

- FM is aka molecular mass or molecular weight.

Molar Mass

- MM = formula mass in g per 1 mole.
- MM = g/mol

Example: Sodium

MM = $\frac{22.99\text{g Na}}{1\text{ mol Na}}$

MM Example: NaCl

1. Need FM
   1Na x 22.99 g Na = 22.99 g
   1Cl x 35.45 g = 35.45 g
   58.44 g NaCl
2. Write MM
   $\frac{58.44\text{ g NaCl}}{1\text{ mol NaCl}}$

What is MM used for?

- MM is used as a conversion factor between mass and moles.
- Mole → Mass:
  mol x $\frac{\text{FM g}}{1\text{ mol}}$ = g
- Mass → Mole:
  g x $\frac{1\text{ mol}}{\text{FM g}}$ = mol

Percentage Composition

- It is useful to know the percentage by mass of an element in a compound.
- If we needed a source of oxygen you would want to choose a compound that has a lot in it in order to be efficient.
- Formula used to calculate % comp.:

%comp = FM of element in cmpd x 100%
FM of cmpd

Example: % Comp. of Cu_2S

1. FM of compound
   2Cu x 63.55g = 127.10g
   1S x 32.07g = 32.07g
   159.17 g Cu_2S
2. % Cu
   127.10 g / 159.17 g x 100% = 79.85% Cu
3. % S
   32.07 g / 159.17 g x 100% = 20.15% S

You can subtract one from 100% to get 2nd answer, but....
What if you are wrong?!?!?

HWQ 7-3

- You should be able to:
  - Determine the formula mass of a compound.
  - Determine the molar mass of a compound.
  - Determine the moles of a compound from the mass of a compound.
  - Determine the mass of a compound from the moles of a compound.
  - Determine the number of molecules of a compound from the moles of a compound.
  - Calculate the percentage composition of a compound.

Determining Chemical Formulas

What Is an Empirical Formula?

- An empirical formula consists of the symbols for the elements combined in a compound, with subscripts showing the smallest whole-number mole ratio of the different atoms in the compound.
- aka: simplest formula

Diborane
EF = BH_3
Molecular formula = B_2H_6

Calculation of Empirical Formula

A. Need composition data. This can be given in mass or % composition in the problem.

78% boron
22% hydrogen

Calculation of Empirical Formula

1. If given in % comp., change it to grams. You may assume you have 100g of the cmpd.

   78% B = 78g B

   22% H = 22 g H
2. If given in mass - begin with that data.

Calculation of Empirical Formula

B. Convert the mass data to moles.

$$78\text{ g B} \times \frac{1\text{ mol B}}{10.81\text{ g B}} = 7.216\text{ mol B}$$

$$22\text{ g H} \times \frac{1\text{ mol H}}{1.01\text{ g H}} = 21.78\text{ mol H}$$

Calculation of Empirical Formula

C. Calculate the ratio of the elements in the cmpd.

7.216 mol B : 21.78 mol H

*Must be a simple whole number ratio.

$$\frac{7.216\text{ mol B}}{7.216} : \frac{21.78\text{ mol H}}{7.216}$$

1 mol B : 3.01 mol H or 1 mol B : 3 mol H

Calculation of Empirical Formula

D. Write the empirical formula.

1 mol B : 3 mol H

BH_3

EF Summary of Steps

1. Composition Data
2. Composition in g
3. Convert to moles
4. Calculate mole ratio
5. Write EF

Calculation of Molecular Formula

- The relationship between the EF and its MF is

  X(EF) = MF

  X = whole number multiplier
- Once the X is known, it can be used to calculate the MF.
- To calculate X

  X(EF FM) = MF FM

Calculation of Molecular Formula

A. Calculate FM of EF

BH_3 = 1 B x 10.81 g = 10.81 g
3H x 1.01 g = 3.03 g
13.84 g BH_3

Calculation of Molecular Formula

B. Need FM of MF
- This will be given in the problem.

MF FM = 27.67 g

Calculation of Molecular Formula

C. Calculate X

X(EF FM) = MF FM
X(13.84 g) = 27.67 g

X = 2

Calculation of Molecular Formula

D. Determine MF

X(EF) = MF

2(BH_3) = B_2H_6

MF Summary of Steps

1. Calculate FM of EF
2. FM of MF (given)
3. Calculate X
4. Determine MF

HWQ 7-4

- You should be able to:
  - Determine the empirical formula of a compound given its composition data.
  - Determine the molecular formula of a compound given its empirical formula and it's molecular mass.

Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-1

Name_______________________

Due Date:

Thomson Model of the Atom

J. J. Thomson performed experiments with cathode rays in an attempt to understand electricity – which was still a mystery in the late 1800s. Review the website *A Look Inside the Atom*[1] to find the conclusions that Thomson and other physicists drew regarding the mysterious cathode rays.

Thomson's 1897 Experiments - state the conclusions Thomson drew from each of his famous cathode ray experiments:

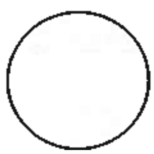
1. **First Experiment:** Thomson directed the beam at an electrometer and tried to separate the evidence of charge from the path of the beam. *What connection did Thomson find between charge and the cathode rays? Was the charge positive or negative?*

2. **Second Experiment**: Thomson tried passing the cathode ray through an electric field. *How did cathode ray beam behave when it passed through an electric field? What did he conclude after his second experiment?*

[1] http://www.aip.org/history/electron/jjhome.htm

3. **Third Experiment**: Thomson did some careful measurements on how much the path of the cathode ray was bent in a magnetic field and how much energy they carried. From this work Thomson could describe the mass/charge ratio of the cathode ray particles. *What amazing result did Thomson find?*

Thomson's Atomic Model: Thomson presented three hypotheses from his experiments. Only two were accepted by physicists – in fact the third was shown to be wrong! From the first two came a model of the atom known as the *Plum Pudding* model. Complete the atom drawing below to illustrate Thomson's plum pudding model. Explain how this fits with his observations.



Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
LAB

"Sticky Tape" Lab

In Unit 4 our model of the atom moved from simple particles to one in which some substances were made from "compound particles". Using the electrolysis of water, we showed that these particles combined in definite ratios. What we didn't address, however, was what held these particles together in these well-defined ratios.

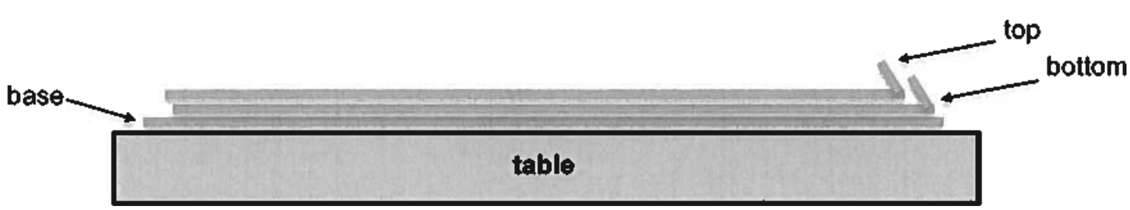
The phenomena we've studied thus far did not require that these particles have any internal structure. However, in the electrolysis of water, it is clear that electrical forces are somehow involved in the formation of compounds. In this lab we will study the behavior of the charged particles and develop a more complex model of the atom that accounts for the fact that some particles have positive charge whereas others are negatively charged.

Materials:

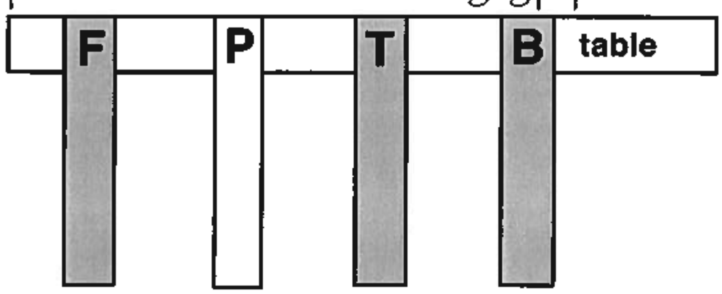
- One roll of transparent tape
- Piece of wool or fur
- Two strips of paper, 15 cm x 1.5 cm
- Two strips of aluminum foil, 15 cm x 1.5 cm
- Plastic ruler
- Glass rod

Procedure A:

1. Stick a piece of tape that is about 15 cm long on the table. This is the base tape.



2. Attach a similar piece of tape to the base tape. Make sure you have made a handle, or flap, at one end in order to be able to separate it from the base. Label this piece of tape "B" for bottom.
3. Attach another piece of tape to the top layer again forming a handle, or flap, at the end. Label this piece of tape "T" for top.
4. Repeat steps 1-3 so that you have two sets of base + top + bottom layers of tape.
5. Cut two pieces of paper, about the same size as the tape, and hang one from the edge of the table. Label the hanging paper "P".
6. Cut two pieces of aluminum foil, about the same size as the tape, and hang one from the edge of the table. Label the hanging foil "F".
7. Peel one set of "T" and "B" tapes from its base tape, keeping the "T" and "B" tapes together.
8. Run a finger along the non-sticky side of the tapes to "ground" them.
9. Very quickly, peel the "T" and "B" tapes apart.
10. Hang each tape from the table next to the hanging paper and foil.



11. Take the piece of paper that is not hanging and bring it close to, but not touching, each of the hanging strips. Describe what you see happening. Include a series of sketches of the materials as they approach one another with vectors to represent the forces on the materials. Record your results in the Data Table.

12. Take the piece of foil and repeat step 11.
13. Repeat steps 7-9 with the second set of tapes.
14. Repeat step 11 with the top tape.

15. Repeat step 11 with the bottom tape.

Data Table:

	Top	Bottom	Paper	Foil
Top				
Bottom				
Paper				
Foil				
Plastic rod				
Fur or Wool				

Our Model of the Atom and the Assignment of (+) and (-) Charges

Our current model of the atom is consistent with the existence of 2 types of charge. An atom has a positively charged nucleus surrounded by mobile negatively charged electrons. Materials become charged by the gain or loss of these mobile electrons. Based on a number of observations we have assigned the label of negative to a plastic rod when rubbed with fur or wool. The fur or wool, having lost electrons to the plastic, becomes positively charged.

Procedure B:

1. Rub a plastic rod with wool or fur and approach the "T" tape. Then approach the "B" tape. Describe, like you did before, what you see happening.
2. Based on your observations from using the plastic rod, label the "T" and "B" tapes with either a (+) or a (-). Restate the interaction between the "T" and "B" tapes using the terms positive and negative instead of top and bottom.
3. Approach the hanging strips of paper and foil with the plastic rod. Then approach the hanging strips of paper and foil with the piece of wool or fur. Describe, like you did before, what you see happening. How does the strength of these interactions compare to those observed with the "T" and "B" tapes?

Sticky Tape Lab Discussion

Charge?

- Which of the items do you believe had a charge?
  - Why do you believe this?
  - Two tapes - demonstrated attraction and repulsion

Not charged?

- Were there any items that did not have a charge?
  - Why do you believe this?
  - Paper and Foil – while they were attracted to both tapes, they were not attracted to themselves or each other

Neutral?

- If the Paper and Foil are neutral, how could they have been attracted to both the positive and negative tape?
- What does neutral really mean?
- No charge?
- Equal amounts of positive and negative charge

Timing

- When did the tape become charged?
  - After we ripped them apart.
- If they didn't become charged until we ripped them apart, what conclusion can we draw?
  - ** There was something transferred during the ripping

Transfer?

- What is the smallest thing we are aware of that could be transferred?
  - Atoms
- Does moving an atom or group of atoms from one place to another change the charge of something?
  - No - therefore ** there must be something smaller than an atom that was transferred

Something smaller?

- Based on our observations so far, what characteristics can we assign to this object?
  - It's smaller than an atom
  - It's mobile (it moved from one tape to another)
  - It has a charge (moving it changed the charge of both tapes)

Which charge?

- If it's charged, is it positive or negative?
  - If it's positive, it moved from the bottom tape to the top tape, increasing the + charge of T and decreasing the + charge of B
  - If it's negative, it moved from the top tape to the bottom tape, increasing the - charge of B and decreasing the - charge of T

Now what do we know?

- It's smaller than an atom
- It's mobile
- It has a charge
- According to Thomson that charge is negative
- What do we call this??
  - Electron

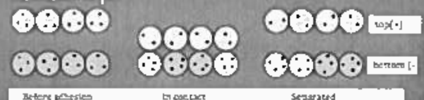
New Model

- J.J. Thomson came up with a new model of an atom to incorporate this tiny negative particle that we call electrons.

- The black dots represent the electrons, which he called plums. These are negative. The rest of the atom was like a bowl of pudding. The bowl of pudding is positive
  - This model is called Plum Pudding

Transfer?

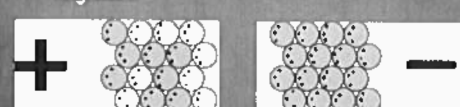
- So, the plums (electrons) transferred from the pudding (atom) of the top tape to the bottom tape



So, the bottom tape is "plum rich" and the top tape is "plum poor"

Neutral objects?

- Can this model explain how a neutral object can be attracted to both positive and negative?



We still have one question to answer...

- Why was the foil more attracted to the charged objects than the paper was?

- The electrons are MORE mobile in the foil than in the paper.

Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-2

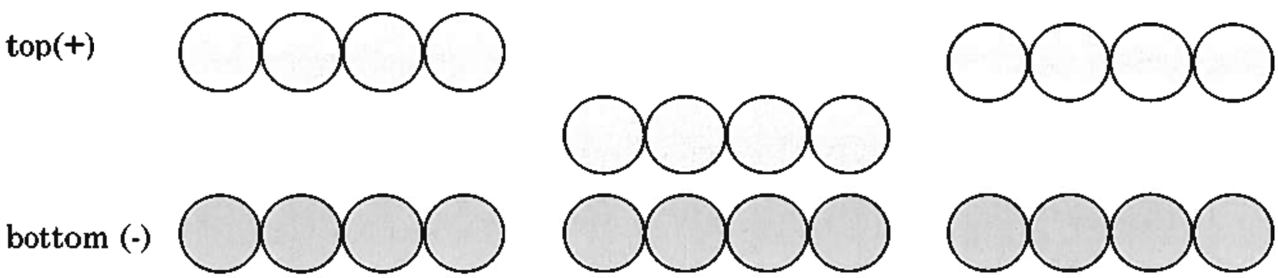
Name______________________

Due Date:

Thomson Model and Sticky Tape

Let's see how we can use Thomson's model to explain the behavior of the sticky tape when we made our tape stacks.

A few atoms from the *top tape* and the *bottom tape* are represented in the diagram below. Add electrons to each atom to show what happens to the electrons when we make a tape stack out of neutral pieces of tape and then pull them apart.



Before adhesion   In contact   Separated

Describe the *macroscopic* changes in the tapes and then provide a *microscopic* explanation based on Thomson's model of the atom and your drawings.

Behavior of Foil and Paper with Charged Tapes

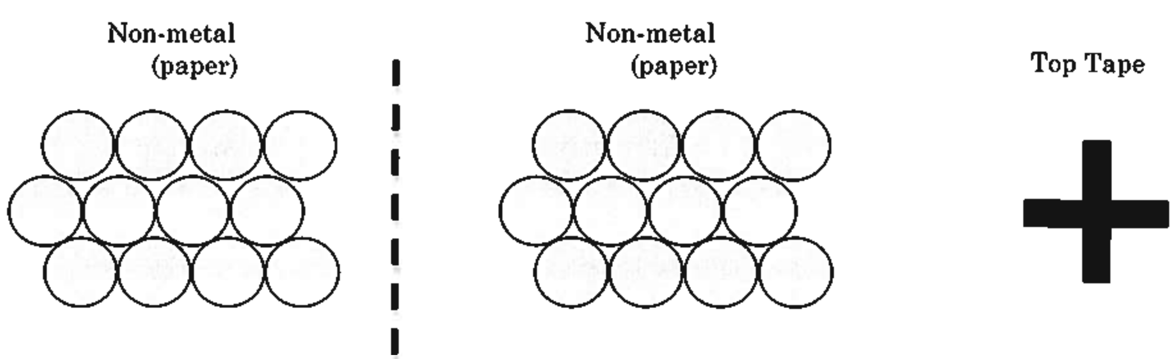
We observed that neither foil (metal atoms) nor paper (non-metal atoms) would attract each other. But foil and paper are **both** attracted to **both** the charged tapes (top and bottom).

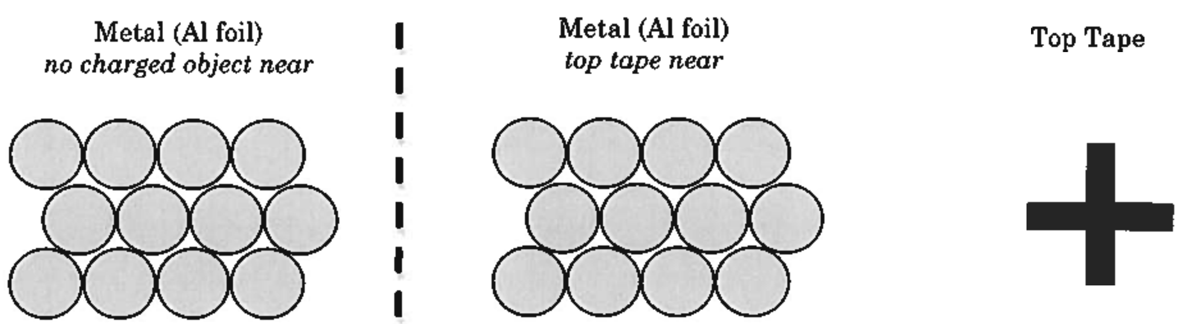
How can we use the pudding model of atoms to explain the differences we observed?

Several atoms from the paper and foil are drawn on the next page. The ones on the left have no charged object near them. The ones on the right are next to a top tape (+ charge).

Add force vectors to the non-metal (paper) atoms and the top tape in the first row to show the attraction between the paper and the tape. Then do the same for the foil and the tape in the second row. Be sure the *size of the vectors* shows the relative strengths of the attractions.

Now draw the electrons in each atom "bowl" to show their arrangements when no charged object is near present and then when a charged object is brought near.





Explain why these arrangements of electrons would produce the observed attractions.

Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-3

Name________________________

Due Date:

Patterns of Charge in the Periodic Table

We have observed evidence that when metal-nonmetal compounds are dissolved, the metal particles tend to form positively charged ions (cations), while non-metal particles tend to form negatively charged ions (anions). However, when these same metal and non-metal particles are combined to form compounds they do not conduct electricity as solids. We will now examine the patterns that exist for the ratios in which these elements combine in order to determine the charges of the ions they form.

1. Write the formula and draw the particle diagram for each compound.
The ratio of ions in each compound is given.

Atoms involved	1 calcium 1 oxygen	2 lithium 1 oxygen	2 aluminum 3 sulfur	1 beryllium 1 sulfur
formula				
particle diagram				

Atoms involved	2 boron 3 oxygen	1 magnesium 1 oxygen	2 sodium 1 sulfur
formula			
particle diagram			

Atoms involved	1 magnesium 2 chlorine	1 lithium 1 fluorine	1 beryllium 2 bromine	1 boron 3 chlorine
formula				
particle diagram				

Atoms involved	1 sodium 1 chlorine	1 calcium 2 bromine	1 aluminum 3 chlorine
formula			
particle diagram			

2. Write each formula from Question 1 in the boxes corresponding to its elements. For example, the compound formed from sodium and sulfur has been written in the box for sodium and in the box for sulfur. Now add the rest.

1A	2A	3A	4A	5A	6A	7A	8A
Hydrogen 1 H							Helium 2 He
Lithium 3 Li	Beryllium 4 Be	Boron 5 B	Carbon 6 C	Nitrogen 7 N	Oxygen 8 O	Fluorine 9 F	Neon 10 Ne
Sodium 11 Na_2S	Magnesium 12 Mg	Aluminum 13 Al	Silicon 14 Si	Phosphorus 15 P	Sulfur 16 Na_2S	Chlorine 17 Cl	Argon 18 Ar
Potassium 19 K	Calcium 20 Ca	Gallium 31 Ga	Germanium 32 Ge	Arsenic 33 As	Selenium 34 Se	Bromine 35 Br	Krypton 36 Kr

3. What patterns do you find in the formulas of the compounds formed in the table in #2?

Based on these patterns, predict the formulas of the compounds formed by the ions below.

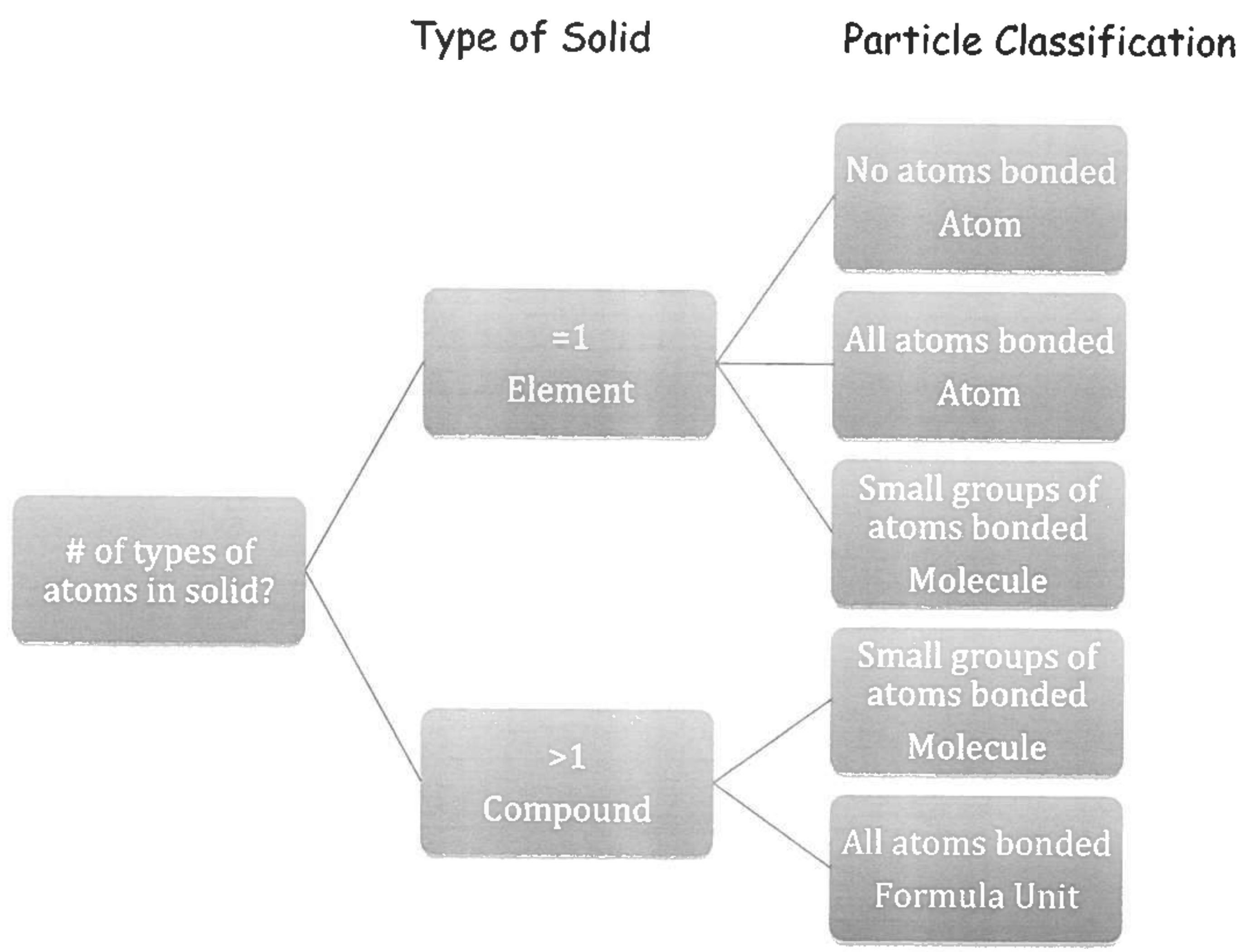
	Ratio of ions in compound		
Atoms involved	__K:__O	__Ca: __S	__Ga: __O
formula			

4. How does a neutral atom become a positive ion? a negative ion?

5. Do the elements in Group 1A behave more like top or bottom tape? How about the elements in Group 7A? How so?

6. Make whatever generalizations you can about the charge of the ions formed by elements in columns 1A, 2A, 3A and 7A based on the ratio of atoms in each of the compounds they form. It might help to look at your particle diagrams in #1 and consider what charges the ions might have in order to result in neutral compounds.

7. Using the fact that compounds are also neutral, account for the fact that the ions combine in the ratios you have listed in the table in #2. Provide a couple of specific examples to support your explanation.


Type of Solid
Particle Classification
# of types of atoms in solid?
=1 Element
>1 Compound
No atoms bonded Atom
All atoms bonded Atom
Small groups of atoms bonded Molecule
Small groups of atoms bonded Molecule
All atoms bonded Formula Unit

Activity: Distinguishing Ionic, Molecular, and Atomic Solids

Part 1: Look at the X-Ray Crystallography image of water, what distinguishing features can you cite?

1. ______________________________ 2. ______________________________

Part 2: Complete the table below for the solids listed. Specifically, you are looking for:

- The types of particles (ions, atoms, or molecules)
- The connections between those particles (T-connected throughout, S-connected only in some directions, N-no connections between particles).
- Identify the type of solid that best describes each row - write a brief statement summarizing what the solids in each row have in common.

Type of Solid	Type of Particles in the Solid (atom, molecule, ion// metal, non-metal)	Connections Within and Between Particles in the Solid	Generalization Concerning Particle Types and Connections
Row 1			
1. Argon			
2. Copper			
3. Graphite			
Row 2			
1. Dry Ice (CO_2)			
2. Sulfur (S_8)			
3. Sugar ($C_{12}H_{22}O_{11}$)			
Row 3			
1. Table Salt (NaCl)			
2. Marble ($CaCO_3$)			
3. Baking Soda ($NaHCO_3$)			

Part 3: On a white board, write a set of **"Rules for Identification"** of these 3 categories of solids.
Your Rules for Identification must:

- Allow for correct classification of any substance.
- Identify the type of particles involved in the class of solids.
- Specify the types of connections or lack of connections between particles belonging to this category.

Part 4: Write the "Rules for Identification" of the 3 classes of compounds agreed upon by the class.

Atomic Solids - ____

____

Molecular Solids - ____

____

Ionic Solids (Formula Unit Solids) - ____

____

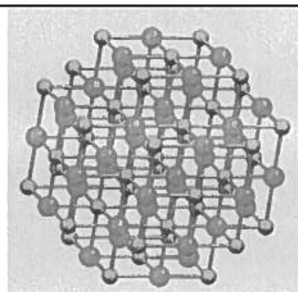
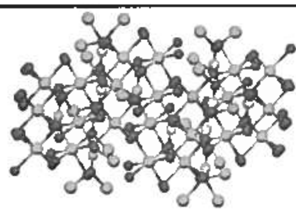
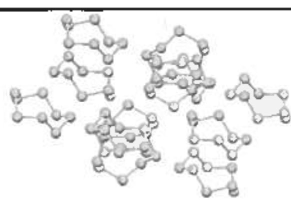
Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-4

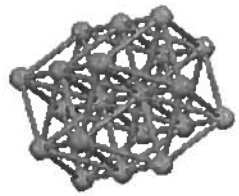
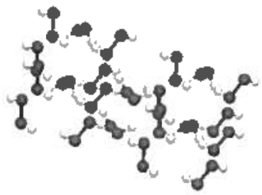
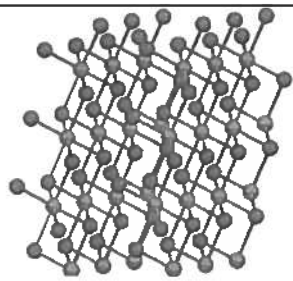
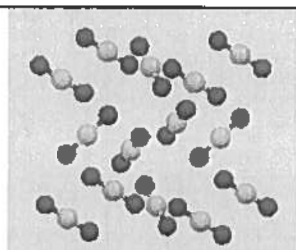
Name____________________________

Due Date:

Why Structure is Important

In the table below, identify the type of solid (atomic, molecular, ionic) each substance forms. Then predict in which phase (solid, liquid or gas) each substance would exist on the Earth, on Mercury and on Pluto.

Substance	Crystal structure	Type	melting pt (°C) boiling pt (°C)	Phase at room temp on
NaCl			801 1413	Earth (25°C) Mercury (450°C) Pluto (-230°C)
$CaCO_3$			520 decomposes at 825	E M P
S_8			115 444	E M P

Cu			1084 2567	E M P
H_2O_2			-0.41 150	E M P
PbI_2			402 954	E M P
CO_2			-78 -57	E M P
Ar			-189 -186	E M P

Account for differences in the melting and boiling points of the three types of structures.

Predict which of these substances would conduct electricity when molten.

Would any of these conduct electricity as a solid?

Common Polyatomic Ions

+1

Ammonium ion NH_4^+

+2

Dimercury ion Hg_2^{+2}

-1

acetate ion $C_2H_3O_2^-$
bromate ion BrO_3^-
chlorate ion ClO_3^-
chlorite ion ClO_2^-
cyanide ion CN^-
dihydrogen phosphate ion $H_2PO_4^-$
hydrogen carbonate ion HCO_3^-
hydrogen sulfate ion HSO_4^-
hydroxide ion OH^-
hypochlorite ion ClO^-
iodate ion IO_3^-
nitrate ion NO_3^-
nitrite ion NO_2^-
perchlorate ion ClO_4^-
permanganate ion MnO_4^-

-2

carbonate ion CO_3^{-2}
chromate ion CrO_4^{-2}
dichromate ion $Cr_2O_4^{-2}$
hydrogen phosphate ion HPO_4^{-2}
oxalate ion $C_2O_4^{-2}$
peroxide ion O_2^{-2}
sulfate ion SO_4^{-2}
sulfite ion SO_3^{-2}

-3

phosphate ion PO_4^{-3}
arsenate ion AsO_4^{-3}

Common Monatomic Ions

+1

Lithium ion Li^{+1}
Sodium ion Na^{+1}
Potassium ion K^{+1}
Rubidium ion Rb^{+1}
Cesium ion Cs^{+1}
Copper (I) ion Cu^{+1}
Silver ion Ag^{+1}

+2

Magnesium ion Mg^{+2}
Calcium ion Ca^{+2}
Strontium ion Sr^{+2}
Barium ion Ba^{+2}
Cadmium ion Cd^{+2}
Chromium (II) ion Cr^{+2}
Cobalt (II) ion Co^{+2}
Copper (II) ion Cu^{+2}
Iron (II) ion Fe^{+2}
Lead (II) ion Pb^{+2}
Manganese (II) ion Mn^{+2}
Mercury (II) ion Hg^{+2}
Nickel (II) ion Ni^{+2}
Tin (II) ion Sn^{+2}
Vanadium (II) ion V^{+2}
Zinc ion Zn^{+2}

+3

Aluminum ion Al^{+3}
Chromium (III) ion Cr^{+3}
Iron (III) ion Fe^{+3}
Lead (III) ion Pb^{+3}
Vanadium (III) ion V^{+3}

+4

Lead (IV) ion Pb^{+4}
Vanadium (IV) ion V^{+4}
Tin (IV) ion Sn^{+4}

-1

Fluoride ion F^-
Hydride ion H^-
Chloride ion Cl^-
Bromide ion Br^-
Iodide ion I^-

-2

Oxide ion O^{-2}
Sulfide ion S^{-2}

-3

Nitride ion N^{-3}

Diatomic Molecules

H_2
N_2
O_2
F_2
Cl_2
Br_2
I_2

Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-5

Name______________________________

Due Date:

Ionic Compounds

Properties:

Basic structural unit:

1. Give the name of the following simple binary ionic compounds.

Chemical Formula	Work Space	Compound Name
Na_2O		
K_2S		
$MgCl_2$		
$CaBr_2$		
BaI_2		
Al_2S_3		
CsBr		
AgF		

2. Give the name of the following simple binary ionic compounds.

Chemical Formula	Work Space	Compound Name
Na_3N		
K_2O		
AgBr		
MgI_2		
SrO		

3. Write the formula for the following binary ionic compounds.

Compound Name	Work Space	Chemical Formula
Sodium iodide		
Silver sulfide		
Cesium oxide		
Beryllium iodide		
Barium hydride		
Aluminum fluoride		
Lithium bromide		
Potassium oxide		

4. Write the formula for these ionic substances.

Compound Name	Work Space	Chemical Formula
Silver oxide		
Aluminum sulfide		
Sodium nitride		
Barium chloride		
Strontium hydride		

5. Write the name of these ionic substances using the Stock System (a Roman numeral to specify the charge of the cation).

Chemical Formula	Work Space	Stock Name
$SnBr_2$		
$SnBr_4$		
CrO		
Cr_2O_3		
Hg_2I_2		
HgI_2		
$PbCl_2$		
Fe_2O_3		
SnI_2		
Hg_2O		
HgS		

6. Write the formulas of each ionic compound.

Compound Name	Work Space	Chemical Formula
Chromium (III) chloride		
Tin (IV) oxide		
Lead (II) oxide		
Copper (II) iodide		
Cobalt (II) oxide		
Cobalt (III) oxide		
Chromium (III) sulfide		
Manganese (IV) oxide		
Gold (III) chloride		
Titanium (IV) chloride		
Iron (II) oxide		

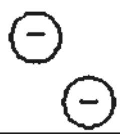
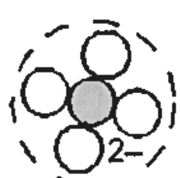
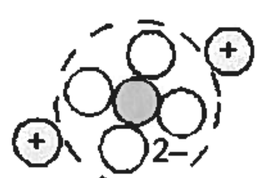
Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-6

Name______________________________

Due Date:

Representing Ions and Formula Units

Complete the following table by identifying the cation and anion in the compound, determining the formula for the compound and writing the name of the compound. Below the cation, anion, and formula draw a particle diagram for each.

Cation	Anion	Formula	Name
Ca^{+2}	Br^-		
			
Fe^{+2}	Cl^-		
K^+	SO_4^{-2}		
			

Cation	Anion	Formula	Name
Al^{+3}	NO_3^-		
Pb^{+2}	S^{-2}		
		NH_4OH	
		$KHCO_3$	
		$Mg(NO_3)_2$	

Cation	Anion	Formula	Name
		$ZnCO_3$	
		Na_3PO_4	

Complete the following table by identifying the cation and anion in the compound and determining the formula for the compound. Below the cation, anion, and formula draw a particle diagram for each. Below the name of the compound state the total number of atoms and the number of ions in the compound.

<table>
<tr><th>Cation</th><th>Anion</th><th>Formula</th><th colspan="2">Name</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">Silver chromate</td></tr>
<tr><td></td><td></td><td></td><td># atoms</td><td>#ions</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Lithium chlorate</td></tr>
<tr><td></td><td></td><td></td><td># atoms</td><td># ions</td></tr>
</table>

Cation	Anion	Formula	Name	
			Copper (I) nitrate	
			# atoms	# ions
			Iron (III) sulfide	
			# atoms	# ions
			Calcium sulfate	
			# atoms	# ions
			Potassium phospate	
			# atoms	# ions

Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson
WS 6-7

Name______________________

Due Date:

Molecular Compounds

Properties:

Basic structural unit:

1. Name each of the following binary compounds of non-metallic elements

Chemical Formula	Compound Name
CBr_4	
N_2P_3	
PCl_3	
ICl	
N_2O	
SiF_4	
GeH_4	

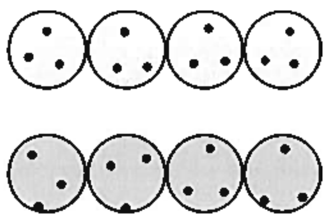
2. Write the formula for the following binary compounds of nonmetallic elements.

Compound Name	Chemical Formula
Phosphorus triodide	
Silicon tetrachloride	
Dinitrogen pentoxide	
Dinitrogen tetroxide	
Carbon monoxide	
Carbon dioxide	
Sulfur hexafluoride	
Dinitrogen tetrachloride	
Carbon tetraiodide	
Phosphorus pentaflouride	
Diphosphorus pentoxide	

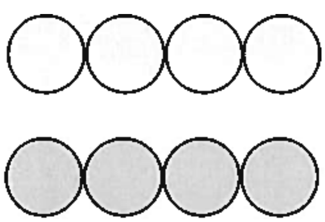
Honors Chemistry
Unit 6: Particles with Internal Structure
Mrs. Eytcheson

Unit 6 Review

1. Recall your representations of the atoms in the Sticky Tape activity. Below is a pair of tapes before they have been pulled apart. Explain why they would **not** exert a force (either attractive or repulsive) on one another.

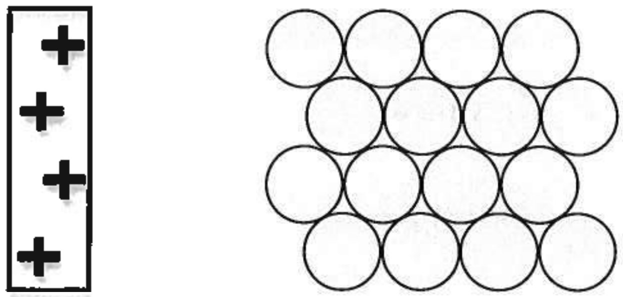


2. Below are groups of the inner cores of the atoms of the tapes after they have been pulled apart. Sketch in the mobile negative charges to show how the top tape becomes (+) and the bottom becomes (-).



3. What evidence allowed us to conclude that the top tape was (+)?

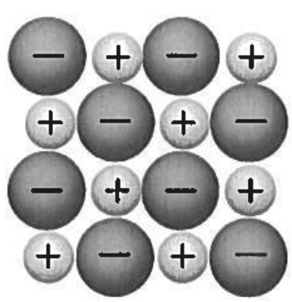
4. Below is a group of the inner cores of a piece of metal foil. Sketch in where you would expect to find the mobile negative charges if a top (+) tape were brought to the left of the foil. Explain your diagram.

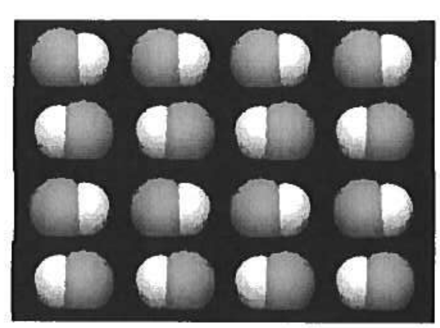


5. Describe how JJ Thomson concluded that the mobile charged particle in the atom had a (–) charge.

6. A solution of salt conducts electricity; a solution of sugar does not. Explain.

7. Below left is a 2-D array that represents an ionic lattice. At right is a 2-D array that represents a molecular solid. In what ways are they similar? In what ways are they different?





8. What evidence helped us to conclude that chloride ions have a (–) charge?

9. How do you decide how many ions of each type combine to form an ionic compound?

10. Why do ionic solids have higher melting and boiling points than do most molecular solids?

11. Why do we use the term "formula unit" rather than "molecule" when we refer to the simplest repeating unit of an ionic solid?

12. How many ions are formed when solid Na_2SO_4 dissolves? ____________
In what ways are the (+) and (–) ions different?

13. Apart from making life difficult for beginning chemistry students, why do chemists refer to CO_2 as carbon dioxide, yet use the name tin(IV) oxide to describe SnO_2?

14. Make sure that you know which combinations of elements give rise to ionic compounds and which form molecular compounds.

15. Make sure that you are familiar with the names, formulas and charge of the common ions you were assigned to learn so that you can readily name ionic compounds as well as write formulas for compounds whose names are given.

Honors Chemistry

Unit 7: Chemical Reactions: Particles and Energy

Activities and Assignments

- ✓ Nail Lab
- ✓ WS 7-1: Rearranging Atoms
- ✓ WS 7-2: Balancing Equations
- ✓ WS 7-3: Balancing More Equations
- ✓ Quiz
- ✓ WS 7-4: Writing and Balancing Word Equations
- ✓ Reaction Types Lab
- ✓ WS 7-5: Patterns of Chemical Reactions
- ✓ WS 7-6: Types of Chemical Reactions
- ✓ WS 7-7: Representing Chemical Potential Energy in Change
- ✓ Unit Review WS
- ✓ Unit 7 Exam

Standards

33. I am able to model chemical change as the rearrangement of atoms and depict those changes using a particle diagram.
34. I am able to able to correctly represent a chemical change as a balanced chemical equation.
35. I am able to classify a chemical change as one of the following types of reactions and use the patterns in these reaction types to predict the products of a reaction: synthesis, decomposition, single replacement, double replacement, and combustion.
36. I am able to describe a reaction as exothermic or endothermic based on the change in energy and use energy bar graphs to account for those changes.

Study Guide

- Describe chemical changes in terms of rearranging atoms to form new substances.

- Recognize that the total number of particles (sum of the coefficients) can change during a reaction because of differences in the bonding ratios of each substance.
- Recognize that the total number of atoms does not change during a reaction because every reactant atom must be included in a product molecule.
- Learn to describe reactions in terms of macroscopic observations.
- Learn to describe reactions in terms of microscopic behavior of atoms.
- Learn to write balanced equations to represent these changes symbolically.
- Explain that the coefficients in a chemical equation describe the quantities of the individual atoms or molecules involved and the moles of the substances involved.
- Observe basic patterns in the way substances react and learn to generalize them to other reactions encountered: synthesis, decomposition, single replacement, double replacement, and combustion.
- Describe endothermic and exothermic reactions in terms of storage of chemical potential energy.

Chemical Equations and Reactions

Unit 7

Describing Chemical Reactions

Chemical Reaction

- Process in which substances are changed into other substances.
- Reactants are changed; products are the result.
- Total mass of reactant(s) must = total mass of product(s).

Chemical Equation

- Describes chemical reactions.
- Uses symbols and formulas to indicate what substances and relative amounts of the substances are involved.

$$(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + Cr_2O_3(s) + 4H_2O\ (g)$$

Indications of Chemical Reactions

- Gives off energy (heat, light, sound).
- Gives off gas (bubbles).
- Forms a solid (ppt).

Characteristics of Chemical Equations

- To be correct, the chemical equation must:
  - Represent known facts.
  - Contain correct formulas.
  - Satisfy Law of Conservation of Mass.

How To Write a Chemical Equation

Write a Word Equation

- Identify facts to be represented.

Iron (III) oxide + Aluminum → Iron (III) + Aluminum oxide

Write a Formula Equation

- Replace names of reactants and products with the correct formulas.

$$Fe_2O_3 + Al \rightarrow Fe + Al_2O_3$$

Balance the Equation

- Satisfy the Law of Conservation of Mass.
- Never change a formula.
- Only use coefficients to balance equation.

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$$

- If you can't get it balanced, usually there is a formula mistake.

Symbols Used in Chemical Equations

- Table 8-2, pg. 246 (Red book).
- Be able to interpret them when given.
- Be able to supply them when the appropriate information is given.

Significance of Chemical Equations

A. Chemical equations and algebra are similar because they express equalities.

B. Chemical equations can be interpreted quantitatively.

1. Relative amounts of reactants and products.

$$H_2 + Cl_2 \rightarrow 2HCl$$

- 1 molecule of hydrogen reacts with 1 molecule of chlorine to produce 2 molecules of hydrogen chloride.
- 1 mole of hydrogen reacts with 1 mole of chlorine to produce 2 moles of hydrogen chloride.
- 2 g of hydrogen react with 71 g of chlorine to produce 73 g of hydrogen chloride.

2. Ratios of reactants to products.

$$H_2 + Cl_2 \rightarrow 2HCl$$

1 mol H_2 : 1 mol Cl_2 : 2 mol HCl
20 mol H_2 : 20 mol Cl_2 : 40 mol HCl
2 g H_2 : 71 g Cl_2 : 73 g HCl
4 g H_2 : 142 g Cl_2 : 146 g HCl

3. Reverse reactions
   - Products become reactants in reverse.
   - Law of Conservation of Mass still applies.

$$2HCl \rightarrow H_2 + Cl_2$$

Chemical Equations Don't Give:

- Indication whether reaction actually occurs.
- Info. about how fast reaction occurs.
- How the atoms/ions move from reactant to product.

Types of Chemical Reactions

Synthesis Reactions

- Two or more substances combine to form a new compound.

$$A + X \rightarrow AX$$

- A and X are elements or cmpds.
- AX is a cmpd.

Reactions of Elements w/Oxygen

- Produces oxide of the element.

$2Mg + O_2 \rightarrow 2MgO$
$2Fe + O_2 \rightarrow 2FeO$
$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Reactions of Two Nonmetals

- Forms covalent cmpd.

$2H_2 + O_2 \rightarrow 2H_2O$
$S + O_2 \rightarrow SO_2$
$C + O_2 \rightarrow CO_2$

Reactions of Metals w/ Nonmetals Other than Oxygen

- Produces an ionic cmpd.

$2Na + Cl_2 \rightarrow 2NaCl$
$Co + F_2 \rightarrow CoF_2$
$2Na + F_2 \rightarrow 2NaF$
$U + 3F_2 \rightarrow UF_6$
$2Na + S \rightarrow Na_2S$

Synthesis Reactions of Oxides

A. Oxides of active metals react with H_2O to produce metal hydroxides.

$CaO + H_2O \rightarrow Ca(OH)_2$

Synthesis Reactions of Oxides

- Nonmetal oxides react with H_2O to produce an oxyacid.

$SO_3 + H_2O \rightarrow H_2SO_4$

Synthesis Reactions of Oxides

- Metal oxides react with nonmetal oxides to produce a salt.

$CaO + SO_3 \rightarrow CaSO_4$

Decomposition Reactions

- A single cmpd. undergoes a reaction that produces 2 or more simpler substances.

$AX \rightarrow A + X$

- Most take place only if heat or energy is added.
  - Use the symbol Δ above the yield arrow.

Decomposition of Binary Cmpds.

- Binary compounds decompose into their constituent elements.

$2HgO \rightarrow 2Hg + O_2$

Electrolysis

- Decomposition of substances by electrical current.

$2H_2O \rightarrow 2H_2 + O_2$

- Over the yield arrow, write "elect".

Decomposition of Metal Carbonates

- When heated, breaks down to metal oxide and carbon dioxide.

$CaCO_3 \rightarrow CaO + CO_2$

Decomposition of Metal Hydroxides

- When heated, give metal oxides and H_2O.

$Ca(OH)_2 \rightarrow CaO + H_2O$

Decomposition of Metal Chlorates

- When heated, gives metal chloride and oxygen.

$2KClO_3 \rightarrow 2KCl + 3O_2$

Decomposition of Acids

- Decompose into nonmetallic oxides and H_2O.

$H_2CO_3 \rightarrow CO_2 + H_2O$

$H_2SO_4 \rightarrow SO_3 + H_2O$

Single Replacement Reactions

- One element replaces a similar element in a compound.

$A + BX \rightarrow AX + B$

$Y + BX \rightarrow BY + X$

Replacement of a Metal by a More Reactive Metal

$2Al + 3Fe(NO_3)_2 \rightarrow 3Fe + 2Al(NO_3)_3$

Replacement of H in H_2O by a Metal

- Active metals react with H_2O to produce metal hydroxides and hydrogen.

  $2Na + 2H_2O \rightarrow 2NaOH + H_2$

- Less active metals react with H_2O to produce metal oxides and hydrogen.

  $2Fe + 3H_2O \rightarrow Fe_2O_3 + 3H_2$

Replacement of H in an Acid by a Metal

- Active metals replace H in the acid to produce a metal cmpd. and hydrogen.

$Mg + 2HCl \rightarrow H_2 + MgCl_2$

Replacement of Halogens

- One halogen replaces another halogen.
- Can replace only those below it in the group on periodic table.

$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$

$F_2 + 2NaI \rightarrow 2NaF + I_2$

Double Replacement Reactions

- Ions of 2 cmpds exchange positions to form new compounds.
- Products usually are: a ppt, gas or H_2O

$AX + BY \rightarrow AY + BX$

Formation of a Precipitate

- Positive ions react with negative ions of the other cmpd and an insoluble product results.
- See "Solubility Rules".

$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2 \downarrow + 2KNO_3(aq)$

Formation of a Gas

- A product is an insoluble gas and bubbles out.

$FeS(aq) + 2HCl(aq) \rightarrow H_2S \uparrow + FeCl_2(aq)$

Formation of Water

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Combustion Reactions

- A substance combines with oxygen releasing a large amount of energy in the form of light and heat.
- Burning hydrocarbons (H & C) yields CO_2 and H_2O.

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Activity Series of the Elements

The Activity Series

- The ability to react is the activity of the element.
- Basic principles of use:
  1. Those listed can replace all those below it but none above it.
  2. Check side notes.

*Useful in predicting whether or not reaction actually occurs or not.

Activity Series of the Elements

Activity of Metals		Activity of Halogen Nonmetals
Li Rb K Ba Sr Ca Na	React with cold H_2O and acids, replacing hydrogen. React with oxygen, forming oxides.	F_2 Cl_2 Br_2 I_2
Mg Al Mn Zn Cr Fe Cd	React with steam (but not cold water) and acids, replacing hydrogen. React with oxygen, forming oxides.	
Co Ni Sn Pb	Do not react with water. React with acids, replacing hydrogen. React with oxygen, forming oxides.	
H_2 Sb Bi Cu Hg	React with oxygen, forming oxides.	
Ag Pt Au	Fairly unreactive, forming oxides only indirectly.	

Honors Chemistry
Unit 7: Chemical Reactions: Particles and Energy
Mrs. Eytcheson
WS 7-1

Name________________________

Date Due:

Rearranging Atoms

Background

Describe what you already know about each of these ideas. Give an example in each of the last 4 items.

Conservation of Mass

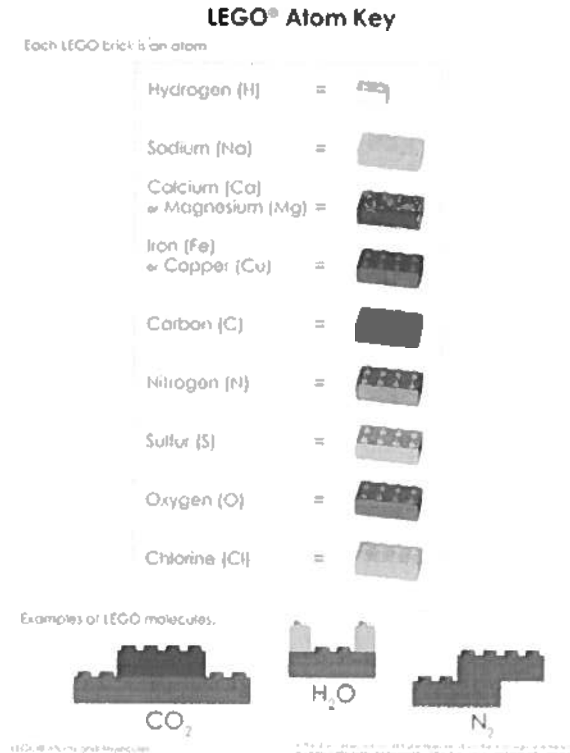
Chemical Formula

Subscripts in formulas

Coefficient (Hint: what is the function of a coefficient in math?)

Procedure:

1. Use your atom model kit to construct the reactant molecules for each chemical change below. Then rearrange the atoms to form the product molecules. Add more reactant molecules as needed to form complete product molecules with no left-overs.



2. Draw particle diagrams for each reactant molecule used and each product molecule produced under the reaction.

3. Determine the number of each <u>reactant</u> molecule you needed in order to make the product(s) with no leftovers (a complete reaction) and record each number as a coefficient in front of its reactant formula.

4. Determine how many <u>product</u> molecules you would get from the complete reaction. Write that number as a coefficient in front of each product formula.

Data and Observations:

1. _____ H_2 + _____ O_2 → _____ H_2O

Diagram:

2. _____ H_2 + _____ Cl_2 → _____ HCl

Diagram:

3. ______Na + ______O_2 → ______Na_2O

Diagram:

4. ______N_2 + ______H_2 → ______NH_3

Diagram:

5. ______CH_4 + ______O_2 → ______CO_2 + ______H_2O

Diagram:

6. ______NO + ______O_2 → ______NO_2

Diagram:

7. ______Fe + ______Cl_2 → ______$FeCl_3$

Diagram:

8. ______CH_3OH + ______O_2 → ______CO_2 + ______H_2O

Diagram:

Analysis

1. In the equation for each reaction, compare the total number of atoms you have before the reaction (reactant atoms) to the total number after the reaction (product atoms).

2. At the beginning of the year we observed that mass is conserved in changes. How does your answer to question 1 explain conservation of mass?

3. Look at the product molecule (ammonia) in reaction #4.
   a. What does the coefficient tell us about this substance?

   b. What do the subscripts on the nitrogen and hydrogen in NH_3 tell us about the composition of the ammonia molecule?

   c. Note that the sum of the reactant coefficients does not equal the sum of the product coefficients for reaction #4. Yet in reaction #2, the sums are equal. Explain why the sums of coefficients do not necessarily have to equal one another in a reaction.

Honors Chemistry
Unit 7: Chemical Reactions: Particles & Energy
Mrs. Eytcheson
WS 7-2

Name______________________________

Due Date:

Balancing Equations

PART I

Balance each of the following equations by inserting the proper coefficients. For selected reactions, draw "before" and "after" particle diagrams to show the particles involved in the reaction.

1. ______C + ______H_2O → ______CO + ______H_2

2. ______MgO → ______Mg + ______O_2

3. ______Al + ______O_2 → ______Al_2O_3

BEFORE	AFTER

4. ______Zn + ______H_2SO_4 → ______$ZnSO_4$ + ______H_2

5. ______Cl_2 + ______KI → ______KCl + ______I_2

6. ______CuCl → ______Cu + ______Cl_2

7. ______Na + ______Cl_2 → ______NaCl

8. ______ Al + ______ HCl → ______ $AlCl_3$ + ______ H_2

BEFORE	AFTER

9. ______ Fe_2O_3 → ______ Fe + ______ O_2

10. ______ P + ______ O_2 → ______ P_2O_5

11. ______ Mg + ______ HCl → ______ $MgCl_2$ + ______ H_2

12. ______ H_2 + ______ N_2 → ______ NH_3

13. ______ $BaCl_2$ + ______ H_2SO_4 → ______ $BaSO_4$ + ______ HCl

14. ______ CH_4 + ______ O_2 → ______ CO_2 + ______ H_2O

BEFORE	AFTER

15. ______$ZnCl_2$ + ______$(NH_4)_2S$ → ______ZnS + ______NH_4Cl

a. Find the molar mass of each of the reactants.

b. How many moles of $ZnCl_2$ would be in 25 g of $ZnCl_2$?

c. How much mass would 0.55 moles of $(NH_4)_2S$ have?

PART II

Write the formulas of the reactants and products, then balance the equations.

Clues & Hints:

- Products usually follow words like "produces, yields, forms".
- Watch for diatomic elements, which are often gases.
- Include "state designations" behind each substance, (s), (l), (g), when the state is given.
- Remember air is a mixture of primarily two gases, O_2 and N_2. Which is most likely to participate in this reaction?
- Elemental metals exist as single, unbonded atoms, like copper (Cu).
- Watch for ionic vs. molecular compounds. Use nomenclature rules, your ion list, and periodic table to figure out formulas.

1. Nitric oxide (NO) reacts with ozone (O_3) to produce nitrogen dioxide and oxygen gas.

2. Iron burns in air to form a black solid, Fe_3O_4.

3. Sodium metal reacts with chlorine gas to form sodium chloride.

4. Acetylene, C_2H_2, burns in air to form carbon dioxide and water.

5. Hydrogen peroxide, H_2O_2, easily decomposes into water and oxygen gas.

6. Hydrazine, N_2H_4, and hydrogen peroxide are used together as rocket fuel. The products are nitrogen gas and water.

7. If potassium chlorate is strongly heated, it decomposes to yield oxygen gas and potassium chloride.

8. When sodium hydroxide is added to sulfuric acid, H_2SO_4, the products are water and sodium sulfate.

9. In the Haber process, hydrogen gas and nitrogen gas react to form ammonia, NH_3.

Honors Chemistry — Name________________________

Unit 7: Chemical Reactions: Particles & Energy

Mrs. Eytcheson — Due Date:

WS 7-3

Balancing More Equations

PART 1

Balance each of the following equations by inserting the proper coefficients.

1. ______SO_2 + ______O_2 → ______SO_3

2. ______CH_4 + ______O_2 → ______CO + ______H_2O

3. ______P + ______Cl_2 → ______PCl_3

4. ______CO + ______O_2 → ______CO_2

5. ______CH_4 + ______O_2 → ______CH_3OH

6. ______Li + ______Br_2 → ______LiBr

7. ______Al_2O_3 → ______Al + ______O_2

8. ______Na + ______H_2O → ______NaOH + ______H_2

9. ______CO_2 + ______H_2O → ______$C_6H_{12}O_6$ + ______O_2

10. ______H_2SO_4 + ______NaCl → ______HCl + ______Na_2SO_4

11. ______H_2 + ______SO_2 → ______H_2S + ______H_2O

12. ______$CaCO_3$ → ______CaO + ______CO_2

13. ______$AgNO_3$ + ______$CaCl_2$ → ______AgCl + ______$Ca(NO_3)_2$

14. ______HCl + ______$Ba(OH)_2$ → ______$BaCl_2$ + ______H_2O

15. ______H_3PO_4 + ______$NaOH$ → ______Na_3PO_4 + ______H_2O

16. ______$Pb(NO_3)_2$ + ______KI → ______PbI_2 + ______KNO_3

17. ______CuO + ______NH_3 → ______N_2 + ______Cu + ______H_2O

18. ______C_2H_5OH + ______O_2 → ______CO_2 + ______H_2O

19. ______C_2H_6 + ______O_2 → ______CH_3COOH + ______H_2O

20. ______NO_2 + ______H_2O → ______HNO_3 + ______NO

PART II

Write the formulas of the reactants and products, then balance the equations. Include state designations for solids, liquids, and gases when the necessary information is provided. An aqueous solution results when a substance is dissolved in water and designated with (aq).

1. When a solution of hydrogen chloride is added to solid sodium bicarbonate, $NaHCO_3$, the products are carbon dioxide, water and aqueous sodium chloride.

2. Steam (gaseous water) reacts with carbon at high temperatures to produce carbon monoxide and hydrogen gases.

3. Limestone, $CaCO_3$, decomposes when heated to produce lime, CaO, and gaseous carbon dioxide.

4. Ethyl alcohol, C_2H_6O, is a liquid that burns in air to produce carbon dioxide and gaseous water.

5. Solid titanium (IV) chloride reacts with water, forming solid titanium (IV) oxide and aqueous hydrogen chloride.

6. At high temperatures, the gases chlorine and water react to produce hydrogen chloride and oxygen gases.

7. Steel wool is nearly pure iron that burns in air to form the solid iron (III) oxide.

8. During photosynthesis in plants, carbon dioxide and water are converted into glucose, $C_6H_{12}O_6$, and oxygen gas.

9. Solutions of calcium hydroxide and nitric acid, $HNO_3(aq)$, react to produce water and aqueous calcium nitrate.

Honors Chemistry — Name________________

Unit 7: Chemical Reactions: Particles & Energy

Mrs. Eytcheson — Date Due:

WS 7-4

Writing and Balancing Word Equations

Write balanced chemical equations for the following reactions.

1. Ammonia, NH_3, reacts with hydrogen chloride to form ammonium chloride.

2. Calcium carbonate decomposes upon heating to form calcium oxide and carbon dioxide.

3. Barium oxide reacts with water to form barium hydroxide.

4. Acetaldehyde, CH_3CHO, decomposes to form methane, CH_4, and carbon monoxide.

5. Zinc reacts with copper (II) nitrate to form zinc nitrate and copper.

6. Calcium sulfite decomposes when heated to form calcium oxide and sulfur dioxide.

7. Iron reacts with sulfuric acid, H_2SO_4, to form iron (II) sulfate and hydrogen gas.

8. A nitrogen containing carbon compound, $C_2H_6N_2$, decomposes to form ethane, C_2H_6, and nitrogen gas.

9. Phosgene, $COCl_2$, is formed when carbon monoxide reacts with chlorine gas.

10. Manganese (II) iodide decomposes when exposed to light to form manganese and iodine.

11. Dinitrogen pentoxide reacts with water to produce nitric acid, HNO_3.

12. Magnesium reacts with titanium (IV) chloride to produce magnesium chloride and titanium.

13. Carbon reacts with zinc oxide to produce zinc and carbon dioxide.

14. Bromine reacts with sodium iodide to form sodium bromide and iodine.

15. Phosphorus, a tetratomic molecule, P_4, reacts with bromine to produce phosphorus tribromide.

16. Ethanol, C_2H_5OH, reacts with oxygen gas to produce carbon dioxide and water.

17. Calcium hydride reacts with water to produce calcium hydroxide and hydrogen gas.

18. Sulfuric acid, H_2SO_4, reacts with potassium hydroxide to produce potassium sulfate and water.

19. Propane, C_3H_8, burns in air to produce carbon dioxide and water.