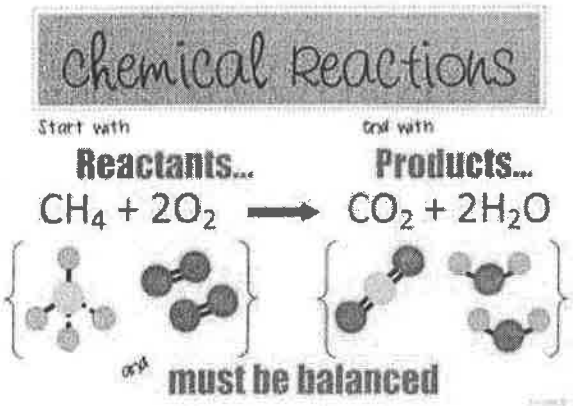
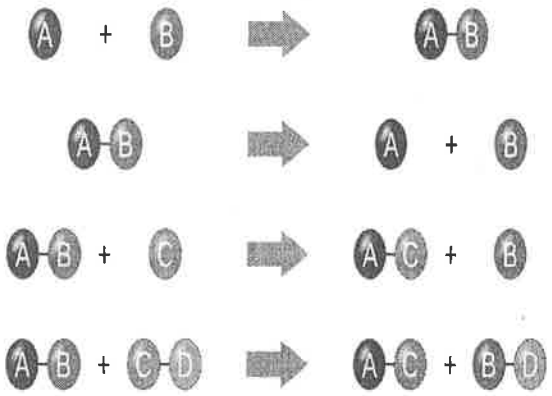
Chapter 8: Chemical Reactions and Types of Chemical Reactions





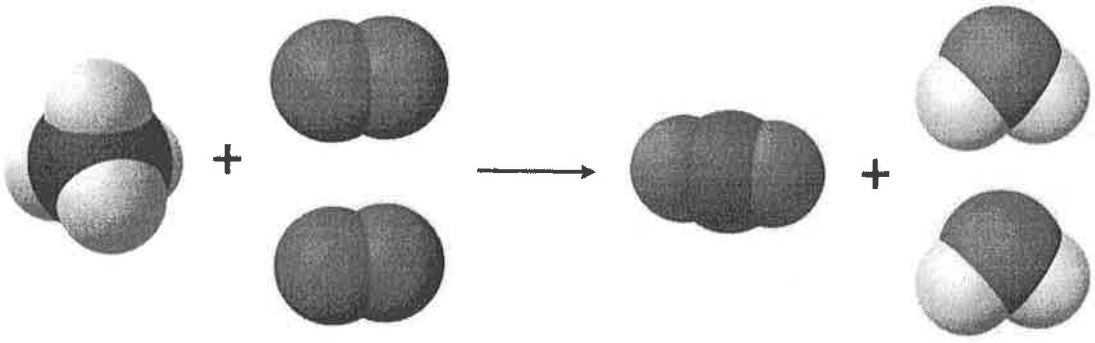
Chapter 9: Stoichiometry

28gN2	1mole N2	2molesNH3	17g NH3	= 34g NH3
	28 g N2	1 mole N2	1 mole NH3	

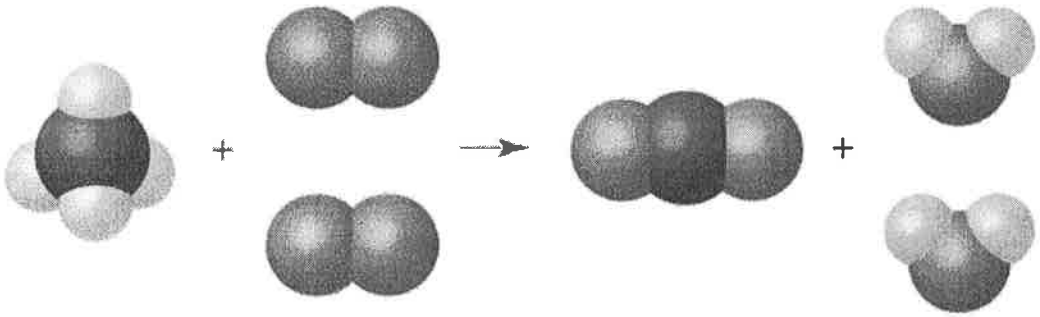
25g H2	1mole	2NH3	17gNH3	=141.7g NH3
	25g H2	3moles H2	1 mole NH3	

Name _____Period_____

Two visual models of a balanced equation:



$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$



One methane molecule		Two oxygen molecules		One carbon dioxide molecule		Two water molecules
CH_4	+	$2O_2$	→	CO_2	+	$2H_2O$
(1 C, 4 H)		(4 O)		(1 C, 2 O)		(2 O, 4 H)

Guidelines for Balancing Chemical Equations

One of the basic skills you will develop as you study chemistry is the ability to balance a chemical equation. One you have written a balanced equation, you will be in a good position to perform all manner of calculations! Balancing a chemical equation refers to establishing the mathematical relationship between the quantity of reactants and products. The quantities are expressed as grams or moles.

It takes practice to be able to write balanced equation. There are essentially three steps to the process:

1. Write the unbalanced equation.
    - Chemical formulas of reactants are listed on the left hand side of the equation.
    - Products are listed on the right hand side of the equation.
    - Reactants and products are separated by putting an arrow between them to show the direction of the reaction. Reactions at equilibrium will have arrows facing both directions.
2. Balance the equation.
    - Apply the Law of Conservation of Mass to get the same number of atoms of every element on each side of the equation. Tip: Start by balancing an element that appears in only *one* reactant and product.
    - Once one element is balanced, proceed to balance another, and another, until all elements are balanced.
    - Balance chemical formulas by placing coefficients in front of them. Do not add subscripts, because this will change the formulas.
3. Indicate the states of matter of the reactants and products.
    - Use (g) for gaseous substances.
    - Use (s) for solids.
    - Use (l) for liquids.
    - Use (aq) for species in solution in water.
    - Write the state of matter immediately following the formula of the substance it describes.

Worked Example Problem

Tin (IV) oxide is heated with hydrogen gas to form tin metal and water vapor. Write the balanced equation that describes this reaction.

1. Write the unbalanced equation.

    $SnO_2 + H_2 \rightarrow Sn + H_2O$

2. Balance the equation.

Look at the equation and see which elements are not balanced. In this case, there are two oxygen atoms on the lefthand side of the equation and only one on the righthand side. Correct this by putting a coefficient of 2 in front of water:

$SnO_2 + H_2 \rightarrow Sn + 2\ H_2O$

This puts the hydrogen atoms out of balance. Now there are two hydrogen atoms on the left and four hydrogen atoms on the right. To get four hydrogen atoms on the right, add a coefficient of 2 for the hydrogen gas. Remember, coefficients are multipliers, so if we write 2 H_2O it denotes 2x2=4 hydrogen atoms and 2x1=2 oxygen atoms.

$SnO_2 + 2\ H_2 \rightarrow Sn + 2\ H_2O$

The equation is now balanced. Be sure to double-check your math! Each side of the equation has 1 atom of Sn, 2 atoms of O, and 4 atoms of H.

3. Indicate the physical states of the reactants and products.

To do this, you need to be familiar with the properties of various compounds or you need to be told what the phases are for the chemicals in the reaction. Oxides are solids, hydrogen forms a diatomic gas, tin is a solid, and the term 'water vapor' indicates that water is in the gas phase:

$SnO_2(s) + 2\ H_2(g) \rightarrow Sn(s) + 2\ H_2O(g)$

There you go! This is the balanced equation for the reaction. Remember, no elements appear on one side of the reaction and not on the other. It's always a good idea to check by counting up the number of atoms of each element just to be sure you have balanced your equation correctly. This was a straightforward example, using conservation of mass. For reactions involving ions, conservation of charge will also come into play!

Name _____ Period _____ Date _____

Balance the following chemical equations.

1. ____ Na + ____ I_2 → ____ NaI

2. ____ $KClO_3$ → ____ KCl + ____ O_2

3. ____ K_3PO_4 + ____ HCl → ____ KCl + ____ H_3PO_4

4. ____ C_3H_8 + ____ O_2 → ____ CO_2 + ____ H_2O

Write and balance the following chemical equations.

5. Nitrogen plus hydrogen produce ammonia. (Remember diatomic elements!)

6. Sodium oxide combines with water to form sodium hydroxide.

7. Sodium sulfate reacts with calcium nitrate to produce sodium nitrate and calcium sulfate.

8. Zinc reacts with iron(III) chloride yielding zinc chloride plus iron.

Balancing Equations - Practice Problems

Balance the following chemical equations.

1. ____ N_2 + ____ O_2 → ____ N_2O

2. ____ KI + ____ Cl_2 → ____ KCl + ____ I_2

3. ____ C_2H_6 + ____ O_2 → ____ CO_2 + ____ H_2O

4. ____ $Mg(NO_3)_2$ + ____ K_3PO_4 → ____ $Mg_3(PO_4)_2$ + ____ KNO_3

Write and balance the following chemical equations.

5. Hydrogen plus oxygen produce water. (Remember diatomic elements!)

6. Sodium reacts with magnesium chloride yielding sodium chloride plus magnesium.

7. Aluminum bromide plus chlorine yield aluminum chloride and bromine.

8. Aluminum nitrate and sodium sulfide react to form aluminum sulfide and sodium nitrate.

Homework problems. Write balanced formula equations for each of the following word equations.

1. Zinc + Chlorine $\longrightarrow$ Zinc chloride

2. Phosphorus + Oxygen $\longrightarrow$ Diphosphorus pentaoxide

3. Iron + Chlorine $\longrightarrow$ Iron(III) chloride

4. Sodium + Water $\longrightarrow$ Sodium hydroxide + Hydrogen

5. Oxygen $\xrightarrow{\text{electricity}}$ Ozone

6. Iron + Oxygen $\longrightarrow$ Iron (III) oxide

7. Magnesium + Hydrochloric acid $\longrightarrow$ Magnesium chloride + Hydrogen

8. Methane (CH_4) $\longrightarrow$ Carbon + Hydrogen

9. Zinc + Sulfuric acid $\longrightarrow$ Zinc sulfate + Hydrogen

10. Methane + Oxygen $\longrightarrow$ Carbon dioxide + Water

11. Carbon monoxide + Water $\longrightarrow$ Carbon dioxide + Hydrogen

12. Sodium chloride + Sulfuric acid $\longrightarrow$ Sodium sulfate + Hydrogen chloride

13. Potassium + Water $\longrightarrow$ Potassium hydroxide + Hydrogen

14. Strontium chloride + Sulfuric acid $\longrightarrow$ Hydrogen chloride + Strontium sulfate

Name _____ Date _____ Class _____

9–2 Practice Problems

1. Write the formula equation for the following reaction: Ammonia reacts with hydrogen chloride to form ammonium chloride.

2. When heated, calcium carbonate ($CaCO_3$) decomposes to form calcium oxide and carbon dioxide. Write an equation for this reaction.

3. Write the formula equation for the following reaction: Barium oxide (BaO) reacts with water to form barium hydroxide.

4. Acetaldehyde (CH_3CHO) decomposes to form methane (CH_4) and carbon monoxide. Write an equation for this reaction.

5. Write the formula equation for the following reaction: Zinc reacts with copper(II) nitrate ($Cu(NO_3)_2$) to form zinc nitrate and copper.

6. When heated, calcium sulfite ($CaSO_3$) decomposes to form calcium oxide and sulfur dioxide. Write an equation for this reaction.

7. Write the formula equation for the following reaction: Iron reacts with sulfuric acid (H_2SO_4) to form iron(II) sulfate ($FeSO_4$) and hydrogen gas.

8. Azomethane ($C_2H_6N_2$) decomposes to form ethane (C_2H_6) and nitrogen gas at 297°C. Write an equation for this reaction.

9. Write out the formula equation for the following reaction: Carbon monoxide reacts with chlorine gas to form phosgene ($COCl_2$).

10. Manganese(II) iodide decomposes when exposed to light to form manganese and iodine. Write an equation for this reaction.

Name _____ Date _____ Class _____

9–2 *Practice Problems (continued)*

11. Write a balanced chemical equation for the reaction in which dinitrogen pentoxide (N_2O_5) reacts with water to produce nitric acid (HNO_3).

12. Magnesium reacts with titanium(IV) chloride ($TiCl_4$) to produce magnesium dichloride ($MgCl_2$) and titanium. Write the balanced equation for this reaction.

13. Write a balanced chemical equation for the reaction in which carbon reacts with zinc oxide to produce zinc and carbon dioxide.

14. Bromine reacts with sodium iodide to form sodium bromide and iodine. Write the balanced equation for this reaction.

15. Write a balanced chemical equation for the reaction in which phosphorus trichloride (PCl_3) reacts with chlorine gas to produce phosphorus pentachloride (PCl_5).

16. Phosphorus reacts with bromine to produce phosphorus tribromide (PBr_3). Write the balanced equation for this reaction.

17. Calcium hydride (CaH_2) reacts with water to produce calcium hydroxide ($Ca(OH)_2$) and hydrogen gas. Write the balanced equation for this reaction.

18. Write a balanced chemical equation for the reaction in which sulfuric acid (H_2SO_4) reacts with potassium hydroxide to produce dipotassium sulfate (K_2SO_4) and water.

19. Write a balanced chemical equation for the reaction in which propane (C_3H_8) reacts with oxygen gas to produce carbon dioxide and water.

20. Benzene (C_6H_6) reacts with oxygen gas to produce carbon dioxide and water. Write the balanced equation for this reaction.

Types of Chemical Reactions

***Direct Combination Reactions** (also called Synthesis Reactions)
- two or more reactants come together to form a single product

$$A + B \rightarrow AB$$

$$4\,Na\,(s) + O_2\,(g) \rightarrow 2\,Na_2O\,(s)$$

***Decomposition Reactions**
- a single compound is broken down into two or more smaller compounds or elements

$$AB \rightarrow A + B$$

$$2\,HgO\,(s) \rightarrow 2\,Hg\,(l) + O_2\,(g)$$

***Single Replacement Reactions**
- an uncombined element displaces an element that is part of a compound
- use the activity series list for metals (or halogens) to determine if reaction will occur

$$A + BX \rightarrow AX + B$$

$$Cu\,(s) + 2AgNO_3\,(aq) \rightarrow 2Ag\,(s) + Cu(NO_3)_2\,(aq)$$

***Double Replacement Reactions**
- atoms or ions from two different compounds replace each other
- things to look for: a precipitate, a gas released, a molecular compound formed
- use a solubility chart to check for precipitates that will form

$$AX + BY \rightarrow AY + BX$$

$$AgNO_3\,(aq) + NaCl\,(aq) \rightarrow AgCl\,(s) + NaNO_3\,(aq)$$

***Combustion Reactions**
- a substance reacts with oxygen and produces energy in the form of heat and/or light

some combustion reactions fall into the "Direct Combination" category:

$$2\,Mg\,(s) + O_2\,(g) \rightarrow 2\,MgO\,(s)$$

other combustion reactions can be described as

"*complete combustion*" (carbon dioxide and water are products)

$$C_6H_{12}O_6\,(s) + 6\,O_2\,(g) \rightarrow 6\,CO_2\,(g) + 6\,H_2O\,(l)$$

OR

"*incomplete combustion*" (when there is an insufficient supply of oxygen present carbon monoxide and elemental carbon may also be products)

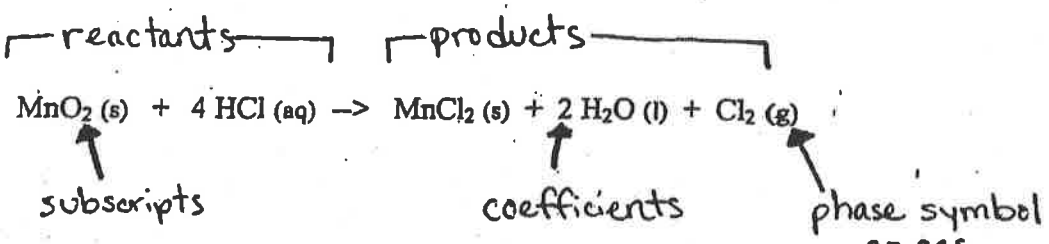
$$4\,C_2H_5OH\,(l) + 7\,O_2\,(g) \rightarrow 2\,CO\,(g) + 4\,C\,(s) + 2\,CO_2\,(g) + 12\,H_2O\,(g)$$

Chemistry 1A
Chapter 9 – Chemical Reactions and Equations

Chemical reaction
- the process in which one or more substances are converted into new substances with different physical & chemical properties

Law of conservation of matter
- matter is neither created nor destroyed
- matter has mass, so mass also is neither created nor destroyed
- therefore before and after a chemical reaction the number of atoms of each element must be the same

Parts of a Chemical Equation



Balancing Chemical Equations

1. Write the correct chemical formulas for the reactants and products.
2. Make a list of the elements in the equation.
3. Count the number of atoms of each element on both sides of the equation.
4. Use coefficients (whole numbers written before the formulas) to balance the number of atoms of each element.
5. Verify that the equation is balanced.
6. Make sure all of the coefficients are in the lowest possible ratio that balances

Name_____Period _____

Activity of Metals Equation Worksheet

For each of the following: Determine if a reaction occurs by using the Metal or Nonmetal Activity Table
If no reaction occurs, write NR
If a reaction occurs, write the appropriate products.(Make sure each compound is written correctly.)
Balance the equation. Write the name of the compound in the product.

1. $Na + KNO_3 \longrightarrow$

2. $Cu + K_2CO_3 \longrightarrow$

3. $Al + AgNO_3 \longrightarrow$

4. $K + Li_3PO_4 \longrightarrow$

5. $Sn + PbSO_4 \longrightarrow$

6. $Fe(NO_3)_2 + Zn \longrightarrow$

7. $KBr + Cl_2 \longrightarrow$

8. $CaF_2 + Br_2 \longrightarrow$

9. $F_2 + NaCl \longrightarrow$

10. $Mg_3(PO_4)_2 + Na \longrightarrow$

Metal Activity Series
Li
K
Ca
Na
Mg
Al
Zn
Cr
Fe
Ni
Sn
Pb
Cu
Hg
Ag
Pt
Au

NonMetal Activity Series
F
Cl
Br
I

Name _____ Period _____ Date _____

Types of Reactions – Ch. 8

For each of the following reactions, identify the reaction type, predict the products and balance the equation. Include physical states. Word equations must first be converted to formulas.

1. ____ $Li(s)$ + ____ $N_2(g)$ →

Reaction Type: _____

2. ____ $Mg(s)$ + ____ $CrCl_3(aq)$ →

Reaction Type: _____

3. ____ $CoBr_2(s)$ $\xrightarrow{\Delta}$

Reaction Type: _____

4. ____ $C_4H_8(g)$ + ____ $O_2(g)$ →

Reaction Type: _____

5. Aqueous solutions of potassium bromide and silver nitrate react to form a white precipitate.

Reaction Type: _____

6. Solid nickel is added to an aqueous solution of iron(II) sulfate.

Reaction Type: _____

Name _____ Date _____

Identifying and Balancing Chemical Equations

Balance each equation and identify the type as:

SYN = synthesis DEC= decomposition

SR = single replacement DR= Double replacement COM= combustion

_____	1.	HgO			→	Hg	+	O_2
_____	2.	$NaCl$	+	$AgNO_3$	→	$NaNO_3$	+	$AgCl$
_____	3.	Mg	+	HCl	→	$MgCl_2$	+	H_2
_____	4.	CH_4	+	O_2	→	CO_2	+	H_2O
_____	5.	Zn	+	H_2SO_4	→	$ZnSO_4$	+	H_2
_____	6.	$NaOH$	+	HCl	→	$NaCl$	+	H_2O
_____	7.	$Al_2(SO_4)_3$	+	$Ca(OH)_2$	→	$Al(OH)_3$	+	$CaSO_4$
_____	8.	H_2	+	O_2	→	H_2O		
_____	9.	Fe	+	$CuNO_3$	→	$Fe(NO_3)_2$	+	Cu
_____	10.	$KClO_3$			→	KCl	+	O_2
_____	11.	H_2O	+	Fe	→	Fe_2O_3	+	H_2
_____	12.	$Ca(OH)_2$	+	HNO_3	→	$Ca(NO_3)_2$	+	H_2O
_____	13.	Na_2O	+	CO_2	→	Na_2CO_3		
_____	14.	H_2	+	N_2	→	NH_3		

Write the chemical formula for the following

_____ 15. Potassium chloride

_____ 16. Sodium hydroxide

_____ 17. Calcium oxide

_____ 18. Calcium fluoride

_____ 19. Silicon dioxide

_____ 20. Aluminum oxide

_____ 21. Silver nitrate

_____ 22. Calcium carbonate

_____ 23. Magnesium nitrate

_____ 24. Sodium hydrogen carbonate

Balance each of the following equations

25. P_4 + O_2 → P_4O_{10}

26. FeS_2 + O_2 → Fe_2O_3 + SO_2

Write a balanced equation for each of the following word equations:

27. silver + chlorine → silver chloride

28. hydrogen + fluorine → hydrogen monofluoride

29. hydrochloric acid + sodium hydroxide → sodium chloride + water

30. magnesium hydroxide + hydrochloric acid → magnesium chloride + water

31. calcium carbonate → calcium oxide + carbon dioxide

Identify the type of reaction in #25-31
Syn = synthesis DEC = decomposition SR = single replacement DR = double replacement
COM = combustion

25. _____

26. _____

27. _____

28. _____

29. _____

30. _____

_____

ACTIVITY SERIES OR ELECTROMOTIVE SERIES

In parentheses following the elements are the chemical symbols or oxidation numbers of the elements that the student has not been required to learn.

Metals

Lithium
Rubidium(Rb)
Potassium
Barium
Strontium
Calcium
Sodium
Magnesium
Aluminum
Beryllium (Be)
Uranium(+4)
Manganese
Zinc
Chromium
Gallium(Ga)
Iron
Cadmium(Cd)
Indium(In)
Cobalt
Nickel
Tin
Lead
HYDROGEN (not a metal but can be displaced in a reaction)
Antimony(Sb)
Bismuth
Arsenic
Copper
Polonium (Po, +2, +4)
Mercury
Silver
Palladium (Pd, +2, +4)
Platinum (Pt, +2, +4)
Gold (+1, +3)

Non-metals (halogens)

Fluorine
Chlorine
Bromine
Iodine

GENERAL SOLUBILITY RULES OF COMMON COMPOUNDS IN WATER

(A compound is considered soluble if it can dissolve to a concentration of more than 0.1M at 20 C.)

1. *Ammonium* compounds and *all compounds having members of the sodium family* (Li, Na, K, Rb, Cs and Fr) are **soluble**.

2. All common *acetates*, *chlorates*, and *nitrates* are **soluble.**

3. All common *chlorides*, *bromides*, and *iodides* are **soluble** except copper (I), silver, mercury(I), and lead(II). (Lead(II) is highly soluble in hot water.)

4. All common *sulfates* are **soluble** except calcium, strontium, barium, lead(II) and silver.

5. All common *carbonates*, *phosphates*, *silicates*, and *sulfites* are **insoluble** except ammonium and sodium family compounds.

6. All common *oxides* and *sulfides* are **insoluble** except calcium, strontium, barium, ammonium, and sodium family compounds. (Magnesium sulfide decomposes in water)

7. All *hydroxides* are **insoluble** except those of the sodium family, ammonium, calcium, strontium, and barium.

Chemical Reactions Review – Ch. 8

IDENTIFY THE TYPE OF REACTION AND BALANCE THE EQUATION:

1. $Sb + I_2 \rightarrow SbI_3$
2. $Li + H_2O \rightarrow LiOH + H_2$
3. $AlCl_3 \rightarrow Al + Cl_2$
4. $C_6H_{12} + O_2 \rightarrow CO_2 + H_2O$
5. $AlCl_3 + Na_2CO_3 \rightarrow Al_2(CO_3)_3 + NaCl$
6. $HNO_3 + Ba(OH)_2 \rightarrow Ba(NO_3)_2 + H_2O$
7. $Al + Pb(NO_3)_2 \rightarrow Al(NO_3)_3 + Pb$

IDENTIFY THE TYPE OF REACTION & WRITE A BALANCED EQUATION (INCL. STATES):

8. Aqueous solutions of ammonium chloride and lead(II) nitrate produce lead(II) chloride precipitate and aqueous ammonium nitrate.
9. Solid carbon disulfide burns in oxygen to yield carbon dioxide and sulfur dioxide gases.
10. Iron metal reacts with aqueous silver nitrate to produce aqueous iron(III) nitrate and silver metal.
11. Solid potassium nitrate yields solid potassium nitrite and oxygen gas.
12. Calcium metal reacts with chlorine gas to produce solid calcium chloride.
13. Fluorine gas added to aqueous potassium chloride produces aqueous potassium fluoride and chlorine gas.
14. Phosphorus reacts with oxygen gas to produce solid diphosphorous pentoxide.

IDENTIFY THE TYPE OF REACTION, PREDICT THE PRODUCTS (STATES NOT REQUIRED), AND BALANCE THE EQUATION:

15. $Al(s) + NaOH(aq) \rightarrow$
16. $C_2H_4(g) + O_2(g) \rightarrow$
17. $FeCl_2(aq) + K_2S(aq) \rightarrow$
18. $Ba(s) + O_2(g) \rightarrow$
19. $NH_4NO_3(aq) + NaCl(aq) \rightarrow$
20. $SO_2(g) \rightarrow$
21. Magnesium metal is added to aqueous hydrochloric acid.
22. Potassium metal is combined with chlorine gas.
23. Aqueous solutions of potassium bromide and silver nitrate are combined.
24. Solid mercury(II) oxide breaks down into its component elements.

CLASSIFY EACH REACTION AS EXOTHERMIC OR ENDOTHERMIC:

25. $PCl_3 + Cl_2 \rightarrow PCl_5 + \text{energy}$
26. $P_4O_{10} \xrightarrow{\Delta} P_4 + 5O_2$
27. $2Sb + 3I_2 + \text{heat} \rightarrow 2SbI_3$
28. $CaO + H_2O \rightarrow Ca(OH)_2 + \text{heat}$
29. $CaCO_3 + \text{energy} \rightarrow CaO + CO_2$
30. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O + \text{heat}$

Name _____ Date _____ Class _____

CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. Match the symbol on the left with its appropriate description on the right.

_____ $\xrightarrow{\Delta}$	**(a)** A precipitate forms.
_____ $\downarrow$	**(b)** A gas forms.
_____ $\uparrow$	**(c)** A reversible reaction occurs.
_____ (l)	**(d)** Heat is applied to the reactants.
_____ (aq)	**(e)** A chemical is dissolved in water.
_____ $\rightleftarrows$	**(f)** A chemical is in the liquid state.

2. Finish balancing the following equation:

$3Fe_3O_4 +$ _____ $Al \rightarrow$ _____ $Al_2O_3 +$ _____ Fe

3. In each of the following formulas, write the total number of atoms present.

_____ **a.** $4SO_2$

_____ **b.** $8O_2$

_____ **c.** $3Al_2(SO_4)_3$

_____ **d.** $6 \times 10^{23}\ HNO_3$

4. Convert the following word equation into a balanced chemical equation:
aluminum metal + copper(II) fluoride → aluminum fluoride + copper metal

5. One way to test the salinity of a water sample is to add a few drops of silver nitrate solution with a known concentration. As the solutions of sodium chloride and silver nitrate mix, a precipitate of silver chloride forms, and sodium nitrate is left in solution. Translate these sentences into a balanced chemical equation.

6. **a.** Balance the following equation: $NaHCO_3(s) \xrightarrow{\Delta} Na_2CO_3(s) + H_2O(g) + CO_2(g)$

SECTION 1 continued

b. Translate the chemical equation in part **a** into a sentence.

_____

_____

_____

_____

7. The poisonous gas hydrogen sulfide, H_2S, can be neutralized with a base such as sodium hydroxide, NaOH. The unbalanced equation for this reaction follows:

$$NaOH(aq) + H_2S(g) \rightarrow Na_2S(aq) + H_2O(l)$$

A student who was asked to balance this equation wrote the following:

$$Na_2OH(aq) + H_2S(g) \rightarrow Na_2S(aq) + H_3O(l)$$

Is this equation balanced? Is it correct? Explain why or why not, and supply the correct balanced equation if necessary.

_____

_____

_____

_____

PROBLEM **Write the answer on the line to the left. Show all your work in the space provided.**

8. Recall that coefficients in a balanced chemical equation give relative amounts of moles as well as numbers of molecules.

_____ **a.** Calculate the number of moles of CO_2 that form if 10 mol of C_3H_4 react according to the following balanced equation:

$$C_3H_4 + 4O_2 \rightarrow 3CO_2 + 2H_2O$$

_____ **b.** Calculate the number of moles of O_2 that are consumed.

Name _____ Date _____ Class _____

CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. Match the equation type on the left to its representation on the right.

_____ synthesis	**(a)** $AX + BY \rightarrow AY + BX$
_____ decomposition	**(b)** $A + BX \rightarrow AX + B$
_____ single-displacement	**(c)** $A + B \rightarrow AX$
_____ double-displacement	**(d)** $AX \rightarrow A + X$

2. _____ In the reaction described by the equation $2Al(s) + 3Fe(NO_3)_2(aq) \rightarrow 3Fe(s) + 2Al(NO_3)_3(aq)$, iron has been replaced by

(a) nitrate. **(c)** aluminum.
(b) water. **(d)** nitrogen.

3. _____ Of the following chemical equations, the only reaction that is both synthesis and combustion is

(a) $C(s) + O_2(g) \rightarrow CO_2(g)$.
(b) $2C_4H_{10}(l) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$.
(c) $6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$.
(d) $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(aq) + 6H_2O(l)$.

4. _____ Of the following chemical equations, the only reaction that is both combustion and decomposition is

(a) $S(s) + O_2(g) \rightarrow SO_2(g)$.
(b) $2C_4H_{10}(l) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$.
(c) $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$.
(d) $2HgO(s) \xrightarrow{\Delta} 2Hg(l) + O_2(g)$.

5. Identify the products when the following substances decompose:

_____ **a.** a binary compound

_____ **b.** most metal hydroxides

_____ **c.** a metal carbonate

_____ **d.** the acid H_2SO_3

6. The complete combustion of a hydrocarbon in excess oxygen yields the products _____ and _____.

Name _____ Date _____ Class _____

SECTION 2 continued

7. For the following four reactions, identify the type, predict the products (make sure formulas are correct), and balance the equations:

a. $Cl_2(aq) + NaI(aq) \rightarrow$

b. $Mg(s) + N_2(g) \rightarrow$

c. $Co(NO_3)_2(aq) + H_2S(aq) \rightarrow$

d. $C_2H_5OH(aq) + O_2(g) \rightarrow$

8. Acetylene gas, C_2H_2, is burned to provide the high temperature needed in welding.

a. Write the balanced chemical equation for the combustion of C_2H_2 in oxygen.

_____ **b.** If 1.0 mol of C_2H_2 is burned, how many moles of CO_2 are formed?

_____ **c.** If 1.0 mol of C_2H_2 is burned how many moles of oxygen gas are consumed?

9. a. Write the balanced chemical equation for the reaction that occurs when solutions of barium chloride and sodium carbonate are mixed. Refer to **Table 1** on page 437 in **Chapter 13** for solubility.

b. To which of the five basic types of reactions does this reaction belong?

10. For the commercial preparation of aluminum metal, the metal is extracted by electrolysis from alumina, Al_2O_3. Write the balanced chemical equation for the electrolysis of molten Al_2O_3.

Name _____ Date _____ Class _____

CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. List four metals that will *not* replace hydrogen in an acid.

2. Consider the metals iron and silver, both listed in **Table 3** on page 286 of the text. Which one readily forms an oxide in nature, and which one does not?

3. In each of the following pairs, identify the more active element.

_____ **a.** F_2 and I_2

_____ **b.** Mn and K

_____ **c.** Cu and H

4. Use the information in **Table 3** on page 286 of the text to predict whether each of the following reactions will occur. For each reaction that will occur, complete the chemical equation by writing in the products formed and balancing the final equation.

a. $Al(s) + CH_3COOH(aq) \xrightarrow{50°C}$

b. $Al(s) + H_2O(l) \xrightarrow{50°C}$

c. $Cr(s) + CdCl_2(aq) \rightarrow$

d. $Br_2(l) + KCl(aq) \rightarrow$

Name _____ Date _____ Class _____

SECTION 3 continued

5. Very active metals will react with water to release hydrogen gas and form hydroxides.

a. Complete, and then balance, the equation for the reaction of Ca(*s*) with water.

_____

b. The reaction of rubidium, Rb, with water is faster and more violent than the reaction of Na with water. Use the atomic structure and radius of each metal to account for this difference.

_____

_____

_____

_____

6. Gold, Au, is often used in jewelry. How does the relative activity of Au relate to its use in jewelry?

_____

_____

_____

7. Explain how to use an activity series to predict the outcome of a single-displacement reaction.

_____

_____

_____

_____

8. Aluminum is above copper in the activity series. Will aluminum metal react with copper(II) nitrate, $Cu(NO_3)_2$, to form aluminum nitrate, $Al(NO_3)_3$? If so, write the balanced chemical equation for the reaction.

_____

_____

_____

_____

Name _____ Date _____ Class _____

CHAPTER 8 REVIEW

Chemical Equations and Reactions

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. _____ A balanced chemical equation represents all the following *except*

(a) experimentally established facts.
(b) the mechanism by which reactants combine to form products.
(c) identities of reactants and products in a chemical reaction.
(d) relative quantities of reactants and products in a chemical reaction.

2. _____ According to the law of conservation of mass, the total mass of the reacting substances is

(a) always more than the total mass of the products.
(b) always less than the total mass of the products.
(c) sometimes more and sometimes less than the total mass of the products.
(d) always equal to the total mass of the products.

3. Predict whether each of the following chemical reactions will occur. For each reaction that will occur, identify the reaction type and complete the chemical equation by writing in the products formed and balancing the final equation. General solubility rules are in **Table 1** on page 437 of the text.

a. $Ba(NO_3)_2(aq) + Na_3PO_4(aq) \rightarrow$

b. $Al(s) + O_2(g) \rightarrow$

c. $I_2(s) + NaBr(aq) \rightarrow$

d. $C_3H_4(g) + O_2(g) \rightarrow$

Name _____ Date _____ Class _____

MIXED REVIEW continued

e. electrolysis of molten potassium chloride

4. Some small rockets are powered by the reaction represented by the following unbalanced equation:

$$(CH_3)_2N_2H_2(l) + N_2O_4(g) \rightarrow N_2(g) + H_2O(g) + CO_2(g) + \text{heat}$$

a. Translate this chemical equation into a sentence. (Hint: The name for $(CH_3)_2N_2H_2$ is dimethylhydrazine.)

b. Balance the formula equation.

5. In the laboratory, you are given two small chips of each of the unknown metals X, Y, and Z, along with dropper bottles containing solutions of $XCl_2(aq)$ and $ZCl_2(aq)$. Describe an experimental strategy you could use to determine the relative activities of X, Y, and Z.

6. List the observations that would indicate that a reaction had occurred.

Name _____ Date _____

Now that your mind is brimming with intelligence on how to complete all types of equations, let's see how much you have really learned.

\ .e the type of reaction- (C = composition, D = decomposition, R = single replacement, I= ionic, S = special) next to the number of each problem. Use the summary sheet that is provided to complete each problem. Don't forget to write out all word formulas into symbol formulas!

_____1. $FeI_2 \cdot 4H_2O \xrightarrow{\Delta}$

_____2. $Zn + O_2 \longrightarrow$

_____3. $Sr(OH)_2 \xrightarrow{\Delta}$

_____4. $PdO \xrightarrow{\Delta}$

_____5. $Cr + H_2O$ (steam) $\xrightarrow{\Delta}$

_____6. $Fe + ZnBr_2 \longrightarrow$

_____7. $K + Cl_2 \longrightarrow$

_____8. $KCl + AgC_2H_3O_2 \longrightarrow$

_____9. $NaCl$(fused) $\xrightarrow{\text{electricity}}$

_____10. $Li_2CO_3 \xrightarrow{\Delta}$

_____11. $K + H_2O \longrightarrow$

_____12. $Zn + HC_2H_3O_2 \longrightarrow$

_____13. $Sr(ClO_3)_2 \xrightarrow{\Delta}$

_____14. $Cu_2O + H_2 \longrightarrow$

_____15. $KBr + Cl_2 \longrightarrow$

_____16. $Mg(OH)_2 + HCl \longrightarrow$

_____17. $Au + O_2 \longrightarrow$

_____18. $H_2CO_3 \xrightarrow{\Delta}$

_____19. $ZnS + H_2SO_4 \longrightarrow$

_____20. Copper plus hydrochloric acid yields

_____21. Cobalt(II) acetate tetrahydrate is heated

_____22. Zinc acetate plus sodium sulfite yields

_____23. Aluminum plus oxygen yields

_____24. Sodium iodide is melted and then electricity is run through it

_____25. Sulfuric acid plus strontium carbonate yields

_____26. Barium chloride plus sodium sulfate yields

_____27. Magnesium plus bromine yields

_____28. Radium carbonate is heated

_____30. Magnesium chlorate is heated

_____31. Tin (IV)oxide is heated

_____32. Sulfuric acid is heated

_____33. Barium hydroxide is heated

_____34. Iodine plus arsenic trichloride yields

_____35. Cobalt(III)oxide plus carbon are reacted together with heat

_____36. Strontium plus water yields

SUMMARY SHEET OF EQUATIONS

COMPOSITION

1. Element + element $\longrightarrow$ compound
2. Metal above silver on activity series + O_2 $\longrightarrow$ metallic oxide
   Metal below mercury on activity series + O_2 $\longrightarrow$ No reaction
3. Compound + compound $\longrightarrow$ more complex compound

DECOMPOSITION

1. Hydrate $\xrightarrow{\Delta}$ anhydrous form + $H_2O\uparrow$
2. Fused compound $\xrightarrow{\text{electricity}}$ element + element
3. Unstable compound $\xrightarrow{\text{light}}$ element + element or simpler compound
4. Metallic hydroxide $\xrightarrow{\Delta}$ Metallic oxide + $H_2O\uparrow$
5. Metallic carbonate $\xrightarrow{\Delta}$ Metallic oxide + $CO_2\uparrow$
6. Metallic chlorate $\xrightarrow{\Delta}$ Metallic chloride + $O_2\uparrow$
7. Oxides of metals below Pb $\xrightarrow{\Delta}$ Metal + $O_2\uparrow$
   Oxides of metals Pb-Po $\xrightarrow{\Delta}$ Metallic oxides of lower valences + $O_2\uparrow$
8. Certain acids $\xrightarrow{\Delta}$ Nonmetallic oxide + H_2O

REPLACEMENT

1. Active metal + metallic compound → different metallic compound + less active metal$\downarrow$
2. Metal above H_2 on activity series + acid $\longrightarrow$ metallic salt + $H_2\uparrow$
3. Active metal (Li-Mg) + H_2O $\longrightarrow$ metallic hydroxide + $H_2\uparrow$
4. More stable metal (Al-Fe) + water(steam) $\longrightarrow$ metallic oxide + $H_2\uparrow$
5. Active halogen + halide $\longrightarrow$ different halide + less active halogen

IONIC

1. Ionic compound + ionic compound → insoluble ionic compound$\downarrow$ + another ionic comp
2. Ionic compound + ionic compound $\longrightarrow$ gas$\uparrow$ + another ionic compound
   Ionic compound + ionic compound → compound that decomposes into a gas + ionic compound
3. Ionic compound + ionic compound → nongaseous molecular compound (H_2O) + ionic compound

Note: If a precipitate, gas, or nongaseous molecular compound is not formed, there is NO REACTION

SPECIAL REACTIONS

1. Metallic oxide (above gallium) + hydrogen $\longrightarrow$ no reaction
   Metallic oxide (below gallium) + hydrogen $\longrightarrow$ free metal + $H_2O\uparrow$
   Metallic oxide (below chromium) + carbon or CO$\uparrow$ → free metal + $CO_2\uparrow$
2. C-H fuel + sufficient O_2 $\longrightarrow$ $CO_2\uparrow$ + $H_2O\uparrow$
   C-H fuel + insufficient O_2 → C or CO$\uparrow$ + $H_2O\uparrow$

You should be able to recognize the following compounds as gases---
CO_2, CO, NH_3, SO_2, H_2S , HF, HCl, HBr, HI, N_2O, NO, NO_2, N_2O_3 and N_2O_4

hydrogen halides nitrogen oxides

$H_2CO_3 \rightarrow H_2O + CO_2$ (This is carbonic acid , the acid in soda)

$H_2SO_3 \rightarrow H_2O + SO_2$

$NH_4OH \rightarrow H_2O + NH_3$

PERIODIC TABLE OF THE ELEMENTS

(based on Carbon-12 = 12.0000)

	1/ 1A	2/ 2A	3/ 3B	4/ 4B	5/ 5B	6/ 6B	7/ 7B	8/ 8B	9/ 8B	10/ 8B	11/ 1B	12/ 2B	13/ 3A	14/ 4A	15/ 5A	16/ 6A	17/ 7A	18/ 8A
1	1 H Hydrogen 1.01																	2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.30											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.90	56 Ba Barium 137.33	71 Lu Lutetium 174.97	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	103 Lr Lawrencium (262)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Uut # (284)	114 Uuq # (285)	115 Uup # (288)	116 Uuh # (292)	117 Uus # (293)	118 Uuo # (294)

Lanthanide Series	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04
Actinide Series	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

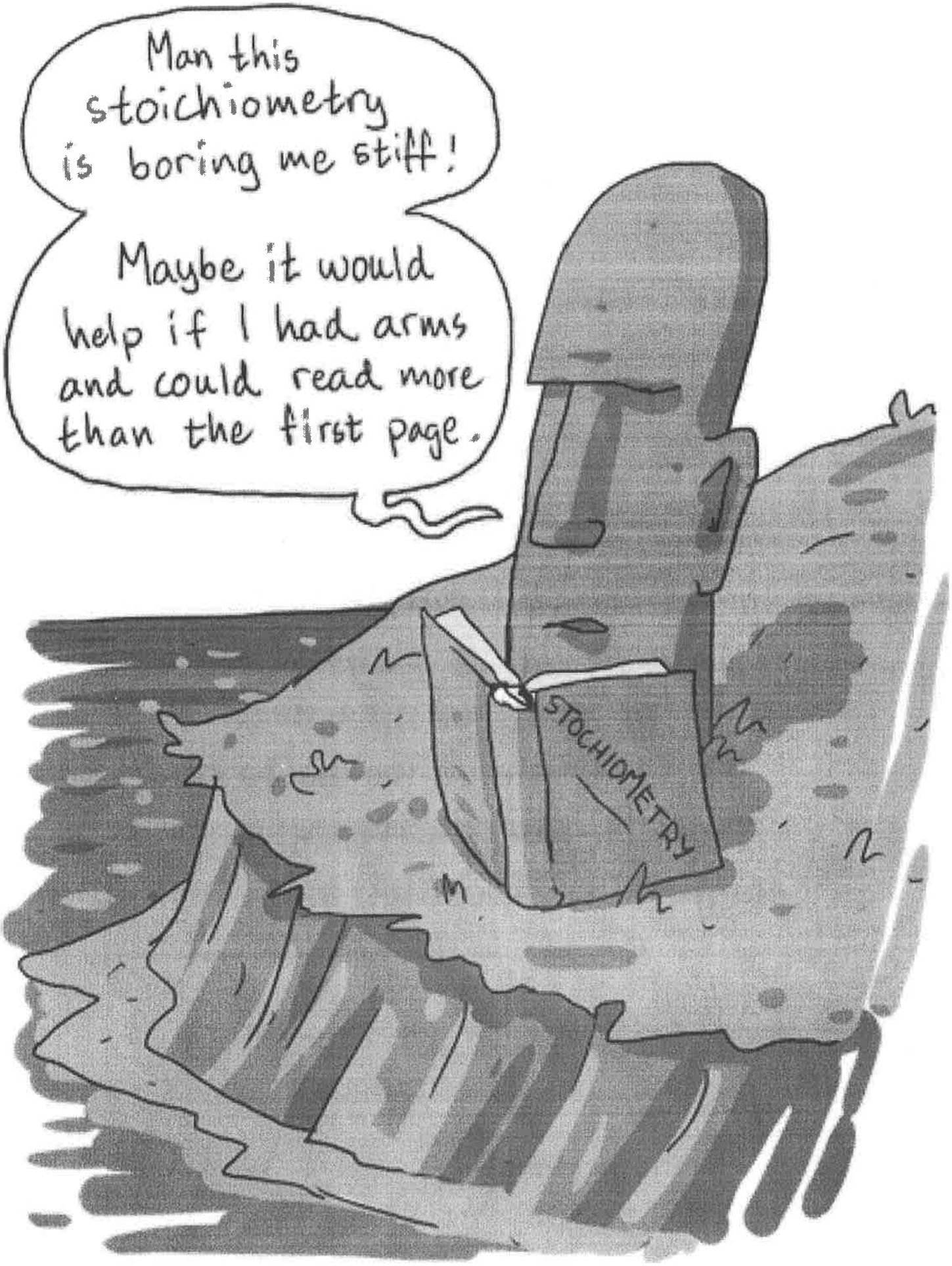
Revised 4/8/2010

Notes; *proposed name, #has not been confirmed

CHAPTER 9

Stoichiometry

Derived from the Greek "*stoicheion*" or element and "*metron*" or measure. This is the term we use to refer to all quantitative aspects of chemical composition and reaction


Man this stoichiometry is boring me stiff!
Maybe it would help if I had arms and could read more than the first page.
STOCHIOMETRY

Examples of how to set up a stoichiometry problem.

$$\frac{28\text{g N2}}{} \left| \frac{1\text{mole N2}}{28\text{ g N2}} \right| \frac{2\text{moles NH3}}{1\text{ mole N2}} \left| \frac{17\text{g NH3}}{1\text{ mole NH3}} \right. = 34\text{g NH3}$$

$$\frac{25\text{g H2}}{} \left| \frac{1\text{mole}}{25\text{g H2}} \right| \frac{2\text{NH3}}{3\text{moles H2}} \left| \frac{17\text{gNH3}}{1\text{ mole NH3}} \right. = 141.7\text{g NH3}$$

$$\frac{4\text{ g } \cancel{H_2}}{} \left| \frac{1\text{ mole } \cancel{H_2}}{2\text{ g } \cancel{H_2}} \right| \frac{2\text{ mole } H_2O}{2\text{ mole } \cancel{H_2}} = 2\text{ mole } H_2O$$

$$\frac{16\text{ g } \cancel{O_2}}{} \left| \frac{1\text{ mole } \cancel{O_2}}{32\text{ g } \cancel{O_2}} \right| \frac{2\text{ mole } H_2O}{1\text{ mole } \cancel{O_2}} = 1\text{ mole } H_2O$$

WORKSHEET- WRITING BALANCED EQUATIONS FROM WORD PROBLEMS

The biggest problem that students have when working mass-mass problems, volume-volume problems, or mass-volume problems is being able to write a balanced formula equation from a word problem. Once a correct balanced equation is written, most students can work the rest of the problem with ease. Therefore, the purpose of this worksheet is to teach the student how to read a problem and write a balanced formula equation from it by using the following steps.

Step1 Read the problem through carefully. Then figure out whether it is a composition decomposition , replacement, ionic, combustion, or reduction reaction.

Step2 Figure out what elements or compounds in the problem are the reactants. In doing this keep the following things in mind:

1. Generally all of the reactants will be given in the problem.
2. Key words which indicate reactants are *reacted with, added to, treated with, decomposed, reduced, required, or needed.*
3. Generally, whenever burning occurs, one of the reactants must be *oxygen.*
4. Generally, when something is reacted with air, *oxygen* is the component of air that is involved.
5. A **composition reaction** has two reactants, two elements or two compounds.
   A **decomposition reaction** has one reactant, a compound.
   A **replacement reaction** has two reactants, an element and a compound.
   An **ionic reaction** has two reactants, two compounds. Note, all reactions have two reactants except decomposition reactions.

Step 3 Figure out what elements or compounds in the problem are the products. In doing this keep the following things in mind:

1. All of the products may **not** be mentioned in the problem, but all of the products formed must be included in the balanced equations. The student may have to figure out what some or all of the products are.
2. Key words which indicate products are *collected, formed, obtained,prepared, produced, precipitated, or liberated.*

Step 4 If you have forgotten some of your rules for completing and balancing equations refer back to the worksheet on balancing

Step 5 Write the balanced formula equation. Remember to use valences to write the formulas correctly.

(2)

Example1 How many grams of oxygen can be prepared by the decomposition of 25.0g of mercury(II) oxide?

Step 1 Type of reaction--Decomposition
Step2 Reactant(s) Mercury(II)oxide (Key word--Decomposition)
Step3 Product(s) Oxygen (Key word--can be prepared). All products are not given, therefore, a second product must be figured out.
Step 4 Remember to look up rule, Metallic oxide $\longrightarrow$ Free metal + oxygen (Hg-Au)
Step 5 $2HgO \longrightarrow 2Hg + O_2$

Check problem 1 How many liters of hydrogen may be obtained by the action of 33.3 grams of calcium with dilute sulfuric acid?

Example 2 How many grams of magnesium hydroxide are necessary to neutralize 42.7 grams of hydrochloric acid?
Step 1 Type of reaction--ionic
Step 2 Reactant(s)--Magnesium hydroxide and hydrochloric acid-Key word-neutralize
Step 3 Product(s) No products are given in the problem. They must be figured out.
Step 4 Rule--Ionic reaction goes to completion because of formation of water.
Step 5 $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$

Check problem 2 How many grams of air are needed(assuming air to be 23% oxygen) to burn 16.2 grams of sulfur in the formation of sulfur dioxide?

HOMEWORK PROBLEMS For each problem below , write a balanced formula equation. **Do not attempt to work the problem.** Write the correct equation only.

1. How many liters of carbon dioxide will be produced when 12.9 liters of carbon monoxide burn in air?

2. How many liters of oxygen are needed to burn 34.4 liters of acetylene, C_2H_2, assuming that all gases are at the same conditions?

3. How many moles of potassium are required to liberate 3.29 liters of hydrogen form water if conditions are standard?

4. Hydrogen and nitrogen are reacted to form 47.1 liters of ammonia. How many grams of nitrogen are needed if the reaction occurs at S.T.P.? Assuming air to be 75.5% nitrogen by weight, how many grams of air would be needed to supply this amount of nitrogen?

5. How many liters of hydrogen at 750 torrs and 123 degrees Celsius are needed to completely reduce 35.6 grams of hot copper(II)oxide?

6. What volume of hydrogen at S.T.P. can be produced by the electrolysis of 50.0 grams of water?

7. How many moles of potassium bromide are needed to completely react with 75.8 grams of silver nitrate in a water solution?

8. In a composition reaction between sulfur trioxide and water, 3.19 moles of sulfuric acid are formed. How many liters of sulfur trioxide are needed at S.T.P.?

9. In a neutralization reaction, how many grams of hydrochloric acid are needed to completely react with 9.25 grams of calcium hydroxide?

10. What will be the mass of the water produced when 135 grams of copper(II)sulfate pentahydrate are heated?

11. If 55.5 grams of ferrous sulfide are treated with enough hydrochloric acid to complete the reaction, how many liters of hydrogen sulfide gas will be collected at S.T.P.?

12. How many moles of calcium oxide can be produced from 0.670 moles of limestone (calcium carbonate) upon heating? How many liters of CO_2 would be formed if conditions were standard?

13. 5.98 liters of chlorine at 752 mm Hg and 20 degrees Celsius will react with how many grams of calcium bromide?

14. How many grams of magnesium are needed to replace 0.392 moles of copper form copper(II) nitrate?

15. How many grams of strontium oxide will be formed when 26.3 grams of strontium hydroxide are decomposed by heating?

16. 34.9 liters of hydrogen are formed by the action of aluminum with steam at 100 degrees Celsius and 750 mm Hg pressure. Assuming an excess of steam, how many grams of aluminum are needed?

17. How many liters of carbon dioxide will be formed when 57.2grams of carbonic acid break down at 1 atmosphere pressure and 20 degrees Celsius?

18. How many moles of oxygen will be produced when 217 grams of silver oxide are heated?

Name _____ Date _____

Stoichiometry- Mole- Mole Problems

1. If 7.5 moles of AlI_3 are consumed in the reaction, how many moles of Br_2 are consumed?

_____AlI_3 + _____Br_2 → _____$AlBr_3$ + _____I_2

a. How many moles of Br_2 are consumed?

b. How many moles of $AlBr_3$ are produced?

c. How many moles of I_2 are produced?

d. If 9.2 moles of I_2 are produced how many moles of $AlBr_3$ are made?

2. If 2.3 moles of Al_2O_3 are reacted, how many moles of Al are made?

_____Al_2O_3 → _____Al + _____O_2

If 4.7 moles of Al_2O_3 are reacted , how many moles of O_2 are made?

3. If 7.5 moles of Ag_3PO4 are required as a product, how many moles of $AgNO_3$ have to be used?

_____$AgNO_3$ + ____K_3PO_4 → _____Ag_3PO_4 + _____KNO_3

If 5.0 mole of K_3PO_4 are used, how many moles of Ag_3PO_4 can be made?

_____$AgNO_3$ + ___K_3PO_4 → _____Ag_3PO_4 + _____KNO_3

If 1.9 moles of $AgNO_3$ are used, how many moles of KNO_3 can be made?

If 85.0 moles of $AgNO_3$ are used, how many moles of K_3PO4 are required, and how many moles of Ag_3PO_4 and KNO_3 are made?

4. If 8.9 moles of O_2 react, how many moles of H_2 are required?

_____O_2 + _____H_2 → _____H_2O

If 43.0 moles of H_2 react, how many moles of H_2O are made?

Stoichiometry Mass –Mass problems

1. **If 200.g of Mg are used, what mass of HCl was required?**

$Mg + HCl \rightarrow H_2 + MgCl_2$

a. **How many moles of Mg are used?**

b. **How many moles of HCl are required?**

c. **If 325 g of Mg are used, what mass of H_2 was made?**

d. **How many moles of Mg are used?**

e. **How many moles of HCl are required?**

f. **What mass of Mg is required to make 125 grams of magnesium chloride?**

g. **How many moles of magnesium chloride were made?**

h. **How many moles of magnesium were used?**

2. What mass of oxygen gas is required to burn 490 grams of ethanol?

$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

a. How many grams of water are produced when 750 grams of oxygen are consumed?

b. If 750 grams of carbon dioxide are made, what mass of oxygen gas was consumed?

3. If 200.0 g of H_2 gas are used, what mass of nitrogen gas is required?

$H_2 + N_2 \rightarrow NH_3$

a. If 325.0 grams of nitrogen gas are used, what mass of ammonia gas was made?

b. If 125.0 grams of ammonia gas are produced, what mass of hydrogen gas is required?

4. What mass of oxygen gas is required to burn 490 grams of propane?

$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

a. How many grams of water are produced when 750 g of oxygen are consumed?

b. If 750 grams of carbon dioxide gas are made what mass of oxygen gas was consumed?

If 185.0g of Cu are reacted, how much silver nitrate will be consumed?

$Cu + AgNO_3 \rightarrow Ag + Cu(NO_3)_2$

6. How many grams of iron are needed to produce 100.g of hydrogen gas?

$$Fe + HCl \rightarrow FeCl_3 + H_2$$

How many grams of hydrogen chloride are needed to produce 200.0 g of H_2gas?

If 500.g of iron (III) chloride are produced, how many grams of H_2 gas are made?

If 740.0g of Fe are used, what mass of HCl is required?

7. If 80 g of HCl are reacted, what mass of calcium hydroxide will be consumed?

$$HCl + Ca(OH)_2 \rightarrow H_2O + CaCl_2$$

8. What mass of Al_2O_3 is produced when 660.0 g of Al is burned in sufficient O_2?

$$Al + O_2 \rightarrow Al_2O_3$$

9. What mass of Na is produced when 1870.0g of Na_2O are decomposed?

$$Na_2O \rightarrow O_2 + Na$$

Volume – Volume problems

Assuming STP, how many liters of oxygen are needed to produce 19.8L of SO_3?

$$SO_2 + O_2 \rightarrow SO_3$$

2. How many liters of oxygen are required to burn 3.86 L of carbon monoxide?

$$CO + O_2 \rightarrow CO_2$$

3. How many liters of phosphine are formed when 0.42 L of hydrogen reacts with phosphorus?

$$P_{4(s)} + H_{2(g)} \rightarrow PH_{3(g)}$$

Liter –Mass / Liter-Mole Problems

4. How many grams of magnesium are needed to form 11.0 L of Hydrogen from HCl?

$$Mg + HCl \rightarrow MgCl_2 + H_2$$

5. Find the volume of carbon dioxide evolved when 61.3 grams of carbonic acid decomposes at STP.

$$H_2CO_3 \rightarrow H_2O + CO_2$$

6. How many grams of sodium chlorate must be decomposed to form 7.81 liters of oxygen at STP?

7. What volume of chlorine gas will be produced when 2.37 grams of sodium chloride dissolved in water is reacted with an excess of fluorine at STP?

8. How many moles of hydrogen bromide will be formed when 16.2 liters of hydrogen at STP react with bromine?

9. How many moles of oxygen are needed for the complete combustion of 425 grams of sulfur at STP? Note: Sulfur dioxide is the product

10. Find the mass of benzene (C_6H_6) required to produce 2.66 L of carbon dioxide gas at STP?

$$2C_6H_6 + 15O_2 \rightarrow 6H_2O + 12\,CO_2$$

11. What volume of carbon dioxide is produced when 2.8 L of oxygen are consumed?

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

12. Nitroglycerin decomposes explosively. What volume of nitrogen are produced if 4.3 L of carbon dioxide is produced?

$$4C_3H_5(NO_3)_3 + 12CO_2 \rightarrow 10H_2O + O_2 + 6N_2$$

13. TNT is also very explosive. What volume of hydrogen is produced if 5.8 L of CO is produced?

$$2C_7H_5(NO_2)_3 \rightarrow 2C + 12CO + 5H_2 + 3N_2$$

Name _____ Date _____ Class _____

11–1 Practice Problems

1. Lead will react with hydrochloric acid to produce lead(II) chloride and hydrogen. How many moles of hydrochloric acid are needed to completely react with 0.36 mol of lead?

2. How many moles of HNO_3 will be produced when 0.51 mol of N_2O_5 reacts according to the following equation?
$$N_2O_5 + H_2O \rightarrow 2HNO_3$$

3. Carbon will react with zinc oxide to produce zinc and carbon dioxide. How many moles of carbon dioxide will be produced if 0.38 mol of ZnO is completely reacted?

4. How many moles of NaBr will be produced when 0.69 mol of bromine reacts according to the following equation?
$$Br_2 + 2NaI \rightarrow 2NaBr + I_2$$

5. Phosphorus will react with bromine to produce phosphorus tribromide. How many moles of phosphorus tribromide will be produced if 0.78 mol of bromine is reacted?

6. How many moles of hydrogen will be produced if 0.44 mol of CaH_2 reacts according to the following equation?
$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$$

7. How many moles of oxygen will be needed to react with 0.38 mol of C_3H_8 according to the following equation?
$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

8. Nitrogen can react with hydrogen to produce ammonia. How many moles of nitrogen will be needed to produce 0.48 mol of NH_3?

9. Iron will react with oxygen to produce Fe_2O_3. How many moles of Fe_2O_3 will be produced if 0.18 mol of Fe reacts?

10. How many moles of water will be produced if 2.35 mol of oxygen reacts according to the following equation?
$$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$$

Name _____ Date _____ Class _____

11–2 Practice Problems

1. Determine the mass of lithium hydroxide produced when 0.38 g of lithium nitride reacts with water according to the following equation:
   $Li_3N + 3H_2O \rightarrow NH_3 + 3LiOH$

2. What mass of sodium chloride is produced when chlorine reacts with 0.29 g of sodium iodide?

3. Determine the mass of carbon dioxide produced when 0.85 g of butane reacts with oxygen according to the following equation:
   $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

4. Determine the mass of antimony produced when 0.46 g of antimony(III) oxide reacts with carbon according to the following equation:
   $Sb_2O_3 + 3C \rightarrow 2Sb + 3CO$

5. What mass of hydrogen peroxide (H_2O_2) must decompose to produce 0.77 g of water?

6. What mass of carbon monoxide must react with oxygen to produce 0.69 g of carbon dioxide?

7. Determine the mass of sodium nitrate produced when 0.73 g of nickel(II) nitrate reacts with sodium hydroxide according to the following equation:
   $Ni(NO_3)_2 + 2NaOH \rightarrow Ni(OH)_2 + 2NaNO_3$

8. Determine the mass of calcium hydroxide produced when calcium carbide reacts with 0.64 g of water according to the following equation:
   $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

9. How many grams of ozone (O_3) must decompose to produce 0.87 g of oxygen?

10. Find the mass of sugar ($C_6H_{12}O_6$) required to produce 1.82 L of carbon dioxide gas at STP from the reaction described by the following equation:
    $C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$

11. How many liters of oxygen are necessary for the combustion of 425 g of sulfur, assuming that the reaction occurs at STP? The balanced equation is $S + O_2 \rightarrow SO_2$.

12. Find the mass of benzene (C_6H_6) required to produce 2.66 L of carbon dioxide gas at STP from the reaction described by the following equation:
    $2C_6H_6 + 15O_2 \rightarrow 6H_2O + 12CO_2$

Name_____ Date_____ Class _____

11–2 *Practice Problems (continued)*

13. Find the mass of sodium required to produce 5.68 L of hydrogen gas at STP from the reaction described by the following equation:
$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

14. How many liters of oxygen are necessary for the combustion of 277 g of carbon monoxide, assuming that the reaction occurs at STP? The balanced equation is
$$2CO + O_2 \rightarrow 2CO_2$$

15. How many liters of oxygen are necessary for the combustion of 134 g of magnesium, assuming that the reaction occurs at STP? The balanced equation is
$$2Mg + O_2 \rightarrow 2MgO$$

16. Find the mass of aluminum required to produce 4.72 L of hydrogen gas at STP from the reaction described by the following equation:
$$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$$

17. How many liters of hydrogen are produced if 225 g of iron reacts with hydrochloric acid, assuming that the reaction occurs at STP? The balanced equation is
$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

18. Find the mass of S_8 required to produce 2.47 L of sulfur dioxide gas at STP from the reaction described by the following equation:
$$S_8 + 8O_2 \rightarrow 8SO_2$$

19. Propane (C_3H_8) burns in oxygen to produce carbon dioxide and water vapor. The balanced equation for this reaction is $C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2$. What volume of carbon dioxide is produced when 2.8 L of oxygen are consumed?

20. What volumes of H_2S gas and oxygen are necessary to produce 14.2 L of sulfur dioxide gas? The balanced equation is
$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

21. What volumes of sulfur dioxide and dihydrogen sulfide gases are necessary to produce 11.4 L of water vapor? The balanced equation is
$$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$$

22. Glucose ($C_6H_{12}O_6$) burns in oxygen to produce carbon dioxide and water vapor as described in the following equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$. What volume of carbon dioxide is produced when 3.7 L of oxygen are consumed?

23. The compound TNT (trinitrotoluene) decomposes explosively into carbon, carbon monoxide, hydrogen, and nitrogen. What volumes of hydrogen and nitrogen are produced if 5.8 L of CO is produced? The balanced equation is
$$2C_7H_5(NO_2)_3 \rightarrow 2C + 12CO + 5H_2 + 3N_2$$

24. Nitroglycerin decomposes explosively to produce carbon dioxide, water, nitrogen, and oxygen. What volumes of nitrogen and oxygen are produced if 4.3 L of carbon dioxide is produced? The balanced equation is
$$4C_3H_5(NO_3)_3 \rightarrow 12CO_2 + 10H_2O + O_2 + 6N_2$$

25. Acetylene (C_2H_2) burns in oxygen to produce carbon dioxide and water. The balanced equation for this reaction is $2C_2H_2 + 5O_2 \rightarrow 2H_2O + 4CO_2$. What volume of carbon dioxide is produced when 1.6 L of oxygen are consumed?

Name _____ Date_____

Limiting Reactant and Percent Yield Practice

1. Identify the limiting reactant when 1.22g of oxygen reacts with 1.05 grams of hydrogen to produce water.

2. Identify the limiting reactant when 43.25 grams of CaC_2 reacts with 33.71g of water to produce calcium hydroxide and C_2H_2.

3. Calculate how many grams of the excess reactant remains after the reaction is complete in question 2.

4. If 4.1 grams of Cr is heated with 9.3 grams of Cl_2, what mass of $CrCl_3$ will be produced?

5. What mass of SO_2 is produced from the reaction between 31.5 g of S_8 and 8.65 grams of oxygen gas?

6. What mass of CdS is produced if 8.47 grams of cadmium reacts with 2.51 grams of sulfur?

7. Determine the percent yield for the reaction between 3.74 grams of Na and excess oxygen if 5.34 grams of Na_2O_2 is recovered.

8. Determine the percent yield for the reaction between 6.92 grams of K and 4.28 grams of oxygen if 7.36 grams of K_2O is produced.

9. Determine the percent yield for the reaction between 46.1 grams of Cs and 13.4 grams of oxygen if 28.3 grams of Cs_2O is produced.

10. Determine the percent yield for the reaction between 45.9 grams of NaBr and excess chlorine gas to produce 12.8 grams of NaCl and an unknown quantity of bromine gas.

11. Determine the percent yield for the reaction between 46.5 grams of ZnS and 13.3 grams of oxygen if 18.4 grams of ZnO is recovered along with an unknown quantity of sulfur dioxide.

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW

Stoichiometry

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. _____ The coefficients in a chemical equation represent the

(a) masses in grams of all reactants and products.
(b) relative number of moles of reactants and products.
(c) number of atoms of each element in each compound in a reaction.
(d) number of valence electrons involved in a reaction.

2. _____ Which of the following would not be studied within the topic of stoichiometry?

(a) the mole ratio of Al to Cl in the compound aluminum chloride
(b) the mass of carbon produced when a known mass of sucrose decomposes
(c) the number of moles of hydrogen that will react with a known quantity of oxygen
(d) the amount of energy required to break the ionic bonds in CaF_2

3. _____ A balanced chemical equation allows you to determine the

(a) mole ratio of any two substances in the reaction.
(b) energy released in the reaction.
(c) electron configuration of all elements in the reaction.
(d) reaction mechanism involved in the reaction.

4. _____ The relative number of moles of hydrogen to moles of oxygen that react to form water represents a(n)

(a) reaction sequence.
(b) bond energy.
(c) mole ratio.
(d) element proportion.

5. Given the reaction represented by the following unbalanced equation: $N_2O(g) + O_2(g) \rightarrow NO_2(g)$

a. Balance the equation.

_____

_____ **b.** What is the mole ratio of NO_2 to O_2?

_____ **c.** If 20.0 mol of NO_2 form, how many moles of O_2 must have been consumed?

_____ **d.** Twice as many moles of NO_2 form as moles of N_2O are consumed. True or False?

_____ **e.** Twice as many grams of NO_2 form as grams of N_2O are consumed. True or False?

Name _____ Date _____ Class _____

SECTION 1 continued

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

6. Given the following equation: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

_____ **a.** Determine to one decimal place the molar mass of each substance and express each mass in grams per mole.

_____

_____

b. There are six different mole ratios in this system. Write out each one.

_____

_____

7. Given the following equation: $4NH_3(g) + 6NO(g) \rightarrow 5N_2(g) + 6H_2O(g)$

_____ **a.** What is the mole ratio of NO to H_2O?

_____ **b.** What is the mole ratio of NO to NH_3?

_____ **c.** If 0.240 mol of NH_3 react according to the above equation, how many moles of NO will be consumed?

8. Propyne gas can be used as a fuel. The combustion reaction of propyne can be represented by the following equation:

$$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(g)$$

a. Write all the possible mole ratios in this system.

_____

_____

_____

_____

b. Suppose that x moles of water form in the above reaction. The other three mole quantities (*not* in order) are $2x$, $1.5x$, and $0.5x$. Match these quantities to their respective components in the equation above.

_____

_____

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW

Stoichiometry

SECTION 2

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

1. _____ The following equation represents a laboratory preparation for oxygen gas:

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

How many moles of O_2 form if 3.0 mol of $KClO_3$ are totally consumed?

2. _____ Given the following equation: $H_2(g) + F_2(g) \rightarrow 2HF(g)$
How many grams of HF gas are produced as 5 mol of fluorine react?

3. _____ Water can be made to decompose into its elements by using electricity according to the following equation:

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

How many grams of O_2 are produced when 0.033 mol of water decompose?

4. _____ Sodium metal reacts with water to produce NaOH according to the following equation:

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

How many grams of NaOH are produced if 20.0 g of sodium metal react with excess oxygen?

Name _____ Date _____ Class _____

SECTION 2 continued

5. _____ **a.** What mass of oxygen gas is produced if 100. g of lithium perchlorate are heated and allowed to decompose according to the following equation?

$LiClO_4(s) \rightarrow LiCl(s) + 2O_2(g)$

_____ **b.** The oxygen gas produced in part **a** has a density of 1.43 g/L. Calculate the volume of this gas.

6. A car air bag requires 70. L of nitrogen gas to inflate properly. The following equation represents the production of nitrogen gas:

$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

_____ **a.** The density of nitrogen gas is typically 1.16 g/L at room temperature. Calculate the number of grams of N_2 that are needed to inflate the air bag.

_____ **b.** Calculate the number of moles of N_2 that are needed.

_____ **c.** Calculate the number of grams of NaN_3 that must be used to generate the amount of N_2 necessary to properly inflate the air bag.

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW

Stoichiometry

SECTION 3

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

1. _____ The actual yield of a reaction is 22 g and the theoretical yield is 25 g. Calculate the percentage yield.

2. 6.0 mol of N_2 are mixed with 12.0 mol of H_2 according to the following equation:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

_____ **a.** Which chemical is in excess? What is the excess in moles?

_____ **b.** Theoretically, how many moles of NH_3 will be produced?

_____ **c.** If the percentage yield of NH_3 is 80%, how many moles of NH_3 are actually produced?

3. 0.050 mol of $Ca(OH)_2$ are combined with 0.080 mol of HCl according to the following equation:

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

_____ **a.** How many moles of HCl are required to neutralize all 0.050 mol of $Ca(OH)_2$?

SECTION 3 continued

_____ **b.** What is the limiting reactant in this neutralization reaction?

_____ **c.** How many grams of water will form in this reaction?

4. Acid rain can form in a two-step process, producing $HNO_3(aq)$.

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$$

$$3NO_2(g) + H_2O(g) \rightarrow 2HNO_3(aq) + NO(g)$$

_____ **a.** A car burns 420. g of N_2 according to the above equations. How many grams of HNO_3 will be produced?

_____ **b.** For the above reactions to occur, O_2 must be in excess in the first step. What is the minimum amount of O_2 needed in grams?

_____ **c.** What volume does the amount of O_2 in part **b** occupy if its density is 1.4 g/L?

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW

Stoichiometry

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. Given the following equation: $C_3H_4(g) + xO_2(g) \rightarrow 3CO_2(g) + 2H_2O(g)$

_____ **a.** What is the value of the coefficient x in this equation?

_____ **b.** What is the molar mass of C_3H_4?

_____ **c.** What is the mole ratio of O_2 to H_2O in the above equation?

_____ **d.** How many moles are in an 8.0 g sample of C_3H_4?

_____ **e.** If z mol of C_3H_4 react, how many moles of CO_2 are produced, in terms of z?

2. a. What is meant by *ideal conditions* relative to stoichiometric calculations?

_____

_____

b. What function do ideal stoichiometric calculations serve?

_____

_____

c. Are actual yields typically larger or smaller than theoretical yields?

_____

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

3. Assume the reaction represented by the following equation goes all the way to completion:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

_____ **a.** If 6 mol of H_2 are consumed, how many moles of NH_3 are produced?

_____ **b.** How many grams are in a sample of NH_3 that contains 3.0×10^{23} molecules?

Name _____ Date _____ Class _____

MIXED REVIEW continued

c. If 0.1 mol of N_2 combine with H_2, what must be true about the quantity of H_2 for N_2 to be the limiting reactant?

_____

_____

4. _____ If a reaction's theoretical yield is 8.0 g and the actual yield is 6.0 g, what is the percentage yield?

5. Joseph Priestley generated oxygen gas by strongly heating mercury(II) oxide according to the following equation:

$$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$$

_____ **a.** If 15.0 g HgO decompose, how many moles of HgO does this represent?

_____ **b.** How many moles of O_2 are theoretically produced?

_____ **c.** How many grams of O_2 is this?

_____ **d.** If the density of O_2 gas is 1.41 g/L, how many liters of O_2 are produced?

_____ **e.** If the percentage yield is 95.0%, how many grams of O_2 are actually collected?

Study guide for Chapter 8(equations and balancing) and Chapter 9 (Stoichiometry and Limiting Reactants)

1. Know that the word reactant has the same meaning as the word reagent.
2. Know how to balance equations.
3. Know how to predict the type of equation.
4. Be ready to predict the products of a reaction.
5. Be ready to identify a reaction as single replacement AND then to review the activity series to make sure the reaction actually goes to completion.
6. Be ready to identify a reaction as double replacement AND then to review a solubility table to predict if a precipitate will form and the identity of the precipitate.
7. Be ready to write correct formulas for products.
8. Know that a precipitate means the state symbol is (s) solid.
9. Know that if an ionic substance dissolves the state symbol is (aq). Dissolved in water = aqueous
10. Be ready to look at balanced equations to find the mole ratios between reactants and products.
11. Be ready to solve for moles when given moles.
12. Be ready to solve for grams when given moles or grams.
13. Be ready to solve for Liters when given moles or grams.
14. Know the three steps to stoichiometry are:
    1. Change initial quantity to moles.
    2. Look at the mole ratio of initial substance to the substance you are solving for.
    3. Change the moles of the substance you are solving for to the desired unit.
        a. If you need grams, then multiply by the molar mass.
        b. If you need Liters, then multiply by 22.4 L/mol
15. Know what is meant by limiting reactant and excess reactant.
16. Be ready to figure out which reactant is the limiting reactant if given amounts of both reactants.
17. Be ready to do the stoichiometry twice if given the amounts of both reactants to figure out how much product you will make. (After you do the two stoichiometry problems, the lower quantity will give you your answer and identify the limiting reactant.)
18. Be ready to predict products by using the summary sheet.
19. Know what the law of conservation of mass is and how it relates to these chapters.
20. Know how to represent a catalyst in a chemical equation.
21. Be ready to calculate the percent yield if given the actual amount collected and the amounts of the reactants used. (Percent yield = actual amount collected/theoretical amount calculate x 100)