BALANCING CHEMICAL EQUATIONS

Name _____

Rewrite and balance the equations below.

1. $N_2 + H_2 \rightarrow NH_3$ _____

2. $KClO_3 \rightarrow KCl + O_2$ _____

3. $NaCl + F_2 \rightarrow NaF + Cl_2$ _____

4. $H_2 + O_2 \rightarrow H_2O$ _____

5. $AgNO_3 + MgCl_2 \rightarrow AgCl + Mg(NO_3)_2$ _____

6. $AlBr_3 + K_2SO_4 \rightarrow KBr + Al_2(SO_4)_3$ _____

7. $CH_4 + O_2 \rightarrow CO_2 + H_2O$ _____

8. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$ _____

9. $C_8H_{18} + O_2 \rightarrow 1O_2 + H_2O$ _____

10. $FeCl_3 + NaOH \rightarrow Fe(OH)_3 + NaCl$ _____

11. $P + O_2 \rightarrow P_2O_5$ _____

12. $Na + H_2O \rightarrow NaOH + H_2$ _____

13. $Ag_2O \rightarrow Ag + O_2$ _____

14. $S_8 + O_2 \rightarrow SO_3$ _____

15. $CO_2 + H_20 \rightarrow C_6H_{12}O_6 + O_2$ _____

16. $K + MgBr_2 \rightarrow KBr + Mg$ _____

17. $HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$ _____

WORD EQUATIONS

Name _____

Write the word equations below as chemical equations and balance.

1. zinc + lead (II) nitrate yield zinc nitrate + lead

2. aluminum bromide + chlorine yield aluminum chloride + bromine

3. sodium phosphate + calcium chloride yield calcium phosphate + sodium chloride

4. potassium chlorate when heated yields potassium chloride + oxygen gas

5. aluminum + hydrochloric acid yield aluminum chloride + hydrogen gas

6. calcium hydroxide + phosphoric acid yield calcium phosphate + water

7. copper + sulfuric acid yield copper (II) sulfate + water + sulfur dioxide

8. hydrogen + nitrogen monoxide yield water + nitrogen

TYPES OF REACTIONS

There are 5 main types of reactions.

1. <u>Direct Combination—Composition—Synthesis:</u>
   Two or more elements or compounds (A and B) combine to form a more complex substance. (AB—one product)

   $$A + B \rightarrow AB$$

   Examples: Write equations showing the direct combination of the elements below:
   a. Sodium and iodine

   b. calcium and oxygen

   c. hydrogen and chlorine

   d. hydrogen and carbon monoxide and oxygen to form carbonic acid

   e. nitrogen and hydrogen to form ammonia

2. <u>Decomposition—Analysis:</u>
   Reverse of direct combination. A complex compound (AB—one reactant) is broken down into two or more simpler substances. (A and B, elements and/or compounds)

   $$AB \rightarrow A + B$$

   Examples: Write equations showing the decomposition of each of the following substances:
   a. Water

   b. silver chloride

   c. aluminum oxide

   d. lithium phosphate to form lithium, phosphorous and oxygen

   e. sulfuric acid to form hydrogen, sulfur and oxygen

3. <u>Single Replacement:</u>
   One substance is replaced from its compound by another substance.

   Element + compound → element + compound

   $$A + BC \rightarrow B + AC$$

Note: Cationic single replacement: is when metals replace metals and hydrogen. (+ ion)

Anionic Single replacement: is when nonmetals replace nonmetals. (- ion)

To see if a reaction takes place use Table J. A more active metal replaces a less active metal or a more active nonmetal replaces a less active nonmetal. If this is not the case a reaction will not occur.

Examples: Decide if the following reactions will occur. If they do take place determine the products of each reaction.

a. zinc and nitric acid

b. iron and copper II sulfate

c. sodium and water

d. magnesium chloride and fluorine

e. sodium chloride and bromine

4. <u>Double Replacement:</u>

Two compounds combine to form two new compounds.

$$AB + CD \rightarrow AD + CB$$

Note: + ions switch places.

These equations are also known as ionic equations. Ionic equations have two possibilities:

a. Reactions go to completion (stops): When ions in a solution combine to form a product that leaves the scene of a reaction. There are three types of products that leave the scene of a reaction.
   1. Slightly ionized water
   2. Gases escape (↑)
   3. Precipitates settle to the bottom (↓)
      Precipitates are solid substances formed by a physical or chemical change in a liquid medium. It separates from the liquid by settling to the bottom. Precipitates are insoluble compounds see table F.

b. If a reaction does not go to completion they are said to be Reversible. (⇆). A reversible reaction is one in which the products can themselves react to form the reactants.

Examples: For each reaction write the molecular, ionic and Net ionic equations:

a. silver nitrate and zinc chloride

b. copper II hydroxide and acetic acid

c. iron II sulfate and ammonium sulfide

5. <u>Complete Combustion:</u>
When a hydrocarbon (compound composed of only carbon and hydrogen) or a carbohydrate (compound composed of carbon, hydrogen and oxygen) react with oxygen to form carbon dioxide and water.

Example: Write an equation for the complete combustion of each of the following organic substances:

a. C_3H_8

b. CH_4

c. C_2H_2

d. $C_6H_{12}O_6$

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW ACTIVITY

Text Reference: Section 9-13

Chemical Changes

Choose words from the list to fill in the blanks in the paragraphs.

Word List

analysis	exothermic
arrow	ionic equation
chemical equation	precipitate
chemical reaction	product
coefficient	reactant
delta	single replacement
double replacement	spectator
electrolysis	synthesis
endothermic	

Another name for a chemical change is a(n) __(1)__. Such a change can be represented by means of a written statement called a(n) __(2)__. The symbol for the word "yields" in such a statement is a(n) __(3)__. Any substance written to the left of this symbol is called a(n) __(4)__. Any substance written to the right of this symbol is called a(n) __(5)__. A number written just to the left of a formula is called a(n) __(6)__.

A chemical change in which energy is absorbed is called a(n) __(7)__ reaction. One in which energy is released is called a(n) __(8)__ reaction.

Some chemical changes involve charged particles. An equation that shows the reaction or production of such particles is called a(n) __(9)__. Any charged particle that is present but that does not change or react during a reaction is usually omitted from the equation; it is called a(n) __(10)__.

A chemical change in which two or more substances combine to form a more complex substance is called a(n) __(11)__ reaction. A change in which a substance is broken down into simpler substances is called a(n) __(12)__ reaction. Any such change that is caused by the flow of an electric current is called a(n) __(13)__. If the change is caused by heat supplied to the reaction, the Greek symbol __(14)__ is often written above the "yields" symbol in the equation.

A chemical change in which a free element replaces and releases another element in a compound is called a(n) __(15)__ reaction. A chemical change in which there is an exchange of ions between two compounds is called a(n) __(16)__ reaction. A solid substance produced by such a reaction in a liquid medium is called a(n) __(17)__.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____

Name _____ Date _____ Class _____

CHAPTER 9 REVIEW ACTIVITY

Text Reference: Section 9-12

Categories of Chemical Reactions

State whether each of the following equations represents a synthesis (s), analysis (a), single replacement (sr), or double replacement (dr) reaction.

1. $CO_2 \rightarrow C + O_2$ — 1. _____
2. $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$ — 2. _____
3. $S + Cl_2 \rightarrow SCl_2$ — 3. _____
4. $BaCl_2 + 2NaOH \rightarrow 2NaCl + Ba(OH)_2$ — 4. _____
5. $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$ — 5. _____
6. $CH_4 \rightarrow C + 2H_2$ — 6. _____
7. $Pb(NO_3)_2 + Mg \rightarrow Pb + Mg(NO_3)_2$ — 7. _____
8. $Mg + 2HCl \rightarrow MgCl_2 + H_2$ — 8. _____
9. $H_2SO_4 \rightarrow H_2 + S + 2O_2$ — 9. _____
10. $2O_2 + N_2 \rightarrow N_2O_4$ — 10. _____
11. $3CaBr_2 + 2Na_3P \rightarrow Ca_3P_2 + 6NaBr$ — 11. _____
12. $2KI + Br_2 \rightarrow 2KBr + I_2$ — 12. _____
13. $C_6H_{12}O_6 \rightarrow 6C + 6H_2O$ — 13. _____
14. $2NaF \rightarrow 2Na + F_2$ — 14. _____
15. $Si + O_2 \rightarrow SiO_2$ — 15. _____
16. $2NaI + Pb(NO_3)_2 \rightarrow 2NaNO_3 + PbI_2$ — 16. _____
17. $NaI + Cs \rightarrow CsI + Na$ — 17. _____
18. $H_2 + CO + O_2 \rightarrow H_2CO_3$ — 18. _____
19. $Li_3PO_4 \rightarrow 3Li + P + 2O_2$ — 19. _____
20. $CS_2 + 2F_2 \rightarrow CF_4 + 2S$ — 20. _____

CLASSIFICATION OF CHEMICAL REACTIONS

Name _____

Classify the reactions below as synthesis, decomposition, single replacement (cationic or anionic) or double replacement.

1. $2H_2 + O_2 \rightarrow 2H_2O$ _____

2. $2H_2O \rightarrow 2H_2 + O_2$ _____

3. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ _____

4. $2CO + O_2 \rightarrow 2CO_2$ _____

5. $2HgO \rightarrow 2Hg + O_2$ _____

6. $2KBr + Cl_2 \rightarrow 2KCl + Br_2$ _____

7. $CaO + H_2O \rightarrow Ca(OH)_2$ _____

8. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ _____

9. $2H_2O_2 \rightarrow 2H_2O + O_2$ _____

10. $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$ _____

PREDICTING PRODUCTS OF CHEMICAL REACTIONS

Name _____

Predict the products of the reactions below. Then, write the balanced equation and classify the reaction.

1. magnesium bromide + chlorine

2. aluminum + iron (III) oxide

3. silver nitrate + zinc chloride

4. hydrogen peroxide (catalyzed by manganese dioxide)

5. zinc + hydrochloric acid

6. sulfuric acid + sodium hydroxide

7. sodium + hydrogen

8. acetic acid + copper

PROBLEMS INVOLVING EQUATIONS

The coefficients used in balancing a chemical equation represent moles. In stoichiometric problems involving equations it is assumed that the reaction is the single reaction (with no side reactions), that the reaction goes to completion and the reactants are completely reacted.

Every stoichiometric problem involves the following three basic steps.

Step1: Find the moles of the substance you are given information about.

Moles = g/gfm Moles = 1/22.4 Moles = #p/6.02 x 10^{23}

Step 2: Set up a mole ratio.

$$\frac{\text{Actual moles (from step 1)}}{\text{Theoretical moles}} = \frac{\text{Actual moles (unknown)}}{\text{(from coefficients) Theoretical moles}}$$

Step 3: Find the grams, liters or particles of your unknown using one of the three mole equations from step 1.

Type 1: Mass-Mass Problems:

A balanced equation shows the mole proportions of products to reactants. It is possible to determine the mass of one substance that reacts with or is produced from a given mass of another substance.

Examples:

1. How many grams of sodium chloride are needed to react to produce 35.5 grams of chlorine gas?

2. How many grams of hydrogen are produced by the action of water on 100. grams of sodium?

3. What mass of oxygen will combine with 3.0 grams of hydrogen to produce water?

4. Given the reaction: $N_2 + O_2 \rightarrow 2NO$. What is the total number of grams of oxygen needed to react completely with 2.0 moles of nitrogen?

Type 2: Mass-Volume Problems:

A mole (6.02×10^{23}) of molecules of any gas occupies a volume of 22.4 liters at STP. This numerical value is called the molar volume. It has a mass equal to the molecular mass expressed in grams. In a balanced equation where the mole unit serves to relate the quantities of products and reactants, it is possible to determine quantitative results in desired units, which may not necessarily be the same as the original units.

Examples:

1. How many grams of zinc metal are needed to react with hydrochloric acid to produce 11.2 liters of hydrogen gas at STP.

2. How many grams of carbon dioxide at STP are produced by the complete combustion of C_2H_6?

Type 3: Volume-Volume Problems:

Since one mole of any gas occupies the same volume as one mole of any other gas, at the same temperature and pressure, the volumes of gases involved in a reaction are proportional to the number of moles indicated by the numerical coefficients in a balanced equation.

Examples:

1. In the reaction $N_2 + H_2 \rightarrow 2NH_3$, calculate the volume of hydrogen gas required to form 100. liters of ammonia?

2. What volume of carbon dioxide will be formed from the complete combustion of 21.2 liters of camphene ($C_{10}H_6$)?

STOICHIOMETRY: MOLE-MOLE PROBLEMS

Name _____

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

   How many moles of hydrogen are needed to completely react with two moles of nitrogen?

   _____

2. $2KClO_3 \rightarrow 2KCl + 3O_2$

   How many moles of oxygen are produced by the decomposition of six moles of potassium chlorate?

   _____

3. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

   How many moles of hydrogen are produced from the reaction of three moles of zinc with an excess of hydrochloric acid?

   _____

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

   How many moles of oxygen are necessary to react completely with four moles of propane (C_3H_8)?

   _____

5. $K_3PO_4 + Al(NO_3)_3 \rightarrow 3KNO_3 + AlPO_4$

   How many moles of potassium nitrate are produced when two moles of potassium phosphate react with two moles of aluminum nitrate?

   _____

STOICHIOMETRY: MASS-MASS PROBLEMS

Name _____

1. $2KClO_3 \rightarrow 2KCl + 3O_2$

   How many grams of potassium chloride are produced if 25 g of potassium chlorate decompose?

   _____

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

   How many grams of hydrogen are necessary to react completely with 50.0 g of nitrogen in the above reaction?

   _____

3. How many grams of ammonia are produced in the reaction in Problem 2?

   _____

4. $2AgNO_3 + BaCl_2 \rightarrow 2AgCl + Ba(NO_3)_2$

   How many grams of silver chloride are produced from 5.0 g of silver nitrate reacting with an excess of barium chloride?

   _____

5. How much barium chloride is necessary to react with the silver nitrate in Problem 4?

   _____

STOICHIOMETRY: VOLUME-VOLUME PROBLEMS

Name _____

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

   What volume of hydrogen is necessary to react with five liters of nitrogen to produce ammonia? (Assume constant temperature and pressure.)

   _____

2. What volume of ammonia is produced in the reaction in Problem 1?

   _____

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

   If 20 liters of oxygen are consumed in the above reaction, how many liters of carbon dioxide are produced?

   _____

4. $2H_2O \rightarrow 2H_2 + O_2$

   If 30 mL of hydrogen are produced in the above reaction, how many milliliters of oxygen are produced?

   _____

5. $2CO + O_2 \rightarrow 2CO_2$

   How many liters of carbon dioxide are produced if 75 liters of carbon monoxide are burned in oxygen? How many liters of oxygen are necessary?

   _____

   _____

STOICHIOMETRY: MASS-MASS PROBLEMS

Name _____

1. $2KClO_3 \rightarrow 2KCl + 3O_2$

   How many grams of potassium chloride are produced if 25 g of potassium chlorate decompose?

   _____

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

   How many grams of hydrogen are necessary to react completely with 50.0 g of nitrogen in the above reaction?

   _____

3. How many grams of ammonia are produced in the reaction in Problem 2?

   _____

4. $2AgNO_3 + BaCl_2 \rightarrow 2AgCl + Ba(NO_3)_2$

   How many grams of silver chloride are produced from 5.0 g of silver nitrate reacting with an excess of barium chloride?

   _____

5. How much barium chloride is necessary to react with the silver nitrate in Problem 4?

   _____

STOICHIOMETRY: VOLUME-VOLUME PROBLEMS

Name _____

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

   What volume of hydrogen is necessary to react with five liters of nitrogen to produce ammonia? (Assume constant temperature and pressure.)

   _____

2. What volume of ammonia is produced in the reaction in Problem 1?

   _____

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

   If 20 liters of oxygen are consumed in the above reaction, how many liters of carbon dioxide are produced?

   _____

4. $2H_2O \rightarrow 2H_2 + O_2$

   If 30 mL of hydrogen are produced in the above reaction, how many milliliters of oxygen are produced?

   _____

5. $2CO + O_2 \rightarrow 2CO_2$

   How many liters of carbon dioxide are produced if 75 liters of carbon monoxide are burned in oxygen? How many liters of oxygen are necessary?

   _____

   _____

STOICHIOMETRY: MIXED PROBLEMS

Name _____

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

   What volume of NH_3 at STP is produced if 25.0 g of N_2 is reacted with an excess of H_2?

   _____

2. $2KClO_3 \rightarrow 2KCl + 3O_2$

   If 5.0 g of $KClO_3$ is decomposed, what volume of O_2 is produced at STP?

   _____

3. How many grams of KCl are produced in Problem 2?

   _____

4. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

   What volume of hydrogen at STP is produced when 2.5 g of zinc react with an excess of hydrochloric acid?

   _____

5. $H_2SO_4 + 2NaOH \rightarrow H_2O + Na_2SO_4$

   How many molecules of water are produced if 2.0 g of sodium sulfate are produced in the above reaction?

   _____

6. $2AlCl_3 \rightarrow 2Al + 3Cl_2$

   If 10.0 g of aluminum chloride are decomposed, how many molecules of Cl_2 are produced?

   _____

STOICHIOMETRY: LIMITING REAGENT (optional topic)

Name _____

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

   How many grams of NH_3 can be produced from the reaction of 28 g of N_2 and 25 g of H_2?

   _____

2. How much of the excess reagent in Problem 1 is left over?

   _____

3. $Mg + 2HCl \rightarrow MgCl_2 + H_2$

   What volume of hydrogen at STP is produced from the reaction of 50.0 g of Mg and the equivalent of 75 g of HCl?

   _____

4. How much of the excess reagent in Problem 3 is left over?

   _____

5. $3AgNO_3 + Na_3PO_4 \rightarrow Ag_3PO_4 + 3NaNO_3$

   Silver nitrate and sodium phosphate are reacted in equal amounts of 200. g each. How many grams of silver phosphate are produced?

   _____

6. How much of the excess reagent in Problem 5 is left?

   _____

Name _____ Class _____ Date _____

Mass-Mass Problems

Solving mass-mass problems usually involves these steps:

1. Convert given masses in grams to moles.
2. Use coefficients in the balanced equation to establish mole ratios between the substances involved in the problem.
3. Calculate the number of moles of the required substance.
4. Convert that number of moles to mass in grams.

Examples

How many moles of F_2 are there in 60.0 g of F_2? (F = 19.0 g/mole)

mole mass of F_2 = 2 × 19.0 g/mole = 38.0 g/mole

$$\frac{60.0\text{ g}}{38.0\text{ g/mole}} = 1.58\text{ moles}$$

In the following reaction, how many moles of F_2 are needed to produce 1.5 moles of HF?

$$H_2 + F_2 \rightarrow 2HF$$

mole ratio of F_2 to HF = 1:2

1:2 = ?:1.5 ? = .75

How many grams of HF is .75 moles of HF? (H = 1.0 g/mole)

mole mass of HF = 1.0 g/mole + 19.0 g/mole = 20 g/mole

.75 moles × 20 g/mole = 15 g

Solve the following problems. Show your work.

1. Given the equation $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ answer the following questions.
   a. How many moles of N_2 are there in 200 g of N_2? (N = 14.0 g/mole)

1a. _____

   b. How many moles of NH_3 could be produced from the above amount of N_2?

b. _____

   c. How many grams of NH_3 would this be? (H = 1.00 g/mole)

c. _____

Name _____ Class _____ Date _____

Mass-Mass Problems (*Continued*)

2. Given the equation $2CO + O_2 \rightarrow 2CO_2$ answer the following questions. **2a.** _____

   a. How many moles are there in 55.0 g of CO_2? (C = 12.0 g/mole; O = 16.0 g/mole)

   b. How many moles of CO would be needed to produce this amount of CO_2? **b.** _____

   c. How many grams of CO would this be? **c.** _____

3. **a.** Write a balanced equation for the reaction of methane (CH_4) with oxygen gas (O_2) to produce carbon dioxide and water. **3a.** _____

   b. How many grams of H_2O would be produced from the reaction of 74.6 g of CH_4? (C = 12.0 g/mole; H = 1.00 g/mole; O = 16.0 g/mole) **b.** _____

Name _____ Class _____ Date _____

Volume-Volume and Mass-Volume Problems

Volume-volume problems involve direct comparison of the coefficients in a balanced equation. The reason is that equal volumes of gases at the same temperature and pressure contain equal numbers of moles and molecules. Also involved is the fact that at STP the volume of a gas is equal to 22.4 L/mole. Calculation of numbers of molecules involves the use of Avogadro's number, 6.02×10^{23} molecules/mole.

Examples

How many liters of HCl gas can be produced from 10 L of Cl_2 gas by the reaction $H_2 + Cl_2 \rightarrow 2HCl$?

$$1:2 = 10\text{ L}:?\text{ L} \qquad ? = 20\text{ L}$$

How many grams of hydrogen gas (H_2) are needed to produce 5.00 L of water vapor, measured at STP, according to the reaction $2H_2 + O_2 \rightarrow 2H_2O$? (H = 1.00 g/mole; O = 16.0 g/mole)

$$\frac{5.00\text{ L}}{22.4\text{ L/mole}} = .223\text{ moles of } H_2O\text{ vapor}$$

$$2:2 = ?\text{ moles } H_2 : .223\text{ moles } H_2O \qquad ? = .223\text{ moles } H_2$$

$$.223\text{ moles} \times 2.00\text{ g/mole} = .446\text{ g } H_2$$

How many H_2 molecules are there in .223 moles of H_2 at STP?

$$.223\text{ moles} \times 6.02 \times 10^{23}\text{ molecules/mole}$$
$$= 1.34 \times 10^{23}\text{ molecules } H_2$$

Solve the following problems. Show your work.

1. How many liters of CO_2 can be produced from 14.5 L of C_2H_2 by the reaction

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$$

1. _____

2. How many liters of oxygen are released from the decomposition of 3.6 L of hydrogen peroxide gas (H_2O_2) to produce water vapor and oxygen? (Write the balanced equation for the reaction as part of your work.)

$$2H_2O_2(g) \rightarrow 2H_2O(g) + O_2(g)$$

2. _____

Name _____ Class _____ Date _____

Volume-Volume and Mass-Volume Problems *(Continued)*

3. How many grams of zinc (Zn = 65.4 g/mole) are required to produce 67.2 L of hydrogen gas at STP, according to the reaction

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

3. _____

4. a. How many liters of Cl_2 gas at STP can be produced by decomposing 70.0 g of HCl gas? (H = 1.00 g/mole; Cl = 35.5 g/mole) (Include a balanced equation in your work.)

4a. _____

b. How many Cl_2 molecules would be produced?

b. _____

5. How many liters of H_2O vapor could be produced by the reaction of 9.03×10^{23} molecules of O_2, according to the reaction

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

5. _____