Chapter 3: Mass Relationships in Chemical Reactions

Name _____ **Class:** _____

Molar Mass Practice Worksheet

Find the molar masses of the following compounds in gram. Show all work:

1) $NaBr$

2) $PbSO_4$

3) $Ca(OH)_2$

4) Na_3PO_4

5) $(NH_4)_2CO_3$

6) $C_6H_{12}O_6$

7) $Fe_3(PO_4)_2$

8) $(NH_4)_2S$

9) $Zn(C_2H_3O_2)_2$

10) AgF

grams ↓ mass from Periodic table ↓ moles – molecules – atoms

1 mole / 6.02×10^{23} molec or $\frac{6.02 \times 10^{23}\ \text{molec}}{1\ \text{mole}}$ ↓ look @ Formula

Solve show all work:

1) How many moles are in 25 grams of water?

2) How many grams are in 4.5 moles of Li_2O?

3) How many molecules are in 23 moles of oxygen?

4) How many moles are in 3.4×10^{23} molecules of H_2SO_4?

5) How many molecules are in 25 grams of NH_3?

6) How many grams are in 8.2×10^{22} molecules of N_2I_6?

Word Equations Worksheet

Write the word equations for each of the following chemical reactions:

1) When dissolved beryllium chloride reacts with dissolved silver nitrate in water, aqueous beryllium nitrate and silver chloride powder are made.

2) When isopropanol (C_3H_8O) burns in oxygen, carbon dioxide, water, and heat are produced.

3) When dissolved sodium hydroxide reacts with sulfuric acid (H_2SO_4), aqueous sodium sulfate, water, and heat are formed.

4) When fluorine gas is put into contact with calcium metal at high temperatures, calcium fluoride powder is created in an exothermic reaction.

5) When sodium metal reacts with iron (II) chloride, iron metal and sodium chloride are formed.

Name:_____ Class:_____

Balancing Equations Practice Worksheet

Balance the following equations:

1) ___ $NaNO_3$ + ___ PbO → ___ $Pb(NO_3)_2$ + ___ Na_2O

2) ___ AgI + ___ $Fe_2(CO_3)_3$ → ___ FeI_3 + ___ Ag_2CO_3

3) ___ $C_2H_4O_2$ + ___ O_2 → ___ CO_2 + ___ H_2O

4) ___ $ZnSO_4$ + ___ Li_2CO_3 → ___ $ZnCO_3$ + ___ Li_2SO_4

5) ___ V_2O_5 + ___ CaS → ___ CaO + ___ V_2S_5

6) ___ $Mn(NO_2)_2$ + ___ $BeCl_2$ → ___ $Be(NO_2)_2$ + ___ $MnCl_2$

7) ___ $AgBr$ + ___ $GaPO_4$ → ___ Ag_3PO_4 + ___ $GaBr_3$

8) ___ H_2SO_4 + ___ $B(OH)_3$ → ___ $B_2(SO_4)_3$ + ___ H_2O

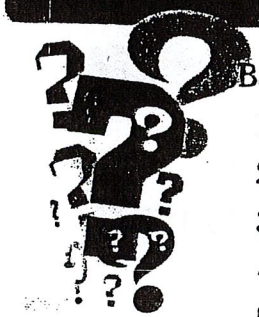
9) ___ S_8 + ___ O_2 → ___ SO_2

10) ___ Fe + ___ $AgNO_3$ → ___ $Fe(NO_3)_2$ + ___ Ag

5. ____ SiC + ____ Cl_2 → ____ $SiCl_4$ + ____ C
6. ____ Zn + ____ $FeCl_3$ → ____ Fe + ____ $ZnCl_2$
7. ____ $NaBr$ + ____ Cl_2 → ____ $NaCl$ + ____ Br_2
8. ____ K + ____ $NiCl_2$ → ____ Ni + ____ KCl
9. ____ Ca + ____ HCl → ____ $CaCl_2$ + ____ H_2
10. ____ Li + ____ $BaSO_4$ → ____ Li_2SO_4 + ____ Ba

5.23

The fourth type of reaction is the **double replacement** reaction. This involves the interchanging of various elements in one set of compounds to form a new set of compounds. You cannot always predict if such equations as these will occur, but at least two elements must exchange places in the equation. Follow the same procedures you have used to balance simpler equations. It is usually good advice to leave the oxygen and hydrogen atoms until last because many times they appear in more than two compounds in the equation.



Balance the double replacement equations below.

1. ____ Hg_2Cl_2 + ____ HI → ____ Hg_2I_2 + ____ HCl
2. ____ KCl + ____ H_2SO_4 → ____ K_2SO_4 + ____ HCl
3. ____ $BaCO_3$ + ____ H_2SO_4 → ____ $BaSO_4$ + ____ H_2CO_3
4. ____ PbI_2 + ____ HNO_3 → ____ $Pb(NO_3)_2$ + ____ HI
5. ____ $FeBr_3$ + ____ $Ba(OH)_2$ → ____ $Fe(OH)_3$ + ____ $BaBr_2$
6. ____ Ag_2SO_4 + ____ $Cu(ClO_3)_2$ → ____ $CuSO_4$ + ____ $AgClO_3$
7. ____ V_2O_5 + ____ HCl → ____ $VOCl_3$ + ____ H_2O
8. ____ HI + ____ H_2SO_4 → ____ H_2S + ____ H_2O + ____ I_2
9. ____ C_3H_8 + ____ O_2 → ____ CO_2 + ____ H_2O
10. ____ Ag_2S + ____ KCN → ____ $KAg(CN)_2$ + ____ K_2S
11. ____ Ag_2SO_4 + ____ NH_4Cl → ____ $(NH_4)_2SO_4$ + ____ $AgCl$
12. ____ $CaCl_2$ + ____ K_3PO_4 → ____ $Ca_3(PO_4)_2$ + ____ KCl
13. ____ NH_4OH + ____ H_2SO_4 → ____ $(NH_4)_2SO_4$ + ____ H_2O
14. ____ $AgNO_3$ + ____ $AlCl_3$ → ____ $Al(NO_3)_3$ + ____ $AgCl$
15. ____ MnO_2 + ____ HCl → ____ Cl_2 + ____ $MnCl_2$ + ____ H_2O
16. ____ $Ba(OH)_2$ + ____ HNO_3 → ____ $Ba(NO_3)_2$ + ____ H_2O
17. ____ $Ca_3(PO_4)_2$ + ____ SiO_2 + ____ C → ____ $CaSiO_3$ + ____ P + ____ CO_2
18. ____ H_3PO_4 + ____ $NaOH$ → ____ Na_2HPO_4 + ____ H_2O
19. ____ Ca_3P_2 + ____ H_2O → ____ PH_3 + ____ $Ca(OH)_2$
20. ____ Mg_3As_2 + ____ HCl → ____ AsH_3 + ____ $MgCl_2$

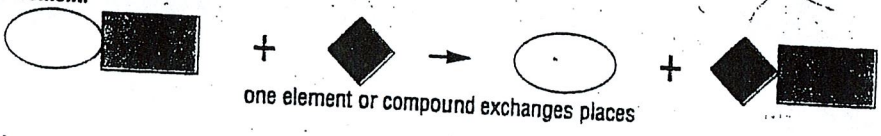
5.25 In the last few pages you have been presented with examples of four types of chemical reactions: combination, decomposition, single replacement, and double replacement. You have read about the various equations, worked sample problems, and manipulated Legos. To give you one last visual description of these types of reactions, a summary of each type of reaction is presented in Figure 5.1. The summary is provided with the use of geometric symbols. Study these examples carefully.

Types of Reactions

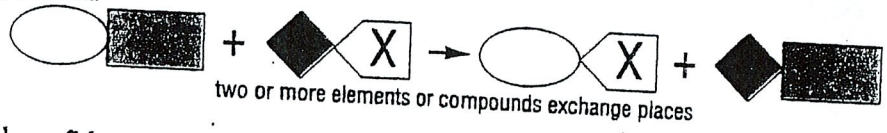
Combination:

Decomposition:

Single Replacement:



Double Replacement:



Do you feel confident you can identify these types of reactions? If so, continue on with 5.26.

Balance the equations below. After each equation indicate whether it is an example of a combination, decomposition, single replacement, or double replacement reaction.

1. ____ P + ____ O_2 → ____ P_2O_5
2. ____ Ca + ____ O_2 → ____ CaO
3. ____ C_6H_6 + ____ O_2 → ____ CO_2 + ____ H_2O
4. ____ CH_4 + ____ O_2 → ____ CO_2 + ____ H_2O
5. ____ $CaCO_3$ + ____ HCl → ____ $CaCl_2$ + ____ H_2O + ____ CO_2
6. ____ C_2H_2 + ____ O_2 → ____ CO_2 + ____ H_2O
7. ____ SO_4 → ____ O_2 + ____ SO_2
8. ____ CaH_2 + ____ H_2O → ____ $Ca(OH)_2$ + ____ H_2
9. ____ C_8H_{18} + ____ O_2 → ____ CO_2 + ____ H_2O
10. ____ HI + ____ H_2SO_4 → ____ H_2S + ____ H_2O + ____ I_2
11. ____ CH_4 + ____ O_2 → ____ C + ____ H_2O

12. ____ B + ____ O_2 → ____ B_2O_3

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

14. ____ $MgNH_4PO_4$ → ____ $Mg_2P_2O_7$ + ____ NH_3 + ____ H_2O

15. ____ Ca + ____ O_2 → ____ CaO

16. ____ PCl_3 + ____ H_2O → ____ HCl + ____ H_3PO_3

17. ____ H_2SO_4 + ____ $NaHCO_3$ → ____ Na_2SO_4 + ____ H_2O + ____ CO_2

18. ____ $CuSO_4$ + ____ PH_3 → ____ Cu_3P_2 + ____ H_2SO_4

19. ____ Ca_3N_2 + ____ H_2O → ____ $Ca(OH)_2$ + ____ NH_3

20. ____ Ag_2S + ____ KCN → ____ $KAg(CN)_2$ + ____ K_2S

21. ____ Mg_3As_2 + ____ HCl → ____ AsH_3 + ____ $MgCl_2$

22. ____ $Ca_3(PO_4)_2$ + ____ SiO_2 + ____ C → ____ $CaSiO_3$ + ____ P + ____ CO

23. ____ $MgNH_4PO_4$ → ____ $Mg_2P_2O_7$ + ____ NH_3 + ____ H_2O

24. ____ $(NH_4)_2Cr_2O_7$ → ____ Cr_2O_3 + ____ N_2 + ____ H_2O

Some recipes often call for baking soda (sodium bicarbonate). Sodium bicarbonate, $NaHCO_3$, releases carbon dioxide gas after the baking temperature reaches 50°C (122°F). This is a chemical reaction in which the products are sodium carbonate (Na_2CO_3), carbon dioxide, and water. Write a balanced chemical equation for this change.

Name: _____ Class: _____

Part A

Types of Reactions Worksheet

Balance the following equations and indicate the type of reaction taking place:

1) ____ $NaBr$ + ____ H_3PO_4 → ____ Na_3PO_4 + ____ HBr

Type of reaction: _____

2) ____ $Ca(OH)_2$ + ____ $Al_2(SO_4)_3$ → ____ $CaSO_4$ + ____ $Al(OH)_3$

Type of reaction: _____

3) ____ Mg + ____ Fe_2O_3 → ____ Fe + ____ MgO

Type of reaction: _____

4) ____ C_2H_4 + ____ O_2 → ____ CO_2 + ____ H_2O

Type of reaction: _____

5) ____ $PbSO_4$ → ____ $PbSO_3$ + ____ O_2

Type of reaction: _____

6) ____ NH_3 + ____ I_2 → ____ N_2I_6 + ____ H_2

Type of reaction: _____

7) ____ H_2O + ____ SO_3 → ____ H_2SO_4

Type of reaction: _____

Name: _____ Class: _____

Classifying Types of Reactions

Part I:

Classify each type of reaction as synthesis, decomposition, single replacement, double replacement, or combustion. Then write a sentence for each reaction on the line below.

1. $N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$ **Classification:** _____

_____

2. $2Li\,(s) + 2H_2O\,(l) \rightarrow 2LiOH\,(aq) + H_2\,(g)$ **Classification** _____

(hint think of H_2O like H(OH)

_____

3. $2NaNO_3\,(S) \rightarrow 2NaNO_2\,(s) + O_2\,(g)$ **Classification:** _____

_____

4. $2C_6H_4\,(l) + 19\,O_2\,(g) \rightarrow 12CO_2\,(g) + 14H_2O\,(l)$ **Classification:** _____

Skip

_____

Part II:

Identify the missing reactant or product and balance the equation. Don't forget about diatomic elements!

1. **Synthesis:** _____ + _____ → Li_2O

2. **Decomposition:** $Mg(ClO_3)_2$ → _____ + _____

3. **Double Replacement:** HNO_3 + $Ca(OH)_2$ → _____ + _____

4. **Combustion:** C_5H_{12} + O_2 → _____ + _____

5. Br_2 + KI → _____ + _____

6. $NaClO_3$ → _____ + _____

7. C_7H_{14} + O_2 → _____ + _____

8. $CuCl_2$ + Na_2S → _____ + _____

Name: _____ Class:

	Formula Weight	Number of grams	Number of moles	Number of Molecules	Number of Atoms of H
1. H_2		6.35			
2. NH_3			2		
3. NO_2				3.0×10^{23}	
4. CH_4		4.00			
5. H_2S		0.584			

g → m[redacted] → molec → at

1 mole = 6.02×10^{23} mole

1.

2.

3.

4.

5.

Word Equations

Write the word equations below as chemical equations and balance:

1) Solid Zinc and aqueous lead (II) nitrate react to form aqueous zinc nitrate and solid lead.

2) Aqueous aluminum bromide and chlorine gas react to form aqueous aluminum chloride and bromine gas.

3) Aqueous sodium phosphate and calcium chloride react to form aqueous calcium phosphate and sodium chloride.

4) Potassium metal and chlorine gas combine to form aqueous potassium chloride.

5) Aluminum metal and aqueous hydrochloric acid reacts to form aqueous aluminum chloride and hydrogen gas.

6) aqueous solutions of calcium hydroxide and phosphoric acid react to form aqueous calcium phosphate and water.

Name_____

Chemical Equations and Stoichiometry

Complete the reaction, balance the reaction, and classify the reaction where applicable

1. $\_\_ZnS + \_\_HCl \rightarrow \_\_ZnCl_2 + \_\_H_2S$

type of reaction _____

2. $\_\_HCl + \_\_Cr \rightarrow$

type of reaction _____

3. $\rightarrow \_\_Al_2O_3 + \_\_Fe$

type of reaction _____

4. $\_\_H_2 + \_\_Br_2 \rightarrow$

type of reaction _____

5. $\_\_Na_2S_2O_3 + \_\_I_2 \rightarrow \_\_NaI + \_\_Na_2S_4O_6$

type of reaction _____

6. $\_\_LaCl_3 + \_\_Na_2CO_3 \rightarrow$

type of reaction _____

7. $\_\_NH_4Cl + \_\_Ba(OH)_2 \rightarrow \_\_BaCl_2 + \_\_NH_3 + \_\_H_2O$

8. $\_\_Ca(OH)_2 + \_\_H_3PO_4 \rightarrow$

type of reaction _____

9. $\_\_La_2(CO_3)_3 + \_\_H_2SO_4 \rightarrow \_\_La_2(SO_4)_3 + \_\_H_2O + \_\_CO_2$

10. $\_\_Na_2O + \_\_(NH_4)_2SO_4 \rightarrow \_\_Na_2SO_4 + \_\_H_2O + \_\_NH_3$

11. $\_\_C_4H_{10} + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$

type of reaction _____

12. $\_\_C_7H_6O_2 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$

type of reaction _____

13. $\_\_P_4O_{10} + \_\_H_2O \rightarrow \_\_H_3PO_4$

type of reaction _____

14. $\_\_FeS_2 + \_\_O_2 \rightarrow \_\_Fe_2O_3 + \_\_SO_2$

type of reaction _____

15. $\_\_NH_3 + \_\_O_2 \rightarrow \_\_NO + \_\_H_2O$

type of reaction _____

16. $\rightarrow \_\_H_2 + \_\_FeCl_2$

type of reaction _____

17. $\_\_PbO_2 + \_\_HCl \rightarrow \_\_H_2O + \_\_PbCl_2 + \_\_Cl_2$

Name:_____ Class:_____

Molecular and Empirical Formulas

1) What's the empirical formula of a molecule containing 65.5% carbon, 5.5% hydrogen, and 29.0% oxygen?

2)If the molar mass of the compound in problem 1 is 110.00 grams/mole, what's the molecular formula?

3)What's the empirical formula of a molecule containing 18.7% lithium, 16.3% carbon, and 65.0% oxygen?

4) If the molar mass of the compound in problem 3 is 73.8 grams/mole, what's the molecular formula?

5) Determine the empirical formula for each of the following

a. 0.0130 mol C, 0.0390 mol H, 0.0065 mol O

b. 11.66 g iron, 5.01 g oxygen

c. 5.28 g Sn 337 g F

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6) Write the molecular formulas of the following compounds:

a. A compound with an empirical formula of C_2OH_4 and a molar mass of 88.00 grams per mole.

b. A compound with an empirical formula of C_4H_4O and a molar mass of 136.00 grams per mole.

c. compound with an empirical formula of CFBrO and a molar mass of 254.7 grams per mole.

d. A compound with an empirical formula of C_2H_8N and a molar mass of 46 grams per mole.

7) Emperical formula = HCO_2 , molar mass = 90.0g

8) Determine the empirical and molecular formulas of each of the following substances caffeine: 49.56% C, 5.15 % H, 28.9% N, 16.5% O by mass with a molar mass of 195.00 g/mol

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Name _____

Determine the percentage composition of each of the compounds below.

1. $KMnO_4$

   K = _____

   Mn = _____

   O = _____

2. HCl

   H = _____

   Cl = _____

3. $Mg(NO_3)_2$

   Mg = _____

   N = _____

   O = _____

4. $(NH_4)_3PO_4$

   N = _____

   H = _____

   P = _____

   O = _____

5. $Al_2(SO_4)_3$

   Al = _____

   S = _____

   O = _____

Solve the following problems.

6. How many grams of oxygen can be produced from the decomposition of 100. g of $KClO_3$? _____

7. How much iron can be recovered from 25.0 g of Fe_2O_3? _____

8. How much silver can be produced from 125 g of Ag_2S? _____

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3.57 Aluminum sulfide reacts with water to form aluminum hydroxide and hydrogen sulfide. (a) Write the balanced chemical equation for this reaction. (b) How many grams of aluminum hydroxide are obtained from 10.5 g of aluminum sulfide?

3.59 Automotive air bags inflate when sodium azide, NaN_3, rapidly decomposes to its component elements:

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

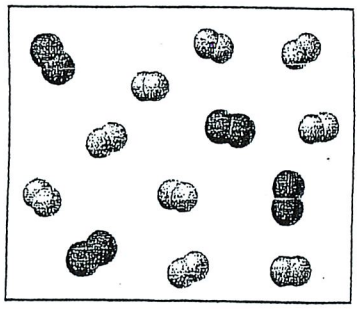
(a) How many moles of N_2 are produced by the decomposition of 2.50 mol of NaN_3?
(b) How many grams of NaN_3 are required to form 6.00 g of nitrogen gas?
(c) How many grams of NaN_3 are required to produce 10.0 ft^3 of nitrogen gas if the gas has a density of 1.25 g/L?

Limiting Reactants; Theoretical Yields

3.63 (a) Define the terms limiting reactant and excess reactant. (b) Why are the amounts of products formed in a reaction determined only by the amount of the limiting reactant?

3.64 (a) Define the terms theoretical yield, actual yield, and percent yield. (b) Why is the actual yield in a reaction almost always less than the theoretical yield?

3.65 Nitrogen (N_2) and hydrogen (H_2) react to form ammonia (NH_3). Consider the mixture of N_2 and H_2 shown in the accompanying diagram. The blue spheres represent N, and the white ones represent H. Draw a representation of the product mixture, assuming that the reaction goes to completion. How did you arrive at your representation? What is the limiting reactant in this case?



3.69 Sodium hydroxide reacts with carbon dioxide as follows:

$$2NaOH(s) + CO_2(g) \longrightarrow Na_2CO_3(s) + H_2O(l)$$

Which reagent is the limiting reactant when 1.70 mol NaOH and 1.00 mol CO_2 are allowed to react? How many moles of Na_2CO_3 can be produced? ~~How many moles of the excess reactant remain after the completion of the reaction?~~

3.70 Aluminum hydroxide reacts with sulfuric acid as follows:

$$2Al(OH)_3(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 6H_2O(l)$$

Which reagent is the limiting reactant when 0.450 mol $Al(OH)_3$ and 0.550 mol H_2SO_4 are allowed to react? How many moles of $Al_2(SO_4)_3$ can form under these conditions? ~~How many moles of the excess reactant remain after the completion of the reaction?~~

3.71 The fizz produced when an Alka-Seltzer® tablet is dissolved in water is due to the reaction between sodium bicarbonate ($NaHCO_3$) and citric acid ($H_3C_6H_5O_7$):

$$3NaHCO_3(aq) + H_3C_6H_5O_7(aq) \longrightarrow 3CO_2(g) + 3H_2O(l) + Na_3C_6H_5O_7(aq)$$

In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react. (a) Which is the limiting reactant? (b) How many grams of carbon dioxide form? (c) ~~How many grams of the excess reactant remain after the limiting reactant is completely consumed?~~

3.75 When benzene (C_6H_6) reacts with bromine (Br_2), bromobenzene (C_6H_5Br) is obtained:

$$C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$$

(a) What is the theoretical yield of bromobenzene in this reaction when 30.0 g of benzene reacts with 65.0 g of bromine? (b) If the actual yield of bromobenzene was 56.7 g, what was the percentage yield?

3.77 Lithium and nitrogen react to produce lithium nitride:

$$6Li(s) + N_2(g) \longrightarrow 2Li_3N(s)$$

If 5.00 g of each reactant undergo a reaction with a 80.5% yield, how many grams of Li_3N are obtained from the reaction?

3.78 When hydrogen sulfide gas is bubbled into a solution of sodium hydroxide, the reaction forms sodium sulfide and water. How many grams of sodium sulfide are formed if 2.00 g of hydrogen sulfide is bubbled into a solution containing 2.00 g of sodium hydroxide, assuming that the sodium sulfide is made in 92.0% yield?

Name:_____ Class:_____

General Chemistry Chapter 3 Review

This is a general review for some of the topics that we covered in chapter 3. This is intended as a supplementary study tool, all material in notes, worksheets, and in the text may be tested on. Please show all work and circle your final answer for full credit.

1. What is the empirical formula of the compounds below
   a. 75% carbon, 25% hydrogen

   b. 22.1% aluminum 25.4% phosphorous, 52.5% oxygen

2. The compound is 64.9% carbon, 13.5% hydrogen and 21.6% oxygen. Its molecular mass is 74 g/mol. What is its molecular formula?

3. Determine the number of moles of each compound below:
   a. 125.00 g H_2SO_4

   b. 74.0 g KCl

4. Determine the number of grams in each of the compounds below:
   a. 0.50 moles of $CuSO_4$

   b. 2.5 moles of $KMnO_4$

5. A recommended daily allowance of chromium is 1.0×10^{-6} g. Convert this to number of atoms.

6. An important reaction in the production of **ammonia** based fertilizer is:

$$N_2 + H_2 \rightarrow NH_3$$

Calculate how many grams of ammonia can be produced from 25.0 g of nitrogen and excess hydrogen.

7. Write a balanced chemical equation for the following reactions:
   a. The decomposition of solid **ammonium** nitrate into nitrogen gas, oxygen gas and water vapor.

   b. $P_4O_{10} + H_2O \rightarrow H_3PO_4$

   c. The decomposition of solid potassium chlorate to yield solid potassium chloride and oxygen gas.

8. Calculate the percent of each type of atom in Al_2O_3

9. How many grams of CO_2 are produced when 20.0 g C_3H_8 are burned as follows:

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

10. In a chemical reaction the actual yield is 2.80 g. What is the percent yield if the theoretical yield is 3.23 g.

11. The empirical formula of a substance is CH. If the molar mass is 78 g/mol, what is the molecular formula?

12. A flask contains 1.69×10^{18} water molecules. How many grams of water are in the flask?

13. Identify and balance the following reactions:

a._____ Fe +_____ S_8 ---> _____FeS Type:_____

b. _____$C_{10}H_8$ + ___O_2 ---> _____CO_2 + _____ H_2O Type:_____

c. _____Mg + _____H_2O ---> _____$Mg(OH)_2$ + _____H_2 Type:_____

14. Complete the reactions and identify the type of reaction.

a. $FeBr_3 + Ba(OH)_2 \rightarrow$ type of rxn_____

b. $CaCl_2 + K_3PO_4 \rightarrow$ type of rxn_____

c. $Ba + N_2 \rightarrow$ type of rxn_____

15. How many atoms of chlorine are in 5.46×10^3 g of $MgCl_2$.

16. How many moles are in 3.457×10^4 molecules of Li(CN).

17. How many grams of urea can be produced from 5.00 g of NH3 and 5.00 g of CO2?

$2NH_3 + CO_2 \rightarrow CH_4N_2O + H_2O$
(Urea)

18. In a chemical reaction the theoretical yield is 3.95×10^2 g. If the percent yield was 36.8 %, what was the actual yield?