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?

3

Name _____ Date _____ Class _____

11–2 Review and Reinforcement

Solving Stoichiometry Problems

If the statement is true, write "true." If it is false, change the underlined word or words to make it true. Write your answer on the line provided.

_____ 1. The major types of stoichiometry problems are mass-mass, mass-volume, and volume-volume.

_____ 2. In a mass-mass problem, the coefficients in the balanced equation represent the actual numbers of moles of reactants and products.

_____ 3. In solving a mass-mass problem, it is necessary to convert the given mass to volume.

_____ 4. The molar volume of any gas at STP is 24.2 L.

_____ 5. When the mass of a reactant is given, the number of moles can be found by dividing the mass by the reactant's molar mass.

_____ 6. The coefficients in a chemical equation also represent the ratio of the mass of gases involved in the reaction.

Write the balanced equations for each of the following problems. Then solve the problems as directed. Show all your work.

7. When 9.8 g of aluminum oxide (Al_2O_3) decomposes, how many grams of aluminum metal are produced?

8. How many grams of iodine are produced when 0.72 mol of fluorine react with potassium iodide (KI)?

9. How many grams of sodium are required to react with water to produce 5.0 g of sodium hydroxide? How many grams of H_2 are produced? What volume would be occupied by the resulting hydrogen at STP?

4,

Name _____ Date _____ Class _____

11–2 Review and Reinforcement (continued)

10. 20.0 g of potassium react with water to produce potassium hydroxide and hydrogen gas. How many liters would the hydrogen gas occupy at STP?

11. If 30.2 g of aluminum react with HCl to produce aluminum chloride and hydrogen gas, how many liters of hydrogen are produced at STP?

12. How many liters of HCl are produced by the reaction of 5.7 L of hydrogen with an equal amount of chlorine?

13. How many liters of hydrogen are required to react with 0.45 mol of oxygen to produce water?

14. How many liters of SO_2 are produced from the reaction of sulfur with 26.9 L of oxygen?

15. How many grams of zinc chloride will be produced if zinc is allowed to react with 16.8 L of chlorine at STP?

5.

Name _____ Date _____ Class _____

11–3 Practice Problems

1. Identify the limiting reactant when 1.22 g of O_2 reacts with 1.05 g of H_2 to produce water.

2. Identify the limiting reactant when 4.68 g of Fe reacts with 2.88 g of S to produce FeS.

3. Identify the limiting reactant when 5.87 g of $Mg(OH)_2$ reacts with 12.84 g of HCl to form $MgCl_2$ and water.

4. Identify the limiting reactant when 6.25 g of $AgNO_3$ reacts with 4.12 g of NaCl to form $NaNO_3$ and AgCl.

5. Identify the limiting reactant when 7.81 g of HCl reacts with 5.24 g of NaOH to produce NaCl and H_2O.

6. Identify the limiting reactant when 6.33 g of H_2SO_4 reacts with 5.92 g of NaOH to produce Na_2SO_4 and water.

7. Identify the limiting reactant when 43.25 g of CaC_2 reacts with 33.71 g of water to produce $Ca(OH)_2$ and C_2H_2.

8. Identify the limiting reactant when 65.14 g of $CaCl_2$ reacts with 74.68 g of Na_2CO_3 to produce $CaCO_3$ and NaCl.

9. Identify the limiting reactant when 4.687g of SF_4 reacts with 6.281 g of I_2O_5 to produce IF_5 and SO_2.

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

11. What mass of SO_2 is produced from the reaction between 31.5 g of S_8 and 8.65 g of O_2?

12. What mass of SO_3 is produced from the reaction of 12.4 g of SO_2 and 3.45 g of O_2?

13. What mass of H_2SO_4 is produced from the reaction of 6.58 g of SO_3 and 1.64 g of H_2O?

14. What mass of CdS is produced if 8.47 g of cadmium reacts with 2.51 g of sulfur?

6.

Name _____ Date _____ Class _____

11–3 *Practice Problems (continued)*

15. If 21.4 g of aluminum is reacted with 91.3 g of Fe_2O_3, the products will be Al_2O_3 and iron. What mass of iron will be produced?

16. If 41.6 g of N_2O_4 reacts with 20.8 g of N_2H_4, the products will be nitrogen and water. What mass of water will be produced?

17. If 16.8 g of CO is mixed under high pressure with 1.78 g of H_2, what mass of methanol (CH_3OH) will be produced?

18. What mass of NaCl will be produced by the reaction of 58.7 g of NaI with 29.4 g of Cl_2 gas if the products are sodium chloride and I_2 ?

19. Determine the percent yield for the reaction between 3.74 g of Na and excess O_2 if 5.34 g of Na_2O_2 is recovered.

20. Determine the percent yield for the reaction between 6.92 g of K and 4.28 g of O_2 if 7.36 g of K_2O is produced.

21. Determine the percent yield for the reaction between 82.4 g of Rb and 11.6 g of O_2 if 39.7 g of Rb_2O is produced.

22. Determine the percent yield for the reaction between 46.1 g of Cs and 13.4 g of O_2 if 28.3 g of Cs_2O is produced.

23. Determine the percent yield for the reaction between 28.1 g of Sb_4O_6 and excess C if 17.3 g of Sb is recovered along with an unknown amount of CO.

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

25. Determine the percent yield for the reaction between 15.8 g of NH_3 and excess oxygen to produce 21.8 g of NO gas and water.

26. Determine the percent yield for the reaction between 98.7 g of Sb_2S_3 and excess oxygen if 72.4 g of Sb_4O_6 is recovered along with an unknown amount of sulfur dioxide gas.

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

7.

Name _____ Date _____ Class _____

11–3 Review and Reinforcement

Limiting Reactants and Percent Yield

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.

_____ 1. When quantities of reactants are available in the exact ratio described by the balanced equation, they are said to be in molar proportions.

_____ 2. The reactant that limits the amount of product that can be formed is the limiting reactant.

_____ 3. Identifying the limiting reactant in a reaction is similar to solving a mass-volume problem.

_____ 4. If the amount of the limiting reactant is known, it is possible to predict the amount of all products formed by the reaction.

_____ 5. Even though it is possible to predict the amount of reactants formed in a chemical reaction, the expected yield often differs from this prediction.

_____ 6. The actual yield of a chemical reaction is never more than the expected yield.

Answer each of the following questions in the space provided below.

7. Describe the steps you would take to determine which of two reactants in a given equation is the limiting reactant.

8. What is percent yield and how is it determined?

Solve each of the following problems as directed. Show all your work.

9. Identify the limiting reactant when 2.2 g of magnesium react with 4.5 L of oxygen at STP to produce magnesium oxide.

8.

Name _____ Date _____ Class _____

11–3 *Review and Reinforcement (continued)*

10. Hydrogen is produced when methane (CH_4) reacts with water. The other product is CO_2. Using 80.0 g of methane and 16.3 g of water, how many liters of H_2 can be produced at STP? What is the limiting reactant?

11. Methyl alcohol (CH_3OH) is made by reacting carbon monoxide with H_2. Starting with 2.5 g of H_2 and 30.0 L of CO, what mass of methyl alcohol could be produced at STP? Which is the limiting reactant?

12. In a reaction of 15.3 g of NaCl with 60.8 g of $Pb(NO_3)_2$, how many grams of lead(II) chloride will be produced? What is the limiting reactant?

13. Diborane (B_2H_6) is widely used in the synthesis of organic compounds. Diborane itself is made by the reaction $2NaBH_4 + I_2 \rightarrow B_2H_6 + 2NaI + H_2$. If 6.3 g of $NaBH_4$ are reacted with excess I_2, how many grams of diborane could theoretically be isolated? If 1.9 g of diborane is actually produced, what is the percent yield of the reaction?

14. Ammonia gas can be produced by reacting CaO with NH_4Cl. Water and calcium chloride are produced in addition to ammonia. If 23.0 g of CaO and 50.0 g of NH_4Cl are mixed, what is the maximum possible volume of NH_3 that can be produced at STP? If 16.1 L of NH_3 are actually produced, what is the percent yield of NH_3?

9.

4 Answer Key

11–1 Explore, page 7

1. 6 eggs, 2 cups of milk, 1 teaspoon salt, 12 slices of bread, 4 tablespoons sugar.
2. The amount of bread is doubled. Therefore, the amount of each ingredient must be doubled. Students may note that salt is often not doubled in recipes.
3. The ratio is 3:6 or 1:2. This ratio remains constant when the recipe is doubled.
4. The ratio is 2:1.
5. The ratio should remain constant, as does the ratio in the recipe. If the amount of water produced is to be doubled, the amount of "ingredients" must be doubled also.

11–1 Practice Problems, page 8

Answers marked with an asterisk denote additional practice problems that appear in the Teacher's Edition.

*1. 0.72 mol HCl
*2. 1.0 mol HNO_3
3. 0.19 mol CO_2
4. 1.4 mol NaBr
5. 0.52 mol PBr_3
6. 0.88 mol H_2
7. 1.9 mol O_2
8. 0.24 mol N_2
9. 0.090 mol Fe_2O_3
10. 0.940 mol H_2O

11–1 Enrich, page 9

In nuclear reactions, a small amount of mass is converted to energy. The conversion factor between energy and mass is the square of the speed of light, which is an extremely large number. Therefore, fusion would be a potentially huge source of energy. If it were possible to carry out fusion in a simple table-top process, the resulting energy source would be extremely valuable. Students may also know that the small scale of the reaction was attractive, since the existing nuclear power reactors (fission reactors) are extremely expensive industrial installations. Some students may also be aware that at present it is not possible to produce energy commercially by fusion reactions.

11–1 Review and Reinforcement, pages 10–11

1. quantitative
2. reactants
3. coefficients
4. particles
5. actual
6. molar ratio or coefficients
7. conservation of matter
8. true
9. one
10. 2:1
11. true
12. moles
13. 1.0 mol
14. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$; 2.6 mol HCl
15. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; 1.5 mol O_2; 1.5 mol CO_2; 1.5 mol H_2O
16. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$; 5.0 mol HCl; 2.5 mol CO_2
17. 0.36 mol H_2; 65.4 g Zn + 98 g H_2SO_4 = 161.4 g $ZnSO_4$ + 2 g H_2; the mass of products and reactants are equal.

11–2 Explore, page 12

Answers will vary depending on the exact mass of each coin. Nickels have approximately twice the mass of pennies, 5.6 g vs. 2.8 g.

1. a. 2.5 (3)
   b. 4
2. 4
3. 1
4. 5.6 g
5. The mass of the reactants in a chemical equation will determine the mass of the products. The mass of the products can be predicted mathematically, just as the mass of the nickels was calculated in this activity.

11–2 Practice Problems, pages 13–14

Answers marked with an asterisk denote additional practice problems that appear in the Teacher's Edition.

*1. 0.78 g LiOH
*2. 0.11 g NaCl
3. 2.6 g CO_2
4. 0.38 g Sb

5. 1.4 g H_2O_2
6. 0.44 g CO
7. 0.68 g $NaNO_3$
8. 1.3 g $Ca(OH)_2$
9. 0.87 g O_3
*10. 7.32 g $C_6H_{12}O_6$
*11. 297 L O_2
12. 1.55 g C_6H_6
13. 11.6 g Na
14. 111 L O_2
15. 61.7 L O_2
16. 3.79 g Al
17. 90.2 L H_2
18. 3.54 g S_8
*19. 1.7 L CO_2
*20. 14.2 L H_2S and 21.3 L of O_2
21. 5.70 L SO_2 and 11.4 L H_2S
22. 3.7 L CO_2
23. 2.4 H_2 and 1.4 L N_2
24. 2.2 L N_2 and 0.36 L O_2
25. 1.3 L CO_2

11–2 Apply, page 15

1. 241 g $FeCl_3$; 40.2 g H_2O
2. 325 g HCl
3. 8.3×10^{24} formula units $Fe_2(CO_3)_3$; 4000 g $Fe_2(CO_3)_3$
4. Even though the total numbers of moles on each side of the equation are not equal, the total number of atoms on each side of the equation is the same. This number of atoms is distributed over a smaller number of particles on the reactant side of the equation and over a larger number of particles on the product side.

11–2 Review and Reinforcement, pages 16–17

1. true
2. relative
3. moles
4. 22.4
5. true
6. volume
7. $2Al_2O_3 \rightarrow 4Al + 3O_2$; 5.2 g Al
8. $2KI + F_2 \rightarrow 2KF + I_2$; 180 g I_2
9. $2Na + 2H_2O \rightarrow 2NaOH + H_2$; 2.9 g Na; 0.13 g H_2; 1.4 L H_2
10. $2K + 2H_2O \rightarrow 2KOH + H_2$; 5.73 L H_2
11. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$; 37.6 L H_2
12. $H_2 + Cl_2 \rightarrow 2HCl$; 11 L HCl
13. $2H_2 + O_2 \rightarrow 2H_2O$; 20. L H_2
14. $S + O_2 \rightarrow SO_2$; 26.9 L SO_2
15. $Zn + Cl_2 \rightarrow ZnCl_2$; 102 g $ZnCl_2$

11–3 Explore, page 18

1. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
2. Zinc was left over; HCl was completely used.
3. There was not enough HCl to react with all of the zinc.
4. HCl. If more acid had been added, more of the zinc would have reacted. Therefore, the acid limited the amount of product that was able to form.

11–3 Practice Problems, pages 19–20

Answers marked with an asterisk denote additional practice problems that appear in the Teacher's Edition.

*1. O_2
*2. Fe
3. $Mg(OH)_2$
4. $AgNO_3$
5. NaOH
6. H_2SO_4
7. CaC_2
8. $CaCl_2$
9. SF_4
*10. 16 g $CrCl_3$
*11. 17.3 g SO_2
12. 15.5 g SO_3
13. 8.06 g H_2SO_4
14. 10.9 g CdS
15. 44.3 g Fe
16. 23.4 g H_2O
17. 14.1 g CH_3OH
18. 22.9 g NaCl
*19. 84.2 percent
*20. 88.2 percent
21. 44.1 percent
22. 57.9 percent