BASIC STOICHIOMETRY

Name _____ Class _____ Date _____

Additional Problems

1. How many moles of ammonium sulfate can be made from the reaction of 30.0 mol of NH_3 with H_2SO_4 according to the following equation?

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

2. In a very violent reaction called a thermite reaction, aluminum metal reacts with iron(III) oxide to form iron metal and aluminum oxide according to the following equation:

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

   a. What mass of Al will react with 150 g of Fe_2O_3?

   b. If 0.905 mol Al_2O_3 is produced in the reaction, what mass of Fe is produced?

   c. How many moles of Fe_2O_3 will react with 99.0 g of Al?

3. As you saw in Sample Problem 1, the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is used to produce ammonia commercially. If 1.40 g of N_2 are used in the reaction, how many grams of H_2 will be needed?

4. What mass of sulfuric acid, H_2SO_4, is required to react with 1.27 g of potassium hydroxide, KOH? The products of this reaction are potassium sulfate and water.

5. Ammonium hydrogen phosphate, $(NH_4)_2HPO_4$, a common fertilizer, is made from reacting phosphoric acid, H_3PO_4, with ammonia.

   a. Write the equation for this reaction.

   b. If 10.00 g of ammonia react, how many moles of fertilizer will be produced?

   c. What mass of ammonia will react with 2800 kg of H_3PO_4?

6. The following reaction shows the synthesis of zinc citrate, a ingredient in toothpaste, from zinc carbonate and citric acid.

$$3ZnCO_3(s) + 2C_6H_8O_7(aq) \rightarrow Zn_3(C_6H_5O_7)_2(aq) + 3H_2O(l) + 3CO_2(g)$$

   a. How many moles of $ZnCO_3$ and $C_6H_8O_7$ are required to produce 30.0 mol of $Zn_3(C_6H_5O_7)_2$?

   b. What quantities, in kilograms, of H_2O and CO_2 are produced by the reaction of 500. mol of citric acid?

7. Methyl butanoate, an oily substance with a strong fruity fragrance, can be made by reacting butanoic acid with methanol according to the following equation:

$$C_3H_7COOH + CH_3OH \rightarrow C_3H_7COOCH_3 + H_2O$$

   a. What mass of methyl butanoate is produced from the reaction of 52.5 g of butanoic acid?

   b. In order to purify methyl butanoate, water must be removed. What mass of water is produced from the reaction of 5800. g of methanol?

8. Ammonium nitrate decomposes to yield nitrogen gas, water, and oxygen gas in the following reaction:

$$2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O$$

a. How many moles of nitrogen gas are produced when 36.0 g of NH_4NO_3 reacts?

b. If 7.35 mol of H_2O are produced in this reaction, what mass of NH_4NO_3 reacted?

9. Lead(II) nitrate reacts with potassium iodide to produce lead(II) iodide and potassium nitrate. If 1.23 mg of lead nitrate are consumed, what is the mass of the potassium nitrate produced?

10. A car battery produces electrical energy with the following chemical reaction:

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

If the battery loses 0.34 kg of lead in this reaction, how many moles of lead(II) sulfate are produced?

11. In a space shuttle, the CO_2 that the crew exhales is removed from the air by a reaction within canisters of lithium hydroxide. On average, each astronaut exhales about 20.0 mol of CO_2 daily. What mass of water will be produced when this amount reacts with LiOH? The other product of the reaction is Li_2CO_3.

12. Water is sometimes removed from the products of a reaction by placing them in a closed container with excess P_4O_{10}. Water is absorbed by the following reaction:

$$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$$

a. What mass of water can be absorbed by 1.00×10^2 g of P_4O_{10}?

b. If the P_4O_{10} in the container absorbs 0.614 mol of water, what mass of H_3PO_4 is produced?

c. If the mass of the container of P_4O_{10} increases from 56.64 g to 63.70 g, how many moles of water are absorbed?

13. Ethanol, C_2H_5OH, is considered a clean fuel because it burns in oxygen to produce carbon dioxide and water with few trace pollutants. If 95.0 g of H_2O are produced during the combustion of ethanol, how many grams of ethanol were present at the beginning of the reaction?

14. Sulfur dioxide is one of the major contributors to acid rain. Sulfur dioxide can react with oxygen and water in the atmosphere to form sulfuric acid, as shown in the following equation:

$$2H_2O(l) + O_2(g) + 2SO_2(g) \rightarrow 2H_2SO_4(aq)$$

If 50.0 g of sulfur dioxide from pollutants reacts with water and oxygen found in the air, how many grams of sulfuric acid can be produced? How many grams of oxygen are used in the process?

15. When heated, sodium bicarbonate, $NaHCO_3$, decomposes into sodium carbonate, Na_2CO_3, water, and carbon dioxide. If 5.00 g of $NaHCO_3$ decomposes, what is the mass of the carbon dioxide produced?

16. A reaction between hydrazine, N_2H_4, and dinitrogen tetroxide, N_2O_4, has been used to launch rockets into space. The reaction produces nitrogen gas and water vapor.

a. Write a balanced chemical equation for this reaction.

b. What is the mole ratio of N_2O_4 to N_2?

c. How many moles of N_2 will be produced if 20 000 mol of N_2H_4 are used by a rocket?

d. How many grams of H_2O are made when 450. kg of N_2O_4 are consumed?

17. Joseph Priestley is credited with the discovery of oxygen. He produced O_2 by heating mercury(II) oxide, HgO, to decompose it into its elements. How many moles of oxygen could Priestley have produced if he had decomposed 517.84 g of mercury oxide?

18. Iron(III) chloride, $FeCl_3$, can be made by the reaction of iron with chlorine gas. How much iron, in grams, will be needed to completely react with 58.0 g of Cl_2?

19. Sodium sulfide and cadmium nitrate undergo a double-replacement reaction, as shown by the following equation:

$$Na_2S + Cd(NO_3)_2 \rightarrow 2NaNO_3 + CdS$$

What is the mass, in milligrams, of cadmium sulfide that can be made from 5.00 mg of sodium sulfide?

20. Potassium permanganate and glycerin react explosively according to the following equation:

$$14KMnO_4 + 4C_3H_5(OH)_3 \rightarrow 7K_2CO_3 + 7Mn_2O_3 + 5CO_2 + 16H_2O$$

a. How many moles of carbon dioxide can be produced from 4.44 mol of $KMnO_4$?

b. If 5.21 g of H_2O are produced, how many moles of glycerin, $C_3H_5(OH)_3$, were used?

c. If 3.39 mol of potassium carbonate are made, how many grams of manganese(III) oxide are also made?

d. How many grams of glycerin will be needed to react with 50.0 g of $KMnO_4$? How many grams of CO_2 will be produced in the same reaction?

21. Calcium carbonate found in limestone and marble reacts with hydrochloric acid to form calcium chloride, carbon dioxide, and water according to the following equation:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

a. What mass of HCl will be needed to produce 5.00×10^3 kg of $CaCl_2$?

b. What mass of CO_2 could be produced from the reaction of 750 g of $CaCO_3$?

22. The fuel used to power the booster rockets on the space shuttle is a mixture of aluminum metal and ammonium perchlorate. The following balanced equation represents the reaction of these two ingredients:

$$3Al(s) + 3NH_4ClO_4(s) \rightarrow Al_2O_3(s) + AlCl_3(g) + 3NO(g) + 6H_2O(g)$$

a. If 1.50×10^5 g of Al react, what mass of NH_4ClO_4, in grams, is required?

b. If aluminum reacts with 620 kg of NH_4ClO_4, what mass of nitrogen monoxide is produced?

23. Phosphoric acid is typically produced by the action of sulfuric acid on rock that has a high content of calcium phosphate according to the following equation:

$$3H_2SO_4 + Ca_3(PO_4)_2 + 6H_2O \rightarrow 3[CaSO_4 \cdot 2H_2O] + 2H_3PO_4$$

a. If 2.50×10^5 kg of H_2SO_4 react, how many moles of H_3PO_4 can be made?

b. What mass of calcium sulfate dihydrate is produced by the reaction of 400. kg of calcium phosphate?

c. If the rock being used contains 78.8% $Ca_3(PO_4)_2$, how many metric tons of H_3PO_4 can be produced from 68 metric tons of rock?

24. Rusting of iron occurs in the presence of moisture according to the following equation:

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

Suppose that 3.19% of a heap of steel scrap with a mass of 1650 kg rusts in a year. What mass will the heap have after one year of rusting?