14. Sulfuric acid reacts with sodium hydroxide according to the following:
$H_2SO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$.
   a. Balance the equation for this reaction.
   b. What mass of H_2SO_4 would be required to react with 0.75 mol NaOH?
   c. What mass of each product is formed by this reaction? (Hint: See Sample B.)

15. Copper reacts with silver nitrate through single replacement.
   a. If 2.25 g of silver are produced from the reaction, how many moles of copper(II) nitrate are also produced?
   b. How many moles of each reactant are required in this reaction? (Hint: See Sample Problem D.)

16. Aspirin, $C_9H_8O_4$, is produced through the following reaction of salicylic acid, $C_7H_6O_3$, and acetic anhydride, $C_4H_6O_3$: $C_7H_6O_3(s) + C_4H_6O_3(l) \longrightarrow C_9H_8O_4(s) + HC_2H_3O_2(l)$.
   a. What mass of aspirin (kg) could be produced from 75.0 mol of salicylic acid?
   b. What mass of acetic anhydride (kg) would be required?
   c. At 20°C, how many liters of acetic acid, $HC_2H_3O_2$, would be formed? The density of $HC_2H_3O_2$ is 1.05 g/mL.

Limiting Reactants and Percentage Yield

SECTION 3 REVIEW

17. Distinguish between ideal and real stoichiometric calculations.

18. Distinguish between the limiting reactant and the excess reactant in a chemical reaction.

19. a. Distinguish between the theoretical yield and actual yield in stoichiometric calculations.
   b. How does the value of the theoretical yield generally compare with the value of the actual yield?

20. What is the percentage yield of a reaction?

21. Why are actual yields usually less than calculated theoretical yields?

PRACTICE PROBLEMS

22. Given the reactant amounts specified in each chemical equation, determine the limiting reactant in each case:

   a. $\underset{2.0\ mol}{HCl} + \underset{2.5\ mol}{NaOH} \longrightarrow NaCl + H_2O$

   b. $\underset{2.5\ mol}{Zn} + \underset{6.0\ mol}{2HCl} \longrightarrow ZnCl_2 + H_2$

   c. $\underset{4.0\ mol}{2Fe(OH)_3} + \underset{6.5\ mol}{3H_2SO_4} \longrightarrow Fe_2(SO_4)_3 + 6H_2O$

   (Hint: See Sample Problem F.)

23. For each reaction specified in Problem 22, determine the amount in moles of excess reactant that remains. (Hint: See Sample Problem G.)

24. For each reaction specified in Problem 22, calculate the amount in moles of each product formed.

25. a. If 2.50 mol of copper and 5.50 mol of silver nitrate are available to react by single replacement, identify the limiting reactant.
   b. Determine the amount in moles of excess reactant remaining.
   c. Determine the amount in moles of each product formed.
   d. Determine the mass of each product formed.

26. Sulfuric acid reacts with aluminum hydroxide by double replacement.
   a. If 30.0 g of sulfuric acid react with 25.0 g of aluminum hydroxide, identify the limiting reactant.
   b. Determine the mass of excess reactant remaining.
   c. Determine the mass of each product formed. Assume 100% yield.

27. The energy used to power one of the Apollo lunar missions was supplied by the following overall reaction: $2N_2H_4 + (CH_3)_2N_2H_2 + 3N_2O_4 \longrightarrow 6N_2 + 2CO_2 + 8H_2O$. For the phase of the mission when the lunar module ascended from the surface of the moon, a total of 1200. kg N_2H_4 was available to react with 1000. kg $(CH_3)_2N_2H_2$ and 4500. kg N_2O_4.
   a. For this portion of the flight, which of the allocated components was used up first?
   b. How much water, in kilograms, was put into the lunar atmosphere through this reaction?