

**MASS AND MOLES**

- Determine molar masses for the following:  
a)  $C_{22}H_{10}O_2$       b)  $Ca(NO_3)_2$       c)  $P_2O_5$       d)  $Al_2(CO_3)_3$
- Determine molar masses for the following:  
a)  $Mg(C_2H_3O_2)_2$       b)  $PtCl_2(NH_3)_2$       c)  $(NH_4)_2SO_4$       d)  $C_{18}H_{27}NO_3$
- Determine mass of each of the following:  
a) 0.694 mol  $C_{22}H_{10}O_2$       b) 2.84 mol  $Ca(NO_3)_2$   
c) 0.00652 mol  $P_2O_5$       d) 8.44 mol  $Al_2(CO_3)_3$
- Determine mass of each of the following:  
a) 1.86 mol  $Mg(C_2H_3O_2)_2$       b) 0.0356 mol  $PtCl_2(NH_3)_2$   
c) 18.4 mol  $(NH_4)_2SO_4$       d) 0.488 mol  $C_{18}H_{27}NO_3$
- Determine mass of each of the following:  
a)  $2.24 \times 10^{20}$  molecules of  $CO_2$       b)  $2.24 \times 10^{24}$  molecules of  $H_2$   
c) 12 C atoms      d)  $8.66 \times 10^{18}$  Pt atoms
- Determine mass of each of the following:  
a) 2.00 million ammonia molecules      b) 1 water molecule  
c)  $6.02 \times 10^{23}$   $PF_3$  molecules      d)  $4.02 \times 10^{28}$  C atoms
- How many moles of people were on the earth when the population was 6.3 billion ( $6.3 \times 10^9$ ) people?
- It is estimated that there are over 400 billion ( $4 \times 10^{11}$ ) stars in the Milky Way galaxy. How many moles of stars is that?
- A bottle contains 12.6 g of  $(NH_4)_3PO_4$ .  
a) How many moles of  $(NH_4)_3PO_4$  does it contain?  
b) How many oxygen atoms does it contain?  
c) What mass of nitrogen atoms does it contain?  
d) How many moles of H does it contain?
- A heaping teaspoon of sugar ( $C_{12}H_{22}O_{11}$ ) has a mass of 8.0 g.  
a) How many moles of sugar does it contain?  
b) How many oxygen atoms does it contain?  
c) What mass of carbon atoms does it contain?  
d) How many moles of H does it contain?

**SUBSTANCE STOICHIOMETRY**

- What is the simplest formula of each of the following compounds?  
a)  $C_{22}H_{10}O_2$       b)  $C_3H_6O$       c)  $C_6H_6$       d)  $C_3H_6O_3$
- What is the simplest formula of each of the following compounds?  
a)  $Na_2S_2O_8$       b)  $B_2H_6$       c)  $N_3S_3Cl_3$       d)  $Na_2Re_2Cl_8$
- What is the elemental composition of each of the molecules in Exercise 11? Express your answer as mass percents?
- What is the elemental composition of each of the compounds in Exercise 12, Express your answer as mass percents?
- How many moles of magnesium are present in a sample of each of the following that contains 3.0 moles of oxygen atoms?  
a)  $MgSO_4$       b)  $MgSO_3$       c)  $Mg_3(PO_4)_2$       d)  $Mg(ClO_3)_2$
- How many grams of nitrogen atoms are present in a sample of each of the following that contains 1.25 moles of oxygen atoms?  
a) NO      b)  $N_2O_3$       c)  $N_2O_5$       d)  $NH_4NO_3$
- What mass of Al is in a sample of  $Al_2(SO_4)_3$  that contains 3.2 grams of S?

18. What mass of potassium is in a sample of potassium carbonate ( $\text{K}_2\text{CO}_3$ ) that contains 12.0 g of oxygen?
19. Caffeine has the molecular formula  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ . What mass of caffeine contains 5.0 mg of nitrogen?
20. Nicotine is  $\text{C}_{10}\text{H}_{14}\text{N}_2$ . What mass of nicotine contains 1.5 moles of nitrogen?
21. What mass of  $\text{Na}_2\text{CO}_3$  contains  $2.1 \times 10^{22}$  oxygen atoms?
22. What mass of oxygen is in a sample of  $\text{Na}_3\text{PO}_4$  that contains  $3.5 \times 10^{21}$  sodium atoms?
23. What mass of KCl was in a solution if all of the chloride in the solution was precipitated as 1.68 g of  $\text{PbCl}_2$ ?
24. What mass of  $\text{Ag}_2\text{SO}_4$  was in a solution if all of the silver was precipitated as 375 mg of  $\text{Ag}_3\text{PO}_4$ ?

### DETERMINING CHEMICAL FORMULAS

25. What is the simplest formula of a compound in which 0.362 mol X is combined with 1.267 mol Y? How many moles of X are present in 6.336 mol of the compound?
26. What is the simplest formula of a compound if a sample of the compound contains 0.236 mol X, 0.354 mol Y, and 0.590 mol Z? How many moles of Z would be in a sample that contained 0.668 mol X?
27. What is the simplest formula of a hydrocarbon that is 81.71 % C?
28. What is the empirical formula of a rhenium oxide that is 76.88% Re?
29. Ibuprofen (*Advil*<sup>®</sup> or *Motrin*<sup>®</sup>) is an anti-inflammatory agent that is 75.69% C, 8.80% H and 15.51% O. What is the simplest formula of ibuprofen?
30. Acetaminophen (*Tylenol*<sup>®</sup>) is an analgesic (pain killer) and an antipyretic (fever reducer) that is 63.56% C, 6.00% H, 9.27% N and 21.17% O. What is the empirical formula of acetaminophen?
31. The sugar arabinose, found in ripe fruits, is 40.00% C, 6.71% H and 53.29% O and has a molar mass of  $150. \text{g} \cdot \text{mol}^{-1}$ . What is the molecular formula for this compound?
32. What is the simplest formula of a compound that is 39.81% Cu, 20.09% S, and 40.10% O?
33. Burning 1.346 g of chromium in air results in 1.967 g of an oxide. What is the simplest formula of the oxide of chromium?
34. A 3.228-g sample of platinum oxide is found to contain 2.773 g of platinum. What is the empirical formula of the oxide?
35. A 2.500-g sample of an oxide of lead produces 0.376 g of water when reduced with hydrogen. What is the simplest formula of this lead oxide? Assume all of the oxygen in the oxide is converted to water.
36. What is the empirical formula of a hydrocarbon if combustion of 1.00 mg produces 3.14 mg of  $\text{CO}_2$  and 1.29 mg of  $\text{H}_2\text{O}$ ? If its molar mass is around  $40 \text{ g} \cdot \text{mol}^{-1}$ , what is its molecular formula?
37. A 0.540-g sample of Anavenol, a compound containing C, H, and O that is used as an anesthetic in veterinary surgeries is analyzed by combustion. What is its empirical formula if the combustion produces 0.310 g of  $\text{H}_2\text{O}$  and 1.515 g of  $\text{CO}_2$ ? If its molar mass is  $188.22 \text{ g} \cdot \text{mol}^{-1}$ , what is the molecular formula for Anavenol?
38. Antifreeze (ethylene glycol) contains carbon, hydrogen and oxygen. Combustion of 50.00 mg of ethylene glycol yields 43.55 mg of  $\text{H}_2\text{O}$  and 70.97 mg of  $\text{CO}_2$ . What is the empirical formula of ethylene glycol? The molar mass of ethylene glycol is  $62.0 \text{ g} \cdot \text{mol}^{-1}$ , what is its molecular formula?
39.  $\text{KClO}_x$  produces KCl and  $\text{O}_2$  upon heating. What is the value of x if a 22.6-g sample produces 7.07 L of  $\text{O}_2$  at 0.956 atm and  $25^\circ\text{C}$ ?
40. A 0.525-g sample of an iron carbonyl,  $\text{Fe}(\text{CO})_x$ , is heated to remove all of the CO. The CO gas is collected in a 0.500-L flask at  $26^\circ\text{C}$ . What is the empirical formula of the carbonyl if the pressure of the CO is 499 torr?
41. Heating a 27.7-mg sample of  $\text{MnSO}_4 \cdot x\text{H}_2\text{O}$  results in 15.1 mg of anhydrous  $\text{MnSO}_4$ . What is value of x?
42. What mass of  $\text{MgCO}_3$  contains the same mass of oxygen as does 376 mg of  $\text{MgCr}_2\text{O}_7$ ?

**BALANCING EQUATIONS**

43. Balance the equations by inspection:

- $\text{Al}_2\text{S}_3 + \text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + \text{H}_2\text{S}$
- $\text{Fe}_3\text{O}_4 + \text{H}_2 \rightarrow \text{Fe} + \text{H}_2\text{O}$
- $\text{Al} + \text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + \text{H}_2$
- $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- $\text{KOH} + \text{H}_3\text{PO}_4 \rightarrow \text{K}_3\text{PO}_4 + \text{H}_2\text{O}$
- $\text{Ag} + \text{H}_2\text{S} + \text{O}_2 \rightarrow \text{Ag}_2\text{S} + \text{H}_2\text{O}$

44. Balance the equations by inspection:

- $\text{P}_4\text{O}_6 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_3$
- $\text{NaOH} + \text{NCl}_3 \rightarrow \text{HOCl} + \text{N}_2 + \text{NaCl}$
- $\text{H}_3\text{PO}_4 + \text{NH}_3 \rightarrow (\text{NH}_4)_2\text{HPO}_4$
- $\text{Bi}_2\text{O}_3 + \text{C} \rightarrow \text{Bi} + \text{CO}$
- $\text{HCl} + \text{MnO}_2 \rightarrow \text{MnCl}_2 + \text{H}_2\text{O} + \text{Cl}_2$
- $\text{Ca}_3\text{N}_2 + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{NH}_3$

45. Balance the equations by inspection:

- $\text{FeS}_2 + \text{O}_2 \rightarrow \text{FeSO}_4 + \text{SO}_3$
- $\text{S}_2\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{SO}_2 + \text{HCl} + \text{S}$
- $\text{V}_2\text{O}_5 + \text{C} + \text{Cl}_2 \rightarrow \text{VOCl}_3 + \text{COCl}_2$
- $\text{NH}_3 + \text{O}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$
- $\text{BF}_3 + \text{NaBH}_4 \rightarrow \text{NaBF}_4 + \text{B}_2\text{H}_6$
- $\text{Al}_4\text{C}_3 + \text{HCl} \rightarrow \text{CH}_4 + \text{AlCl}_3$

46. Balance the equations by inspection:

- $\text{Cr}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow \text{Cr}(\text{OH})_3$
- $\text{PCl}_5 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4 + \text{HCl}$
- $\text{Mg}_2\text{C} + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{CH}_4$
- $\text{BF}_3 + \text{NaH} \rightarrow \text{NaBF}_4 + \text{B}_2\text{H}_6$
- $\text{SiO}_2 + \text{Ca}_3(\text{PO}_4)_2 \rightarrow \text{P}_2\text{O}_5 + \text{CaSiO}_3$
- $\text{Ba}_3\text{P}_2 + \text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{PH}_3$

**REACTION STOICHIOMETRY**

47. A mixture of 3.0 mol of  $\text{CS}_2$  and 2.0 mol of  $\text{O}_2$  reacts according to the equation:  $\text{CS}_2 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{SO}_2$

- What is the limiting reactant?
- How many moles of  $\text{SO}_2$  are produced?
- How many moles of which reactant are unreacted?
- If 72 g of  $\text{SO}_2$  are actually isolated, what is the percent yield?

48. An excess of  $\text{O}_2$  is added to 4.86 g of Fe and allowed to react. What is the percent yield if 6.76 g of  $\text{Fe}_2\text{O}_3$  are isolated?

49. Consider the reaction  $\text{N}_2\text{O}_4 + 2\text{N}_2\text{H}_4 \rightarrow 3\text{N}_2 + 4\text{H}_2\text{O}$

- How many moles of  $\text{N}_2$  are formed by reaction of 5.0 g of  $\text{N}_2\text{H}_4$ ?
- What mass of  $\text{N}_2\text{O}_4$  would be required for Part a?
- What is the percent yield if 4.8 g of water is produced?

50. What mass of oxygen is required for the complete combustion of 7.65 g of propane ( $\text{C}_3\text{H}_8$ ) to produce  $\text{CO}_2$  and  $\text{H}_2\text{O}$ ?

51. What mass of HCl is produced by the reaction of 23.6 g of  $\text{PCl}_3$  and water? The other product is  $\text{H}_3\text{PO}_3$ .

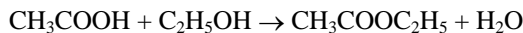
52. How many liters of  $\text{O}_2$  gas measured at 835 torr and 250. °C are formed by the decomposition of 236 g of  $\text{KClO}_3$ ? The other product is KCl.

53. Consider the following reaction that occurs at 1000. °C:
- $$4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g}).$$
- A mixture of 2.65 atm of  $\text{NH}_3$  and 3.80 atm of  $\text{O}_2$  reacts to completion (no limiting reactant remains). Determine the pressures of all gases remaining when the reaction is complete. (Hint: because the reaction is carried out at constant temperature and volume, the pressures are proportional to the number of moles.) What is the total pressure inside the vessel at the beginning and end of the reaction? Why are the total pressures different?
54. Construct the reaction table for the reaction of 2.0 mol  $\text{Fe}_3\text{O}_4$  and 6.0 mol  $\text{H}_2$  to produce elemental iron and water. How many moles of iron form and how many moles of the excess reactant are unused?
55. Construct the reaction table for the reaction of 7.0 g of  $\text{N}_2$  and 6.0 g of  $\text{H}_2$  to form ammonia. What mass of ammonia forms and what mass of the excess reactant remains after reaction?
56. Consider the reaction between  $\text{H}_3\text{PO}_4$  and  $\text{NH}_3$  to produce  $(\text{NH}_4)_2\text{HPO}_4$ .
- What mass of ammonia would have to be added to 20.0 g of phosphoric acid if a 10% excess of ammonia is required?
  - What is the theoretical yield of ammonium hydrogenphosphate under the conditions given in Part a?
57. Construct a reaction table for the reaction of 0.200 mol of iron(III) oxide and 0.270 mol of carbon to produce elemental iron and carbon monoxide. What is the percent yield if 19.4 g of iron are produced?
58. Construct the reaction table for the reaction of 1.46 mol Al and 3.61 mol HCl to produce  $\text{AlCl}_3$  and  $\text{H}_2$ .
59. The most common acid in acid rain is sulfuric acid ( $\text{H}_2\text{SO}_4$ ). When sulfuric acid reacts with sodium hydroxide (NaOH), sodium sulfate is formed along with water. The reaction is
- $$\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$$
- A 10.0-L sample of rain water was treated with a 0.200-g tablet of NaOH. When the reaction was complete, 0.0018 moles of NaOH remained unreacted.
- What was the limiting reagent in this reaction?
  - How many grams of  $\text{H}_2\text{SO}_4$  were in the 10.0-L sample of rain water?
  - How many moles of  $\text{H}_2\text{SO}_4$  were present in each liter of rain water?
60. One step in the production of margarine from vegetable oils is the hydrogenation of the double bonds. In an experiment to test a new hydrogenation catalyst, a 2.36-g sample of linolenic acid,  $\text{C}_{18}\text{H}_{30}\text{O}_2$ , was placed in a sealed flask along with a catalyst. Then 1.50 L of  $\text{H}_2$  gas (measured at 1.0 atm pressure and 25 °C) was bubbled into the mixture. The completely hydrogenated product of the reaction is stearic acid,  $\text{C}_{18}\text{H}_{36}\text{O}_2$ .
- Write the balanced reaction for the complete hydrogenation of linolenic acid to stearic acid.
  - What was the limiting reagent in this reaction mixture?
  - After the reaction, 2.06 g of stearic acid was recovered. What was the percent yield of the reaction?
61. It is desired to remove the lead from a solution containing 6.41 g of  $\text{Pb}(\text{NO}_3)_2$  by adding KCl and precipitating  $\text{PbCl}_2$ . What mass of KCl should be added if a 15.0% excess is required? What mass of  $\text{PbCl}_2$  would form? The other product is  $\text{KNO}_3$ .
62. Consider the reaction  $5\text{P}_4\text{O}_6 + 8\text{I}_2 \rightarrow 4\text{P}_2\text{I}_4 + 3\text{P}_4\text{O}_{10}$ .
- How many grams of  $\text{I}_2$  should be added to 4.50 g of  $\text{P}_4\text{O}_6$  in order to have a 10.0% excess?
  - What is the theoretical yield of  $\text{P}_4\text{O}_{10}$ ?
  - How many grams of  $\text{P}_2\text{I}_4$  would be isolated if actual yield is 83.7%?
63. Consider the reaction of 27.8 g of  $\text{FeS}_2$  with  $\text{O}_2$  to produce  $\text{Fe}_2\text{O}_3$  and  $\text{SO}_2$ .
- What mass of oxygen would be required for a 20% excess?
  - What is the theoretical yield of  $\text{Fe}_2\text{O}_3$ ?
  - What mass of  $\text{SO}_2$  would form if the actual yield is 94.2%?
64. Construct the reaction table for the reaction of 19.25 g  $\text{V}_2\text{O}_5$ , 12.80 g C, and 30.66 g of  $\text{Cl}_2$  to produce  $\text{COCl}_2$  and  $\text{VOCl}_3$ .

## MISCELLANEOUS PROBLEMS

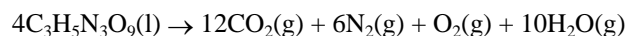
65. What element forms an oxide  $X_2O_3$  that is 88.39% X by mass?
66. The compound  $X_2Y_3$  is found to be 75.0% X. What is the ratio of the molar masses?
67. Aspartame,  $C_{14}H_{18}N_2O_5$ , is the active ingredient in *Nutrasweet*<sup>®</sup>.
- What is the elemental composition of aspartame expressed as percents?
  - What is the mass of a sample of aspartame that contains 2.6 mg of carbon?
  - A tablet of *Equal*<sup>®</sup> has a mass of 0.088 g and the “sweetness of one teaspoon of sugar.” A teaspoon of sugar ( $C_{12}H_{22}O_{11}$ ) has a mass of 4.8 g. Assume the *Equal*<sup>®</sup> tablet is 30% aspartame and estimate the relative “sweetness” of a molecule of aspartame and a molecule of sugar.
68. Methyl alcohol,  $CH_3OH$ , is a clean-burning fuel. It can be synthesized from  $CO(g)$  and  $H_2(g)$ , obtained from coal and water, respectively. If you start with 12.0 g of  $H_2$  and 74.5 g of  $CO$ , what mass of methyl alcohol can be obtained theoretically?
69. Cisplatin,  $Pt(NH_3)_2Cl_2$ , a compound used in chemotherapy for cancer patients, is synthesized by reacting ammonia with tetrachloroplatinate,  $K_2PtCl_4$ , to form the product and potassium chloride.
- What is the maximum mass of cisplatin that can be formed by the reaction of 60.0 g of  $K_2PtCl_4$  and 40.0 g of  $NH_3$ ?
  - What is the percent yield if 35.0 g are obtained experimentally?
70. Excess hydrochloric acid reacts with 0.750 g of aluminum to form aluminum chloride and hydrogen gas.
- How many liters of gas would be collected at 0 °C and 1.00 atm?
  - How many grams of aluminum chloride would be formed?
71. A 5.00-g mixture of  $NaCl$  and  $BaCl_2$  is dissolved in water, then a solution of  $Na_2SO_4$  is added to precipitate  $BaSO_4$ . What percent of the mass of the original mixture is due to  $BaCl_2$  if the mass of  $BaSO_4$  is 2.78 g?
72. What is the molar mass of hemoglobin if its four iron atoms are 0.33% of its mass?
73. Chlorophyll contains 2.72% magnesium. If there is one magnesium per chlorophyll molecule, what is the molar mass of chlorophyll?
74. Vitamin  $B_1$  is 16.6% N by mass and contains 4 nitrogen atoms. What is its molar mass?
75. A mixture of  $NH_4Cl$  and  $NH_4Br$  is 27.4%  $NH_4Cl$  by mass. What mass of the mixture contains 0.200 mol  $NH_4^{1+}$  ions?
76. A mixture is 18.6%  $NaCl$ , 22.1%  $CaCl_2$ , and 59.3%  $NaBr$ .
- What mass of the mixture contains 0.500 mole of chloride ions?
  - How many moles of sodium ions are present in 23.8 g of the mixture?
77. A metal (M) reacts with acid according to the following equation:  
$$2M + 6HCl \rightarrow 2MCl_3 + 3H_2.$$
What is the metal if reaction of 0.305 g of M produces 161 mL of  $H_2$  measured at 23 °C and 753 torr?
78. What is the identity of a metal (M) if 4.26 g of  $MCl_2$  produces 11.00 g of  $AgCl$  upon reaction with excess  $AgNO_3$ ? The balanced equation is  
$$MCl_2 + 2AgNO_3 \rightarrow 2AgCl + M(NO_3)_2.$$
79. Epsom salts have the formula  $MgSO_4 \cdot xH_2O$ . What is the value of  $x$  if drying a 3.268-g sample results in 1.596 g of anhydrous  $MgSO_4$ ?
80. The inflation in automotive air bags is the result of the rapid decomposition of sodium azide (a compound that contains only Na and N) to metallic sodium and nitrogen gas. What is the simplest formula of sodium azide if the decomposition 8.462 g of sodium azide produces 4.8052 L of  $N_2$  measured at 23.6 °C and 752 torr?
81. Sodium nitride is prepared by reacting nitrogen gas with sodium.  
$$6Na + N_2 \rightarrow 2Na_3N$$
How many liters of nitrogen measured at 765 torr and 27.5 °C are required for the complete reaction of 7.22 g of Na? How many grams of sodium nitride would be produced?

82. Ethyl acetate, the active ingredient in nail polish remover, is an ester prepared by the reaction of acetic acid (vinegar) and ethanol (grain alcohol):



The amount of ester increases by removing water (LeChatelier's principle). In a given reaction, 7.65 g  $\text{CH}_3\text{COOH}$  and 9.88 g  $\text{CH}_3\text{OH}$  are mixed and allowed to react. What is the percent yield if 8.96 g of the ester is isolated?

83. How many carbon atoms are present in a 2.0 carat diamond? 1 carat = 0.200 g.
84. The explosion of nitroglycerin is due to the following exothermic reaction:



What volume of gas is produced at 1.00 atm and 200 °C by the reaction of 2.35 g of nitroglycerin?

85. A mixture of  $\text{KBr}$  and  $\text{MgBr}_2$ , which has a mass of 6.81 g, is dissolved in water. An excess of  $\text{AgNO}_3$  is then added to the solution to precipitate all of the bromide as  $\text{AgBr}$ . What are the mass percents of K and Mg in the mixture if 13.24 g of  $\text{AgBr}$  precipitate?
86. 3.62 g of a Group 1A metal reacts with an excess of oxygen to produce 4.36 g of its oxide. What is the metal?
87. Vanillin, which is the primary ingredient in vanilla flavoring, contains C, H, and O. What is its empirical formula if the combustion of 0.6427 g of vanillin produces 0.3043 g of  $\text{H}_2\text{O}$  and 1.487 g of  $\text{CO}_2$ ? If the molar mass of vanillin is found to be near  $150 \text{ g}\cdot\text{mol}^{-1}$ , what is its molecular formula?
88. 6.824 g of an iron chloride is dissolved in acid. Lead nitrate is then added to the solution to precipitate all of the chloride as  $\text{PbCl}_2$ . What is the empirical formula of an iron chloride if 17.568 g of  $\text{PbCl}_2$  is produced?
89. Analysis of a compound shows that it is 17.71% N, 40.55% S, and 40.46% O by mass. It is also known to contain H. What is its empirical formula? If its molar mass is close to  $240 \text{ g}\cdot\text{mol}^{-1}$ , what is its molecular formula?
90. It is desired to prepare exactly 5.0 g of  $\text{PbCl}_2$  by the reaction of  $\text{KCl}$  and  $\text{Pb}(\text{NO}_3)_2$ . How many grams of each starting material should be used if a 10% excess of  $\text{KCl}$  is recommended and a 78% yield can be expected?
91. Construct a reaction table for the reaction of 12.0 g  $\text{N}_2$  with 21.0 g  $\text{O}_2$  to produce  $\text{N}_2\text{O}_5$ . How many g of  $\text{N}_2\text{O}_5$  are produced, and what is the mass of the excess reactant if the reaction goes 100% to completion?