22. $0.3460(283.4 \text{ amu}) + 0.2120(284.7 \text{ amu}) + 0.4420(287.8 \text{ amu}) = 285.6 \text{ amu}$

26. Let A = mass of $^{185}$Re: $186.207 = 0.6260(186.956) + 0.3740(A)$, $186.207 - 117.0 = 0.3740(A)$

$A = \frac{69.2}{0.3740} = 185 \text{ amu}$ (A = 184.95 amu without rounding to proper significant figures.)

30. $500.0 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} = 8.953 \text{ mol Fe}$

$8.953 \text{ mol Fe} \times \frac{6.022 \times 10^{23} \text{ atoms Fe}}{\text{mol Fe}} = 5.391 \times 10^{24} \text{ atoms Fe}$

36. a. $P_4O_6$: $4(30.97 \text{ g/mol}) + 6(16.00 \text{ g/mol}) = 219.88 \text{ g/mol}$

b. $Ca_3(PO_4)_2$: $3(40.08) + 2(30.97) + 8(16.00) = 310.18 \text{ g/mol}$

c. $Na_2HPO_4$: $2(22.99) + 1(1.008) + 1(30.97) + 4(16.00) = 141.96 \text{ g/mol}$

52. a. A chemical formula gives atom ratios as well as mole ratios. We will use both ideas to show how these conversion factors can be used.

Molar mass of $C_2H_5O_2N = 2(12.01) + 5(1.008) + 2(16.00) + 14.01 = 75.07$ g/mol

$$5.00 \text{ g } C_2H_5O_2N \times \frac{1 \text{ mol } C_2H_5O_2N}{75.07 \text{ g } C_2H_5O_2N} \times \frac{6.022 \times 10^{23} \text{ molecules } C_2H_5O_2N}{\text{mol } C_2H_5O_2N} \times \frac{1 \text{ atom N}}{\text{molecule } C_2H_5O_2N} = 4.01 \times 10^{22} \text{ atoms N}$$

b. Molar mass of $Mg_3N_2 = 3(24.31) + 2(14.01) = 100.95$ g/mol

$$5.00 \text{ g } Mg_3N_2 \times \frac{1 \text{ mol } Mg_3N_2}{100.95 \text{ g } Mg_3N_2} \times \frac{6.022 \times 10^{23} \text{ formula units } Mg_3N_2}{\text{mol } Mg_3N_2} \times \frac{2 \text{ atoms N}}{\text{mol } Mg_3N_2} = 5.97 \times 10^{22} \text{ atoms N}$$

c. Molar mass of $Ca(NO_3)_2 = 40.08 + 2(14.01) + 6(16.00) = 164.10$ g/mol

$$5.00 \text{ g } Ca(NO_3)_2 \times \frac{1 \text{ mol } Ca(NO_3)_2}{164.10 \text{ g } Ca(NO_3)_2} \times \frac{2 \text{ mol N}}{\text{mol } Ca(NO_3)_2} \times \frac{6.022 \times 10^{23} \text{ atoms N}}{\text{mol N}} = 3.67 \times 10^{22} \text{ atoms N}$$

d. Molar mass of $N_2O_4 = 2(14.01) + 4(16.00) = 92.02$ g/mol

$$5.00 \text{ g } N_2O_4 \times \frac{1 \text{ mol } N_2O_4}{92.02 \text{ g } N_2O_4} \times \frac{2 \text{ mol N}}{\text{mol } N_2O_4} \times \frac{6.022 \times 10^{23} \text{ atoms N}}{\text{mol N}} = 6.54 \times 10^{22} \text{ atoms N}$$

56. a. $C_3H_4O_2$: Molar mass = 3(12.01) + 4(1.008) + 2(16.00) = 36.03 + 4.032 + 32.00 = 72.06 g/mol

$$\%C = \frac{36.03 \text{ g C}}{72.06 \text{ g compound}} \times 100 = 50.00\% \text{ C}; \ \%H = \frac{4.032 \text{ g H}}{72.06 \text{ g compound}} \times 100 = 5.595\% \text{ H}$$

$$\%O = 100.00 - (50.00 + 5.595) = 44.41\% \text{ O or } \%O = \frac{32.00 \text{ g}}{72.06 \text{ g}} \times 100 = 44.41\% \text{ O}$$

b. $C_4H_6O_2$: Molar mass = 4(12.01) + 6(1.008) + 2(16.00) = 48.04 + 6.048 + 32.00 = 86.09 g/mol

$$\%C = \frac{48.04 \text{ g}}{86.09 \text{ g}} \times 100 = 55.80\% \text{ C}; \ \%H = \frac{6.048 \text{ g}}{86.09 \text{ g}} \times 100 = 7.025\% \text{ H}$$

$$\%O = 100.00 - (55.80 + 7.025) = 37.18\% \text{ O}$$

c. $C_3H_3N$: Molar mass = 3(12.01) + 3(1.008) + 1(14.01) = 36.03 + 3.024 + 14.01 = 53.06 g/mol

$$\%C = \frac{36.03 \text{ g}}{53.06 \text{ g}} \times 100 = 67.90\% \text{ C}; \quad \%H = \frac{3.024 \text{ g}}{53.06 \text{ g}} \times 100 = 5.699\% \text{ H}$$

$$\%N = \frac{14.01 \text{ g}}{53.06 \text{ g}} \times 100 = 26.40\% \text{ N or } \%N = 100.00 - (67.90 + 5.699) = 26.40\% \text{ N}$$

64. All three compounds have the same empirical formula, $CH_2O$, and different molecular formulas. The composition of all three in mass percent is also the same (within rounding differences). Therefore, elemental analysis will give us only the empirical formula.

68. Out of 100.00 g of adrenaline, there are:

$$56.79 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 4.729 \text{ mol C}; \ 6.56 \text{ g H} \times \frac{1 \text{mol H}}{1.008 \text{ g H}} = 6.51 \text{ mol H}$$

$$28.37 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.773 \text{ mol O}; \ 8.28 \text{ g N} \times \frac{1 \text{ mol N}}{14.01 \text{ g N}} = 0.591 \text{ mol N}$$

Dividing each mol value by the smallest number:

$$\frac{4.729}{0.591} = 8.00; \ \frac{6.51}{0.591} = 11.0; \ \frac{1.773}{0.591} = 3.00; \ \frac{0.591}{0.591} = 1.00$$

This gives adrenaline an empirical formula of $C_8H_{11}O_3N$.

82. a. $3 \text{ Ca(OH)}_2(aq) + 2 \text{ H}_3\text{PO}_4(aq) \rightarrow 6 \text{ H}_2\text{O}(l) + \text{Ca}_3(\text{PO}_4)_2(s)$

b. $\text{Al(OH)}_3(s) + 3 \text{ HCl}(aq) \rightarrow \text{AlCl}_3(aq) + 3 \text{ H}_2\text{O}(l)$

c. $2 \text{ AgNO}_3(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{Ag}_2\text{SO}_4(s) + 2 \text{ HNO}_3(aq)$

84. a. $16\ Cr(s) + 3\ S_8(s) \rightarrow 8\ Cr_2S_3(s)$

b. $2\ NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

c. $2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$

d. $2\ Eu(s) + 6\ HF(g) \rightarrow 2\ EuF_3(s) + 3\ H_2(g)$

92. a. $Ba(OH)_2 \cdot 8H_2O(s) + 2\ NH_4SCN(s) \rightarrow Ba(SCN)_2(s) + 10\ H_2O(l) + 2\ NH_3(g)$

b. $$6.5\text{ g } Ba(OH)_2 \cdot 8H_2O \times \frac{1\text{ mol } Ba(OH)_2 \cdot 8H_2O}{315.4\text{ g}} = 0.0206\text{ mol} = 0.021\text{ mol}$$

$$0.021\text{ mol } Ba(OH)_2 \cdot 8H_2O \times \frac{2\text{ mol } NH_4SCN}{1\text{ mol } Ba(OH)_2 \cdot 8H_2O} \times \frac{76.13\text{ g } NH_4SCN}{\text{mol } NH_4SCN} = 3.2\text{ g } NH_4SCN$$

96. a. $$1.00 \times 10^2\text{ g } C_7H_6O_3 \times \frac{1\text{ mol } C_7H_6O_3}{138.12\text{ g } C_7H_6O_3} \times \frac{1\text{ mol } C_4H_6O_3}{1\text{ mol } C_7H_6O_3} \times \frac{102.09\text{ g } C_4H_6O_3}{\text{mol } C_4H_6O_3} = 73.9\text{ g } C_4H_6O_3$$

b. $$1.00 \times 10^2\text{ g } C_7H_6O_3 \times \frac{1\text{ mol } C_7H_6O_3}{138.12\text{ g } C_7H_6O_3} \times \frac{1\text{ mol } C_9H_8O_4}{1\text{ mol } C_7H_6O_3} \times \frac{180.15\text{ g } C_9H_8O_4}{\text{mol } C_9H_8O_4}$$

$$= 1.30 \times 10^2\text{ g aspirin}$$

102. An alternative method to solve limiting reagent problems is to assume each reactant is limiting then calculate how much product could be produced from each reactant. The reactant that produces the smallest amount of product will run out first and is the limiting reagent.

$$5.00 \times 10^6\text{ g } NH_3 \times \frac{1\text{ mol } NH_3}{17.03\text{ g } NH_3} \times \frac{2\text{ mol HCN}}{2\text{ mol } NH_3} = 2.94 \times 10^5\text{ mol HCN}$$

$$5.00 \times 10^6\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32.00\text{ g } O_2} \times \frac{2\text{ mol HCN}}{3\text{ mol } O_2} = 1.04 \times 10^5\text{ mol HCN}$$

$$5.00 \times 10^6\text{ g } CH_4 \times \frac{1\text{ mol } CH_4}{16.04\text{ g } CH_4} \times \frac{2\text{ mol HCN}}{2\text{ mol } CH_4} = 3.12 \times 10^5\text{ mol HCN}$$

$O_2$ is limiting since it produces the smallest amount of HCN. Although more product could be produced from $NH_3$ and $CH_4$, only enough $O_2$ is present to produce $1.04 \times 10^5$ mol HCN. The mass of HCN produced is:

$$1.04 \times 10^5\text{ mol HCN} \times \frac{27.03\text{ g HCN}}{\text{mol HCN}} = 2.81 \times 10^6\text{ g HCN}$$

$$5.00 \times 10^6\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32.00\text{ g } O_2} \times \frac{6\text{ mol } H_2O}{3\text{ mol } O_2} \times \frac{18.02\text{ g } H_2O}{1\text{ mol } H_2O} = 5.63 \times 10^6\text{ g } H_2O$$