CHEMISTRY 151 - BALANCING EQUATIONS KEY

Balance the following equations.

1. $Fe_2S_3 + \mathbf{6}HCl \rightarrow \mathbf{2}FeCl_3 + \mathbf{3}H_2S$

2. $C_7H_8 + \mathbf{9}O_2 \rightarrow \mathbf{7}CO_2 + \mathbf{4}H_2O$

3. $\mathbf{4}C_5H_5N + \mathbf{25}O_2 \rightarrow \mathbf{20}CO_2 + \mathbf{10}H_2O + \mathbf{2}N_2$

4. $\mathbf{2}CH_3OH + \mathbf{3}O_2 \rightarrow \mathbf{2}CO_2 + \mathbf{4}H_2O$

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

6. $Al_2S_3 + \mathbf{6}H_2O \rightarrow \mathbf{2}Al(OH)_3 + \mathbf{3}H_2S$

CHEMISTRY 151 - BALANCING EQUATIONS 2 KEY

1. One way in which silicon is produced for the chemical and electronics industry is by reacting silicon tetrachloride with pure magnesium to produce silicon and magnesium chloride. Write a balanced chemical equation, without states, for this reaction.

   $SiCl_4 + 2Mg \rightarrow Si + 2MgCl_2$

2. Write a balanced equation with states for the complete combustion of liquid benzene, $C_6H_6(l)$.

   $C_6H_6(l) + {}^{15}\!/_{2}\, O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$

   or $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$

4. Write a balanced chemical equation with states that describes the reaction of pure indium metal with oxygen to form solid indium(III) oxide.

   $4In(s) + 3O_2(g) \rightarrow 2In_2O_3(s)$

3. Phosphorus occurs naturally in the form of fluorapatite, $CaF_2 \bullet 3Ca_3(PO_4)_2$. The dot indicates 1 part calcium fluoride to 3 parts calcium phosphate. This mineral is reacted with an aqueous solution of sulfuric acid in the preparation of a fertilizer. Water is a reactant. The products are phosphoric acid, hydrogen fluoride, and gypsum, $CaSO_4 \bullet 2H_2O$. Write a balanced equation, without states, describing this process.

   $CaF_2 \bullet 3Ca_3(PO_4)_2 + 10H_2SO_4 + 20H_2O \rightarrow 6H_3PO_4 + 2HF + 10CaSO_4 \bullet 2H_2O$

EQUATION STOICHIOMETRY KEY

1. How many grams of water are produced when 16.2 g glucose, $C_6H_{12}O_6$, are burned completely?

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

$$? \text{ g } H_2O = 16.2 \text{ g } C_6H_{12}O_6 \left(\frac{1 \text{ mol } C_6H_{12}O_6}{180.158 \text{ g } C_6H_{12}O_6}\right)\left(\frac{6 \text{ mol } H_2O}{1 \text{ mol } C_6H_{12}O_6}\right)\left(\frac{18.0153 \text{ g } H_2O}{1 \text{ mol } H_2O}\right)$$

$$\text{or} \quad ? \text{ g } H_2O = 16.2 \text{ g } C_6H_{12}O_6 \left(\frac{6 \text{ x } 18.0153 \text{ g } H_2O}{1 \text{ x } 180.158 \text{ g } C_6H_{12}O_6}\right) = \mathbf{9.72\ g\ H_2O}$$

2. How many kilograms of aluminum oxide are formed from the oxidation of 42.4 lb of aluminum?

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$$? \text{ kg } Al_2O_3 = 42.4 \text{ lb Al} \left(\frac{453.6 \text{ g}}{1 \text{ lb}}\right)\left(\frac{1 \text{ mol Al}}{26.9815 \text{ g Al}}\right)\left(\frac{2 \text{ mol } Al_2O_3}{4 \text{ mol Al}}\right)\left(\frac{101.9612 \text{ g } Al_2O_3}{1 \text{ mol } Al_2O_3}\right)\left(\frac{1 \text{ kg}}{10^3 \text{ g}}\right)$$

$$\text{or} \quad ? \text{ kg } Al_2O_3 = 42.4 \text{ lb Al} \left(\frac{2 \text{ x } 101.9612 \text{ lb } Al_2O_3}{4 \text{ x } 26.9815 \text{ lb Al}}\right)\left(\frac{1 \text{ kg}}{2.205 \text{ lb}}\right) = \mathbf{36.3\ kg\ Al_2O_3}$$

3. How many grams of carbon dioxide will form when 42.65 g of propane, C_3H_8, burns in the presence of 224.652 g of oxygen?

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

$$? \text{ g } CO_2 = 42.65 \text{ g } C_3H_8 \left(\frac{3 \text{ x } 44.010 \text{ g } CO_2}{1 \text{ x } 44.097 \text{ g } C_3H_8}\right) = \mathbf{127.7\ g\ CO_2}$$

$$? \text{ g } CO_2 = 224.652 \text{ g } O_2 \left(\frac{3 \text{ x } 44.010 \text{ g } CO_2}{5 \text{ x } 31.9988 \text{ g } O_2}\right) = 185.387 \text{ g } CO_2$$

4. If 37.26 oz of Fe_3O_4 reacts with 25.25 oz CO and 6.25 oz of Fe are formed, what is the percent yield?

$$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$$

$$\% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \text{ x } 100 = \frac{6.25 \text{ oz Fe}}{26.96 \text{ oz Fe}} = \mathbf{23.2\%\ Fe}$$

$$? \text{ oz Fe} = 37.26 \text{ oz } Fe_3O_4 \left(\frac{3 \text{ x } 55.847 \text{ oz Fe}}{1 \text{ x } 231.53 \text{ oz } Fe_3O_4}\right) = 26.96 \text{ oz Fe}$$

CHEMISTRY 151 - EQUATION STOICHIOMETRY KEY

1. The concern for the depletion of the ozone layer has been growing in the past few years. It is thought that the ozone, O_3, levels in the upper atmosphere are affected by the reaction with naturally occurring nitrogen monoxide gas. The products are nitrogen dioxide gas and oxygen gas. The high altitude jets called SSTs create a significant amount of nitrogen monoxide gas, so many scientists have been concerned with the prospect of a large fleet flying in the stratosphere and perhaps contributing to the depletion of the ozone layer.

   a. Write the complete balanced equation for the reaction.

   $$\mathbf{NO}(g) \;+\; \mathbf{O_3}(g) \;\rightarrow\; \mathbf{NO_2}(g) \;+\; \mathbf{O_2}(g)$$

   b. What is the maximum mass of ozone that can react with 4.2×10^4 pounds of nitrogen monoxide.

   $$?\ \text{lb } O_3 = 4.2 \times 10^4\ \text{lb NO}\left(\frac{453.6\ \text{g}}{1\ \text{lb}}\right)\left(\frac{1\ \text{mol NO}}{30.0061\ \text{g NO}}\right)\left(\frac{1\ \text{mol } O_3}{1\ \text{mol NO}}\right)\left(\frac{47.9982\ \text{g } O_3}{1\ \text{mol } O_3}\right)\left(\frac{1\ \text{lb}}{453.6\ \text{g}}\right)$$

   or $$?\ \text{lb } O_3 = 4.2 \times 10^4\ \text{lb NO}\left(\frac{1 \times 47.9982\ \text{lb } O_3}{1 \times 30.0061\ \text{lb NO}}\right) = \mathbf{6.7 \times 10^4\ lb\ O_3}$$

2. Freon-12 (CCl_2F_2) is strongly suspected of contributing to a depletion of the ozone layer, which protects us from harmful far UV radiant energy from the sun. It is still used in the U.S. as a refrigerant and in many other countries as a propellant in aerosol cans. It is made from the reaction of liquid carbon tetrachloride with solid antimony fluoride, SbF_3. The other product is antimony chloride, $SbCl_3$.

   a. Write a complete balanced equation for the reaction.

   $$\mathbf{3CCl_4}(l) \;+\; \mathbf{2SbF_3}(s) \;\rightarrow\; \mathbf{3CCl_2F_2}(g) \;+\; \mathbf{2SbCl_3}(s)$$

   b. What is the percent yield if 6.746 g of Freon-12 are formed from the combination of 25.000 g CCl_4 with 25.000 g SbF_3?

   $$?\ \text{g } CCl_2F_2 = 25.000\ \text{g } CCl_4\left(\frac{3 \times 120.914\ \text{g } CCl_2F_2}{3 \times 153.823\ \text{g } CCl_4}\right) = 19.651\ \text{g } CCl_2F_2$$

   $$?\ \text{g } CCl_2F_2 = 25.000\ \text{g } SbF_3\left(\frac{3 \times 120.914\ \text{g } CCl_2F_2}{2 \times 178.75\ \text{g } SbF_3}\right) = 25.332\ \text{g } CCl_2F_2$$

   $$\%\ \text{yield} = \frac{6.746\ \text{g } CCl_2F_2}{19.651\ \text{g } CCl_2F_2} \times 100 = \mathbf{34.33\%}$$

3. When strongly heated, dry boron oxide, $B_2O_3(s)$, reacts when strongly heated with magnesium powder to give a mixture of magnesium oxide and magnesium boride, $Mg_3B_2(s)$.

   a. Write the complete balanced equation for this reaction.

   $$\mathbf{B_2O_3}(s) \;+\; \mathbf{6Mg}(s) \;\rightarrow\; \mathbf{3MgO}(s) \;+\; \mathbf{Mg_3B_2}(s)$$

   b. What is the maximum mass of magnesium boride that can be derived from 10.00 g B_2O_3?

   $$?\ \text{g } Mg_3B_2 = 10.00\ \text{g } B_2O_3\left(\frac{1 \times 94.537\ \text{g } Mg_3B_2}{1 \times 69.620\ \text{g } B_2O_3}\right) = \mathbf{13.58\ g\ Mg_3B_2}$$

c. Magnesium boride reacts with hydrochloric acid, HCl(*aq*), to yield a hydride of boron with the formula B_4H_{10}, magnesium chloride, $MgCl_2$, and hydrogen gas, H_2. Consider the experiment in which the magnesium boride formed from 10.00 g of B_2O_3 as described in "b" above is reacted with an excess of hydrochloric acid. What is the percent yield of B_4H_{10} if 1.789 g of the boron hydride are formed from this reaction?

$$2Mg_3B_2(s) + 12HCl(aq) \rightarrow B_4H_{10}(s) + 6MgCl_2(s) + H_2(g)$$

$$? \text{ g } B_4H_{10} = 13.58 \text{ g } Mg_3B_2 \left(\frac{1 \text{ x } 53.324 \text{ g } B_4H_{10}}{2 \text{ x } 94\ 537 \text{ g } Mg_3B_2} \right) = 3.830 \text{ g } B_4H_{10}$$

$$\% \text{ yield} = \frac{1.789 \text{ g } B_4H_{10}}{3.830 \text{ g } B_4H_{10}} \times 100 = \mathbf{46.71\%}$$