Chapter 9

p. 277

5. a) $PCl_3 + H_2O \rightarrow H_3PO_3 + HCl$ (unbalanced)

$\Downarrow$

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ (balanced)

We can read this equation two ways:

1) One molecule of PCl_3 reacts with three molecules of H_2O to yield one molecule of H_3PO_3 and three molecules of HCl.

2) One mole of PCl_3 reacts with three moles of H_2O to yield one mole of H_3PO_3 and three moles of HCl.

b) $XeF_2 + H_2O \rightarrow Xe + HF + O_2$ (unbalanced)

$\Downarrow$

$2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$ (balanced)

Two molecules (moles) of XeF_2 reacts with two molecules (moles) of H_2O to yield two molecules (moles) of Xe, four molecules (moles) of HF, and one molecule (mole) of O_2.

c) $S + HNO_3 \rightarrow H_2SO_4 + H_2O + NO_2$ (unbalanced)

$\Downarrow$

$S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$ (balanced)

Follow examples from (a) + (b).

d) $2NaHSO_3 \rightarrow Na_2SO_3 + SO_2 + H_2O$ (balanced)

p. 278

17. Molar mass serves as the conversion factor between the mass of a sample and how many moles the sample contains.

p. 279

31. $2Fe + 3Cl_2 \rightarrow 2FeCl_3$ (must balance equation first)

$$15.5\times10^{-3}\,g\,Fe \times \frac{1\,mol\,Fe}{55.85\,g\,Fe} \times \frac{2\,mol\,FeCl_3}{2\,mol\,Fe} \times \frac{162.21\,g\,FeCl_3}{1\,mol\,FeCl_3} \times \frac{1000\,mg}{1\,g} = 45.02\,mg\,FeCl_3$$

p. 280

47. a) $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$ (unbalanced)

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ (balanced)

$$10\,g\,C_3H_8 \times \frac{1\,mol\,C_3H_8}{44.0962\,g\,C_3H_8} \times \frac{3\,mol\,CO_2}{1\,mol\,C_3H_8} \times \frac{44.011\,g\,CO_2}{1\,mol\,CO_2} = 29.9420\,g\,CO_2 \text{ produced}$$

$$10\,g\,O_2 \times \frac{1\,mol\,O_2}{32\,g\,O_2} \times \frac{3\,mol\,CO_2}{5\,mol\,O_2} \times \frac{44.011\,g\,CO_2}{1\,mol\,CO_2} = 8.2521\,g\,CO_2 \text{ produced}$$

$8.2521\,g\,CO_2 < 29.9420\,g\,CO_2 \Rightarrow$ O_2 is the limiting reagent

$$10\,g\,O_2 \times \frac{1\,mol\,O_2}{32\,g\,O_2} \times \frac{4\,mol\,H_2O}{5\,mol\,O_2} \times \frac{18.0158\,g\,H_2O}{1\,mol\,H_2O} = 4.5040\,g\,H_2O \text{ produced}$$

$$10\,g\,O_2 \times \frac{1\,mol\,O_2}{32\,g\,O_2} \times \frac{1\,mol\,C_3H_8}{5\,mol\,O_2} \times \frac{44.0962\,g\,C_3H_8}{1\,mol\,C_3H_8} = 2.7560\,g\,C_3H_8 \text{ used}$$

$10\,g - 2.7560\,g = 7.2440\,g\,C_3H_8$ remaining

At the end of the reaction, we have
8.251 g CO_2
4.5040 g H_2O
~~2.7560 g~~ 7.2440 g C_3H_8

b) $2Al + 3Cl_2 \rightarrow 2AlCl_3$ (balanced)

$$10\text{ g Al} \times \frac{1\text{ mol Al}}{26.98\text{ g Al}} \times \frac{2\text{ mol } AlCl_3}{2\text{ mol Al}} \times \frac{133.339\text{ g } AlCl_3}{1\text{ mol } AlCl_3} = 49.4214\text{ g } AlCl_3 \text{ produced}$$

$$10\text{ g } Cl_2 \times \frac{1\text{ mol } Cl_2}{70.906\text{ g } Cl_2} \times \frac{2\text{ mol } AlCl_3}{3\text{ mol } Cl_2} \times \frac{133.339\text{ g } AlCl_3}{1\text{ mol } AlCl_3} = 12.5367\text{ g } AlCl_3 \text{ produced}$$

12.5367 g < 49.4214 g => **Cl_2 is the limiting reagent**

$$10\text{ g } Cl_2 \times \frac{1\text{ mol } Cl_2}{70.906\text{ g } Cl_2} \times \frac{2\text{ mol Al}}{3\text{ mol } Cl_2} \times \frac{26.98\text{ g Al}}{1\text{ mol Al}} = 2.5367\text{ g Al consumed}$$

10 g Al initially − 2.5367 g Al consumed = 7.4633 g Al remaining

At the end of the reaction, we have **12.5367 g $AlCl_3$ produced**

~~[illegible]~~

7.4633 g Al remaining.

c) **limiting reagent = NaOH**

At the end of the reaction, we have **2.2521 g H_2O produced**

13.2496 g Na_2CO_3 produced

4.4983 g CO_2 remaining

d) **limiting reagent = $NaHCO_3$**

At the end of the reaction, we have **6.9577 g NaCl produced**

2.1448 g H_2O produced

5.2395 g CO_2 produced

5.6593 g HCl remaining

p. 281

53. $PbO + C \rightarrow Pb + CO$

$$50\ kg\ PbO \times \frac{1000\ g\ PbO}{1\ kg\ PbO} \times \frac{1\ mol\ PbO}{223.2\ g\ PbO} \times \frac{1\ mol\ Pb}{1\ mol\ PbO} \times \frac{207.2\ g\ Pb}{1\ mol\ Pb} = 46.4158\ kg\ Pb$$

$$50\ kg\ C \times \frac{1000\ g\ C}{1\ kg\ C} \times \frac{1\ mol\ C}{12.011\ g\ C} \times \frac{1\ mol\ Pb}{1\ mol\ C} \times \frac{207.2\ g\ Pb}{1\ mol\ Pb} = 86.2543\ kg\ Pb$$

Expected yield of lead = 46.4158 kg

p. 282

63. $S_8 + Na_2SO_3 + H_2O \rightarrow Na_2S_2O_3 \cdot 5H_2O$ (unbalanced)

⇓

$S_8 + 8Na_2SO_3 + 40H_2O \rightarrow 8Na_2S_2O_3 \cdot 5H_2O$ (balanced)

$$3.25\ g\ S_8 \times \frac{1\ mol\ S_8}{256.48\ g\ S_8} \times \frac{8\ mol\ Na_2S_2O_3 \cdot 5H_2O}{1\ mol\ S_8} \times \frac{248.179\ g\ Na_2S_2O_3 \cdot 5H_2O}{1\ mol\ Na_2S_2O_3 \cdot 5H_2O} = 25.159\ g\ Na_2S_2O_3 \cdot 5H_2O$$

$$13.1\ g\ Na_2SO_3 \times \frac{1\ mol\ Na_2SO_3}{126.04\ g\ Na_2SO_3} \times \frac{8\ mol\ Na_2S_2O_3 \cdot 5H_2O}{8\ mol\ Na_2SO_3} \times \frac{248.179\ g\ Na_2S_2O_3 \cdot 5H_2O}{1\ mol\ Na_2S_2O_3 \cdot 5H_2O} = 25.795\ g\ Na_2S_2O_3 \cdot 5H_2O$$

theoretical yield of $Na_2S_2O_3 \cdot 5H_2O$ = 25.159 g

$$\%\ yield = \frac{\text{actual yield}}{\text{theoretical yield}} = \frac{5.26\ g}{25.159\ g} = 0.20907 = 20.91\%\ yield$$