Stoichiometry

1) The reaction between potassium Chlorate and red phosphorus takes place when you strike a match on a matchbox. If you were to react 52.9 g of potassium chlorate ($KClO_3$) with excess red phosphorus, what mass of tetraphosphorus decaoxide (P_4O_{10}) could be produced?

$$\underset{52.9\,g}{10\,KClO_{3(s)}} + 3P_{4(s)} \rightarrow \underset{g?}{3\,P_4O_{10(s)}} + 10\,KCl_{(s)}$$

Road Map

$$g\ KClO_3 \rightarrow mole\ KClO_3 \rightarrow mole\ P_4O_{10} \rightarrow g\ P_4O_{10}$$

molar mass:

$$KClO_3 = \overset{K}{39.10} + \overset{Cl}{35.45} + \overset{O}{3 \times 16.00} = 122.55\,g/mole$$

$$P_4O_{10} = 4 \times 30.97 + 10 \times 16.00 = 283.9\,g/mole$$

$$\overset{3}{52.9\,g\ KClO_3} \times \frac{1\,mole\ KClO_3}{\underset{5}{122.55\,g\ KClO_3}} \times \overset{\text{Exact}}{\frac{3\,mole\ P_4O_{10}}{10\,mole\ KClO_3}} \times \frac{\overset{4}{283.9\,g\ P_4O_{10}}}{1\,mole\ P_4O_{10}} =$$

$$= 36.7645287\,g\ P_4O_{10}$$

$$\boxed{= 36.8\,g\ P_4O_{10}}$$

2) The reusable booster rockets of the U.S. Space Shuttle employ a mixture of aluminum and ammonium perchlorate for fuel. A possible equation for this reaction is:

$$3Al_{(s)} + 3NH_4ClO_{4(s)} \rightarrow Al_2O_{3(s)} + AlCl_{3(s)} + 3NO_{(g)} + 6H_2O_{(l)}$$

What mass of NH_4ClO_4 should be used in the fuel mixture for every 1.00 kg of Al?

$$3Al_{(s)} + 3NH_4ClO_{4(s)} \rightarrow Al_2O_{3(s)} + AlCl_{3(s)} + 3NO_{(g)} + 6H_2O_{(l)}$$

1.00 kg ? kg

Road Map

kg Al → g Al → mole Al → Mole NH_4ClO_4 → g NH_4ClO_4 → kg NH_4ClO_4

molar mass:

Al = 26.98 g/mole

$NH_4ClO_4 = \underset{N}{14.01} + \underset{H}{4 \times 1.008} + \underset{Cl}{35.45} + \underset{O}{4 \times 16.00} = 117.49\ g/mole$

$$\underset{3}{1.00\,kg\,Al} \times \underset{exact}{\frac{1000\,g\,Al}{1\,kg\,Al}} \times \underset{4}{\frac{1\,mole\,Al}{26.98\,g\,Al}} \times \underset{exact}{\frac{3\,mol\,NH_4ClO_4}{3\,mol\,Al}} \times \underset{5}{\frac{117.49\,g\,NH_4ClO_4}{1\,mole\,NH_4ClO_4}} \times \underset{exact}{\frac{1\,kg\,NH_4ClO_4}{1000\,g\,NH_4ClO_4}} =$$

$= 4.354707191\ kg\ NH_4ClO_4$

$= \boxed{4.35\ kg\ NH_4ClO_4}$

3) One of the few reactions that takes place between two solids at room temperature is

$$Ba(OH)_2 \cdot 8H_2O_{(s)} + 2NH_4SCN_{(s)} \rightarrow Ba(SCN)_{2(s)} + 10H_2O_{(l)} + 2NH_{3(g)}$$

In this equation the $\cdot 8H_2O$ in $Ba(OH)_2 \cdot 8H_2O$ indicates the presence of 8 molecules of H_2O in the formula. The compound is called barium hydroxide octahydrate. What mass of ammonium thiocyanate (NH_4SCN) must be used to react completely with 6.5 g of barium hydroxide octahydrate

$$Ba(OH)_2 \cdot 8H_2O_{(s)} + 2NH_4SCN_{(s)} \rightarrow Ba(SCN)_{2(s)} + 10H_2O_{(l)} + 2NH_{3(g)}$$

6.5 g ? g

Road Map

g $Ba(OH)_2 \cdot 8H_2O$ → mole $Ba(OH)_2 \cdot 8H_2O$ → mole NH_4SCN → g NH_4SCN

Molar Mass:

$$Ba(OH)_2 \cdot 8H_2O = \overset{Ba}{137.3} + 10 \times \overset{O}{16.00} + 18 \times \overset{H}{1.008} = 315.4 \text{ g/mole}$$

$$NH_4SCN = 2 \times \overset{N}{14.01} + 4 \times \overset{H}{1.008} + \overset{S}{32.07} + \overset{C}{12.01} = 76.13 \text{ g/mole}$$

$$\overset{2}{6.5\text{ g } Ba(OH)_2 \cdot 8H_2O} \times \frac{1 \text{ mole } Ba(OH)_2 \cdot 8H_2O}{\underset{4}{315.4\text{ g } Ba(OH)_2 \cdot 8H_2O}} \times \frac{\overset{\text{exact}}{2 \text{ mole } NH_4SCN}}{1 \text{ mole } Ba(OH)_2 \cdot 8H_2O} \times \frac{\overset{4}{76.13\text{ g } NH_4SCN}}{1 \text{ mole } NH_4SCN} =$$

$$= 3.137888396 \text{ g } NH_4SCN$$

$$\boxed{= 3.1 \text{ g } NH_4SCN}$$

4) The compound Cisplatin, $Pt(NH_3)_2Cl_2$, has been studied as an antitumor agent. Cisplatin is synthesized as follows:

$$K_2PtCl_{4(aq)} + 2NH_{3(aq)} \rightarrow Pt(NH_3)_2Cl_{2(s)} + 2KCl_{(aq)}$$

What mass of Cisplatin can be produced from 125 g K_2PtCl_4 and excess (sufficient) NH_3?

$$K_2PtCl_{4(aq)} + 2NH_{3(aq)} \rightarrow Pt(NH_3)_2Cl_{2(s)} + 2KCl_{(aq)}$$

125 g ?

Road Map

g K_2PtCl_4 → mole K_2PtCl_4 → mole $Pt(NH_3)_2Cl_2$ → g $Pt(NH_3)_2Cl_2$

molar mass:

$$K_2PtCl_4 = 2 \times \overset{K}{39.10} + \overset{Pt}{195.1} + 4 \times \overset{Cl}{35.45} = 415.1 \text{ g/mole}$$

$$Pt(NH_3)_2Cl_2 = \overset{Pt}{195.1} + 2 \times \overset{N}{14.01} + 6 \times \overset{H}{1.008} + 2 \times 35.45 = 300.1 \text{ g/mole}$$

$$\overset{3}{125 \text{ g } K_2PtCl_4} \times \frac{1 \text{ mole } K_2PtCl_4}{\underset{4}{415.1 \text{ g } K_2PtCl_4}} \times \overset{\text{exact}}{\frac{1 \text{ mole } Pt(NH_3)_2Cl_2}{1 \text{ mole } K_2PtCl_4}} \times \overset{4}{\frac{300.1 \text{ g } Pt(NH_3)_2Cl_2}{1 \text{ mole } Pt(NH_3)_2Cl_2}} =$$

$$= 90.36979041 \text{ g } Pt(NH_3)_2Cl_2$$

$$= \boxed{90.4 \text{ g } Pt(NH_3)_2Cl_2}$$

5) Ammonia is produced from the reaction of nitrogen and hydrogen according to the following balanced equation:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

a) What is the maximum mass of ammonia that can be produced from 1.00×10^3 g N_2 and 5.00×10^2 g H_2?

b) What mass of which starting material would remain unreacted?

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

1.00×10^3 g 5.00×10^2 g   ??

Limiting Reagent Problem

Road Maps

① g N_2 → mole N_2 → mole NH_3 → g NH_3

② g H_2 → mole H_2 → mole NH_3 → g NH_3

Molar Mass

N_2 = 2×14.01 = 28.02 g/mole

H_2 = 2×1.008 = 2.016 g/mole

NH_3 = $14.01 + 3 \times 1.008$ = 17.03 g/mole

① $1.00 \times 10^3 \text{ g } N_2 \times \frac{1 \text{ mole } N_2}{28.02 \text{ g } N_2} \times \frac{2 \text{ mole } NH_3}{1 \text{ mole } N_2} \times \frac{17.03 \text{ g } NH_3}{1 \text{ mole } NH_3} = \boxed{1215.560314 \text{ g } NH_3}$ Smaller

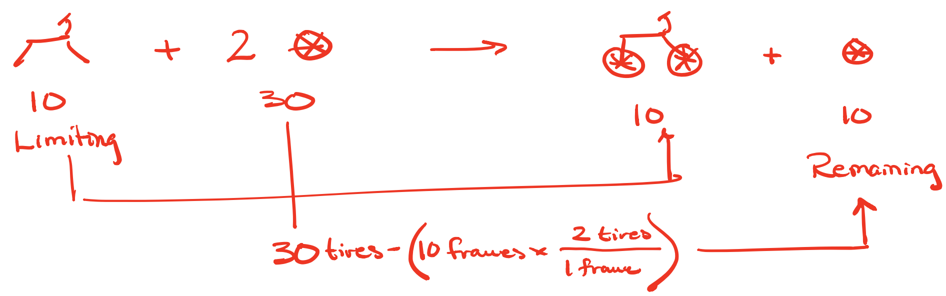
(3 sig figs; 4; exact; 4)

② $5.00 \times 10^2 \text{ g } H_2 \times \frac{1 \text{ mole } H_2}{2.016 \text{ g } H_2} \times \frac{2 \text{ mole } NH_3}{3 \text{ mole } H_2} \times \frac{17.03 \text{ g } NH_3}{1 \text{ mole } NH_3} = 2815.806878 \text{ g } NH_3$

$$\boxed{\begin{array}{l} \text{a) } 1220 \text{ g } NH_3 \text{ produced} \\ = 1.22 \times 10^3 \text{ g } NH_3 \text{ produced} \end{array}}$$

Now for part b. What mass of which starting material would be left over?

Consider



So we need to do the same thing w/ the chemical equation.

Road Map

$g\ H_2$ Initial $- (g\ N_2 \rightarrow \text{mole } N_2 \rightarrow \text{mole } H_2 \rightarrow g\ H_2 \text{ used})$

Represents H_2 used to make NH_3

$$5.00 \times 10^2\ g\ H_2 - \left(1.00 \times 10^3\ g\ N_2 \times \frac{1 \text{ mole } N_2}{28.01\ g\ N_2} \times \frac{3 \text{ mole } H_2}{1 \text{ mole } N_2} \times \frac{2.016\ g\ H_2}{1 \text{ mole } H_2}\right) =$$

1's position

$$= 284.0771153\ g\ H_2$$

$$= \boxed{284\ g\ H_2 \text{ remaining}}$$

6) In the laboratory small amounts of hydrogen peroxide can be prepared by the action of an acid on an alkaline earth metal peroxide such as barium peroxide:

$$BaO_{2(s)} + 2HCl_{(aq)} \rightarrow H_2O_{2(aq)} + BaCl_{2(aq)}$$

What mass of hydrogen peroxide should result when 1.50 g of BaO_2 is treated with 88.0 mL of hydrochloric acid solution containing 0.0272 g HCl per mL?

Concentration (equality)

$$\underset{1.50\,g}{BaO_{2(s)}} + \underset{\substack{88.0\,mL \\ 0.0272\,g/mL}}{2HCl_{(aq)}} \rightarrow \underset{?\ ?}{H_2O_{2(aq)}} + BaCl_{2(aq)}$$

Limiting Reagent Problem w/ Solution

Don't panic ⇒ Done the same way

Road Maps

① g BaO_2 → mole BaO_2 → mole H_2O_2 → g H_2O_2

② mL HCl → g HCl → mole HCl → mole H_2O_2 → g H_2O_2

molar mass

BaO_2 = 137.3 + 2 × 16.00 = 169.3 g/mole

HCl = 1.008 + 35.45 = 36.46 g/mole

H_2O_2 = 2 × 1.008 + 2 × 16.00 = 34.02 g/mole

① $\overset{3}{1.50\ g\ BaO_2} \times \dfrac{1\ mole\ BaO_2}{\underset{4}{169.3\ g\ BaO_2}} \times \dfrac{\overset{exact}{1\ mole\ H_2O_2}}{1\ mole\ BaO_2} \times \dfrac{\overset{4}{34.02\ g\ H_2O_2}}{1\ mole\ H_2O_2} = 0.3014176019\ g\ H_2O_2$

$= \boxed{0.301\ g\ H_2O_2}$ Smaller

BaO_2 Limiting

② $\overset{3}{88.0\ mL\ HCl} \times \dfrac{\overset{3}{0.0272\ g\ HCl}}{1\ mL\ HCl} \times \dfrac{1\ mole\ HCl}{\underset{4}{36.46\ g\ HCl}} \times \dfrac{\overset{exact}{1\ mole\ H_2O_2}}{2\ mol\ HCl} \times \dfrac{\overset{4}{34.02\ g\ H_2O_2}}{1\ mole\ H_2O_2} =$

$= 1.116706967\ g\ H_2O_2$

$= 1.11\ g\ H_2O_2$

⇒ $\boxed{0.301\ g\ H_2O_2}$ Could be produced with BaO_2 Limiting