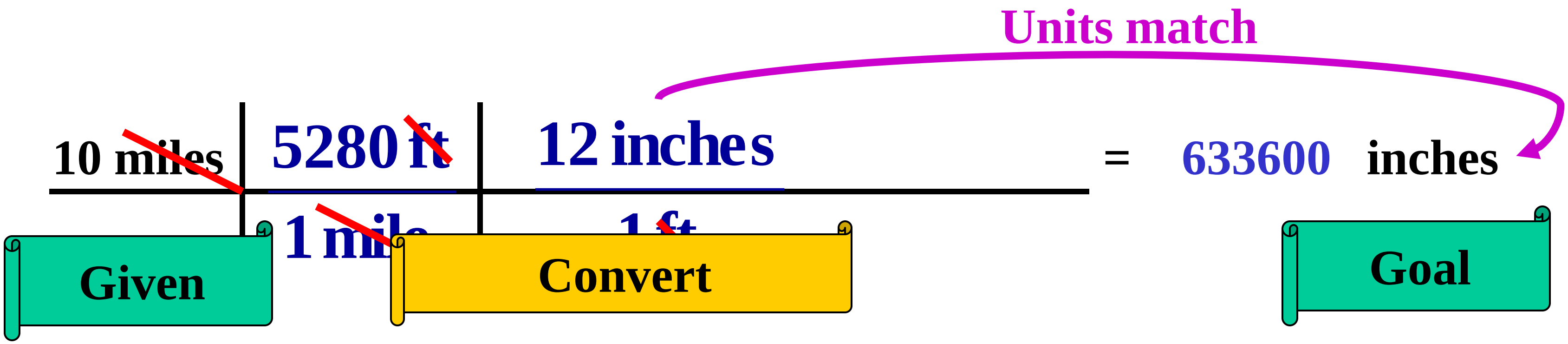
Instructions: **This is a work along tutorial. Attempt to solve each problem before looking at the solution. Record all your work and all steps involved in the problem solving on your notebook paper. Turn in your paper when you are finished.**

Get a pencil and paper, a periodic table and a calculator, and let’s get to work.

Problem #1: Dimensional Analysis Review

Sam has entered into a 10 mile race. Use ALL of the following conversions (ratios) to determine how many inches there are in the race.

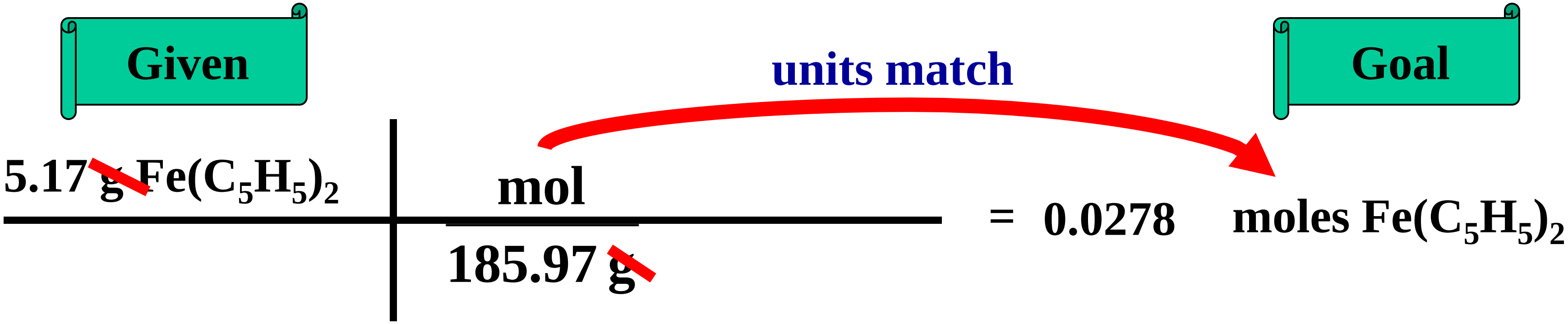
5280 ft = 1 mile; 12 inches = 1 ft



$$10\ \cancel{\text{miles}}\ \left|\ \frac{5280\ \cancel{\text{ft}}}{1\ \cancel{\text{mile}}}\ \right|\ \frac{12\ \text{inches}}{1\ \cancel{\text{ft}}} = 633600\ \text{inches}$$

Problem #2: Grams to moles review

Determine how many moles there are in 5.17 grams of $Fe(C_5H_5)_2$.



Given

Goal

units match

$$5.17\ \cancel{g}\ Fe(C_5H_5)_2 \times \frac{\text{mol}}{185.97\ \cancel{g}} = 0.0278\ \text{moles}\ Fe(C_5H_5)_2$$

Use the molar mass to convert grams to moles.

$Fe(C_5H_5)_2$

2 x 5 x 1.001 = 10.01

2 x 5 x 12.011 = 120.11

1 x 55.85 = 55.85

$$\frac{185.97\ \text{g}}{\text{mol}}$$

Problem #3: Mole – Mole Conversions

When N_2O_5 is heated, it decomposes:

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$

a. How many moles of NO_2 can be produced from 4.3 moles of N_2O_5?

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$

4.3 mol **? mol** **Units match**

$$\begin{array}{l|l} 4.3\ \cancel{\text{mol } N_2O_5} & \dfrac{4\text{mol } NO_2}{2\cancel{\text{mol } N_2O_5}} \\ \hline & \end{array} = 8.6 \quad \text{moles } NO_2$$

b. How many moles of O_2 can be produced from 4.3 moles of N_2O_5?

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$

4.3 mol **? mol**

$$\begin{array}{l|l} \cancel{4.3\ \text{mol } N_2O_5} & \dfrac{1\text{mol } O_2}{\cancel{2\text{mol } N_2O_5}} \\ \hline & \end{array} = 2.\underline{2} \quad \text{mole } O_2$$

Problem #4 gram ↔ mole and gram ↔ gram conversions

When N_2O_5 is heated, it decomposes:

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$

a. How many moles of N_2O_5 were used if $21\underline{0}$g of NO_2 were produced?

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

? moles $\qquad$ $21\underline{0}$g

Units match

$$\frac{21\underline{0}\ \cancel{g\ NO_2}}{} \left| \frac{\cancel{mol\ NO_2}}{46.0\cancel{g\ NO_2}} \right| \frac{2mol\ N_2O_5}{4\cancel{mol\ NO_2}} = 2.2\underline{8} \text{ moles } N_2O_5$$

b. How many grams of N_2O_5 are needed to produce 75.0 grams of O_2?

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

? grams $\qquad$ 75.0 g

$$\frac{75.0\ \cancel{g\ O_2}}{} \left| \frac{\cancel{mol\ O_2}}{32.0\ \cancel{g\ O_2}} \right| \frac{2\cancel{mol\ N_2O_5}}{1\cancel{mol\ O_2}} \left| \frac{108g\ N_2O_5}{\cancel{mol\ N_2O_5}} \right. = 50\underline{6} \text{ grams } N_2O_5$$

Problem #5: Gram to Gram Conversions

Aluminum is an active metal that when placed in hydrochloric acid produces hydrogen gas and aluminum chloride. How many grams of aluminum chloride can be produced when 3.45 grams of aluminum are reacted with an excess of hydrochloric acid?

$$2\,Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

First write a balanced equation.

gram to gram conversions

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$$\underset{3.45\ g}{2\,Al(s)} + 6HCl(aq) \rightarrow \underset{?\ grams}{2AlCl_3(aq)} + 3H_2(g)$$

Units match

$$\begin{array}{c|c|c|c} 3.45\ \cancel{g\ Al} & \cancel{mol\ Al} & 2\ \cancel{mol\ AlCl_3} & 133.3\ g\ AlCl_3 \\ \hline & 27.0\ \cancel{g\ Al} & 2\ \cancel{mol\ Al} & \cancel{mol\ AlCl_3} \end{array} = 17.0\ g\ AlCl_3$$

Now use the molar mass to convert to grams.

Problem # 6 Limiting/Excess/ Reactant and Theoretical Yield Problems :

Potassium superoxide, KO_2, is used in rebreathing gas masks to generate oxygen.

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

a. **How many moles of O_2 can be produced from 0.15 mol KO_2 and 0.10 mol H_2O?**

b. **Determine the limiting reactant.**

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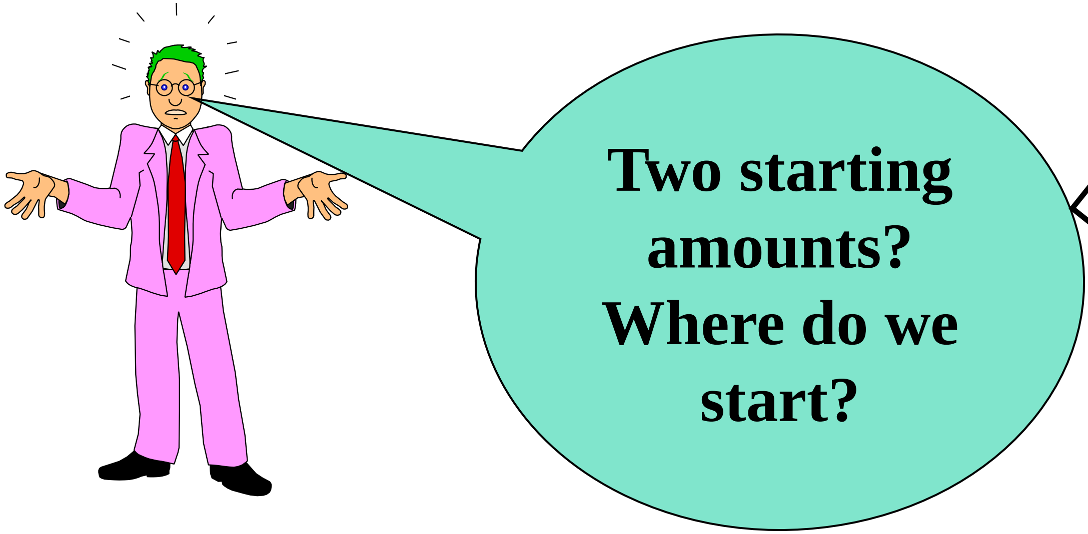
0.15 mol **0.10 mol** **? moles**



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$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

0.15 mol **Hide** **? moles**

Based on: KO_2

$$\frac{\cancel{0.15\text{ mol KO}_2}}{} \left| \frac{3\text{mol O}_2}{\cancel{4\text{mol KO}_2}} \right. = 0.1\underline{1}25 \text{ mol O}_2$$

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$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

Hide

0.10 mol

? moles

Based on:
KO_2

$$\begin{array}{l|l} 0.15\ \cancel{\text{mol }KO_2} & 3\text{mol }O_2 \\ \hline & 4\cancel{\text{mol }KO_2} \end{array} = 0.1\underline{1}25 \quad \text{mol }O_2$$

Based on:
H_2O

$$\begin{array}{l|l} 0.10\ \cancel{\text{mol }H_2O} & 3\text{mol }O_2 \\ \hline & 2\cancel{\text{mol }H_2O} \end{array} = 0.1\underline{5}0 \quad \text{mol }O_2$$

Limiting/Excess/ Reactant and Theoretical Yield Problems :

Potassium superoxide, KO_2, is used in rebreathing gas masks to generate oxygen.

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

a. How many moles of O_2 can be produced from 0.15 mol KO_2 and 0.10 mol H_2O? Determine the limiting reactant.

$$\underset{0.15\ \text{mol}}{4KO_2(s)} + \underset{0.10\ \text{mol}}{2H_2O(l)} \rightarrow 4KOH(s) + \underset{?\ \text{moles}}{3O_2(g)}$$

Based on: KO_2

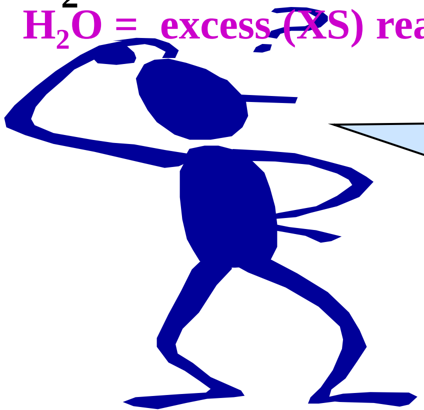
$$0.15\ \cancel{\text{mol}\ KO_2} \times \frac{3\text{mol}\ O_2}{4\cancel{\text{mol}\ KO_2}} = 0.1\underline{1}25\ \text{mol}\ O_2$$

It was limited by the amount of KO_2.

Based on: H_2O

$$0.10\ \cancel{\text{mol}\ H_2O} \times \frac{3\text{mol}\ O_2}{2\cancel{\text{mol}\ H_2O}} = 0.1\underline{5}0\ \text{mol}\ O_2$$

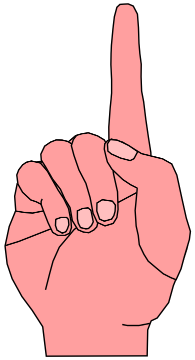
H_2O = excess (XS) reactant!



What is the theoretical yield?
Hint: Which is the smallest amount? The is based upon the limiting reactant?

Problem #7 Theoretical yield vs. Actual yield

Suppose the theoretical yield for an experiment was calculated to be 19.5 grams, and the experiment was performed, but only 12.3 grams of product were recovered. Determine the % yield.



Theoretical yield = 19.5 g based on limiting reactant

Actual yield = 12.3 g experimentally recovered

$$\%\ \text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \text{x}\, 100$$

$$\%\ \text{yield} = \frac{12.3}{19.5} \text{x}\, 100 = 63.1\%\ \text{yield}$$

Problem #8: Limiting/Excess Reactant Problem with % Yield

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

If a reaction vessel contains 120.0 g of KO_2 and 47.0 g of H_2O, how many grams of O_2 can be produced?

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

120.0 g

Hide one

? g

Based on:
KO_2

$$\frac{120.0\,\cancel{g}\,\cancel{KO_2}}{}\,\Bigg|\,\frac{\cancel{mol}}{71.1\,\cancel{g}}\,\Bigg|\,\frac{3\,\cancel{mol\ O_2}}{4\,\cancel{mol\ KO_2}}\,\Bigg|\,\frac{32.0g\ O_2}{\cancel{mol\ O_2}} = 40.\underline{5}1\ g\ O_2$$

Problem #9: Limiting/Excess Reactant Problem with % Yield

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

If a reaction vessel contains 120.0 g of KO_2 and 47.0 g of H_2O, how many grams of O_2 can be produced?

$$4KO_2(s) + 2H_2O(l) \rightarrow 4KOH(s) + 3O_2(g)$$

Hide

47.0 g

? g

Based on: KO_2

$$\begin{array}{c|c|c|c} 120.0\,\cancel{g\,KO_2} & \cancel{mol} & 3\,\cancel{mol\,O_2} & 32.0g\,O_2 \\ \hline & 71.1\,\cancel{g} & 4\,\cancel{mol\,KO_2} & \cancel{mol\,O_2} \end{array} = 40.\underline{5}1 \text{ g } O_2$$

Based on: H_2O

$$\begin{array}{c|c|c|c} 47.0\,\cancel{g\,H_2O} & \cancel{mol\,H_2O} & 3\,\cancel{mol\,O_2} & 32.0g\,O_2 \\ \hline & 18.02\,\cancel{g\,H_2O} & 2\,\cancel{mol\,H_2O} & \cancel{mol\,O_2} \end{array} = 12\underline{5}.3 \text{ g } O_2$$

Problem #9: if only 35.2 g of O_2 were recovered, what was the percent yield?

HONORS ONLY!!!

$$\frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{35.2}{40.51} \times 100 = 86.9\% \text{ yield}$$

If a reaction vessel contains 120.0 g of KO_2 and 47.0 g of H_2O, how many grams of O_2 can be produced?

$$4KO_2(s) \;+\; 2H_2O(l) \rightarrow 4KOH(s) \;+\; 3O_2(g)$$

$$\underset{120.0\text{ g}}{} \qquad \underset{47.0\text{ g}}{} \qquad\qquad\qquad \underset{?\text{ g}}{}$$

Based on: KO_2

$$\frac{120.0\,\cancel{g}\,\cancel{KO_2}}{} \Bigg| \frac{\cancel{mol}}{71.1\cancel{g}} \Bigg| \frac{3\cancel{mol\ O_2}}{4\cancel{mol\ KO_2}} \Bigg| \frac{32.0g\ O_2}{\cancel{mol\ O_2}} = 40.\underline{5}1\ \ g\ O_2$$

Based on: H_2O

$$\frac{47.0\ \cancel{g\ H_2O}}{} \Bigg| \frac{\cancel{mol\ H_2O}}{18.02\ \cancel{g\ H_2O}} \Bigg| \frac{3\ \cancel{mol\ O_2}}{2\ \cancel{mol\ H_2O}} \Bigg| \frac{32.0g\ O_2}{\cancel{mol\ O_2}} = 12\underline{5}.3\ \ g\ O_2$$

Determine how many grams of Water were left over.

The Difference between the above amounts is directly RELATED to the XS H_2O.

125.3 - 40.51 = 84.79 g of O_2 that could have been formed from the XS water.

$$\frac{84.79\ \cancel{g\ O_2}}{} \Bigg| \frac{\cancel{mol\ O_2}}{32.0\ \cancel{g\ O_2}} \Bigg| \frac{2\ \cancel{mol\ H_2O}}{3\ \cancel{mol\ O_2}} \Bigg| \frac{18.02\ g\ H_2O}{1\ \cancel{mol\ H_2O}} = 31.\underline{8}3\ g\ XS\ H_2O$$