Percent Yield Problems

1) What is percent yield and how is it determined?

2) What is the difference between theoretical yield and actual yield?

***The general mechanism for finding percentage yield is as follows:
1. Balance the chemical equation
2. Find the limiting reagent
   - this is the reactant which the product yield depends on, as it is not in excess
3. Find the theoretical yield
   - this is how much product will be synthesized in ideal conditions
4. Find the actual yield
   - given in the problem
5. Find the percentage yield

\[
\text{Percentage Yield} = \frac{\text{mass of Actual Yield}}{\text{mass of Theoretical Yield}} \times 100\%
\]

**Example 1**
A student adds 200.0g of \(C_7H_6O_3\) to an excess of \(C_4H_6O_3\), this produces \(C_9H_8O_4\) and \(C_2H_4O_2\). Calculate the percent yield if 231 g of aspirin \((C_9H_8O_4)\) is produced.

1) \(C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2\) \hspace{1cm} \text{(balanced)}

2) Limiting Reactant = \(C_7H_6O_3\)

3) \[200.0\, \text{g} \, C_7H_6O_3 \times \frac{1 \, \text{mole} \, C_7H_6O_3}{138.13 \, \text{g} \, C_7H_6O_3} \times \frac{1 \, \text{mole} \, C_9H_8O_4}{1 \, \text{mole} \, C_7H_6O_3} \times \frac{180.17 \, \text{g} \, C_9H_8O_4}{1 \, \text{mole} \, C_9H_8O_4} = 260.87 \, \text{g} \, C_9H_8O_4\]

4) Actual yield = 231 g \(C_9H_8O_4\)

5) \[
\text{Percentage Yield} = \frac{231 \, \text{g} \, C_9H_8O_4 \text{ (Actual Yield)}}{260.87 \, \text{g} \, C_9H_8O_4 \text{ (Theoretical Yield)}} \times 100\% = 88.5 \%
\]

2) According to the following equation, Calculate the percentage yield if 550.0 g of toluene \((C_7H_8)\ )added to an excess of nitric acid \((HNO_3)\) provides 305 g of the p-nitrotoluene \((C_7H_7NO_2\ )\) product.

\[C_7H_8 + HNO_3 \rightarrow C_7H_7NO_2 + H_2O\]
3) Determine the percent yield for the reaction between 3.74 g of Na and excess O\textsubscript{2} if 5.34 g of Na\textsubscript{2}O\textsubscript{2} is recovered.

4) Determine the percent yield for the reaction between 6.92 g of K and 4.28 g of O\textsubscript{2} if 7.36 g of K\textsubscript{2}O is produced.

5) Determine the percent yield for the reaction between 28.1 g of Sb\textsubscript{4}O\textsubscript{6} and excess C if 17.3 g of Sb is recovered along with an unknown amount of CO.

6) In the following reaction, 0.157 g of \textit{p}-acetaminophenol was used to react with 0.486 g of acetic anhydride to produce acetaminophen and acetic acid. The product was purified and acetimophen was extracted. The actual mass of acetaminophen produced was 0.198 g. Determine the theoretical yield and the percent yield of isopentyl acetate.

\[
\textit{p}-\text{Aminophenol} + \text{Acetic anhydride} \rightarrow \text{Acetaminophen} + \text{Acetic acid}
\]

\[
C_6H_7NO + C_4H_6O_3 \rightarrow C_8H_9NO_2 + CH_3COOH
\]