Percent Yields from Reactions

- **Theoretical yield** is calculated by assuming that the reaction goes to completion.
- **Actual yield** is the amount of a specified pure product made in a given reaction.
  - In the laboratory, this is the amount of product that is formed in your beaker, after it is purified and dried.
- **Percent yield** indicates how much of the product is obtained from a reaction.

\[
\text{percent yield} = \frac{\text{actual yield of product}}{\text{theoretical yield of product}} \times 100\%
\]
A 10.0 g sample of ethanol, $\text{C}_2\text{H}_5\text{OH}$, was boiled with excess acetic acid, $\text{CH}_3\text{COOH}$, to produce 14.8 g of ethyl acetate, $\text{CH}_3\text{COOC}_2\text{H}_5$. What is the percent yield?

$$\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$$

\[\text{MW} \rightarrow \text{MW}\]

10.0 g $\rightarrow$ X (Theoretical Yield)
Percent Yields from Reactions

\[ \text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \]

1. Calculate the theoretical yield

\[ \text{? g CH}_3\text{COOC}_2\text{H}_5 = 10.0 \text{ g C}_2\text{H}_5\text{OH} \times \frac{88.0 \text{ g CH}_3\text{COOC}_2\text{H}_5}{46.0 \text{ g C}_2\text{H}_5\text{OH}} \]

\[ = 19.1 \text{ g CH}_3\text{COOC}_2\text{H}_5 \]

2. Calculate the percent yield.

\[ \text{% yield} = \frac{14.8 \text{ g CH}_3\text{COOC}_2\text{H}_5}{19.1 \text{ g CH}_3\text{COOC}_2\text{H}_5} \times 100\% = 77.5\% \]
Example 3-11, P.100. A 15.6-g sample of C₆H₆ is mixed with excess HNO₃. We isolate 18.0 g of C₆H₅NO₂. What is the percent yield of C₆H₅NO₂ in this reaction?

\[
\text{C}_6\text{H}_6 + \text{HNO}_3 \rightarrow \text{C}_6\text{H}_5\text{NO}_2
\]

\[
\text{MW} \rightarrow \text{MW}
\]

\[
15.6 \rightarrow X \text{ (Theoretical Yield)}
\]
Percent Yields from Reactions

\[
X = \frac{15.6 \times 123.1 \, \text{g} \, \text{C}_6\text{H}_5\text{NO}_2}{78.1 \, \text{g} \, \text{C}_6\text{H}_6}
\]

\[
X \, \text{(Theoretical Yield)} = 24.6 \, \text{g} \, \text{C}_6\text{H}_5\text{NO}_2
\]

actual Yield (18.9 g)

Percent Yield = \[
\frac{18.9 \, \text{g}}{24.6 \, \text{g}} \times 100 = 73.2 \%
\]

Theoretical Yield (24.6 g)
Salicylic acid reacts with acetic anhydride to form aspirin, acetylsalicylic acid. If the percent yield in this reaction is 78.5%, what mass of salicylic acid is required to produce 150. g aspirin?

\[
2 \text{C}_7\text{H}_6\text{O}_3 + \text{C}_4\text{H}_6\text{O}_3 \rightarrow 2 \text{C}_9\text{H}_8\text{O}_4 + \text{H}_2\text{O}
\]

- salicylic acid
- acetic anhydride
- aspirin
Percent Yields from Reactions

actual Yield (150 g)

78.5 = $rac{X}{\text{Theoretical Yield (g)}} \times 100$

2 C$_7$H$_6$O$_3$ (salicylic acid) + C$_4$H$_6$O$_3$ (acetic anhydride) → 2 C$_9$H$_8$O$_4$ (aspirin) + H$_2$O

ANSWER: X = 146 g