The theoretical yield maximum amount of product you would expect from a reaction based on the amount of limiting reagent. It's the amount of product that could be produced if there were no errors in an experiment. The actual yield is how much product is actually produced during an experiment.

The percent yield is how the actual yield gets reported in science - it tells us what percentage of the theoretical yield we were actually able to obtain. The lower the percentage, the less accurate the experiment was. Ideally, we want to have a percent yield as close to 100% as possible, but this is usually impossible in the real world.

Percent yield is calculated using the following equation:

\[
\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100
\]

Example problems:

1) In the lab, Mike produced 15.4 grams of sodium chloride. While performing the calculations, his lab partner Katie determined that the theoretical yield is 26.7 grams of sodium chloride. What is Mike's percent yield?

Actual yield = 15.4 g  
Theoretical yield = 26.7 g

\[
\text{percent yield} = \frac{15.4}{26.7} \times 100 = 57.7\%
\]

2) Iron reacts with water according to the following reaction: \(3 \text{Fe} + 4 \text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + 4 \text{H}_2\). Use the data in the table to answer the following questions.

<table>
<thead>
<tr>
<th>Mass of Iron</th>
<th>Mass of Water</th>
<th>Theoretical Yield of (\text{Fe}_3\text{O}_4)</th>
<th>Actual Yield of (\text{Fe}_3\text{O}_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0 g</td>
<td>75.0 g</td>
<td>???</td>
<td>53.7 g</td>
</tr>
</tbody>
</table>

What is the theoretical yield of \(\text{Fe}_3\text{O}_4\) in the reaction above?

***This is a limiting reactant problem

\[
50.0 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{1 \text{ mol Fe}_3\text{O}_4}{3 \text{ mol Fe}} = 0.298 \text{ mol Fe}_3\text{O}_4
\]

\[
75.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol Fe}_3\text{O}_4}{4 \text{ mol H}_2\text{O}} = 1.04 \text{ mol Fe}_3\text{O}_4
\]

So Fe is the limiting reactant, which means whatever mass of Fe\(_3\)O\(_4\) produced from Fe is the theoretical yield.

\[
0.298 \text{ mol Fe}_3\text{O}_4 \times \frac{231.55 \text{ g Fe}_3\text{O}_4}{1 \text{ mole Fe}_3\text{O}_4} = 69.0 \text{ g Fe}_3\text{O}_4
\]

What is the percent yield?

\[
\text{percent yield} = \frac{53.7}{69.0} \times 100 = 77.8\%
\]
Percent Yield Practice

1) In the lab, Chris measures 48.9 g of NaCl produced during the experiment. His lab partner, James, performs the calculation and determines that the theoretical yield of NaCl is 63.5 g. What is the percent yield for their experiment?

$$\text{percent yield} = \frac{48.9}{63.5} \times 100 = 77.0\%.$$ 

2) Mg + 2 HNO₃ → Mg(NO₃)₂ + H₂
   a. If I start this reaction with 40.0 g of Mg, how many grams of H₂ will I produce?

$$40.0 \text{ g Mg} \times \frac{1 \text{ mol Mg}}{24.31 \text{ g Mg}} \times \frac{1 \text{ mol H₂}}{1 \text{ mol Mg}} \times \frac{2.02 \text{ g H₂}}{1 \text{ mol H₂}} = 3.32 \text{ g H₂}$$

b. If only 1.7 grams of H₂ is actually produced, what was my percent yield?

$$\frac{1.7}{3.32} \times 100 = 51\%.$$ 

3) 2 ZnS + 3 O₂ → 2 ZnO + 2 SO₂
   a. If 46.5 g of ZnS and 55.3 g of O₂ react, what is the theoretical yield (in grams) of SO₂?

$$46.5 \text{ g ZnS} \times \frac{1 \text{ mol ZnS}}{97.46} \times \frac{2 \text{ mol SO₂}}{2 \text{ mol ZnS}} \times \frac{64.07 \text{ g SO₂}}{1 \text{ mol SO₂}} = 30.6 \text{ g SO₂}$$

$$55.3 \text{ g O₂} \times \frac{1 \text{ mol O₂}}{32.00 \text{ g O₂}} \times \frac{2 \text{ mol SO₂}}{3 \text{ mol O₂}} \times \frac{64.07 \text{ g SO₂}}{1 \text{ mol SO₂}} = 73.8$$

b. How much excess reactant is left over?

$$30.6 \text{ g SO₂} \times \frac{1 \text{ mol SO₂}}{64.07 \text{ g SO₂}} \times \frac{3 \text{ mol O₂}}{2 \text{ mol SO₂}} \times \frac{32.00 \text{ g O₂}}{1 \text{ mol O₂}} = 22.9$$

$$73.8 - 22.9 = 50.9 \text{ g O₂}$$

c. If you perform this experiment and actually produced 25.0 g of SO₂, what is your percent yield of SO₂?

$$\frac{25.0}{30.6} \times 100 = 81.7\%.$$