

Calculating Percent Recovery & Percent Yield

Percent Recovery:

Percent recovery is used in cases where no chemical reaction is taking place, as in purification of a sample. It is calculated as follows:

$$\% \text{ recovery} = \frac{\text{amount pure product recovered (g)}}{\text{amount of crude material used (g)}} \times 100$$

Percent Yield:

Percent yield is used in cases where a chemical transformation occurs. To calculate the % yield, you need the following information:

1. The molar ratio of product to starting material.
2. Molecular weights of product and starting material.
3. Limiting reagent.

Percent yield is calculated as follows:

$$\% \text{ yield} = \frac{\text{actual yield (g)}}{\text{theoretical yield (g)}} \times 100$$

To determine the theoretical yield:

1. Write a balanced chemical equation
2. Calculate the moles of all substrates & reagents used
3. Identify the limiting reagent (note: a catalyst will not be the limiting reagent!)
4. Convert grams of limiting reagent used to grams of possible product using dimensional analysis

In cases where only a portion of the crude product is purified, the equation is modified as shown:

$$\% \text{ yield} = (\% \text{ yield}_{\text{crude}})(\% \text{ recovery})$$

For a multistep process, we can calculate the overall efficiency of the reaction sequence as follows:

$$\text{overall yield} = (\% \text{ yield}_1)(\% \text{ yield}_2)(\% \text{ yield}_3)$$

In more detail:

Calculating percent yield actually involves a series of short calculations. Yield calculations can be broken up into a series of six steps. These are:

1. Write a balanced equation for the reaction
2. Calculate the molecular weight of each reactant and product
3. Convert all amounts of reactants and products into moles
4. Figure out the limiting reagent
5. Calculate the theoretical yield
6. Calculate the percentage yield

1. Write a balanced equation for the reaction: To figure out percentage yield you need to know the correct ratio of each of the reactants and products of interest (the stoichiometry of the reaction). Many times reactions are not written in balanced form. Make sure you are looking at a balanced equation before trying to do any yield calculations. Be sure you can distinguish between reagents, solvents, and catalysts. Any species that is not consumed in the reaction doesn't figure into the yield calculation.

2. Calculate the molecular weight of each reactant and product: You will need to know these numbers to do yield calculations. To calculate the molecular weight of a molecule, simply add up the masses of the individual atoms.

3. Convert all amounts of reactants and products into moles: Usually reactants are measured out by volume or mass. You need to know these quantities in terms of moles to do yield calculations. The conversion of volume and mass into number of moles can be done using the density and molecular weight of the material. Mass can be converted to moles using molecular weight. To convert volume to moles, first convert to mass using density, then convert to moles using molecular weight.

4. Figure out the limiting reagent: Now take inventory of the number of moles of each reactant present and look at the balanced equation. If the reaction takes place consuming the reactants as indicated by the equation, which reactant will run out first? This is the limiting reagent.

5. Calculate the theoretical yield: The theoretical yield is the yield you would get if the reaction worked perfectly with every molecule reacting exactly as it was supposed to and no material was lost. The theoretical yield is based on the moles of limiting reagent used in the reaction. Look at the number of moles of limiting reagent and look at the balanced equation. If the reaction takes place consuming the limiting reagent as indicated by the equation, how much product will be produced? This is the theoretical yield.

6. Calculate the percentage yield: The percent yield is simply the actual yield divided by theoretical yield multiplied by 100. Actual yield is the amount of product you actually got while theoretical is the maximum possible yield. Be sure that actual and theoretical yields are both in the same units so that units cancel in the calculation.