

## 9-3 Limiting Reactants and Percent Yield

**Limiting Reactant** – the reactant that limits the amount of products formed and reactants used (Also called Limiting Reagent)

The limiting reactant is what runs out first.

**Excess Reactant** – any reactant that does not completely react due to having an excess quantity

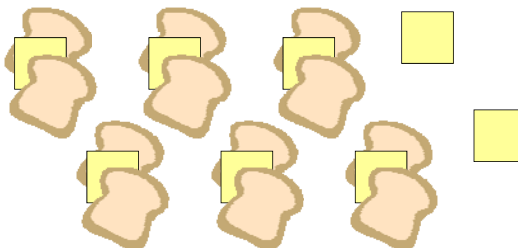
Some common excess reactants are water and oxygen.

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## 9-3 Limiting Reactants and Percent Yield

**Example:**

A recipe for a cheese sandwich calls for 2 slices of bread and 1 slice of cheese. How many sandwiches can we make with 12 slices of bread and 8 slices of cheese? What is the limiting ingredient? What is the excess ingredient? How many extra slices do we have?



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## 9-3 Limiting Reactants and Percent Yield

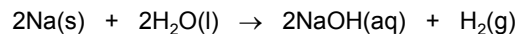
What is the limiting reactant of this picture?



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## 9-3 Limiting Reactants and Percent Yield

46g of sodium metal is added to 100g of water. What is the limiting reactant? What is the excess reactant? How much is excess?



Case 1 (How much H<sub>2</sub>O is needed?)

$$46 \text{ g Na} \left[ \frac{1 \text{ mol Na}}{23.0 \text{ g Na}} \right] \left[ \frac{2 \text{ H}_2\text{O}}{2 \text{ Na}} \right] \left[ \frac{18.0 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \right] = 36 \text{ g H}_2\text{O needed}$$

The excess reactant is → Water

We have 100g and we only need 36g.

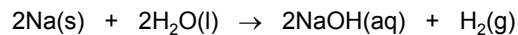
The limiting reactant is → Sodium

The amount of excess → 100g – 36g = 64g of excess water

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## 9-3 Limiting Reactants and Percent Yield

46g of sodium metal is added to 100g of water. What is the limiting reactant? What is the excess reactant? How much is excess?



Case 2 (How much Na is needed?)

$$100 \text{ g H}_2\text{O} \left[ \frac{1 \text{ mol H}_2\text{O}}{18.0 \text{ g H}_2\text{O}} \right] \left[ \frac{2 \text{ Na}}{2 \text{ H}_2\text{O}} \right] \left[ \frac{23.0 \text{ g Na}}{1 \text{ mol Na}} \right] = 127.8 \text{ g Na needed}$$

The limiting reactant is → Sodium

We do not have enough sodium for this reaction. We also do not have enough info to determine the amount of excess water ☹

**Tip** – Guessing the correct limiting reactant can save you time because you will not need to do both cases for more information. ☺

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## 9-3 Limiting Reactants and Percent Yield

**Theoretical Yield** – the maximum amount of product that can be produced in a reaction from a given reactant

This is what you expect if everything goes perfect

**Actual Yield** – the measured amount of product from a reaction

This is what you really get

**Percent Yield** – the ratio of actual yield to theoretical yield

This is a percentage of how close you were to the perfect value.

$$\% \text{ Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

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**Example:**

A birthday party for a friend had 80 invitations given out. There was a total of 68 people who showed up. What is the percent yield of attendance?

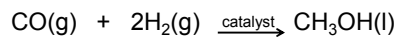
$$\% \text{ Yield} = \frac{A}{T} \times 100 =$$

$$\frac{68 \text{ showed up}}{80 \text{ invited}} \times 100 = 85\%$$

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If 75.0g of CO reacts to produce 68.4g CH<sub>3</sub>OH (methanol), what is the percent yield of CH<sub>3</sub>OH?

**1) Find the Theoretical Yield**

$$75.0 \text{ g CO} \left[ \frac{1 \text{ mol CO}}{28.0 \text{ g CO}} \right] \left[ \frac{1 \text{ CH}_3\text{OH}}{1 \text{ CO}} \right] \left[ \frac{32.0 \text{ g CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} \right] = 85.7 \text{ g CH}_3\text{OH}$$

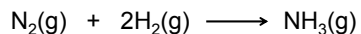
**2) Calculate the Percent Yield**

$$\% \text{ Yield} = \frac{A}{T} \times 100 = \frac{68.4 \text{ g}}{85.7 \text{ g}} \times 100 = 79.8\%$$

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## 9-3 Limiting Reactants and Percent Yield

The Haber Process produces ammonia with a yield of up to 20%. If the actual yield was only 45 grams, what is the theoretical yield?

**1) Solve for Theoretical Yield**

$$\% \text{ Yield} = \frac{A}{T} \times 100 \rightarrow \frac{A}{\% \text{ Yield}} \times 100 = T$$

**2) Calculate the Theoretical Yield**

$$\frac{A}{\% \text{ Yield}} \times 100 = \frac{45 \text{ g}}{20\%} \times 100 = 225 \text{ g}$$

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