

Limiting Reagents and Percent Yield

- Limiting Reagent
- Steps for Determining Limiting Reagent
- Percent vs Actual Yield
- Check Your Understanding

Check Your Understanding

Methane, CH_4 , is burned in a jar producing carbon dioxide and water. There are 20 g of methane and 50 g of oxygen gas in the jar.

- Determine the limiting reagent.
- Determine the amount of water produced.

First write a balanced equation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

Now create your chart and calculate the number of moles of each reactant.

	CH_4	2O_2	CO_2	$2\text{H}_2\text{O}$
m	20 g	50 g		$= 1.5615 \times 18.02$ $= 28.1 \text{ g} = 30 \text{ g}$
M	$= 12.01 + 4(1.01)$	$= 2(16)$		$= 2(1.01) + 16$
n				

Check Your Understanding

40.0 g of sodium carbonate is added to water containing 20.0 g of hydrochloric acid and 8.00 g of CO_2 gas is produced. What is the percent yield?

First, we need to calculate the Theoretical Yield. Write a balanced equation and make a chart. $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$

	Na_2CO_3	2HCl	2NaCl	H_2O	CO_2
m	40 g	20 g			$= 0.274 \times 44.01$ $= 12.1 \text{ g}$
M	$= 2(22.99) + 12.01$ $+ 3(16)$ $= 105.99 \text{ g/mol}$	$= 1.01 + 35.45$ $= 36.46 \text{ g/mol}$			$= 12.01 + 2(16)$ $= 44.01 \text{ g/mol}$
n	$= \frac{40 \text{ g}}{105.99 \text{ g/mol}}$ $= 0.377 \text{ mol}$	$= \frac{20 \text{ g}}{36.46 \text{ g/mol}}$ $= 0.5485 \text{ mol}$			$= 0.274 \text{ mol}$

Find the limiting reagent.

$$\begin{array}{lcl} x \text{ mol CO}_2 & = & 1 \text{ CO}_2 \\ 0.377 \text{ mol Na}_2\text{CO}_3 & = & 1 \text{ Na}_2\text{CO}_3 \end{array} \quad \begin{array}{lcl} x \text{ mol CO}_2 & = & 1 \text{ CO}_2 \\ 0.5485 \text{ mol HCl} & = & 2 \text{ HCl} \end{array}$$

$$x = 0.377 \text{ mol CO}_2 \quad x = 0.274 \text{ mol CO}_2 \quad \text{The limiting reagent is HCl.}$$

Check Your Understanding

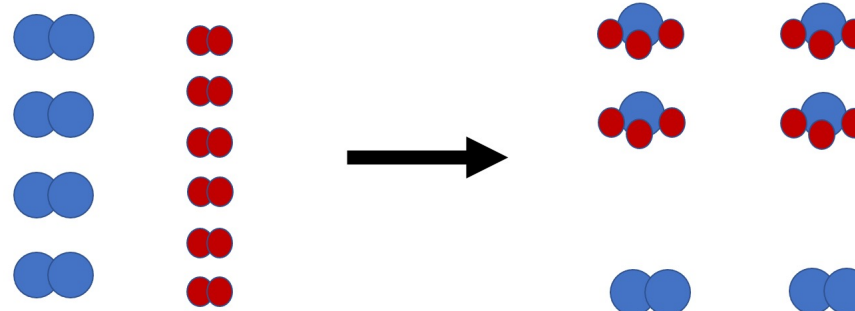
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- Determine the limiting reagent.
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First write a balanced equation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

Now create your chart and calculate the number of moles of each reactant.

	2O_2	CO_2	$2\text{H}_2\text{O}$



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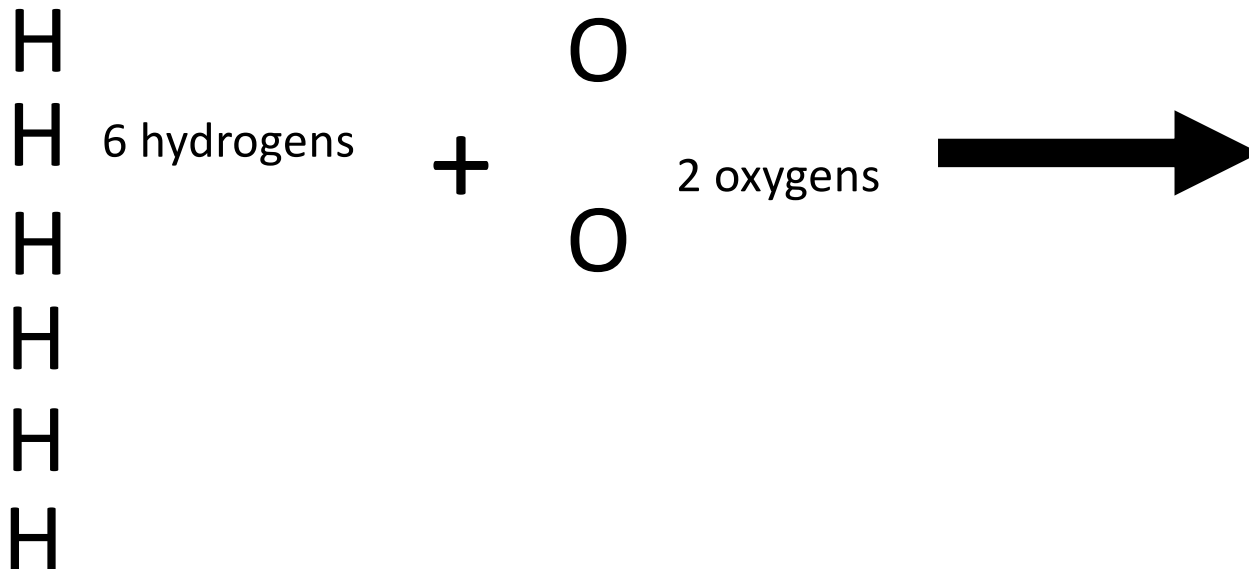


Limiting Reagent

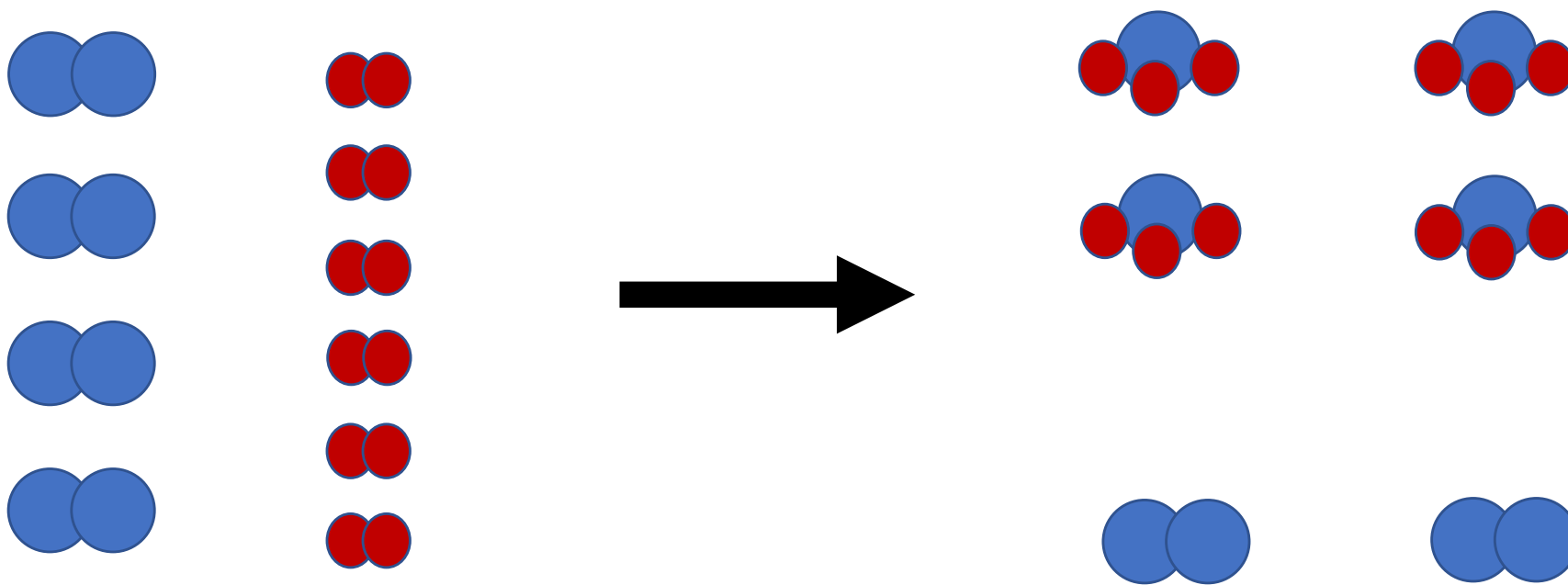
- So far, we have assumed that there is always enough reactant to make our product
- _____
- I.e., Kool Aid requires 6 cups of water to one packet of powder per pitcher
 - how many pitchers can you make if you have 19 cups of water and 2 packets of powder?
 - Which reactant limits the amount of product?
 - Which reactant is there extra of?

Limiting Reagent

- _____
- The number of water molecules created is limited by whichever part component runs out first



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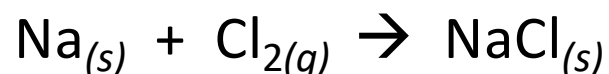


- A molecular view of a limiting reactant situation for the synthesis of ammonia
- To make 4 molecules of NH_3 : 2 molecules of N_2 (blue) and 6 molecules of H_2 (red) are required
- _____

Check Your Understanding

Find the number of moles of NaCl produced when 4.80 mol of Na reacts with 2.70 mol Cl₂ to produce NaCl.

Step 1: Balance the equation and create a chart.



	2Na	Cl ₂	2NaCl
m			
M			
n			

Steps for Determining Limiting Reagent

1. _____

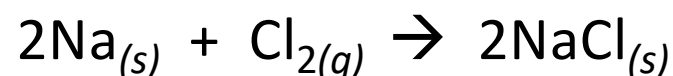
2. _____

3. _____

4. _____

Determining the Limiting Reagent

Looking back at our example:



$$\frac{x \text{ mol NaCl}}{4.80 \text{ mol Na}} = \frac{2 \text{ NaCl}}{2 \text{ Na}}$$

$$x = 4.80 \text{ mol NaCl}$$

$$\frac{x \text{ mol NaCl}}{2.70 \text{ mol Cl}_2} = \frac{2 \text{ NaCl}}{1 \text{ Cl}_2}$$

$$x = 5.40 \text{ mol NaCl}$$

4.80 mol of Na yields
4.80 mol of NaCl

2.70 mol of Cl₂ yields
5.40 mol of NaCl

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Check Your Understanding

Methane, CH_4 , is burned in a jar producing carbon dioxide and water. There are 20 g of methane and 50 g of oxygen gas in the jar.

- a) Determine the limiting reagent.
- b) Determine the amount of water produced.

First write a balanced equation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

Now create your chart and calculate the number of moles of each reactant.

	CH_4	2O_2	CO_2	$2\text{H}_2\text{O}$
m				
M				
n				

Check Your Understanding

Methane, CH₄, is burned in a jar producing carbon dioxide and water. There are 20 g of methane and 50 g of oxygen gas in the jar.

- Determine the limiting reagent.
- Determine the amount of water produced.

First write a balanced equation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

Now create your chart and calculate the number of moles of each reactant.

	CH ₄	2O ₂	CO ₂	2H ₂ O
m	20 g	50 g		= 1.5615 x 18.02 = 28.1 g = 30 g
M	= 12.01 + 4(1.01) = 16.05 g/mol	= 2(16) = 32 g/mol		= 2(1.01) + 16 = 18.02 g/mol
n	= $\frac{20 \text{ g}}{16.05 \text{ g/mol}}$ = 1.246 mol	= $\frac{50 \text{ g}}{32 \text{ g/mol}}$ = 1.5625 mol		

Find the limiting reagent.

Check Your Understanding

First, we need to calculate the Theoretical Yield. Write a balanced equation and make a chart.

40.0 g of sodium carbonate is added to water containing 20.0 g of hydrochloric acid and 8.00 g of CO_2 gas is produced. What is the percent yield?

	Na_2CO_3	2HCl	2NaCl	H_2O	CO_2
m					
M					
n					

Percent vs Actual Yield

- _____
- _____
- Why would the actual yield different from the theoretical one?
- Percent yield is the ratio of the actual yield to the theoretical yield expressed as a percent

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

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