Limiting Reactant Stoichiometry

Mr. Gray's World Famous Smore Recipe

2 Graham Crackers + 1 Marshmallow + 1 Chocolate → 1 Smore

2 G.C. + 1 M + 1 C → 1 Smore

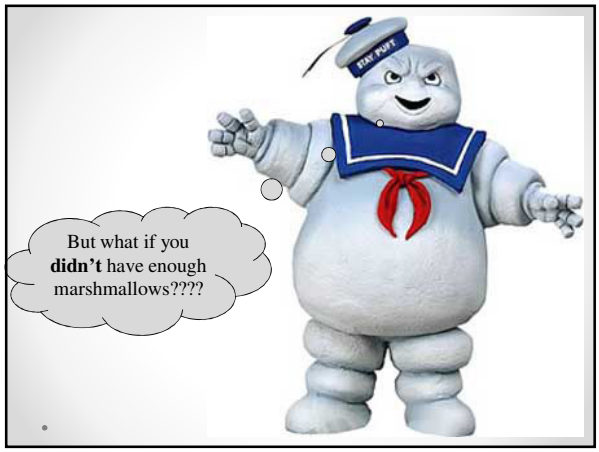
If you have 100 Graham Crackers, how many Smores can you make?

2 G.C. + 1 M + 1 C → 1 Smore

If you answered "50", you are CORRECT!
Because it takes 2 graham crackers to make 1 Smore

2 G.C. + 1 M + 1 C → 1 Smore

You must have assumed there were enough marshmallows and chocolate to go with all those graham crackers



2 GC + 1 M + 1 C → 1 Smore

How many Smores could you make with:
100 Graham Crackers
40 Marshmallows and
60 Chocolates?

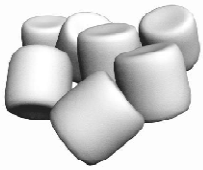
The Answer

If you answered "40", you are correct.

Since you only have 40 Marshmallows, you will run out of Marshmallows first

You will have 10 Graham Crackers and 20 Chocolates left over

In other words, marshmallows "**limit**" the amount of Smores you can make in this example.



2 GC + 1 M + 1 C → 1 Smore

How many Smores could you make with:
80 Graham Crackers
50 Marshmallows and
60 Chocolates?

The Answer

If you answered "40", you are correct

Since you only have 80 Graham Crackers, you will run out of Graham Crackers first

You will have 10 Marshmallows and 20 Chocolates left over

In other words, graham crackers "**limit**" the amount of Smores you can make in this example.

"Limiting Reactant"

- The **reactant** that "limits" how much product you can make
- It is always the **reactant** that you run out of first
- It is **NOT** always the substance you have the least of because it also depends on the ratio of how you are using that substance.

Previous Example: 2 GC + 1M + 1C → 1 Smore

Given: 80 GC ← Even though you had more GC than
50 M anything else, you ran out of it first
60 C because you used 2 GC per 1 Smore

The Big Picture Here Is…

- Once a reactant is used up, you can't make any more product(s)
- Therefore, the amount of the limiting reactant you have determines **how much** product is made

"Stoichiometric Proportions"

If both reactants get used up at exactly the same time, we say they were reacted in "stoichiometric proportions"

(They were mixed in the exact mole ratios indicated by the balanced chemical equation)

This is not common during lab work.

Let's Practice!!!

Consider the reaction:

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 1: Write a balanced chemical equation

If you have 175g N_2 and 50.0g H_2, what mass of NH_3 can you make?

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 2: Determine how many moles of each reactant you HAVE

(Convert "given" to moles)

$175\ g\ N_2 \times \frac{1mol\ N_2}{28.02g\ N_2} = \mathbf{6.25\ mol\ N_2}$

$50.0\ g\ H_2 \times \frac{1mol\ H_2}{2.02g\ H_2} = \mathbf{24.8\ mol\ H_2}$

This is how much we **HAVE** of each reactant

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 3: Determine how many moles of each reactant you NEED

(Multiply each reactant by a mole to mole ratio with the other reactant)

$6.25mol\ N_2 \times \frac{3mol\ H_2}{1mol\ N_2} = \mathbf{18.8mol\ H_2}$

$24.8mol\ H_2 \times \frac{1mol\ N_2}{3mol\ H_2} = \mathbf{8.27mol\ N_2}$

This is how much we **NEED** of each reactant

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 4: Determine which reactant is the "limiting" reactant

(Compare what you NEED to what you HAVE)

- ✓we NEED 18.8 mol H_2
- ✓we HAVE 24.8 mol H_2
- •Therefore, H_2 is the **EXCESS** REACTANT

- ✓we NEED 8.27 mol N_2
- ✓we HAVE 6.25 mol N_2
- •Therefore, N_2 is the **LIMITING** REACTANT

If you **NEED** more moles than you **HAVE**, that is the **limiting** reactant

If you **HAVE** more moles than you **NEED**, that is the **excess** reactant

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 5: Determine the amount of product made based on the limiting reactant you HAVE

(Multiply the moles of limiting reactant you HAVE by a mole to mole ratio with product)

$6.25\text{mol } N_2 \times \frac{2\text{mol } NH_3}{1\text{mol } N_2} = 12.5\text{mol } NH_3$ ← Convert to desired units

$12.5\text{ mol } NH_3 \times \frac{17.04\text{ g } NH_3}{1\text{ mol } NH_3} = 213\text{ g } NH_3$

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

STEP 6: Determine the amount of "excess" reactant remaining

(Moles of excess reactant you HAVE minus moles of excess reactant you NEED)

$24.8\text{mol } H_2$ ← HAVE

$-18.8\text{mol } H_2$ ← NEED

$6.0\text{mol } H_2$ ← EXCESS

$6.0\text{mol } H_2 \times \frac{2.02\text{g } H_2}{1\text{mol } H_2} = 12.1\text{g } H_2$

This much H_2 is left over after you run out of N_2

Summary of Limiting Reactant Problems

Step 1: Write a balanced chemical equation

Step 2: Determine moles of each reactant you HAVE

Step 3: Determine moles of each reactant you NEED.

Step 4: Compare NEED to HAVE to find limiting reactant

Step 5: Use limiting reactant to determine moles of product

Step 6: Subtract (HAVE – NEED) to find amount of excess