How To Do Limiting Reactant Problems

What Are They? Here's a sample:

You want to burn some magnesium metal in oxygen to make magnesium oxide (who doesn't?). You have 5.00 grams of magnesium metal and 5.00 grams of oxygen gas. You need to be able to answer three questions about this.

- Which is the limiting reactant (the one that gets completely used up) and which is the excess reactant (the one that doesn't get completely used up)?
- How much of the excess reactant is left over when the reaction's done?
- How much of the product (magnesium oxide) will you make?

Here's how to answer these three questions.

A. To find which is limiting and which is excess and how much of the excess is left over:

1. You have 5.00 grams of magnesium metal and 5.00 grams of oxygen gas. Which is the limiting and which is the excess reactant?

First balance the equation.

$$2Mg + O_2 \text{ ---> } 2MgO$$

Next choose one of the reactants (Mg or O_2) . Do a grams-grams problem with it to figure out how much of the other reactant you would need to use up all of it:

$$5.00 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31 \text{ g Mg}} \times \frac{1 \text{ mole } O_2}{2 \text{ mole Mg}} \times \frac{32.00 \text{ g } O_2}{1 \text{ mole } O_2} = 3.29 \text{ g } O_2$$

This means that if you start with 5.00 g of Mg, you will need exactly 3.29 g of O_2 to use it all up so that neither Mg nor O_2 is left over.

5.00 g Mg + 3.29 g O_2 = both used up, nothing left over

Now look at what you really have. You really have 5.00 g O_2! More than enough. So if you react 5.00 g Mg and 5.00 g O_2, all of the Mg will be used up but only 3.29 g of the O_2 will be used up.

How much O_2 will be left over?

5.00 g O_2 (what you started with)
- 3.29 g O_2 (what got used in the reaction)
1.71 g O_2 (left over)

Jargon: The stuff that gets used up is called the **limiting reactant**. (Mg)
The stuff that has some of it left over is called the **excess reactant**. (O_2)

[By the way, there are a few other ways to figure out which is the limiting and which is the excess reactant. This is the way that makes the most sense to me. If someone shows you a different way that makes more sense to you, feel free to use it as long as you show your work so that I can figure out what you're doing and you get the right answer.]

2. But what if it hadn't worked out that way? Let's say you started with 25.7 g Mg and 15.6 grams of O_2.

$$25.7 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31 \text{ g Mg}} \times \frac{1 \text{ mole } O_2}{2 \text{ mole Mg}} \times \frac{32.00 \text{ g } O_2}{1 \text{ mole } O_2} = 16.9 \text{ g } O_2$$

This means that if you started with 25.7 g of magnesium you would need 16.9 g of oxygen to completely use it up. But you don't have that much! You only have 15.6 grams of oxygen. This makes oxygen the limiting reactant, because it limits how much magnesium will react. And since oxygen is the limiting reactant, magnesium is the excess reactant.

To figure out how much magnesium is left over you'd have to do another grams-grams problem starting with 15.6 grams of oxygen:

$$15.6 \text{ g } O_2 \times \frac{1 \text{ mole } O_2}{32.00 \text{ g } O_2} \times \frac{2 \text{ mole Mg}}{1 \text{ mole } O_2} \times \frac{24.31 \text{ g Mg}}{1 \text{ mole Mg}} = 23.7 \text{ g Mg}$$

So if you react 15.6 grams of O_2 with 25.7 grams of Mg, only 23.7 grams of the Mg will be used. How much Mg will be left over?

25.7 g Mg (what you started with)
- 23.7 g Mg (what got used up)
2.0 g Mg (what 's left over)

B. How to figure out how much product gets made:

1. In the first case you had 5.00 grams of magnesium and 5.00 grams of oxygen and you figured out that magnesium was the limiting reactant. To figure out how much product gets made, do a grams-grams problem **starting with the limiting reactant**.

$2Mg + O_2 \text{ ---> } 2MgO$

$$5.00 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31 \text{ g Mg}} \times \frac{2 \text{ mole MgO}}{2 \text{ mole Mg}} \times \frac{40.31 \text{ g MgO}}{1 \text{ mole MgO}} = 8.29 \text{ g MgO}$$

Reacting 5.00 g Mg and 5.00 g O_2 produces 8.29 g MgO.

(Did I mention you need to **start with the limiting reactant**?)

2. In the second case you had 25.7 grams of magnesium and 15.6 grams of oxygen and you figured out that oxygen was the limiting reactant. To figure out how much product gets made, do a grams-grams problem **starting with the limiting reactant**.

$2Mg + O_2 \text{ ---> } 2MgO$

$$15.6 \text{ g } O_2 \times \frac{1 \text{ mole } O_2}{32.00 \text{ g } O_2} \times \frac{2 \text{ mole MgO}}{1 \text{ mole } O_2} \times \frac{40.31 \text{ g MgO}}{1 \text{ mole MgO}} = 39.3 \text{ g MgO}$$

Reacting 25.7 g Mg and 15.6 g O_2 produces 39.3 g MgO.

That's it!