## CHEMISTRY 11 <br> Limiting and Excess STOICHIOMETRY

Not all things in life occur exactly as planned.
Even when baking a cake, it is highly probable that, (although I consider myself a pretty adept baker), when I measure my 2 cups of butter and 3 cups of flour, I may inadvertently use a little less or a little more than the required amounts of each ingredient. It may be due to the inaccuracy of the measuring tools I am using, or my own human error in reading these measuring tools. We can sometimes see the consequences of this in our final baked dessert.

In Chemistry, when we don't have exactly the amount of each reactant that was calculated in our mole stoichiometry, we will see a different outcome of our reaction.

But first...consider the following analogies:

## MAKING a GRILLED CHEESE SANDWICH:

The recipe is:

| 2 slices of bread |  | 1 slice of cheese |  | 1 sandwich |
| :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |

But what if I want to open my own food truck?
And I want it to be Toombsy's Cheesy Sandwich Truck. (The name is still being developed
Obviously I will have to make more than one sandwich at a time.
So, for the first day I go out and buy:

| 20 slices of bread | AND | 10 slices of cheese | How many sandwiches <br> can I make? <br> $\mathbf{1 0}$ |
| :--- | :--- | :---: | :--- |

The first day is SUCH a success that the next day I have a bulk order delivered and I get:

| 350 slices of bread | AND | 200 slices of <br> cheese | How many sandwiches <br> can I make? <br> $\mathbf{1 7 5}$ |
| :--- | :--- | :--- | :--- |

What will be leftover at the end of the day? 25 slices of cheese.

Don't like grilled cheese sandwiches? (Seriously?)
Then how about constructing bicycles:


## Now let's try this with MOLE STOICHIOMETRY:

1.00 moles of aluminum phosphate (aq) are reacted with 4.00 moles of solid lithium metal. How many moles of products are formed?
$\mathrm{AlPO}_{4}$ (aq) +
$3 \mathrm{Li}{ }_{(\mathrm{s})} \rightarrow$
$\mathrm{Li}_{3} \mathrm{PO}_{4}(\mathrm{aq})+$
$\mathrm{Al}_{\text {(s) }}$
1.00 mol

### 4.00 mol

## SCENARIO \#1

If the $\mathbf{1 . 0 0}$ mole of $\mathrm{AlPO}_{4}$ (aq)completely reacts, then only 3.00 moles of Li (s) is needed:
$\mathrm{AlPO}_{4}$ (aq) +
$3 \mathrm{Li}(\mathrm{s}) \rightarrow$
$\mathrm{Li}_{3} \mathrm{PO}_{4}(\mathrm{aq})+$
$\mathrm{Al}_{\text {(s) }}$
1.00 mol
3.00 mol

SCENARIO \#2
If the 4.00 mole of $\mathrm{Li}(\mathrm{s})$ completely reacts, then 1.33 moles of $\mathrm{AlPO}_{4}(\mathrm{aq})$ is needed:
$\mathrm{AlPO}_{4}$ (aq)
$+$
1.33 mol
$3 \mathrm{Li}_{(\mathrm{s})} \rightarrow$
$\mathrm{Li}_{3} \mathrm{PO}_{4}$ (aq) +
$\mathrm{Al}_{\text {(s) }}$
4.00 mol

But clearly, only SCENARIO \#1 can happen.
SCENARIO \#2 is impossible, because not enough $\mathrm{AlPO}_{4}(\mathrm{aq})$ was provided to carry that out.
$\mathrm{AlPO}_{4}(\mathrm{aq})$ is called the LIMITING REAGENT: it limits us to the smaller ratio in SCENARIO \#1
The limiting reagent will be completely used up (totally reacted).
$\mathrm{Li}{ }_{\text {(s) }}$ is called the EXCESS REAGENT: We have 1.00 more mole than we need for SCENARIO \#2 The excess reagent will be leftover after the reaction is over (you will see unreacted $\mathrm{Li}(\mathrm{s})$ still in the test tube).

1) 39.9 g of aluminum chloride reacts with 52.3 grams of sodium carbonate.

Step one. Write the balanced chemical reaction:

Step two. Convert all given data in moles.

## Step three.

Determine limiting and excess reactants (also called reagants) by using mole stoichiometry (ratios)

## LIMITING REAGENT IS:

2) 4.763 g of Titanium is reacted with 13.98 g of copper (II) chloride to form titanium (IV) chloride and copper.
3) 33.7 g of aluminum reacts with 114 g of chromium (II) oxide in a single replacement reaction.
a) Name the limiting reactant.
b) Name the excess reactant.
c) Determine the grams of each product formed.
d) Show your check of the Law of Conservation of Mass.
e) Name the amount of excess reactant that remains, in grams.

## LIMITING and EXCESS Stoichiometry Practice Problems

1) $\quad 111 \mathrm{~g}$ of calcium chloride reacts with 100.0 g of sodium phosphide.
a) Which reactant is in excess?
b) Calculate the mass of excess that remains.
c) Calculate the mass of each product that is produced.
d) Show your check of the Law of Conservation of Mass.
2) $\quad 10.0 \mathrm{~g}$ of calcium carbonate reacts with 6.00 g of sodium chloride.
a) Which reactant is in excess?
b) Calculate the mass of excess that remains.
c) Calculate the mass of each product that is produced.
d) Show your check of the Law of Conservation of Mass.
3) A students spills 35.0 g of calcium hydroxide on the lab table and in an effort to neutralize it, they pour 35.0 g of phosphoric acid onto the spill.
a) Which reactant is in excess?
b) Calculate the mass of excess that remains.
c) Calculate the mass of each product that is produced.
d) Show your check of the Law of Conservation of Mass.
4) 314 g of sulphuric acid reacts with 70.5 g of lithium hydroxide
a) Which reactant is in excess?
b) What mass of sulphuric acid was used in the reaction?
c) What mass of each product is produced?
5) Francium reacts explosively with water. If 325 g of Francium react with 84.5 g of water, will both reactants be totally consumed?
What mass of products can we expect from the reaction?
