Chapter 12: Stoichiometry

Introduction: What is stoichiometry?

Unlike in chemistry class, in the real world, chemists perform reactions to make useful chemical compounds such as medicines. When we learned about chemical reactions, we learned about how to figure out what chemicals and conditions will be needed to make reactions take place.

However, the real world also has another limitation: Things are expensive. Though we can make the products we want by putting huge amounts of chemicals together, we'll end up wasting a lot of reactant if we just guess at how much we need. Imagine the following reaction:

2 slices of bread + 1 slice of ham → 1 ham sandwich

Now, it's fine for your parents to go to the store and buy a loaf of bread and a package of sliced ham, even though they know that the amount of ham they buy won't be the exact amount of ham needed to make an entire loaf of bread's worth of sandwiches – after all, ham is cheap. However, if ham cost twenty bucks a slice, they'd be a lot more careful about buying exactly what they need and no more. That's what industrial chemists worry about – in many cases the reactants they work with are very expensive.

As a result, chemists spend a lot of time making sure that they use only the bare minimum of chemicals necessary to make the amount of product that they need.

Stoichiometry: The determination of how much stuff you can make in a reaction from some given amount of reactant.

Look up the definition of stoichiometry in your text book and write it here:

Look up the definition of mole ratio in your text book and write it here:

In the kitchen, we do a very simple kind of stoichiometry whenever we make ourselves lunch. For example, when we make a ham sandwich using the equation:

2 slices bread + 1 slice ham → 1 ham sandwich

We know that to make two ham sandwiches, we will need four slices of bread and two slices of ham. All we need to do is to look at the equation (usually in our heads, though) to know that.

In chemistry, the same thing is true. If we do the reaction:

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

and want to make 2 moles of water, we know that we'll need to start with 2 moles of hydrogen and two moles of water. Likewise, if we want to make 4 moles of water, we'll use 4 moles of hydrogen and 2 moles of oxygen. This is why chemical equations are handy!

Of course, there's more to it than that. We already know that "moles", while handy for chemistry, aren't terribly handy for doing calculations. After all, if we're going to work only with moles, we'll have to count out 6.02×10^{23} things every time we do a reaction. The unit "grams" is a lot more practical in the real world, so we'll learn how to work with them instead.

Fortunately, this doesn't require you to learn anything new.

Stoichiometric Calculations

- Use a proportion (2 ratios set equal to each other) to solve for an unknown quantity.

1. Start with a balanced chemical equation.
2. A question will ask you to compare 2 species in the equation.
3. Use the ratio of those species as the first ratio in your proportion.
4. Use the given and the unknown from the question as your second ratio.
5. Solve for the unknown by cross multiplying.

Example using mole ratios:

How much O_2 will react with 1 mole of Al, according to the reaction:

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$$\frac{4\ mols\ Al}{3\ mols\ O_2} = \frac{1\ mol\ Al}{x\ mol\ O_2}$$

After cross multiplying:

$$4X = 3 \text{ so, } X = .75 \text{ mol } O_2$$

Example using mass ratios:

How much O_2 will react with 100g of Al, according to the reaction:

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

You first have to convert the moles to mass, using the conversion factor
Mass = mols x molar mass

$$\frac{(4\ mols\ Al)(\frac{23g}{mol})}{(3\ mols\ O_2)(\frac{32g}{mol})} \text{ becomes } \frac{92g\ Al}{96g\ O_2} = \frac{100g\ Al}{xg\ O_2}$$

After cross multiplying:

$$92X = 9600 \text{ so, } X = 104.34g\ O_2$$