WHAT IS STOICHIOMETRY?

When the space shuttle took off it used two different rocket systems. The main engines were powered by combining **oxygen** and **hydrogen** in the highly exothermic reaction

$$2H_2 + O_2 \rightleftharpoons 2H_2O$$

The fuel was stored in that brown tank in liquid form as liquid oxygen (LOX) and liquid hydrogen (LH2). Liquids are much more dense than gases, so storage in the liquid phase allows the shuttle to carry an immense amount of fuel.

Unfortunately, that fuel made up the majority of the *weight* of the shuttle at liftoff. So most of what the shuttle engines lifted from the ground was fuel. That means it was very important not to have too much of one or the other reactant on board. We'd want *just enough* hydrogen to react with the amount of oxygen on board, and vice versa. That's where **stoichiometry** and moles are essential.

And maybe you can be the one to invent a kind of rocket propulsion that will release more energy per pound of fuel!

Space Shuttle launch NASA

Stoichiometry is the relationship between the relative quantities of substances involved in a chemical reaction, typically ratios of whole numbers. Stoichiometry is a catch all word for all of the calculations we do to determine how much of what to mix with what.

Example: Space shuttle fuel

Let's begin with a calculation relevant to our opening example: The space shuttle LOX tank held 629,340 Kg (about 630 metric tons) of LOX.

How many kilograms of Hydrogen would it need to carry in order to assure that the reaction

$$2H_2 + O_2 \longrightarrow 2H_2O$$

goes to completion, with no reactants remaining? **(The backward rate of this reaction is** extremely slow compared to the explosive forward rate, thus the single arrow)

Solution: We start by determining the number of moles of O_2 that we have:

$$629{,}340\ \text{Kg } O_2 \left(\frac{1000\ \text{g } O_2}{1\ \text{Kg } O_2}\right)\left(\frac{1\ \text{mol } O_2}{16\text{g } O_2}\right) = 3.93 \times 10^7\ \text{mol } O_2$$

In the calculation above, I've combined the conversion from Kg to grams with the calculation of the number of moles of O_2 (16 g/mol). That's easy if we keep track of units. Now that we have the number of moles of O_2, we use the balanced chemical equation (that's what it's for!) to find out how many moles of H_2we need. From the coefficients, you can see that *two* moles of H_2 are consumed for every one mole of O_2, so we need 7.86 x 10^7 mol of H_2 (3.93 x 2 = 7.86)

The **mole ratio** told us that in this reaction exactly twice the number of moles of H_2 are used as O_2. Now it's just a simple matter of converting 12.5 x 10^4 mol of H_2 to Kg of H_2.

We could move forward and complete the calculation one step at a time - moles O_2 to moles H_2 to grams H_2 to Kg H_2, but there's a faster way if we make good use of units and cancellation of units. Here's how to combine the second part of the calculation into one big step:

$$3.93 \times 10^7 \, \cancel{mol\ O_2} \left(\frac{2\ \cancel{mol\ H_2}}{1\ \cancel{mol\ O_2}}\right)\left(\frac{2\ \cancel{g\ H_2}}{1\ \cancel{mol\ H_2}}\right)\left(\frac{1\ Kg\ H_2}{1000\cancel{g\ H_2}}\right) = 1.57 \times 10^5\ Kg\ H_2$$

Mole ratio: Two H_2 for every one O_2

FW of H_2

Convert from grams to Kg

Notice that in each of the large fractions above, a relationship and its units are written, and written in such a way that the units cancel with those of the previous term to get us closer to the desired units, in this case Kg of H_2.

So about 157,000 Kg of H_2 would be needed to react with 629,340 Kg of LOX. It turns out that in practice the shuttles carried a little *more* LH2 than that because of engine efficiency issues and because the rate of loss of lighter LH2 due to evaporation during the wait for launch is higher than that of LOX.

Nevertheless, I hope you get the idea. This is a very important calculation and it depends 100% on doing good stoichiometry.

Source: http://www.drcruzan.com/ChemistryStoichiometry.html