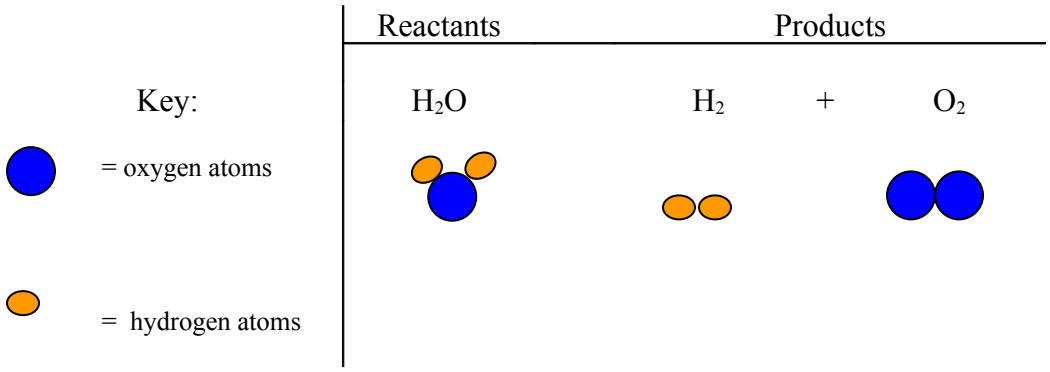
Balancing Simple Chemical Equations

The Law of Conservation of Mass says that atoms are neither created nor destroyed in a chemical reaction. Instead ordinary chemical reactions involve rearranging the atoms that you start with. This means you must always begin and end with the same number of each kind of atom.

Now, let's consider a chemical reaction, the electrolysis of water to make hydrogen and oxygen gas. We can represent this reaction in two different ways, with chemical formulas, and then with molecular drawings.



If we count the atoms in this reaction, we can see that the reaction is not balanced. We can do this from either the chemical formulas, or from the pictures. When counting from chemical formulas, it is helpful to have a systematic way of organizing the information. Throughout this web-site we use the following way:

reactant	element	product
H_2O		H_2+O_2
2	H	2
1	O	2

As it is currently written, somehow one oxygen atoms turns into two. Since this is impossible, we need to rewrite the equation to get it balanced. We are not able to change the **subscripts** (the small numbers beneath the atoms) because doing so would change the chemical identity.

(For example, we couldn't write H_2O as H_2O_2 because that would turn water into hydrogen peroxide).

So in order to balance chemical reactions, we need to change the **coefficients** in front of the chemicals in the reaction. Coefficients are large numbers written in front. Lets look again at our reaction and consider the coefficients.

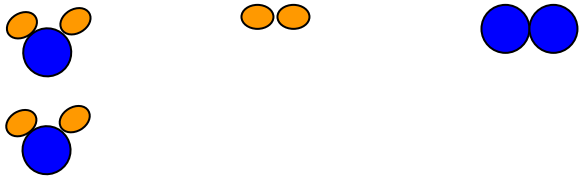
Reactants		Products		
H_2O		H_2	+	O_2

Hmm, there don't appear to be any coefficients. That is because chemists are very efficient, and if the coefficient is exactly one, they don't write it, it is just assumed you know it is there. So really our reaction is

Reactants		Products		
coefficient → **1** H_2O		**1** H_2	+	**1** O_2
← subscript				

Okay, now we have something to work with. Right now, our hydrogen atoms are balanced, so we need to work with our oxygen atoms. Since we can't change the subscript on the oxygen in the product, we need to increase the number of oxygens on the reactant side to match the products. We can do this by changing the subscript in front to the water to 2. Notice how this also changes the number of hydrogen atoms

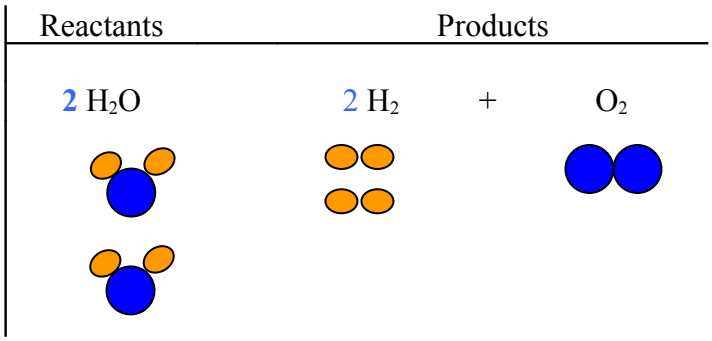
Reactants		Products		
2 H_2O		H_2	+	O_2



reactant	element	product
2 H_2O		H_2+O_2
4	H	2
2	O	2

We can get the numbers for the water either by counting from the picture, or by simply multiplying the coefficient by the subscript for each element. For H: 2 x 2 = 4.
For O: 2 x 1 = 2 (chemists do the same thing for ones as subscripts, they don't write them)

Now we have balanced the oxygens, but now the hydrogens are not balanced. So we are not done balancing the equation. To balance the Hydrogens, we have get 4 on the products side as well. We can do this by changing the coefficient in front of hydrogen product to 2.



reactant	element	product
2 H_2O		**2** H_2+ O_2
4	H	4
2	O	2

Now the reaction is balanced!

Sometimes when you look at reaction it will be easy to tell what you need to do to balance it, and sometimes it will be more difficult.

In general the process of balancing a chemical equation, involves the following steps:

1. Count the number of atoms on each side. Make your chart to help you keep track.
2. Start balancing each element one at a time. It should not matter which element you start with, you should end up with the same answer. However there are a couple of hints that can make it easier.

    a. If an element is in multiple places on products or reactants side, save that element for last. For example in the following reaction look at oxygen in the products:

    $$CH_4 + O_2 \qquad \underline{CO_2} + \underline{H_2O}$$

    b. If you have odd and even numbers for an element on both sides of the equation, it is easiest to use a common multiple. For example

    $$Fe + O_2 \qquad Fe_2O_3$$

    When you count the oxygen atoms you have 2 on the reactants, and 3 on the products. Simply changing one of the coefficients isn't going to work, there is not a whole number to multiply 2 by to get 3. Instead, you need to multiply them by each other to get 6 O on each side.

    $Fe + 3\ O_2$ $\qquad$ $2\ Fe_2O_3$ But still not balanced, so need to change coefficient on Fe to 4

Final balanced equation: $4\ Fe + 3\ O_2 \quad 2\ Fe_2O_3$

c. If there is no change in a polyatomic ion from reactants to products, you can balance it as a group.

For example in this reaction OH is the polyatomic ion:

$$NaOH + Ag_2S \quad Na_2S + AgOH$$

reactants	element	products
$NaOH + Ag_2S$		$Na_2S + AgOH$
1	Na	2
1	OH	1
2	Ag	1
1	S	1

To get this balanced, we can first put a 2 in front of NaOH to get Na balanced.

$$2\ NaOH + Ag_2S \quad Na_2S + AgOH$$

reactants	element	products
$NaOH + Ag_2S$		$Na_2S + AgOH$
2	Na	2
2	OH	1
2	Ag	1
1	S	1

Now, to balance the OH group, we can put a 2 in front of the AgOH

$$2\ NaOH + Ag_2S \quad Na_2S + AgOH$$

reactants	element	products
$NaOH + Ag_2S$		$Na_2S + 2\ AgOH$
2	Na	2
2	OH	2
2	Ag	2
1	S	1

Now it is balanced!

3. Always check your reaction at the end to make sure that everything is balanced. If you recount, you will be certain you got the answer correct.