Being able to balance chemical equations is a very important skill for students of chemistry, making this one of our most popular chemistry tutorials. All chemical calculations require you to work with a balanced equation. Here we will show you a simple, easy way to balance all chemical equations you will meet at introductory level chemistry courses. (**A completely different method is used if you have to work with Half Equations. If you don't know what a Half Equation is, then don't worry, as that means they are not in your course and you will not have to worry about balancing them.)** The key to balancing chemical equations is to apply the rules below:

**What is a balanced equation?**

A chemical equation is balanced when the number of atoms of each type on each side of the equation is the same. Which means if you have 12 hydrogens on the left hand side of the equation, you must have 12 hydrogens on the right hand side, if there are 4 oxygens on the left, there must 4 oxygens on the right, and so on. This is because of the law of conservation of mass - **you can't make or destroy atoms during a chemical reaction.** But you can't just add atoms at random to each side, you have to work with the molecules of the reactants. Also, you will find it very tricky to try to balance a word equation, it is very much easier to use a chemical equation with chemical symbols, as then you will be able to see how many atoms of each type are in each chemical.

 ***Example 1
Unbalanced Equation:- C3H8 + O2 ---> H2O + CO2***

There are three carbons on the left, but only one on the right.
There are eight hydrogens on the left but only two on the right.
There are two oxygens on the left but three on the right.

**Balanced Equation:- C3H8 + 5O2 ---> 4H2O + 3CO2**

**How do we balance the equation?**

Balancing chemical equations isn't difficult, once you know the way to do it. The key is to practice, practice and more practice**. If there is a complex ion, sometimes called a polyatomic ion, on each side of the equation that has remained intact, then that can often be balanced first, as it is acts as a single species. Treat it as a single unit. Write letter X or any letter you choose underneath it. The ions NO3- and CO32- are examples of a complex ion**.

1. Start by finding out how many atoms of each type are on each side of the equation. Some teachers recommend making a little table listing the numbers of each atom for the left hand side and for the right hand side.
2. Next, look for an element which is in only one chemical on the left and in only one on the right of the equation. (**But it is usually a good idea to leave hydrogen and oxygen until you've done the others first.**) You can start if you choose to with polyatomic ions.
3. To balance that element, multiply the chemical species on the side which doesn't have enough atoms of that type by the number required to bring it up to the same as the other side. The number is called the coefficient.
**BUT
If you have to multiply by, say, 2 1/2, do so, THEN multiply EVERYTHING on each side of the equation by two to get rid of the half.
We don't like having halves in equations, as you can't get half a molecule.**
4. Now look for the next element or species that is not balanced and do the same thing.
5. Repeat until you are forced to balance the hydrogen and oxygens.

A VERY useful rule is to leave balancing oxygen and hydrogen to the last steps as these elements are often in more than one chemical on each side, and it is not always easy to know where to start. Some people also say you should leave any atom or species with a valancy of one until the end, and also generally leave anything present as an element to the end.

In Example 1 above, you would balance the carbons first, by putting a 3 in front of the CO2, then balance the hydrogens by putting a 4 in front of H2O and finally the oxygens (which are in more than one compound on the right, so we leave them until last) by putting a 5 in front of the O2.

**Example 2
*Unbalanced equation:- H2SO4 + Fe ---> Fe2(SO4)3 + H2***

Balance the SO4 first (as it is a complex ion and it is in one chemcial species on each side)

3H2SO4 + Fe ---> Fe2(SO4)3 + H2

Now balance the Fe (which is also in one chemical on each side)

3H2SO4 + 2Fe ---> Fe2(SO4)3 + H2

Finally, balance the hydrogen (although it is in one chemical species on each side, it is usually a good idea to leave it until last)

**Balanced Equation:- 3H2SO4 + 2Fe ---> Fe2(SO4)3 + 3H2**

**We alter the coefficients in the equation. Do NOT touch the subscripts for the atoms in a chemical species, or you will change it into a different chemical. That would be a bit like saying I want six chicken legs for a meal, so I'll go get a six-legged chicken. As chickens have two legs, you will need three normal, two-legged, chickens, not a six-legged mutant monster, probably from outer space.**

If you start by trying to balance something which is in more than one species on one side, you can't easily tell which species you should have more of, and so can end up going round in circles, continually altering things. If this happens, just start again, but balancing atoms or complex ions that are in one species on each side. (This is important or it will not work.)

 **Example 3
*Unbalanced Equation:- Al + O2 ---> Al2O3***

We can start with either the Al or the O, but we will start with Al, as we normally leave O to the end. Even though it wouldn't matter where we started in this case.

Put a two in front of the Al on the left
2Al + O2 ---> Al2O3

Put a 1 1/2 in front of the O2 on the left
2Al + 1 1/2O2 ---> Al2O3

We don't like halves, so multiply everything on BOTH sides by two
4Al + 3O2 ---> 2Al2O3

It's now a balanced equation. Easy, eh?

***Example 4
Unbalanced equation:- Na2CO3 + HCl ---> NaCl + CO2 + H2O***

Well, the sodium (Na) is not balanced yet and is in one chemical species on each side, so we need two NaCl on the right, agreed? Remember, we tend to leave H and O until the end.

Na2CO3 + HCl ---> 2NaCl + CO2 + H2O

There is only one Cl on the left, but two on the right, so let's sort that one next, by making it 2HCl on the left

Na2CO3 + 2HCl ---> 2NaCl + CO2 + H2O

And now if you look carefully, you'll see that the number of carbon, hydrogen and oxygen atoms on each side are the same, so it's balanced.

***Example 5
Unbalanced equation: - Mg3N2 + H2O ---> MgO + NH3***

We can see that there are 3 Mg atoms on the left but only one on the right, so let's sort that one first - Mg3N2 + H2O ---> 3MgO + NH3

We could continue by balancing the O or the N next as we can see they don't add up. But let's stick with our useful rule of leaving O and H to the end if possible, and go for the nitrogen next. There are two on the left side and only one on the right, so put a two in front of the NH3

Mg3N2 + H2O ---> 3MgO + 2NH3

At this point we can go for either the oxygen or the hydrogens, so we'll do the oxygens, just because I want to. We need to add a three in front of the H2O to get three oxygens on each side

Mg3N2 + 3H2O ---> 3MgO + 2NH3

And a quick count shows that we have balanced everything now! For practice, try this one by balancing the O before the N, it will give you the same answer, of course.

**Example: Balance the following:**

 **AgNO3 (aq) + Cu (s) → Cu(NO3)2 (aq) + Ag (s)**

**\* consider the polyatomic nitrate ion (NO3-1) as a single unit**

 **AgNO3 (aq) + Cu (s) → Cu(NO3)2 (aq) + Ag (s)**

 **1 Ag 1 Ag**

 **1 NO3 2 NO3**

 **1 Cu 1 Cu**

 **2 AgNO3 (aq) + Cu (s) → Cu(NO3)2 (aq) + 2 Ag (s)**

 **2 Ag 2 Ag**

 **2 NO3 2 NO3**

 **1 Cu 1 Cu**

 **Balanced**

**Example: Al (s) + O2 (g) → Al2O3 (s)**

 **1 Al 2 Al**

 **2 O 3 O**

 **2 Al (s) + O2 (g) → Al2O3 (s)**

 **2 Al 2 Al**

 **2 O 3 O**

 **2 Al (s) + O2 (g) → 2 Al2O3 (s)**

 **2 Al 4 Al**

 **2 O 6 O**

 **2 Al (s) + 3 O2 (g) → 2 Al2O3 (s)**

 **2 Al 4 Al**

 **6 O 6 O**

 **Balanced**

Once you have had a bit of practice at balancing chemical equations, lots of other questions asked in chemistry become much easier to solve.