Balancing Equations

When balancing chemical equations, it is important to remember that no matter is created or destroyed.

Law of conservation of mass: Matter is neither created nor destroyed in chemical reactions

Chemical equations are written with the **reactants** on the left side of the equation (reaction arrow) and **products** on the right side of the equation (reaction arrow).

$HCl + KOH \longrightarrow H_2O + KCl$

Reactant: A substance that undergoes change in a chemical reaction and is written on the left side of the reaction arrow in a chemical equation.

Product: A substance that is formed in a chemical reaction and is written on the right side of the reaction arrow in a chemical equation.

The bonds between atoms in the reactants are rearranged to form new compounds in chemical reactions, but none of the atoms disappear and no new ones are formed. As a consequence, chemical equations must be **balanced**, meaning that the number and kinds of atoms must be the same on both sides of the reaction arrow.

The numbers placed in front of formulas to balance equations are called **coefficients**, and they multiply all the atoms in a formula. Thus, the symbol "2 $NaHCO_3$" indicates two units of sodium bicarbonate, which contain 2 Na atoms, 2 H atoms, 2 C atoms, and 6 O atoms (2 X 3= 6, the coefficient times the subscript for O). Count the numbers of atoms on the right side of the equation to convince yourself that it is indeed balanced.

$2\ NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Balanced Equation: A chemical equation in which the numbers and kinds of atoms are the same on both sides of the reaction arrow.

Coefficient: A number placed in front of a formula to balance a chemical equation.

The Four Steps of Balancing Equations:

1. **Write an unbalanced equation, using the correct formulas for all reactants and products.** *Remember that the scripts in chemical formulas cannot be changed in balancing an equation because doing so would change the identity of the substances in the reaction.*
2. **Add appropriate coefficients to balance the number of atoms of each element.**
3. **Check the equation to make sure the numbers and kinds of atoms on both sides of the equation are the same.**
4. **Make sure the coefficients are reduced to their lowest whole-number values**
   $2\ H_2SO_4 + 4\ NaOH \longrightarrow 2Na_2SO_4 + 4\ H_2O$ *reduces to* $H_2SO_4 + 2\ NaOH \longrightarrow Na_2SO_4 + 2\ H_2O$

Balancing Chemical Reactions

Elements combine in whole number, that we know to be true. Thus, we need to have the smallest whole number ratio of the coefficients used to balance the equation. To balance an equation initially, you may use a fraction, but then you must modify the coefficients to make them whole numbers. Below is an example.

Reaction: $C_3H_6O_2 + O_2 \rightarrow CO_2 + H_2O$

Hint: Wait to balance oxygen last since placing a coefficient in front of elemental oxygen (O2) will not change any other elements.

Initial balancing: $C_3H_6O_2 + \mathbf{?}O_2 \rightarrow \mathbf{3}CO_2 + \mathbf{3}H_2O$

The carbons and hydrogens have been balanced. All that is left are the oxygens. There are a total of 9 oxygens of the product side (right of the arrow). Notice that 2 oxygens exist in the compound on the reactant side. Thus, to balance out the oxygens, an equation can be set up.

2 + x = 9 --> x = 7 --> Seven oxygens are required to balance the reaction, so this dictates that we use a coefficient in front of oxygen (O_2) that will produce **7** oxygens. This will cause a coefficient of **3.5** to be used. This is not a whole number, but we can deal with that later.

Almost balanced: $C_3H_6O_2 + \mathbf{3.5}O_2 \rightarrow \mathbf{3}CO_2 + \mathbf{3}H_2O$

Having a fraction as a coefficient is not allowed, thus we must convert **3.5** to a whole number. To accomplish this, we will multiply **3.5** by **2**. Just like in algebra, if something is done to one number, we must do the same thing to all of the numbers. Thus, all coefficients will be multiplied by **2**. Doing this keeps the equation balanced.

Almost, nearly balanced: $\mathbf{2}(C_3H_6O_2 + \mathbf{3.5}O_2 \rightarrow \mathbf{3}CO_2 + \mathbf{3}H_2O)$

BALANCED!! $\mathbf{2}C_3H_6O_2 + \mathbf{7}O_2 \rightarrow \mathbf{6}CO_2 + \mathbf{6}H_2O$