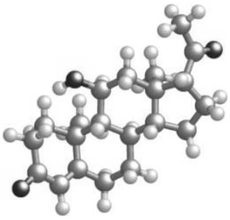

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Guidelines for Writing Balanced Chemical Equations

Chemists often use *word equations* to describe what happens during a chemical reaction. For example, the reaction between methane and oxygen is written as:

methane + oxygen $\rightarrow$ carbon dioxide + water

Writing chemical equations using formulae is another way of describing what happens during a chemical reaction. Instead of writing out the full names of all of the reactants and products, scientists just write the formulae of the chemicals instead. By replacing names with formulae, the reaction between methane and oxygen now looks like this:

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

However, this equation is not *balanced*. When writing chemical equations using formulae, it is very important to ensure that the equation is *balanced*. Balancing an equation means making sure that the numbers of atoms of a given element are the *same* on both sides of the arrow. Chemical equations are balanced by writing *whole numbers* in front of the chemical formulae. Consider the reaction between methane and oxygen once again.

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

Reactants:	Products:
C = 1 ✓	C = 1 ✓
H = 4 ×	H = 2 ×
O = 2 ×	O = 3 ×

Only the carbon is balanced, with one atom on each side of the arrow. The amount of hydrogen on the right-hand-side of the arrow must be doubled from 2 to 4 so that it is balanced with the left-hand-side of the equation. This can be achieved by writing "2" in front of the formula for water:

$$CH_4 + O_2 \rightarrow CO_2 + \mathbf{2}H_2O$$

Reactants:	Products:
C = 1 ✓	C = 1 ✓
H = 4 ✓	H = 4 ✓
O = 2 ×	O = 4 ×

The carbon and hydrogen are now both balanced. Note that writing "2" in front of the formula for water not only doubled the amount of hydrogen, but also increased the amount of oxygen on the right-hand-side of the equation. To finish balancing the equation, the amount of oxygen on the left-hand-side of the equation must be doubled. This can be achieved by writing "2" in front of the formula for oxygen:

$$CH_4 + \mathbf{2}O_2 \rightarrow CO_2 + \mathbf{2}H_2O$$

Reactants:	Products:
C = 1 ✓	C = 1 ✓
H = 4 ✓	H = 4 ✓
O = 4 ✓	O = 4 ✓

Consider another example, the reaction between magnesium hydroxide and nitric acid, forming magnesium nitrate and water as the reaction products. The word equation for this reaction is:

magnesium hydroxide + nitric acid $\rightarrow$ magnesium nitrate + water

Replacing names with formulae, the reaction between magnesium hydroxide and nitric acid becomes:

$$Mg(OH)_2 + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$$

Reactants:	Products:
Mg = 1 ✓	Mg = 1 ✓
O = 5 ✗	O = 7 ✗
H = 3 ✗	H = 2 ✗
N = 1 ✗	N = 2 ✗

Only the magnesium is balanced. Writing “2” in front of the formula for nitric acid will double the amount of nitrogen on the left-hand-side of the equation. This also increases the amount of hydrogen and oxygen on the left-hand-side of the equation:

$$Mg(OH)_2 + \mathbf{2}HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$$

Reactants:	Products:
Mg = 1 ✓	Mg = 1 ✓
O = 8 ✗	O = 7 ✗
H = 4 ✗	H = 2 ✗
N = 2 ✓	N = 2 ✓

Magnesium and nitrogen are now both balanced. To completely balance the equation, one more atom of oxygen and two more atoms of hydrogen are required on the right-hand-side. This can be achieved by writing “2” in front of the formula for water:

$$Mg(OH)_2 + \mathbf{2}HNO_3 \rightarrow Mg(NO_3)_2 + \mathbf{2}H_2O$$

Reactants:	Products:
Mg = 1 ✓	Mg = 1 ✓
O = 8 ✓	O = 8 ✓
H = 4 ✓	H = 4 ✓
N = 2 ✓	N = 2 ✓

One final example, the reaction between aluminium and oxygen to form aluminium oxide:

aluminium + oxygen $\rightarrow$ aluminium oxide

$$Al + O_2 \rightarrow Al_2O_3$$

Reactants:	Products:
A*l* = 1 ✗	A*l* = 2 ✗
O = 2 ✗	O = 3 ✗

In this example, writing “2” in front of the symbol for aluminium and “1.5” in front of the formula for oxygen will balance the equation:

$$\mathbf{2}Al + \mathbf{1.5}O_2 \rightarrow Al_2O_3$$

Reactants:	Products:
A*l* = 2 ✓	A*l* = 2 ✓
O = 3 ✓	O = 3 ✓

In this example, using a fraction succeeds in balancing the equation, but equations should only be balanced using *whole numbers*. This problem is resolved by multiplying the *entire* equation by 2:

$$\mathbf{4}Al + \mathbf{3}O_2 \rightarrow \mathbf{2}Al_2O_3$$

Reactants:	Products:
A*l* = 4 ✓	A*l* = 4 ✓
O = 6 ✓	O = 6 ✓