# Chemical Reaction Decoder for The Science of Combustion

*The Chemical Reaction Decoder can be used to expand understanding of how to write chemical reaction formulas, common symbols in formulas, and the principle of conservation of mass.*

**What are reactants and products in a chemical reaction?**

**Reactants:** Compounds or substances that undergo chemical changes to form new and different compounds.

**Products:** Compounds or substances that are formed by reactants that undergoes chemical changes.

When we write a chemical reaction using words, it is written as “A and B reacts and gives C and D.” In this example, A and B are reactants as they undergo chemical changes. C and D are products formed by the chemical changes to A and B.

**Example in words**: “Propane reacts with oxygen and gives carbon dioxide and water.”

**Example in chemical reaction equation**:

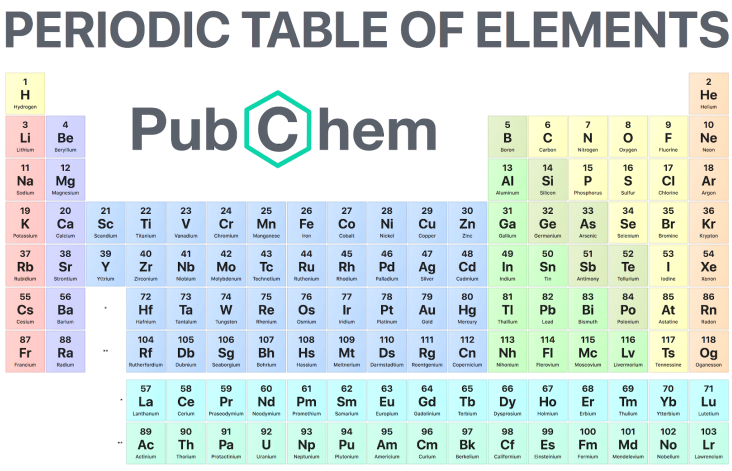
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Propane | + | oxygen | → | carbon dioxide | + | water | | |
| $C_3H_8$ | + | $5O_2$ | → | $3CO_2$ | + | $4H_2O$ | | |

In this example, propane and oxygen are reactants. When they undergo chemical changes, carbon dioxide and water are formed by the chemical changes from propane and oxygen reacting.

In a sentence explaining a chemical reaction, everything that comes before “and gives” are reactants. Everything after “and gives” are products.

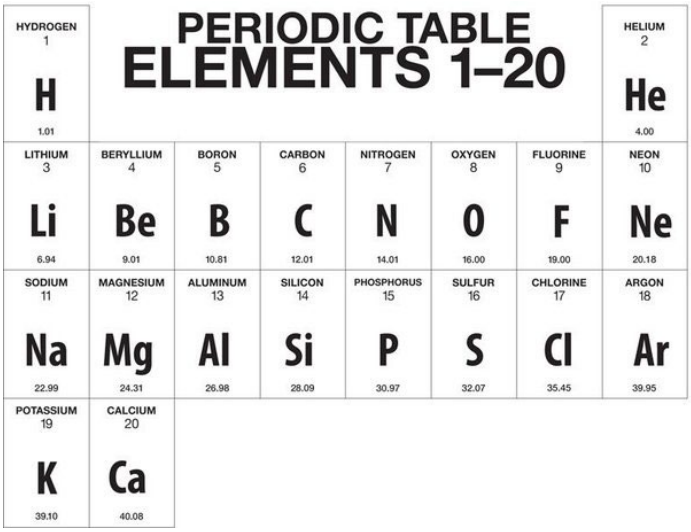
In chemistry, instead of writing sentences for chemical reactions, we use formulas and scientific symbols. For compounds such as oxygen and carbon dioxide, we use symbols from the periodic table.

**What is the periodic table?** The periodic table is a table of the chemical elements arranged in order of atomic number from lowest to highest.




**(https://pubchem.ncbi.nlm.nih.gov/periodic-table/)**

An abbreviated periodic table has the first 20 elements:




**(https://www.quora.com/What-are-the-first-20-elements-in-the-periodic-table)**

**What is an atom?**

An atom is the smallest unit of ordinary matter that forms a chemical element. In the periodic table, the listed elements are atoms.

**What is a chemical compound?**

A chemical compound is known as any substance composed of atoms of two or more chemical elements. Every compound or material in our universe if made from atoms. However, compounds get their own unique names when atoms are combined.

**Example**: Carbon dioxide ($CO_2$) is a compound which has one carbon (C) atom and two oxygen (O) atoms.

Examples of combinations outside of chemistry that become something new: 25 baseball players become the Yankee baseball team and 4 singers combine to make a quartet.

**Writing a chemical reaction equation:**

**Converting words**: propane reacts with oxygen and gives carbon dioxide and water

**Chemical reaction equation:**

| Propane + oxygen → carbon dioxide + water |
| --- |
| $C_3H_8$ + $5O_2$ → $3CO_2$ + $4H_2O$ |

**Arrows in chemical reaction equations:**

When writing a chemical reaction equation, the reactants are written on the left side of the page and the products are written on the right side of the paper. To show that the products are made from the reactants, an arrow is drawn from the reactants towards the products.

**Arrow pointing from left to right:**

The arrow going from left to right indicates that the reactants on the left side undergo change and create products on the right side. This arrow is commonly used.

**Reversible reaction arrow:**

The reverse reaction arrow indicates the reaction is reversible. The reversible reaction arrow is shown below.

$\rightleftharpoons$

**Reversable reaction example:**

For reversible reactions, the example is carbon dioxide ($CO_2$) dissolving in water ($H_2O$) and giving carbonic acid ($H_2CO_3$).

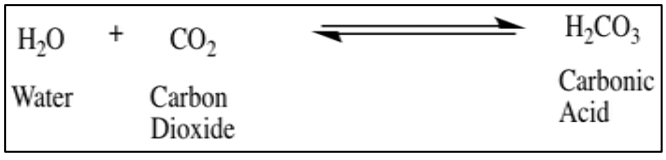

When you open a can of soda that has carbonic acid, the carbon dioxide escapes from the soda. However, carbonic acid is made from carbon dioxide supplied to the water. Therefore, when these arrows are used in an equation, it shows that the reactants react and gives products but, under specific conditions, the products could return to reactants (original form). This type of equation is called a **reversible** reaction. The single left to right arrow equation is an **irreversible** reaction equation where the change back to original form is not impossible.

**Irreversible**

Propane + oxygen → carbon dioxide + water

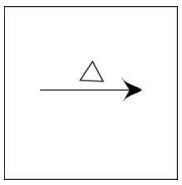
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

**Reversible**



**Adding heat arrow (with triangle above):**

To show a reaction that requires heat, the arrow goes from left to right (irreversible reaction) and has a triangle over the arrow.



Some reactants do not react and give products immediately. Some reactants need to be provided with energy (in the form of heat) for the reaction to take place.

**Adding heat reaction equation example**: To produce oxygen, heat needs to be applied to hydrogen gas ($H_2$) and oxygen gas ($O_2$) to create a reaction. The triangle on top of the arrow indicates heat is applied.

$$H_2 + O_2 \xrightarrow{\Delta} H_2O$$

**Conservation of mass and atom balance:**

In science, we have the principle of conservation of mass. This means that chemical mass is neither created nor destroyed. For example, the carbon atom becomes carbon dioxide when it is reacted with oxygen gas. Mass cannot be created or destroyed according to conservation of mass principle. The exact number of atoms should be present in both the reactant side and product side.

$$C + O_2 \xrightarrow{\Delta} CO_2$$

In chemistry, you need to count the atoms and balance the atoms on both sides of a chemical reaction equation. To count the atoms, make sure to use the individual elements, not the whole compound. Then, multiply by the number that is in front of the compound, taking into account the "invisible" 1 in front of certain compounds.

**Balanced example:**

$$C + O_2 \xrightarrow{\Delta} CO_2$$

In this equation, the atoms are balanced: 1 carbon atom and 2 oxygen atoms on both sides.

**Correcting an unbalanced example:**

$$H_2 + O_2 \xrightarrow{\Delta} H_2O$$

The atoms in this equation are not balanced. There are two oxygen atoms on the reactant side but only one oxygen atom on the product side. To correctly balance the number of atoms, we add 2 in front of water ($H_2O$) which balances the oxygen. But the hydrogen atoms are not balanced now as there is still two hydrogen atoms on reactant side but four in the product side.

$$H_2 + O_2 \xrightarrow{\Delta} 2H_2O$$

To balance the hydrogen atoms, we'll add 2 in front of hydrogen gas ($H_2$). This is now a balanced equation.

$$2H_2 + O_2 \xrightarrow{\Delta} 2H_2O$$