

# “Balancing” Chemical Formulas

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## What is a chemical formula?

- Chemical formulas are combinations of element symbols and numbers called “subscripts” that show the “ratio” of elements in chemical compounds and molecules of diatomic elements.
  - The compound we know as “water” (hydrogen oxide) has the formula  $\text{H}_2\text{O}$ .
    - The formula means that each water molecule is composed of two atoms of hydrogen and one atom of oxygen.
    - The  $2$  is a multiplier called a “subscript”. Subscripts are written to the right and below the element they are intended to multiply.
  - The  $\text{O}$  doesn’t have a subscript because the element symbol itself is used to represent  $1$  atom. For two or more atoms a subscript is used.

## What does “balanced” mean?

- A “balanced” formula accurately represents the ratio between the elements in a compound as they actually combine in a chemical reaction.
- The ratio is always the same for a chemical compound.
- For instance:
  - a 2:1 ratio of hydrogen to oxygen produces water ( $\text{H}_2\text{O}$ ).
  - a 2:2 ratio of hydrogen to oxygen produces hydrogen peroxide ( $\text{H}_2\text{O}_2$ ).
  - a 1:1 ratio of hydrogen to oxygen produces the hydroxide ion ( $\text{OH}^-$ ).

## Why is it necessary to “balance” chemical formulas?

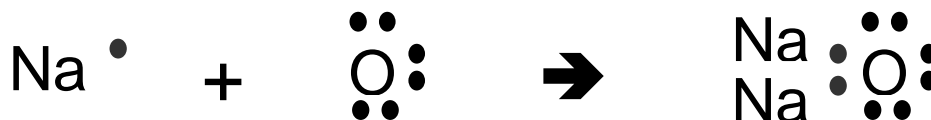
- We “balance” formulas to give us an accurate picture of what happens when elements combine to form compounds.
- If we don’t “balance” the formulas we write, we will not have an accurate model of what is going on when the actual chemical compound is formed.
- If chemists did not have an accurate formula for compounds, the results of chemical reactions would be very unpredictable.
- Manufacturers would not know how much of each reactant (ingredient) to use when making materials (fabric, plastics, metals, medicines, food flavorings, etc.)

## How are chemical formulas balanced?

- Chemical formulas are balanced using “oxidation numbers”.
- They can also be balanced using electron-dot diagrams, but the oxidation number system is easier.

- Suppose we want to know the formula for a compound containing sodium and oxygen.
  - This compound contains only two elements so we can call it **sodium oxide**.
  - Two-element compounds are called “**binary compounds**” and their names must end with the suffix **ide**.
  - Let’s determine the “balanced” formula for sodium oxide.

### Electron-Dot Diagram Method



**Sodium** is a Group IA element and has a single “valence” electron.

**Oxygen** is a Group VIA element and has six valence electrons.

Since oxygen needs two electrons to complete its outside energy level, it takes two sodium atoms to make the compound **sodium oxide**. Each sodium atom can contribute one electron. This results in a 2:1 ratio of sodium to oxygen.

### Oxidation Number Method

Oxidation numbers are assigned to each element based on how many electrons are shared, lost or gained during a chemical reaction.

The oxidation number for sodium is  $1^+$ .

The oxidation number for oxygen is  $2^-$ .



Unbalanced



$1^+ \quad 2^-$   
Balanced

Sodium has a  $1^+$  oxidation number because it gives away one electron leaving 11 protons, but only 10 electrons. Oxygen has a  $2^-$  oxidation number because it gains two electrons in a chemical reaction giving it 10 electrons instead of the normal 8.

