

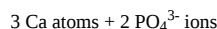
## 5.4: Chemical Formula (Molecular and Empirical Formula)

### Learning Objectives

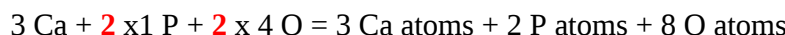
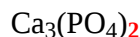
- Determine the number of different atoms in a formula.
- Define chemical formula, molecular formula, and empirical formula.

A **chemical formula** is an expression that shows the elements in a compound and the relative proportions of those elements. Water is composed of hydrogen and oxygen in a 2:1 ratio. The chemical formula for water is  $\text{H}_2\text{O}$ . Sulfuric acid is one of the most widely produced chemicals in the United States and is composed of the elements hydrogen, sulfur, and oxygen. The chemical formula for sulfuric acid is  $\text{H}_2\text{SO}_4$ .

Certain groups of atoms are bonded together to form what is called a polyatomic ion that acts as a single unit. Polyatomic ions are discussed in more detail in [Section 5.5](#). Polyatomic ions are enclosed in parenthesis followed by a subscript if more than one of the same ion exist in a chemical formula. The formula  $\text{Ca}_3(\text{PO}_4)_2$  represents a compound with the following:



To count the total number of atoms for formulas with polyatomic ions enclosed in parenthesis, use the subscript as a multiplier for each atom or number of atoms.



### Molecular Formula

A **molecular formula** is a chemical formula of a molecular compound that shows the kinds and numbers of atoms present in a molecule of the compound. Ammonia is a compound of nitrogen and hydrogen as shown below:

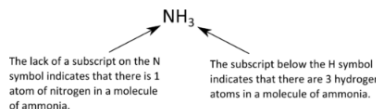


Figure 5.4.1: The molecular formula for ammonia,  $\text{NH}_3$ . There is one atom of nitrogen and 3 atoms of hydrogen in a molecule of ammonia.

Note from the example that there are some standard rules to follow in writing molecular formulas. The arrangements of the elements depend on the particular structure, which is not of concern at this point. The number of atoms of each kind is indicated by a subscript following the atom. If there is only one atom, no number is written. If there is more than one atom of a specific kind, the number is written as a subscript following the atom. We would not write  $\text{N}_3\text{H}$  for ammonia, because that would mean that there are three nitrogen atoms and one hydrogen atom in the molecule, which is incorrect.


### Empirical Formula

An **empirical formula** is a formula that shows the elements in a compound in their lowest whole-number ratio. Glucose is an important simple sugar that cells use as their primary source of energy. Its molecular formula is  $\text{C}_6\text{H}_{12}\text{O}_6$ . Since each of the subscripts is divisible by 6, the empirical formula for glucose is  $\text{CH}_2\text{O}$ . When chemists analyze an unknown compound, often the first step is to determine its empirical formula.

- molecular formula:  $\text{C}_6\text{H}_{12}\text{O}_6$
- empirical formula:  $\text{CH}_2\text{O}$

There are a great many compounds whose molecular and empirical formulas are the same. If the molecular formula cannot be simplified into a smaller whole-number ratio, as in the case of  $\text{H}_2\text{O}$  or  $\text{P}_2\text{O}_5$ , then the empirical formula is also the molecular formula.






regular formula

"regular formula"

How many atoms of each element are in a compound.

$C_4H_8$


ethene



empirical Formula

The simplest or most reduced ratio of atoms in a compound.

$$\begin{array}{l} 4 \text{ Carbon} \div 4 \\ 8 \text{ Hydrogen} \div 4 \end{array}$$



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5.4.2

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