

# Empirical & Molecular Formulas

## molecular formula

the formula for a compound that shows the number of atoms of each element that make up a molecule of that compound

Sometimes **empirical** and **molecular** formulas are the same!

## empirical formula

a formula that shows the smallest whole-number ratio of the elements in a compound

Name	Empirical Formula	Molecular Formula	Whole-Number Multiple	<i>M</i> (g/mol)	Use or Function
Formaldehyde	CH <sub>2</sub> O	CH <sub>2</sub> O	1	30.03	Is used as a disinfectant and biological preservative
Acetic acid	CH <sub>2</sub> O	C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>	2	60.06	Is used to produce acetate polymers; is a component of vinegar (5% solution)
Lactic acid	CH <sub>2</sub> O	C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>	3	90.09	Causes milk to sour; forms in muscles during exercise

Which of the following are empirical and which are molecular?

NO

N<sub>2</sub>ONO<sub>2</sub>N<sub>2</sub>O<sub>4</sub>N<sub>2</sub>O<sub>5</sub>

## Rules for Determining Empirical Formulas

1. Convert percentage composition data into mass data by assuming that the total mass of the sample is 100 g.
2. Determine the number of moles of each element in the sample by dividing the mass by the molar mass of each element.
3. Convert the number of moles of each element into whole numbers that become subscripts in the empirical formula by dividing each amount in moles by the smallest amount.
4. If the subscripts are not yet whole numbers, determine the least common multiple that will make the decimal values into whole numbers. Multiply all subscripts by this least common multiple. Use these numbers as subscripts to complete the empirical formula.

## **Empirical Formula Determination**

**Example:** A compound which contains only carbon, hydrogen and oxygen was analysed. Of the 32.356 g of compound, the results showed that it contained 0.883g of hydrogen and 10.497g of carbon. Calculate the empirical formula of the compound.

**Example:**

Determine the empirical formula for a compound that is found by analysis to contain 27.37% sodium, 1.200% hydrogen, 14.30% carbon, and 57.14% oxygen.

**Example:**

Determine the empirical formula for a compound that contains 69.88 g of iron and 30.12 g of oxygen.

## **Molecular formula Determination**

The molecular formula is defined as the actual number of atoms found in each molecule. So, the molecular formula must be a **multiple of the empirical formula** of the same substance.

**Example:** A compound was found to have the empirical formula CH. Its molar mass was found to be 78 g/mol. Determine the molecular formula.

A certain compound contains 4.0 g of calcium and 7.1 g of chlorine. The molar mass is 111 g/mol. Find its empirical and molecular formulas.

A certain compound has 25.9% nitrogen and 74.1% oxygen. Its relative molecular mass is 108. Find its empirical and molecular formula