

## Study Card: Empirical vs. Molecular Formulae

A lab chemist can analyze an unknown compound to determine the relative number of atoms of each element in the compound.

Mass of Unknown Sample: 10.000 g  
 Mass of Hydrogen in Sample: 0.593 g  
 Mass of Oxygen in Sample: 9.407 g

EXAMPLE

There are two types of chemical formulae –

**Empirical Formula**  
and  
**Molecular Formula**

The relative moles of H and O can be determined:

Moles of H =  $0.593 \text{ g} \cdot (1 \text{ mol}/1.0079 \text{ g})$

Moles of H = 0.588 mol H

Moles of O =  $9.407 \text{ g} \cdot (1 \text{ mol}/15.9994 \text{ g})$

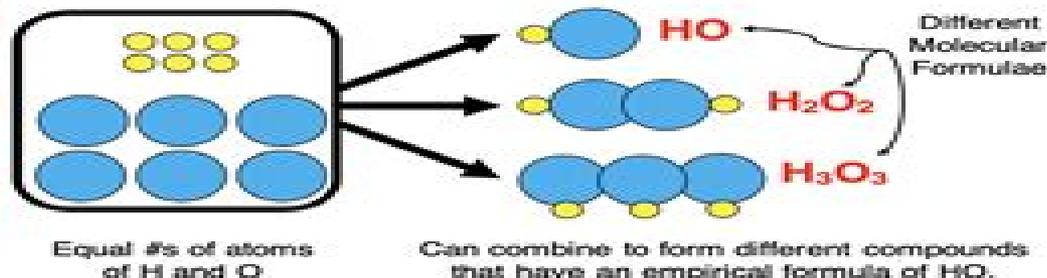
Moles of O = 0.588 mol O

**Conclusion:**

The unknown compound contains an equal number of H and O atoms. The simplest ratio of H to O is 1:1.

This is the **empirical formula** - HO.

An **empirical formula** indicates the **simplest ratio** of atoms. A **molecular formula** indicates the **actual ratio** of atoms. A compound with an empirical formula of HO could have a molecular formula of HO, H<sub>2</sub>O<sub>2</sub>, H<sub>3</sub>O<sub>3</sub>, etc. The subscripts in the molecular formula are whole number multiples (x1, x2, x3, etc.) of those in the empirical formula.



Mass composition data from the lab allows one to determine the **empirical formula** ... the simplest ratio of atoms.

An empirical formula can be combined with a molar mass measurement to determine the **molecular formula** ... the actual ratio of atoms.

Compound Name	Empirical Formula	Molecular Formula
Nitrogen Dioxide	NO <sub>2</sub>	NO <sub>2</sub>
Dinitrogen Tetroxide	NO <sub>2</sub>	N <sub>2</sub> O <sub>4</sub>
Methane	CH <sub>4</sub>	CH <sub>4</sub>
Ethylene	CH <sub>2</sub>	C <sub>2</sub> H <sub>4</sub>
Benzene	CH	C <sub>6</sub> H <sub>6</sub>

Compound	Empirical Formula	Molar Mass	Molecular Formula
Hydrogen Peroxide	HO (~17 g/mol)	34.0 g/mol	H <sub>2</sub> O <sub>2</sub>
Benzene	CH (~13 g/mol)	78.0 g/mol	C <sub>6</sub> H <sub>6</sub>
Dinitrogen Tetroxide	NO <sub>2</sub> (~46 g/mol)	92.0 g/mol	N <sub>2</sub> O <sub>4</sub>

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# Empirical And Molecular Formula Study Guide

**Annelies Wilder-Smith**



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