

# Empirical Formula Notes

Shows the smallest whole number ratio of atoms of each element in a compound. Also called the simplest formula. Empirical formula can be calculated from percentage composition data.

Textbook Empirical formula is explained on pages 87-94 in your textbook (McGraw-Hill Ryerson Chemistry).

Question 8 on the mole calculations worksheet deals with empirical formula.

Questions 8a) 80.0% carbon, 20.0% hydrogen

Step 1 Assume a 100 g sample and calculate the mass of each element in the sample. A 100 g sample is chosen for convenience - it makes converting from percentage to mass simple.

80.0 g carbon      20.0 g hydrogen

Step 2 Calculate moles of each element. Chemical formulas are written in terms of atoms of each element or moles of atoms of each element.

$\frac{80.0 \text{ g carbon}}{12.011 \text{ g/mol}}$	$\frac{20.0 \text{ g hydrogen}}{1.00794 \text{ g/mol}}$
6.66056 mol C	19.84245 mol H

Step 3 Now you have a mole ratio, but it is not whole numbers. Divide all results by the smallest answer - this will give you at least one whole number.

$\frac{6.66056 \text{ mol C}}{6.66056}$	$\frac{19.84245 \text{ mol H}}{6.66056}$
1.00	2.979

Because the data is experimental, the results are often not exact. If the number, when rounded to one decimal place is a whole number, that is close enough. 2.979 - if you round this to one decimal place, the nine would round up as it is followed by a 7, giving you 3.0, which is a whole number. Therefore the ratio of C:H is 1:3 and the empirical formula is



Step 4 If you do not get a whole number from step 3, multiply by a whole number in order to produce a whole number ratio.

8b) 35.0% nitrogen 5.0% hydrogen 60.0% oxygen

Step 1 Convert percentages to mass based on a 100 g sample

Step 2 Convert mass to moles

$\frac{35.0 \text{ g N}}{14.0067 \text{ g/mol}}$	$\frac{5.0 \text{ g H}}{1.00794 \text{ g/mol}}$	$\frac{60.0 \text{ g O}}{15.9994 \text{ g/mol}}$
2.4988 mol N	4.9606 mol H	3.7501 mol O

Step 3 Divide by the smallest

$\frac{2.4988 \text{ mol N}}{2.4988}$	$\frac{4.9606 \text{ mol H}}{2.4988}$	$\frac{3.7501 \text{ mol O}}{2.4988}$
1.00	1.985	1.500

The nitrogen is a whole number (1.00) and the hydrogen will round to a whole number (2.00), but the oxygen is not a whole number

1	2	1.500
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Step 4 Multiply to get a whole number. In order to turn 1.5 into a whole number, we need to multiply by 2 - therefore all results must be multiplied by 2.

2	4	3
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Final Answer: 2:4:3, therefore the empirical formula is  $\text{N}_2\text{H}_4\text{O}_3$