Totally Epic AP Chem Review: Empirical and Molecular Formulas!

Percent Composition: the percent by mass of each element in a compound.

- According to the law of Definite Proportions, the molar ratio of elements in a specific compound is constant, regardless of the compound's source or method of preparation.

$$\%\ \textbf{compostion of an element} = \frac{\textbf{total mass of element in compound}}{\textbf{total mass of compound}} \times 100$$ not on F.C.

Example: As some salts crystallize from a water solution, they bind water molecules in their crystal structure. Sodium carbonate forms such a hydrate: find the mass percentage of water in sodium carbonate decahydrate.

$Na_2CO_3 \cdot 10H_2O$ (MM = 286.15 g/mol)

$$\%\ H_2O = \frac{10 \times 18.016}{286.15} \times 100 = 62.962\%\ H_2O$$ ($MM(H_2O)$)

Empirical Formula: the symbols for the elements combined in a compound, with subscripts showing the smallest whole-number mole ratio of the different atoms in the compound.

Molecular Formula: the actual formula of a compound which shows the total number of each atom in the molecule.

*** It is possible for the empirical formula and the molecular formula to be the same !***

For example:

Molecular	Simplify by dividing	Empirical
P_4O_{10}	2	P_2O_5
$C_9H_3O_3N_{12}$	3	C_3HON_4
NaCl	1	NaCl

The Empirical Song! *(sung with the melody from Twinkle, Twinkle Little Star)*

Percent to mass and mass to mole,
Divide by small then multiply til whole.
That's how you find the empirical
Smallest whole-number ratio.

Let's Practice!

1. Analysis of a sample of a compound known to contain only phosphorus and oxygen indicates that it contains 43.67% phosphorus by mass. What is the empirical formula and name of this compound?

P: 43.67 g / 30.97 g/mol = 1.41 mol
O: 56.33 g / 16.00 g/mol = 3.52 mol
(100 − 43.67)

÷ 1.41 → 1 ; ≈ 2.5

× 2 → = 2 ; = 5

P_2O_5 diphosphorus pentoxide

2. Qualitative analysis shows that a compound contains 32.28% sodium, 22.65% sulfur, and 44.99% oxygen. Find the empirical formula and name of this compound.

Na: 32.28 g / 22.99 g/mol = 1.404 mol
S: 22.65 g / 32.06 g/mol = 0.7065 mol
O: 44.99 g / 16.00 g/mol = 2.812 mol

÷ 0.7065

= 2
= 1
= 4

Na_2SO_4

Sodium sulfate

How to Get the Molecular Formula

1. Find the mass of the empirical formula.
2. Take the molecular mass and divide it by empirical mass (this will always give you a whole number).
3. Multiply the whole # by the empirical formula's subscripts to determine the molecular formula.

Let's Practice!

1. What is the molecular formula for a compound with the empirical formula H_2O and a molecular mass of 54 g/mol?

$$\frac{MM\ (molecule)}{MM\ (emp.)} = \frac{54}{18.016} \approx 3 \times H_2O = H_6O_3$$

2. The analysis of a rocket fuel showed that it contained 87.4% nitrogen and 12.6% hydrogen by weight. Mass spectral analysis showed the fuel to have a molar mass of 32.06 g/mol.

   a. What is the empirical formula of the fuel?

N: 87.4 g / 14.01 g/mol = 6.24 mol
H: 12.6 g / 1.008 g/mol = 12.5 mol

÷ 6.24

= 1
= 2

NH_2

   b. What is the molecular formula of the fuel?

$$\frac{FW\ (molec.)}{FW\ (emp.)} = \frac{32.06}{16.026} = 2 \times NH_2 = N_2H_4$$