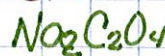


% Composition by Mass

↳ % of each element in a compound by their masses.

$$\% \text{element} = \frac{\text{mass element} \times 100}{\text{molar mass}}$$

Ex (1) Find the % of each element in sodium ⁺¹ ₋₂ oxalate.



MM

$$\begin{array}{l} 2 \text{Na} (22.99 \text{g}) = 45.98 \text{g} \\ 2 \text{C} (12.01 \text{g}) = 24.02 \text{g} \\ 4 \text{O} (16.00 \text{g}) = 64.00 \text{g} \\ \hline 134.00 \text{g} \end{array}$$

$$\% \text{Na} = \frac{45.98 \text{g}}{134.00 \text{g}} \times 100 = 34.31\%$$

$$\% \text{C} = \frac{24.02 \text{g}}{134.00 \text{g}} \times 100 = 17.93\%$$

$$\% \text{O} = \frac{64.00 \text{g}}{134.00 \text{g}} \times 100 = 47.76\%$$

100%

Ex (2) Find the % of each element in vanillin, the chemical responsible for the scent of vanilla, $\text{C}_8\text{H}_8\text{O}_3$.

MM

$$\begin{array}{l} 8 \text{C} \times 12.01 \text{g} = 96.08 \text{g} \\ 8 \text{H} \times 1.01 \text{g} = 8.08 \text{g} \\ 3 \text{O} \times 16.00 \text{g} = 48.00 \text{g} \\ \hline 152.16 \text{g} \end{array}$$

$$\% \text{C} = \frac{96.08 \text{g}}{152.16 \text{g}} \times 100 = 63.15\%$$

$$\% \text{H} = \frac{8.08 \text{g}}{152.16 \text{g}} \times 100 = 5.31\%$$

$$\% \text{O} = \frac{48.00 \text{g}}{152.16 \text{g}} \times 100 = 31.55\%$$

Ex (3) Find the % of each element in cis-3-hexenal, the chemical responsible for the scent of fresh cut grass, $\text{C}_6\text{H}_{10}\text{O}$.

Empirical Formulas (EF)

a chemical formula that has been simplified.

- Calculating an Empirical Formula from data.

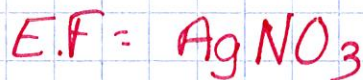
Steps

- (1) Assume there is 100g of the substance, convert % to g.
- (2) convert g to moles.
- (3) Find smallest amount of moles, divide everything by it. (ratio of elements to each other)
- (4) Get whole #'s or very close? Those are the subscripts for the EF
- (5) Get a decimal like $\underline{.5}$ or $\underline{.3}$?
multiply by a whole # to get rid of the decimal. You cannot round up a decimal from step 4.

Example

- (1) A compound contains 63.5% silver, 8.2% nitrogen, and 28.3% oxygen. Determine its empirical formula.

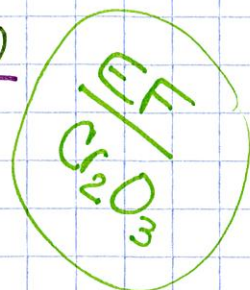
$\frac{63.5g \text{ Ag}}{107.87 \text{ g/mol}}$	$\frac{8.2g \text{ N}}{14.01 \text{ g/mol}}$	$\frac{28.3g \text{ O}}{16.00 \text{ g/mol}}$
$= .5887 \text{ mol Ag}$	$= .5853 \text{ mol N}$	$= 1.7688 \text{ mol O}$
$\frac{.5887 \text{ mol}}{.5853 \text{ mol}}$	$\frac{.5853 \text{ mol}}{.5853 \text{ mol}}$	$\frac{1.7688 \text{ mol}}{.5853 \text{ mol}}$
$= 1 \text{ Ag}$	$= 1 \text{ N}$	$= 3 \text{ O}$



Ex (2) An oxide of chromium is found to have the following composition: 68.4% Cr and 31.6% O. Determine the empirical formula.

$$\begin{aligned} & \frac{68.4 \text{ g Cr}}{52.0 \text{ g/mol}} \\ &= \frac{1.3154 \text{ mol Cr}}{1.3154 \text{ mol}} \\ &= (1 \text{ Cr})_2 \\ &= 2 \text{ Cr} \end{aligned}$$

$$\begin{aligned} & \frac{31.6 \text{ g O}}{16.0 \text{ g/mol}} \\ &= \frac{1.9750 \text{ mol O}}{1.3154 \text{ mol}} \\ &= (1.5 \text{ O})_2 \\ &= 3 \text{ O} \end{aligned}$$



Ex (3) Nicotine is composed of 74.0% carbon, 8.70% hydrogen, and the rest nitrogen. Find the empirical formula.

$$100\% - 74.0 - 8.70 =$$

$$\begin{aligned} & \frac{74.0 \text{ g C}}{12.01 \text{ g/mol}} \\ &= \frac{6.1615 \text{ mol C}}{1.2348 \text{ mol}} \\ &= 5 \text{ C} \end{aligned}$$

$$\begin{aligned} & \frac{8.70 \text{ g H}}{1.01 \text{ g/mol}} \\ &= \frac{8.6139 \text{ mol H}}{1.2348 \text{ mol}} \\ &= 7 \text{ H} \end{aligned}$$

$$\begin{aligned} & \frac{17.30 \text{ g N}}{14.01 \text{ g/mol}} \\ &= \frac{1.2348 \text{ mol N}}{1.2348 \text{ mol}} \\ &= 1 \text{ N} \end{aligned}$$



Ex (4) A 60.00g sample of tetraethyl lead, a gasoline additive contains 38.43g lead, 17.83g carbon, and 3.74g hydrogen. Determine the empirical formula.

$$\begin{aligned} & \frac{\text{Pb}}{38.43 \times 100} \\ & \frac{60.00}{207.20 \text{ g/mol}} \\ &= \frac{64.05 \text{ g Pb}}{207.20 \text{ g/mol}} \\ &= \frac{.3091 \text{ mol Pb}}{.3091 \text{ mol}} \end{aligned}$$

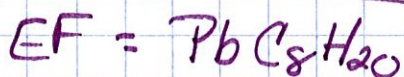
$$= 1 \text{ Pb}$$

$$\begin{aligned} & \frac{\text{C}}{17.83 \times 100} \\ & \frac{60.00 \text{ g}}{12.01 \text{ g/mol}} \\ &= \frac{29.72 \text{ g C}}{12.01 \text{ g/mol}} \\ &= \frac{2.4746 \text{ mol C}}{.3091 \text{ mol}} \end{aligned}$$

$$= 8 \text{ C}$$

$$\begin{aligned} & \frac{\text{H}}{3.74 \times 100} \\ & \frac{60.00}{1.01 \text{ g/mol}} \\ &= \frac{6.23 \text{ g H}}{1.01 \text{ g/mol}} \\ &= \frac{6.1683 \text{ mol H}}{.3091 \text{ mol}} \end{aligned}$$

$$= 20 \text{ H}$$



Molecular Formulas

↳ real formulas (sometimes it is the same as EF, other times it's a multiple of the EF)

Steps

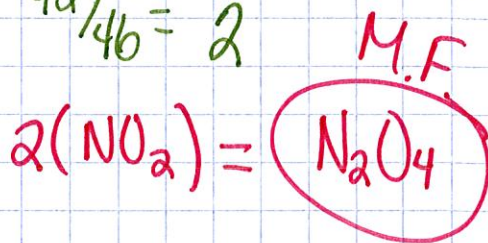
- (1) Find the E.F.
- (2) Find the molar mass of the E.F.
- (3) Divide molar mass of MF (molecular mass) given to you by the molar mass of EF.
- (4) multiply the subscripts in the EF by the answer in #3 to get the M.F.

Ex

The empirical formula is NO_2 and the compound's molar mass is about 92g/mol. Find the molecular formula.

$$\begin{array}{r} \text{N } 1(14.01\text{g}) = 14.01\text{g} \\ \text{O } 2(16.00\text{g}) = 32.00\text{g} \\ \hline 46.01\text{g} \end{array} \quad \text{MM}_{\text{EF}}$$

$$92/46 = 2$$



Ex) A 100g sample of an unknown compound contains 42.56g Pd and .8000g H and its molecular mass is 216.8g. What is the molecular formula?

$$\begin{array}{r} \text{EF} \\ \hline \frac{42.56\text{g Pd}}{106.42\text{g/mol}} = .3999\text{ mol Pd} \\ \frac{.8000\text{g H}}{1.01\text{g/mol}} = .7921\text{ mol H} \\ \hline = 1\text{ Pd} \quad = 2\text{ H} \end{array}$$



$$\begin{array}{r} \text{Pd } 106.42\text{g} \\ 2\text{ H } 2.02\text{g} \\ \hline 108.44\text{g} \end{array}$$

$$\frac{216.8}{108.4} = 2$$

