# % Composition by Mass

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

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

Ex (1) Find the % of each elemint in sodium oxalate. $Na_2C_2O_4$ (Na: +1, O: −2)

MM

| | |
|---|---|
| 2 Na (22.99 g) = | 45.98 g |
| 2 C (12.01 g) = | 24.02 g |
| 4 O (16.00 g) = | 64.00 g |
| | 134.00 g |

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

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

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

$$+ \quad 100\%$$

Ex (2) Find the % of each element in vanillin, the chemical responsible for the scent of vanilla, $C_8H_3O_3$.

MM

| | |
|---|---|
| 8 C × 12.01 g = | 96.08 g |
| 3 H × 1.01 g = | 3.03 g |
| 3 O × 16.00 g = | 48.00 g |
| | 147.11 g |

$$\%C = \frac{96.08\,g}{147.11\,g} \times 100 = 65.31\%$$

$$\%H = \frac{3.03\,g}{147.11\,g} \times 100 = 2.06\%$$

$$\%O = \frac{48.00\,g}{147.11\,g} \times 100 = 32.63\%$$

Ex (3) Find the % of each element in cis-3-hexenal, the chemical responsible for the scent of fresh cut grass, $C_6H_{10}O$.

# 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 mols, 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 .5 or .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.

$\frac{63.5\text{g Ag}}{107.87\text{ g/mol}} = .5887\text{mol Ag}$

$\frac{8.2\text{g N}}{14.01\text{ g/mol}} = .5853\text{mol N}$

$\frac{28.3\text{g O}}{16.00\text{ g/mol}} = 1.7688\text{mol O}$

$\frac{.5887\text{mol Ag}}{.5853\text{mol}} = 1\text{ Ag}$

$\frac{.5853\text{mol N}}{.5853\text{mol}} = 1\text{ N}$

$\frac{1.7688\text{mol O}}{.5853\text{mol}} = 3\text{ O}$

E.F = $AgNO_3$

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

$$\frac{68.4\text{ g Cr}}{52.0\text{ g/mol}} = \frac{1.3154\text{ mol Cr}}{1.3154\text{ mol}} = (1\text{ Cr})2 = 2\text{ Cr}$$

$$\frac{31.6\text{ g O}}{16.0\text{ g/mol}} = \frac{1.9750\text{ mol O}}{1.3154\text{ mol}} = (1.5\text{ O})2 = 3\text{ O}$$

EF: $Cr_2O_3$

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 =

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

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

$$\frac{17.30\text{ g N}}{14.01\text{ g/mol}} = \frac{1.2348\text{ mol N}}{1.2348\text{ mol}} = 1\text{ N}$$

EF: $C_5H_7N$

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

Pb: $\frac{38.43}{60.00} \times 100 = 64.05\text{ g Pb}$; $\frac{64.05\text{ g Pb}}{207.20\text{ g/mol}} = .3091\text{ mol Pb}$; $\frac{.3091\text{ mol Pb}}{.3091\text{ mol}} = 1\text{ Pb}$

C: $\frac{17.83\text{ g}}{60.00\text{ g}} \times 100 = 29.72\text{ g C}$; $\frac{29.72\text{ g C}}{12.01\text{ g/mol}} = 2.4746\text{ mol C}$; $\frac{2.4746\text{ mol C}}{.3091\text{ mol}} = 8\text{ C}$

H: $\frac{3.74\text{ g}}{60.00} \times 100 = 6.23\text{ g H}$; $\frac{6.23\text{ g H}}{1.01\text{ g/mol}} = 6.1683\text{ mol H}$; $\frac{6.1683\text{ mol H}}{.3091\text{ mol}} = 20\text{ H}$

EF = $PbC_8H_{20}$

# 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 molecular mass is about 92 g/mol. Find the molecular formula.

MM MF = 92 g/mol

N 1(14.01 g) = 14.01 g
O 2(16.00 g) = 32.00 g
46.01 g

MM EF

$92/46 = 2$

M.F

$2(NO_2) = N_2O_4$

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

EF

$\frac{42.56\text{ g Pd}}{106.42\text{ g/mol}}$ $\frac{.8000\text{ g H}}{1.01\text{ g/mol}}$

$= \frac{.3999\text{ mol Pd}}{.3999\text{ mol}}$ $= \frac{.7921\text{ mol H}}{.3999\text{ mol}}$

= 1 Pd = 2 H

EF = $PdH_2$

Pd 106.42 g
2 H 2.02 g
108.44 g

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

M.F

$2(PdH_2) = Pd_2H_4$