Percent Composition, Empirical & Molecular Formulas Name BETH "KEY"

Percent composition is the percent by mass of each element found in a compound.

Example: What percent of iron(III) hydroxide, $Fe(OH)_3$, is oxygen?

Step 1: Find the molar mass of the compound.

1 mol Fe	=	55.85 g
3 mol O	= 3 × 16.00 g	= 48.00 g
3 mol H	= 3 × 1.008 g	= 3.024 g
Molar Mass $Fe(OH)_3$	=	106.87 g/mo

Step 2: Find the percentage by dividing the part by the whole and multiplying by 100.

$$\frac{48.00\text{ g O}}{106.87\text{ g Fe(OH)}_3} \times 100\,\% = 44.91\%\text{ oxygen}$$

Part 1: Finding Percent

1. What percent of magnesium bromide, $MgBr_2$, is magnesium?

1 Mg • 24.31 g/mol = 24.31g
2 Br • 79.90g/mol = 159.80g
184.11 g/mol $MgBr_2$

$\frac{24.31g\ Mg}{184.11g} \times 100 =$ 13.20% Mg

$\frac{159.80g\ Br}{184.11g} \times 100 =$ 86.796% Br

2. What percent of glucose, $C_6H_{12}O_6$, is carbon?

6C • 12.01g/mol = 72.06 g C
12H • 1.01 g/mol = 12.12g H
6O • 16.00 g/mol = 96.00g O
180.18g/mol $C_6H_{12}O_6$

$\frac{72.06g\ C}{180.18g} \times 100 =$ 39.99% C

$\frac{12.12g\ H}{180.18g} \times 100 =$ 6.727% H

$\frac{96.00g\ O}{180.18g} \times 100 =$ 53.28% O

3. What percent of $Zn_3(PO_4)_2$ is zinc?

3Zn • 65.41g/mol = 196.23g Zn
2P • 30.97g/mol = 61.94g P
8O • 16.00g/mol = 128.00g O
386.17g/mol $Zn_3(PO_4)_2$

$\frac{196.23g\ Zn}{386.17g} \times 100 =$ 60.162% Zn

$\frac{61.94g\ P}{386.17g} \times 100 =$ 16.04% P

$\frac{128.00g\ O}{386.17g} \times 100$ = 33.146% O

4. Which has the higher percent of aluminum, Al_2O_3 or $Al(NO_3)_3$?

MM Al_2O_3 = 101.96g/mol
$\frac{53.96g\ Al}{101.96g/mol} \times 100 =$ 52.92% Al

MM $Al(NO_3)_3$ = 213.00g/mol
$\frac{26.98}{213.00} \times 100 =$ 12.67% Al

Al_2O_3 has a higher %

Part 2: Find the percent compositions of all of the elements in the following compounds and name all compounds:

5. $CuBr_2$ Name Copper (II) Bromide

MM = 223.37g/mol
$\frac{63.55g\ Cu}{223.37g} \times 100 =$
%Cu: 28.45 %

79.90g Br • 2 = 159.80g Br
%Br: 71.540 %
$\frac{159.80g\ Br}{223.37g} \times 100 =$

6. $(NH_4)_2S$ Name Ammonium Sulfide

MM = 68.15 g/mol

%N: 41.12 %H: 11.9% %S: 47.06

7. N_2S_2 Name dinitrogen disulfide

MM = 92.14 g/mol

%N: 30.41 %S: 69.61

8. $Al_2(SO_4)_3$ Name Aluminum Sulfate

MM = 342.15 g/mol

%Al: 15.77% %S: 28.12 %O: 56.116

Part 3: Empirical Formulas: Find the empirical formula for the following compounds. See page 2 in Baby Blue and pages 86-89 in Big Blue.

9. C_6H_6 $\frac{6}{6}$ CH
10. C_8H_{18} $\frac{2}{2}$ $\frac{2}{2}$ C_4H_9
11. WO_2 $\frac{1}{1}$ WO_2
12. $C_2H_6O_2$ $\frac{2}{2}$ $\frac{2}{2}$ $\frac{2}{2}$ CH_3O
13. $X_{39}Y_{13}$ $\frac{13}{13}$ $\frac{13}{13}$ X_3Y

Example Problem: A compound with an empirical formula of C_2OH_4 and a molar mass of 88 grams per mole. What is the molecular formula of this compound?

First find the empirical formula mass of the compound.
Carbon: 2 (12.01 g/mol)
Oxygen: 1 (16.00 g/mol)
Hydrogen: 4 (1.01 g/mol)
44.01 g/mol

So this compound has a molar mass of 88.02 g/mol and an empirical formula mass of 44.01 g/mol. So the molecular formula must have twice as many of each atom as the empirical formula.

88 / 44 = 2

Molecular formula is 2 times the empirical formula
$2(C_2OH_4) = C_4O_2H_8$

14. A compound with an empirical formula of C_4H_4O and a molar mass of 136 grams per mole. What is the molecular formula of this compound?

MM C_4H_4O = 68 g/mol

$$\frac{\text{Molecular Mass}}{\text{Molar Mass}} = \frac{136}{68} = 2$$

$2(C_4H_4O)$ = $\boxed{C_8H_8O_2}$

15. A compound with an empirical formula of C_2H_8N and a molar mass of 46 grams per mole. What is the molecular formula of this compound?

MM C_2H_8N = 46 g/mol

46/46 = 1

Molecular Formula = Empirical Formula

$\boxed{C_2H_8N}$

16. Nitrogen and oxygen form an extensive series of oxides with the general formula NxOy. One of them is a blue solid that comes apart, reversibly, in the gas phase. It contains 36.84% N. What is the empirical formula of this oxide?

Pretend you have 100 grams of this substance. That way you can convert all the percentages directly into grams.

Divide all mol values by the smallest # of moles.

$\frac{36.84\text{g N}}{14.01\text{g/mol}} = 2.630\text{ mol N}$

$\frac{2.630}{2.630} = 1$

100 − 36.84 g = g O = 63.16 g O

$\frac{63.16\text{g O}}{16.00\text{g/mol}} = 3.948\text{ mol O}$

$\frac{3.948}{2.630} = 1.5$

MUST HAVE WHOLE # RATIO SO....

$2(N_1O_{1.5})$

$= N_2O_3$

17. A sample of indium chloride weighing 0.5000 g is found to contain 0.2404 g of chlorine. What is the empirical formula of the indium compound?

0.5000 g Indium Chloride − 0.2404 g Cl = 0.2596 g In

$\frac{0.2404\text{g Cl}}{35.45\text{g/mol}} = 6.781\times10^{-3}\text{ mol Cl}$

$\frac{6.781\times10^{-3}}{2.261\times10^{-3}} = 3$

$\frac{0.2596\text{g In}}{114.82\text{g/mol In}} = 2.261\times10^{-3}\text{ mol In}$

$\frac{2.261\times10^{-3}}{2.261\times10^{-3}} = 1$

Metal always first in formula!

$\boxed{InCl_3}$

18. Rubbing alcohol was found to contain 60.0 % carbon, 13.4 % hydrogen, and the remaining mass was due to oxygen. What is the empirical formula of rubbing alcohol?

60.0% C + 13.4% H + x = 100%

x = % O = 26.6%

$\frac{60.0\text{g C}}{12.01\text{g/mol}} = 5\text{ mol C} \div 1.66625 = 3$

$\frac{13.4\text{g H}}{1.01\text{g/mol}} = 13.27\text{ mol H} \div 1.66625 = 8$

$\frac{26.6\text{g O}}{16.00\text{g/mol}} = 1.66625\text{ mol} \div 1.66625 = 1$

$\boxed{C_3H_8O}$