Percent By Mass, Empirical Formulas, and Combustion Analysis

1. What is the percent by mass of phosphorous, calcium, and oxygen in $Ca_3(PO_4)_2$?

   M_m $Ca_3(PO_4)_2$ = 310.18 g/mol, M_m P = 30.9738 g/mol, M_m Ca = 40.078 g/mol, M_m O = 15.9994 g/mol

$$\%Ca = \frac{3\times 40.078\ g/mol}{310.18\ g/mol} \times 100 = \mathbf{38.8\%} \qquad \%P = \frac{2\times 30.9738\ g/mol}{310.18\ g/mol} \times 100 = \mathbf{20.0\%}$$

$$\%O = \frac{8 \times 15.9994\ g/mol}{310.18\ g/mol} \times 100 = \mathbf{41.3\%}$$

2. Write the empirical formula for Al_8O_{12}.

   Al_2O_3

3. If a compound contains 59.9% carbon, 8.06% H, and 32.0% O, what is the empirical formula?

Assume 100.0 g of compound. Convert grams H, O, and C to moles.
59.9 g C = 4.987 mol C, 8.06 g H = 7.9965 mol H, 32.0 g O = 2.0 mol O
$C_{4.987}H_{7.9964}O_{2.00}$ Divide the subscripts by 2.00

$$C_{\frac{4.987}{2.00}}H_{\frac{7.9965}{2.00}}O_{\frac{2.00}{2.00}} = C_{2.49}H_4O$$

Multiply the subscripts by 2
The empirical formula is $\boldsymbol{C_5H_8O_2}$

4. A compound contains 28.03 g Mg, 21.60 g Si, 1.16 g H, and 49.21 g of O. What is the empirical formula?

   Convert g Mg, g Si, g H, and g of O to mols

   28.03 g Mg = 1.1533 mol Mg, 21.60 g Si = 0.7691 mol Si,
   1.16 g H = 1.151 mol H, 49.21 g O = 3.0757 mol O

   $Mg_{1.1533}Si_{0.7691}H_{1.151}O_{3.0757}$ Divide subscripts by 1.151

   $Mg_{\frac{1.1533}{1.151}}Si_{\frac{0.7691}{1.151}}H_{\frac{1.151}{1.151}}O_{\frac{3.0757}{1.151}}$ $MgSi_{0.668}HO_{2.67}$ Multiply subscripts by 3
   The empirical formula is $\mathbf{Mg_3Si_2H_3O_8}$ This compound is called chrysotile asbestos. This is found in 90% to 95% of buildings.

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5. A 3.87 g sample of an acid contains C, H, and O. During the combustion analysis, 5.80 g of CO_2 and 1.58 g of H_2O was produced. What is the empirical formula of this acid? If the molar mass of the acid was determined to be 176.12 g/mol, what is the molecular formula?

Find moles of C $5.80\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.0\ g\ CO_2} \times \frac{1\ mol\ C}{1\ mol\ CO_2} = 0.131818\ mol\ C$

0.131818 mol C = 1.5833 g C

Moles of H = $1.58\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g\ H_2O} \times \frac{2\ mol\ H}{1\ mol\ H_2O} = 0.17536\ mol\ H$

$0.17536\ mol\ H = 0.17675\ g\ H$

Moles of Oxygen = 3.87 g – (1.583 g + 0.17675 g) = 2.11 g O

2.11 g O = 0.13188 mol O

$C_{0.131818}H_{0.17536}O_{0.13188}$ Divide the subscripts by 0.131818

$$C_{\frac{0.131818}{0.131818}}H_{\frac{0.17536}{0.131818}}O_{\frac{0.13188}{0.131818}} = CH_{1.33}O$$

Multiply the coefficients by 3. The empirical formula is **$C_3H_4O_3$**

The molar mass of the empirical formula is 88.063 g/mol.

$$\frac{176.12\ g/mol}{88.063\ g/mol} = 1.99 \approx 2$$

Multiply the subscripts of the empirical formula by 2

The molecular formula is **$C_6H_8O_6$**

This is actually the molecular formula for ascorbic acid, vitamin C.

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