Empirical Formula

An empirical formula is the **smallest whole number mole ratio** of the atoms in the element.

When calculating an empirical formula we are usually given the mass of the elements (or the mass ratio or percent composition).

We need to convert this mass into moles and then find the smallest whole number ratio.

Example

A particular compound contains 29.44 % calcium, 23.55% sulfur and 47.01% oxygen. What is the empirical formula?

Step 1 - assume an easy amount to convert the percent to mass (an easy amount is 100 grams).

29.44 g Ca, 23.55 g S and 47.01 g O

Step 2 - convert the mass of each element to moles

$$29.44 \text{ g Ca} \times \frac{1 \text{ mole Ca}}{40.08 \text{ g Ca}} = \frac{.7345 \text{ mole Ca}}{.7344} \qquad 1 \text{ mole Ca}$$

$$23.55 \text{ g S} \times \frac{1 \text{ mole S}}{32.066 \text{ g S}} = \frac{.7344 \text{ mole S}}{.7344} \qquad 1 \text{ mole S}$$

$$47.01 \text{ g O} \times \frac{1 \text{ mole O}}{15.9994 \text{ g O}} = \frac{2.938 \text{ mole O}}{.7344} \qquad 4 \text{ mole O}$$

$CaSO_4$

Step 3 - change this decimal ratio to a whole number ratio - one trick is to divide them all by the smallest number

Example 2

A compound contains 17.55% sodium, 39.70% chromium and 42.75% oxygen. What is the empirical formula.

$$17.55 \text{ g Na} \times \frac{1 \text{ mole Na}}{22.98977 \text{ g Na}} = \frac{.7634 \text{ mole Na}}{.7634} = 1 \text{ mole Na} \quad x2 = 2 \text{ mole Na}$$

$$39.70 \text{ g Cr} \times \frac{1 \text{ mole Cr}}{51.9961 \text{ g Cr}} = \frac{.7635 \text{ mole Cr}}{.7634} = 1 \text{ mole Cr} \quad x2 = 2 \text{ mole Cr}$$

$$42.75 \text{ g O} \times \frac{1 \text{ mole O}}{15.9994 \text{ g O}} = \frac{2.672 \text{ mole O}}{.7634} = 3.5 \text{ mole O} \quad x2 = 7 \text{ mole O}$$

$Na_2Cr_2O_7$