Working out empirical formulae

The empirical formula is the **simplest ratio** of the different atoms in it. For example, for ethane it is CH_3. You can work out the empirical formula of a compound if you know the **mass** of each element in it. This is really the reverse of finding the % mass of a compound from its formula. The method is below.

Example What is the empirical formula of a compound that contains 27.3% carbon and 72.7% oxygen by mass?

Step 1 *Find, and write down the relative atomic masses of the elements involved.*

$A_r(C) = 12$ and $A_r(O) = 16$

Step 2 *Assume that you have 100g of the compound (this makes the maths easy).*

$\therefore$ In 100g there is 27.3g of carbon and 72.7g of oxygen

Step 3 *Work out how many moles of each element this must be using* $\text{number of moles} = \dfrac{\text{mass}}{\text{Ar}}$

$$\text{number of moles of carbon} = \frac{27.3}{12} = 2.275 \qquad \text{number of moles of oxygen} = \frac{72.7}{16} = 4.55$$

Step 4 *Divide both numbers of moles by the smallest number (2.275 in this case).*

$$\text{number of moles of carbon} = \frac{2.275}{2.275} = 1 \qquad \text{number of moles of oxygen} = \frac{4.55}{2.275} = 2$$

$\therefore$ **In the empirical formula, there are 1 carbon atom and 2 oxygen atoms, so it is CO_2.**

Note You can use the same method if you are told how many grams of each element react together to make the compound. In this case, you might be told that 27.3g of carbon react with 72.7g of oxygen atoms. You start at step 3. Another way of asking the question is to tell you how many grams of each element there are in the compound. Again, start from step 3.

1. Find the empirical formulae of the compounds which have the following % compositions by mass:
   a) 60% magnesium, 40% oxygen
   b) 36% beryllium, 64% oxygen
   c) 80% carbon, 20% hydrogen.

2. Find the empirical formulae of the following compounds:
   a) A compound containing 4g of hydrogen and 32g of oxygen
   b) A compound containing 24.0g of calcium and 5.6g of nitrogen
   (Hint: if you get a ½ in your answer, multiply by 2 to make whole numbers)
   c) A compound containing 0.31g of phosphorus and 1.07g of chlorine.

3. Find the empirical formulae of the compounds formed when:
   a) 4.00g of mercury forms 4.64g of a mercury sulphide
   b) 0.62g of phosphorus forms 1.10g of a phosphorus chloride
   c) 5.60g of iron forms 10.65g of an iron chloride