

# Empirical formulae.

An empirical formula is the simplest mol ratio of elements present in a compound. As long as we know the percentage composition of the compound or the mass of each element present in a given mass of the compound then we can find the empirical formula. Below are two examples.

Example 1 - An organic compound was analysed and found to contain the following percentage composition by mass. 59.9% C, 8.1% H, 32.0% O. Calculate its empirical formula.

Follow the steps below

Step 1 Find the mass of each element or convert the percentage composition into mass by assuming you have 100 grams of the compound.

*59.9/12.0 C : 8.1/1.0 H : 32.0/16 O*

*=> 5.0 C : 8.1 H : 2.0 O*

Step 3 Find the simplest mol ratio of each element by dividing by the lowest number of mol.

*Divide all by the lowest number of mol (2.0)*

*5.0/2.0 C : 8.1/2.0 H : 2.0/2.0 O*

*2.5C:4H:O*

Step 4 Multiply to remove any fractions

*It is clear from the ratio that the numbers are nowhere near whole numbers and hence we cannot simply round up or down. Here we have 2.5 mol of carbon for every 4 mol of hydrogen and 1mol of oxygen. We therefore remove the fraction by multiplying the entire ratio by 2.*



Example 2- A 5.82 grams sample of an unknown oxide of aluminium ( $Al_xO_y$ ) was analysed and found to contain 3.08 grams of aluminium. Calculate its empirical formula.

Follow the steps below

Step 1 Find the mass of each element or convert the percentage composition into mass by assuming you have 100 grams of the compound.

*Since we are given masses and not percentages we must do some simple calculations first to find the mass of each element. We know that given 5.82 grams of the substance, 3.08 grams of aluminium is present. We can now find the mass of oxygen 2.74 (5.82 - 3.08) grams, since oxygen is the only other element present.*

Step 2 Calculate the mol of each element present by dividing each element by its relative atomic mass.

*3.08/27.0 Al : 2.74/16.0 O*

*=> 0.114 Al : 0.171 O*

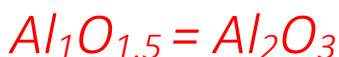
Step 3 Find the simplest mol ratio of each element by dividing by the lowest number of mol.

*0.114/0.114 Al : 0.171/0.114 O*

*1 Al : 1.5 O*

Step 4 Multiply to remove any fractions

*It is clear from the ratio that the numbers are nowhere near whole numbers and hence we cannot simply round up or down. Here we have 1.5 mol of oxygen for every mol of aluminium. We therefore remove the fraction by multiplying the entire ratio by 2.*



## Empirical formulae exercises

1) A polymer is a large molecule composed of smaller repeating units and so has a relatively simple empirical formula. Below are some polymers, usually plastics with their percentage composition, by mass. Calculate the empirical formula of each.

(a) Poly(methyl methacrylate), also known as acrylic or acrylic glass: 59.9% C, 8.06% H, 32.0% O

(b) Polyvinylidene chloride was the predecessor to polyethylene or *Cling Wrap*; 24.8% C, 2.0% H, 73.2% Cl

(c) polyethylene; 86% C, 14% H

(d) polystyrene; 92.3% C, 7.7% H

(e) Orlon is a strong polymer used to make knitting threads; 67.9% C, 5.70% H, 26.4% N



2) A gaseous hydrocarbon is used in the welding of metal. Determine its empirical formula if it contains 92.3% carbon.

[Solution](#)

3) P.V.C. is used to make plastic drain pipes. When analysed it is found to contain, by mass, 4.84% hydrogen, 38.4% carbon and 56.7% chlorine. What is its empirical formula?

[Solution](#)

4) A 5.23 gram sample of iron oxide was analysed and was found to contain 3.68 grams of iron. Calculate the empirical formula of this oxide.

[Solution](#)

5) When 3.90 grams of iron is burned in oxygen 5.00 grams of an oxide of iron is formed. What is the empirical formula of the oxide?

6) A compound is found to contain, by mass, 26.56% potassium, 35.41% chromium, and the remainder oxygen. Find its empirical formula.

7) A 60.00 g sample of tetraethyllead, a gasoline additive, is found to contain 38.43 g lead, 17.83 g carbon, and 3.74 g hydrogen. Find its empirical formula.

8) Determine the empirical formula for a compound with the following percent composition, by mass, 15.8% carbon and 84.2% sulphur.

9) Determine the empirical formula for a compound with the following percent composition, by mass, 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen

10) A 9.90 gram sample of pure *Polyvinylidene chloride*, from question 1b above, contains 0.100 mol of the pure substance. Give the molecular formula of *Polyvinylidene chloride*.