Empirical Formula Notes

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The empirical formula: is the simplest ratio of the numbers of each kind of atom or ion in a compound.

Exam note: we can be asked to calculate the empirical formula of a compound from its masses.
We could also be asked to figure out the empirical formula from the numbers of atoms in a compound or from a diagram. Let's look at determining the empirical formula from the number of atoms first.

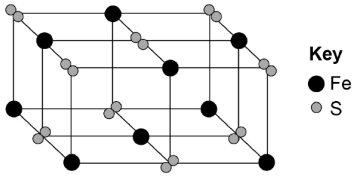
Determining the empirical formula from the number of atoms

This is easier than it sounds, the question might give you the molecular formula of a compound like glucose for example, $C_6H_{12}O_6$. All we have to do is divide by the highest common factor, 6, to get CH_2O.

So, the empirical formula for glucose is **CH_2O**. That's it 😊

Determining the empirical formula from a diagram

This is also quite straight forward 😊 Take the example below.



Q. *The figure on the left shows iron pyrite. Determine the empirical formula of iron pyrite.*

Answer: *do not look at one iron atom! Add up all of the iron atoms and all of the sulphur atoms. There are 9 iron atoms and 18 sulphur atoms. This would give us Fe_9S_{18}. We notice that 9 is the highest common factor so we divide by 9. This will give us FeS_2. The empirical formula is FeS_2.*

Finding the empirical formula by calculation

The empirical formula of a compound can be calculated if its mass is known. It's a straight forward calculation, to make things easier we usually do this calculation in a table 😊

Example 1: 10g of a compound containing N and O only contains 2.59g of N. What is its empirical formula?

	N	O
mass	2.59	7.41
Ar	14	16
moles	0.185	0.463
Divide by the smallest value	0.185 ÷ 0.185 = 1	0.463 ÷ 0.185 = 2.50
Multiply to get whole numbers (x 2) (If needed)	2	5

So, we have two nitrogen atoms and 5 oxygen atoms. This gives us an **empirical formula of N_2O_5**.

Example 2: A compound contains 22.2% N, 76.2% O and 1.6% H by mass. Find its empirical formula.

(Hint: just treat the percentage as if it were grams 😊)

	N	O	H
mass	22.2	76.2	1.6
Ar	14	16	1
moles	1.59	4.76	1.6
Divide by the smallest value	1.59 ÷ 1.59 = 1	4.76 ÷ 1.59 = 2.99	1.6 ÷ 1.59 = 1.01
Round when close to whole numbers	1	3	1

So, we have one nitrogen atoms, 3 oxygen atoms and 1 hydrogen atom. This gives us an empirical formula of **HNO_3.**

Let's look at one more example while we're here.

Example 3: A student heated 3.175g of copper in a crucible with excess oxygen. At the end of the reaction, they obtained 4.775g of copper oxide. Calculate the empirical formula of the copper oxide formed.
(Relative atomic masses: Cu = 63.5, O = 16)

Step 1: we notice that we aren't give the mass of oxygen in the copper oxide. So, the first thing we need to do here is subtract 3.175 from 4.775. This will give us the mass of oxygen.

$$4.775\text{g} - 3.175\text{g} = 1.60\text{g}$$

So the mass of oxygen is 1.60g

Step 2: use the table, fill it in and away we go 😊

	Cu	O
mass	3.175	1.6
Ar	63.5	16
moles	0.05	0.1
Divide by the smallest value	0.05 ÷ 0.05 = 1	0.1 ÷ 0.05 = 2

So the empirical formula is CuO_2