## How to Count Atoms in a Chemical Formula \& Chemical Equation

Skills needed:
Recognize the individual elements in the formula
Recognize the subscript as the number of atoms
Recognize polyatomic ions from their formula
Recognize the coefficients in a chemical equation
How to Recognize the individual elements in the formula-
Start at the left side of the formula and underline the Capital letter plus any lower case letter that occurs before the next capital letter in the formula

NaCl you will underline the $\mathbf{N a}$
Now continue with the remaining elements in the formula
NaCl this means that NaCl has two different elements in the formula
Another example- $\mathrm{NH}_{4} \mathrm{SO}_{4}--$ you will underline the N , then the H , followed by the S and finally the $\mathbf{O}$. That will give you 4 different elements in the chemical compound

How to Recognize the Number of Atoms of an element in the formula
The key is the subscript number written after the Element symbol in the formula; unless a subscript is absent and in this case it is understood that there is only 1 atom
$\mathrm{Fe}_{2} \mathrm{~S}_{3}$ has 2 Fe atoms and 3 S atoms
NaCl has 1 atom of Na and 1 atom of Cl
How do you Recognize a Polyatomic Ion
Polyatomic ions are easily recognized in the formula when there are more than two elements in the formula. Once you know that you can check your Chem Reference Sheet to determine its name
$\mathrm{FeSO}_{4}$ you count three elements- $\mathrm{Fe}, \mathrm{S}$ and O which means that you have a polyatomic ion and in this case it's called sulfate. The number of atoms of each element are $\mathrm{Fe}=1$, $S=1$ and $O=4$

Watch out if there the compound has more than one of the polyatomic ion- these are identified by a parenthesis around the polyatomic ion followed by a subscript.
$\mathrm{Ca}(\mathrm{OH})_{2}$ is calcium hydroxide. Using the rules from above we know that there are Ca , $O$ and $H$ atoms in the compound. Since there is no subscript after the Ca has 1 atom but there are two OH polyatomic ions as indicated by the 2 after the parenthesis giving us 2 Os and 2 Hs . This deciphering approach involves writing the polyatomic ion out the appropriate number of times ( 2 in this case) and counting the atoms of each element. There is a mathematical way that simply has you take the subscript of the element inside the parenthesis and multiply it by the subscript for the entire polyatomic ion outside the parenthesis. In our example, you notice the absence of subscripts for the $\mathbf{O}$ and $\mathbf{H}$ therefore there is one atom of each. Thus, it's 1 time 2 (from the subscript outside the parenthesis) for 2 atoms of $O$ and the same for the $H$.

How to Recognize the Coefficients in a Balanced Chemical Equation
Remember that the chemical formula represents a molecule of the compound and a molecule is two or more atoms bonded together. Sometimes in balancing a chemical equation you need more than 1 molecule of a chemical substance. To denote this we write a number in front of the chemical formula. That number is called the coefficient and tells you how many molecules of that element you need.
$2 \mathrm{NaOH}+\mathrm{H}_{2} \mathrm{SO}_{4}--->\mathrm{Na}_{2} \mathrm{SO}_{4}+2 \mathrm{H}_{2} \mathrm{O}$
This means that it takes 2 molecules of NaOH (sodium hydroxide) to react with 1 molecule of $\mathrm{H}_{2} \mathrm{SO}_{4}$ (sulfuric acid) to produce 1 molecule of $\mathrm{Na}_{2} \mathrm{SO}_{4}$ (sodium sulfate) and 2 molecules of $\mathrm{H}_{2} \mathrm{O}$ (water)

To determine the number of sodium ions (Na) you can write the NaOH twice and count the number of Na atoms giving you two (2); likewise there are 2 Os from the NaOH and 2 Hs . Another way is to use mathematics whereby you multiply the subscript number from the formula for that element by the coefficient. For example there is 1 Na from NaOH and we multiply it by 2 from the coefficient giving us 2 Na atoms.
$2\left(\mathrm{NH}_{4}\right)_{3} \mathrm{PO}_{4}+3 \mathrm{CaCl}_{2}--->3\left(\mathrm{NH}_{4}\right)_{2} \mathrm{Cl}+\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}$
Calculating the number of Ns in the $2\left(\mathrm{NH}_{4}\right)_{3} \mathrm{PO}_{4}$ is 6 which is determined by the fact that there are 3 Ns in the formula and 2 molecules thereby giving us $3 \times 2=6$. For the Hs we take 4 from the $\mathrm{NH}_{4}$ and multiply it by the subscript 3 and then multiply that product (12) by 2 giving us 24 Hs.

Other numbers of atoms for the above chemical equation are:
For $2\left(\mathrm{NH}_{4}\right)_{3} \mathrm{PO}_{4}$ is $1 P \times 2=2 \mathrm{Ps} ; 4 O \times 2=8$
For $\mathrm{H}_{2} \mathrm{SO}_{4}$ there is no coefficient and therefore you treat it like we did before when dealing with the formula alone- $2 \mathrm{Hs}, 1 \mathrm{~S}$ and 4 Os.

For $3\left(\mathrm{NH}_{4}\right)_{2} \mathrm{Cl}$ you have 6 Ns calculated by 1 N in the polyatomic $\mathrm{NH}_{4}$ times 2 of them time the coefficient 3; 24 H from $4 \times 2 \times 3 ; 3$ Cl

For $\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ there is only one molecule (no coefficient) so the number of different atoms is- $3 \mathrm{Ca}, 2 \mathrm{P}$ and 8 O .

