

Writing Formulae Notes

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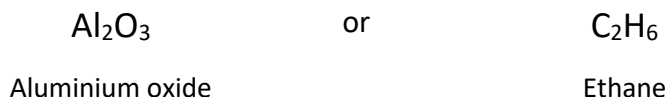


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A chemical formula is a universal shorthand that tells us exactly which atoms, and how many of each, are in a substance. The key is knowing that the rules depend on the type of bonding!

Note: Formulae is the plural of formula.

I'm sure that you have seen lots of formulae in chemistry. When you have looked at them you might have thought, "oh, why does the formula look like that?" The following are examples of formulae:

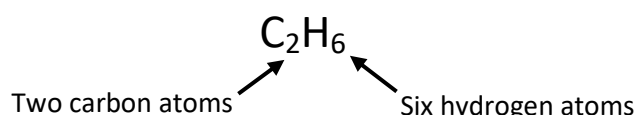
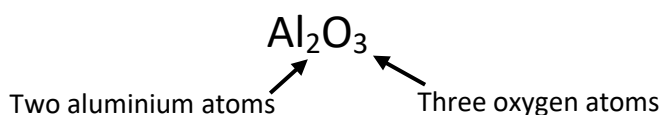


Formulae – what do I need to know?

What are they? Formulae are a shorter way of writing the name of a molecule. Formulae give us a lot of information about the molecule.

What do these formulae tell us? They tell us about the numbers of each type of atom in the molecule.

Let's have a look at two different examples 😊



What are the small numbers? These are called subscripts. In a formula these cannot be changed or you will change the identity of the molecule. For example, Al_3O_4^+ is not the same thing as Al_2O_3 .

Writing formulae is a key skill in chemistry. Ionic and covalent formulae are written differently. Let's look at ionic formulae first.

Ionic Formulae – how do we write them?

Ionic compounds are made up of ions. Let's take a moment to remind ourselves what ions are.

Ions: are electrically charged particles that are formed when electrons are lost or gained from an atom.

Cations: are positive ions.

Anions: are negative ions.

Ionic formula rule: the final formula must be electrically neutral, meaning the positive and negative charges must cancel each other out.

Take the following examples:

Sodium Chloride



The charges are 1 plus to 1 minus.

So, the formula is just



Sodium Oxide



The charges are 1 plus to 2 minuses.

So, we need two sodium ions to cancel out the oxide ion.

The formula then is:



How do we figure out the charges of each of the ions? We use the periodic table 😊

Check out the table below.

Group in Periodic Table	What it does	Charge on its ion	Example
Group 1 (e.g. Na, K)	Loses 1 electron	+1	Na ⁺ and K ⁺
Group 2 (e.g. Mg, Ca)	Loses 2 electrons	+2	Mg ²⁺ and Ca ²⁺
Group 3 (e.g. Al)	Loses 3 electrons	+3	Al ³⁺ and Ga ³⁺
Group 5 (e.g. N, P)	Gains 3 electrons	-3	N ³⁻ and P ³⁻
Group 6 (e.g. O, S)	Gains 2 electrons	-2	O ²⁻ and S ²⁻
Group 7 (e.g. Cl, Br)	Gains 1 electron	-1	F ⁻ and Cl ⁻

Now that we know how the charges are applied, let's look at another example 😊

Example 1: What is the formula for magnesium chloride? Let's do this step by step.

Step 1: symbols and charges: we write down the symbols for the ions.

Magnesium is in group 2 so it will lose two electrons to be a single Mg²⁺ ion.

Chloride is in group 7 so it will gain one electron to become a Cl⁻ ion.

Step 2: swap and drop: we swap the charge numbers (without the charges) and drop them down to become the subscript for the other ion. So right now we have the following ions...



Swap – we swap the charge numbers between the atoms but leave out the charges. This gives us...



Drop – we just drop down the numbers and use them as subscripts. This gives us...



Step 3: we write the formula: we now just put them together and leave out the number one.



Let's, look at another example of an ionic compound.

Example 2: What is the formula for aluminium hydroxide?

Step 1: symbols and charges: we write down the symbols for the ions.

Aluminium is in group 3 so it will lose three electrons to be a single Al³⁺ ion.

Hydroxide is a group ion whose formula we must learn. This is an OH⁻ ion.

Step 2: swap and drop: we swap the charge numbers (without the charges) and drop them down to become the subscript for the other ion.



Step 3: we write the formula: we now just put them together and leave out the number one.



Transition Metal Formulae – how do we write them?

Transition metal formulae are a slightly different version of ionic formulae. Transition metals can have different charges. Iron, for example, can be Fe^{2+} or Fe^{3+} , how can I tell which one to use?

The formula will tell you the charge using roman numerals. So, Fe^{2+} will be Fe(II) and Fe^{3+} will be Fe(III).

Metal ions: metals always form cations (positive ions).

Formula rule: just like ionic formulae, the charges of each ion in the molecule must cancel each other out.

Let's have a look at a couple of examples.

Example 3: What is the formula for iron(II) oxide?

Step 1: symbols and charges: we write down the symbols for the ions.

Iron is a transition metal so we need to use the roman numerals that go with it to determine its charge, in this case it will be Fe^{2+} .

Oxygen is in group 6 so it will gain two electrons to become a O^{2-} ion.

Step 2: swap and drop: we swap the charge numbers (without the charges) and drop them down to become the subscript for the other ion. So right now we have the following ions...



Note: as the subscript numbers are the same we can just simplify by dividing by 2.

Step 3: we write the formula: we now just put them together.



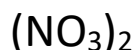
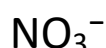
Example 4: What is the formula for copper(II) nitrate?

Step 1: symbols and charges: we write down the symbols for the ions.

Copper is a transition metal so we need to use the roman numerals that go with it to determine its charge, in this case it will be Cu^{2+} .

Nitrate is a group ion who's formula we must learn is an NO_3^- ion.

Step 2: swap and drop: we swap the charge numbers (without the charges) and drop them down to become the subscript for the other ion. So right now we have the following ions...



Step 3: we write the formula: we now just put them together.



Covalent Formulae – how do we write them?

Covalent compounds are made up of atoms that **share electrons** so that they can have full outer shells of electrons.

Covalent formula rule: each atom should have a full outer shell of electrons.

A few handy bonding points to remember are that carbon always forms **four bonds**, oxygen always forms **two bonds** and hydrogen always forms **one bond**.

How do we know how many bonds an atom will form?

For non-metals, there is a simple pattern linked to the periodic table. This number is sometimes called its **valency**.

Group in Periodic Table	What it does to get a full outer shell	Bonds it forms (Valency)
Group 4 (e.g. C, Si)	Needs to gain 4 electrons	4
Group 5 (e.g. N, P)	Needs to gain 3 electrons	3
Group 6 (e.g. O, S)	Needs to gain 2 electrons	2
Group 7 (e.g. Cl, Br)	Needs to gain 1 electron	1
Hydrogen (special case)	Needs to gain 1 electron	1

Note: a handy little shortcut is to take the group number away from 8. This will work for groups 4 to 7.

$$\text{Bonds formed} = 8 - \text{group number}$$

Let's have a look at an example 😊

Example 5: What is the formula for water?

Step 1 – symbols and valency: we state the symbols and the number of bonds each atom needs to form.

Hydrogen (H) needs to form 1 bond.

Oxygen (O) is in group 6 and needs to form 2 bonds.

Step 2 – swap and drop: we can use the same "swap and drop" method as for ionic formulae, but remember these numbers represent the number of bonds that each atom needs to form, not the ionic charges!

We swap the valency numbers and they become the subscript for the other atom.

H – valency 1

H₂

O – valency 2

O₁

Step 3 – write the formula: We now just put them together and leave out the number one.

H₂O

This makes sense! One oxygen atom needs to make 2 bonds. Each hydrogen atom can only make 1 bond.

So, the oxygen atom must bond with two hydrogen atoms. 😊

Common Ions

Here are a few common ions that we must learn off by heart... You're welcome 😊

Ammonium – NH₄⁺

Hydroxide – OH⁻

Nitrate – NO₃⁻

Hydrogencarbonate – HCO₃⁻

Sulfate – SO₄²⁻

Carbonate – CO₃²⁻