

Naming Ionic Compounds

In my time as a teacher, probably the most common question people have for me is “What’s the deal with your beard?” The next common question people have for me is “How do I name ionic compounds?” We’ll explore the answer to one of these questions in this tutorial.



But seriously, what’s up with the beard?

Before we name: Is it ionic?

Before you can write the names of ionic compounds, it’s important that you make sure you’re actually dealing with an ionic compound. After all, if you do a great job of naming your ionic compound but the compound is actually covalent, you still won’t get the answer right.

If you’ll recall the tutorial about ionic compounds, ionic compounds are compounds in which cations (ions with positive charge) are attracted to anions (ions with negative charge) in great big crystals. If you’ve got only nonmetals, and if the ammonium ion isn’t the cation, you’re probably looking at a covalent compound. Go check out the tutorial for those (links to the right of this page).

Writing the names of ionic compounds

If you’d like to learn to name ionic compounds, follow these steps. If you follow these steps, you’ll get everything right and your family will love you. If you don’t follow these steps, your life will descend into misery and bitterness until you eventually have a heart attack when you’re 45.



“...and while we’ve got him on the operating table, it wouldn’t be a bad idea to check his titration gland, either.”

With that totally realistic scenario bouncing around in your head, let’s get started with your stepwise ticket to Namingburg:

1) Ionic compound names consist of two words. The first word is the name of the cation (the first ion) and the second word is the name of the anion (the second one).

First word: naming the cation:

The cation is the first thing in the chemical formula. Here's how you figure out what word to write down to identify it:

- If the cation is a metal, write down the name of the metal.
- If the cation is the ammonium ion (NH_4^+), just write "ammonium" as the first word.

Using these, NaCl has the first word "sodium" and " Li_2SO_4 " has the first word "lithium." It's simple!

Second word: naming the anion:

The anion is the second thing in the chemical formula. Here's how you figure out what word to write down to identify it:

If the anion is just one element (as in the case of NaCl or CaF_2), just write the name of that element with "-ide" at the end. For example, the second word in NaCl would be "chloride" and the second word in CaF_2 is "fluoride".

If the anion has more than one element, then you've got yourself a polyatomic ion. A polyatomic ion is just a fancy way of referring to an ion that has more than one atom in it, like the nitrate ion (NO_3^-) or the sulfate ion (SO_4^{2-}) ion. In the case of polyatomic ions, just write down the names of the ions by consulting either a chart that tells you what they are or your brain (if your teacher is making you memorize them). In case you don't know what the polyatomic ions are, here's a list of some common ones you might want to familiarize yourself with:

<u>Table of common polyatomic ions</u>	
<u>Ion name</u>	<u>Formula/charge</u>
acetate	$\text{C}_2\text{H}_3\text{O}_2^{-1}$
ammonium	NH_4^{+1}
bicarbonate	HCO_3^{-1}
carbonate	CO_3^{-2}
chromate	CrO_4^{-2}
cyanide	CN^{-1}
hydroxide	OH^{-1}
nitrate	NO_3^{-1}
nitrite	NO_2^{-1}
permanganate	MnO_4^{-1}
phosphate	PO_4^{-3}
sulfate	SO_4^{-2}
sulfite	SO_3^{-2}

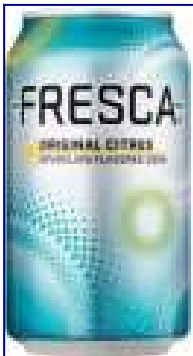
Things to keep in mind:

- Charges written as "-2" or "-2" are considered the same. It doesn't matter in which order you put the number and sign.
- A charge of +1 or -1 may be written as + or -, respectively.
- The bicarbonate ion is sometimes called the "hydrogen carbonate" ion in chemistry classes, but not in the real world.
- The acetate ion is sometimes shown as $\text{CH}_3\text{COO}^{-1}$. It means exactly the same thing as the formula shown here.
- There are many, many other polyatomic ions out there. Make sure you memorize those that your instructor finds important!

This makes NaNO_3 into “sodium nitrate” and PbCO_3 into “lead carbonate.” No biggie, right?

Step 2: Are we done yet?

It's possible that you're finished, and that you can stop writing your formula and go have a congratulatory Fresca¹ soda in one of seven flavors. Fresca: It's a taste and a feeling all wrapped up in one!²



Admit it: Like all people, you love the fresh, crisp flavor of Fresca.

However, it may be the case that you need to do some more stuff before you're finished naming the ionic compound. Let's find out if you're one of those lucky folks:

- **Transition metal cations need Roman numerals.** Exceptions: Zn, Ag, and Cd, which don't require Roman numerals.
- **Main block element cations don't need Roman numerals.** Exceptions: Pb, Sn, and Bi, which do require Roman numerals.
- **Ammonium doesn't need a Roman numeral.**

What is a Roman numeral? Move to Step 3 to find out...

Step 3: Finishing the formula with a Roman numeral

If the rules above have told you that you need a Roman numeral, then congratulations! You've got a little more work ahead of you. If they say that you did not need a Roman numeral, please stop reading. Your formula is finished and adding a Roman numeral will actually make it wrong.

The Roman numerals in formulas indicate the amount of positive charge on a cation. For example, the iron(II) ion has a charge of +2, and the copper(I) ion has a charge of +1. The reason some cations need this and some do not is that some cations can have more than one possible charge. For example, you can have copper with a charge of +1 or with a charge of +2, and it's important that you be able to distinguish them.

An example: CuCl vs. CuCl_2

The first compound, using the rules above, is called “copper chloride.” The second compound, using the rules above, is also called “copper chloride.” Though the compounds are clearly related to one another, it's just as clear that they are not the same thing. As a result, we use Roman numerals to tell people which one we're dealing with. How do we find the right one? I'm glad you asked...

How to find the Roman numeral:

Use the steps below to figure it out:

- Find out how many cations you have. This is the number written as a subscript below the formula of the cation. For example, FeF_2 has one iron atom, while Cu_2O has two copper atoms.
- Find out how many anions you have. If your anion is an element, this is the number written as a subscript below its formula. If your anion is a polyatomic ion, we can assume it's always "1" unless we see parentheses around the anion formula – in this case, the number after the parentheses is the number of anions. As a result, CuCl has one chlorine atom, CuCl_2 has two chlorine atoms, CuNO_3 has one nitrate ion, and $\text{Cu}(\text{NO}_3)_2$ has two nitrate ions.
- Find out the charge on the anion. If the anion is an element, just count on the periodic table to the next noble gas (for example, Cl is one away from Ar, giving it a charge of -1). If it's a polyatomic ion, you should either have the charge memorized or have a table on which you can look it up.
- The grand finale: The Roman numeral for this compound is found by using the numbers we found in this equation:

$$\text{Roman numeral} = \frac{(\text{number of anions})(\text{charge of anion})}{\text{number of cations}}$$

As an example, we would find that $\text{Fe}(\text{OH})_2$ has a Roman numeral of $(2)(-1)/1 = -2$. We'll just leave off the negative sign to call it 2, or II. As a result, $\text{Fe}(\text{OH})_2$ is iron(II) hydroxide.

Other examples to test your prowess:

- CuCl = copper(I) chloride
- MnO_2 = manganese IV) oxide
- $\text{Pb}_3(\text{PO}_4)_2$ = lead(II) phosphate

Because Roman numerals sometimes give people problems, here are some tips you can use to determine if your Roman numeral is wrong. I can't say for sure without seeing the example if you've done it right, but these are good signs that you need to try again:

- If your Roman numeral isn't a whole number, it's wrong.
- If your Roman numeral is greater than seven (VII), it's wrong.
- If you wrote a Roman numeral and you didn't have to, it's wrong.
- If the Roman numeral is 1 (I) and you left it off, it's wrong.
- If you don't remember what the Roman numerals are for each number, don't just write the number in regular numerals – you need to write them using the following numerals: I, II, III, IV, V, VI, VII.³

Anyway, that's how to name compounds. Because this whole tutorial took longer than I thought, I'll include writing ionic formulas in the next one.

Footnotes:

1. Fresca is a registered trademark of the Coca-Cola Company. The Coca-Cola Company neither sponsors nor endorses this website or anything included herein. It would be awesome if they did, but they don't.
 2. The slogan "It's a taste and a feeling all wrapped up in one!" is copyrighted by the Coca-Cola Company, who neither sponsors nor endorses this website or anything included herein. I, on the other hand, would like to tell you that I think Fresca is an absolutely fantastic product. I particularly like the Original Citrus flavor, though they're all quite good. Except peach. I don't care for that one.
 3. You can practice learning the Roman numerals by watching Super Bowl reruns or by getting a really old wristwatch. Or by taking Latin, which has become inexplicably popular lately.
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Photo credits:

- Me and my beautiful beard: My dad has no beautiful beard and is secretly jealous of my beard's awesomeness.
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