

Nomenclature

Chemical **nomenclature** is the names we use for chemicals. For instance, H_2O is called "water", and CH_4 (the gas you burn in a stove) is called "methane." You should learn the chemical nomenclature here on this page now, so that you will be able to understand when it is used.

The Basics

Here is some important info about how we write chemicals.

1. Elements have symbols of one or two letters. The first is a capital letter (ABC). If there is a second letter, it is a lower-case letter (abc). For instance, "m" is one unit, and "M" is a different unit. "K" is the symbol for one type of constant, and "k" is the symbol for a different type. You need to remember that capital letter symbols are usually different from lower-case symbols. For instance, Co is cobalt, a metal element next to iron, and CO is carbon monoxide, a poisonous gas made of one carbon atom and one oxygen atom.



2. We write the charge of a chemical using a superscript, which looks like this: H^+ or H^- . If we write just H, that means an H atom, which is one proton and one electron. H^+ means 1 H atom – 1 electron, so it means just one proton, also called hydrogen ion. If we write H^- this means one hydrogen atom + one electron, so a proton and 2 electrons, also called hydride ion. If there's an number in the superscript, that says how many electrons are added or removed. For instance, Ca^{2+} is a calcium atom – 2 electrons, or calcium ion. S^{2-} is sulfide, or sulfur + 2 electrons.



3. We indicate the number of atoms of a particular type using a subscript, like this: CO_2 . This means one carbon atom and 2 oxygen atoms. If we write O_2 that means the oxygen molecule, which is two atoms of oxygen connected together. Sometimes people might write O2 to mean the same thing. If the number comes first, though, it has a different meaning. 2 O means 2 atoms of oxygen that aren't connected to anything.

 1 ball is used to show atomic oxygen. 2 conjoined ball is used to show diatomic oxygen and 3 conjoined ball represents ozone.

4. If we want to show how many protons and neutrons are protons in an atom, we can use the mass number, as a superscript *before* the element symbol, such as ^{13}C . This means carbon with (protons + neutrons) = 13. You can tell that this is different from the charge, because the charge will always include + or – and come after the symbol.

5. Most molecules or ions that are stable have an even number of electrons. If they have an odd number of electrons, this is called a radical. For instance, H is a radical, because it has one electron. Because this is unusual, it might be indicated with a dot, like this: H^\cdot . For instance, water is H_2O , and if you remove hydrogen ion, you are left with hydroxide ion, OH^- . If you remove H^+ from water, you are left with OH molecule, which is neutral. This is also called hydroxyl radical, written OH^\cdot .



6. The phase of a substance is often indicated by a letter in () after the symbol. For instance, He is almost always a gas, written He(g). If it's a liquid (4.2K or below, less than -269°C) that is written He(l). You'll probably never hear about He(s), since it would be very hard to make it a solid. You might also see something written with (aq), which means "dissolved in water." For instance, NaCl(aq) means salt dissolved in water so there is no solid left. Or you might just see $\text{K}^+(\text{aq})$, meaning potassium ions dissolved in water.



Elements

There are lots of elements and you don't need to memorize them all. Here are a few that you should learn right now, though, because they are common or important, so that you won't be confused when they are mentioned later. They are organized by their type.

1. Non-metals

- Light elements: the elements with smallest mass
 - Hydrogen (H): exists as H_2 or in combination with other elements, such as in water
 - Helium (He): named after the sun, because it was discovered in the sun before being discovered on Earth (we'll explain how later); it doesn't react with anything
- Major gases in air
 - Oxygen (O): we get most of our energy from reactions with oxygen, when we breathe or when we burn fuel; O_2 is 21% of air
 - Nitrogen (N): often the limiting factor for agriculture or population growth, even though N_2 is 78% of air, because it only reacts under special circumstances.
- Halogens: reactive elements that make salts; common negative ions
 - Fluorine (F): the lightest halogen and most reactive element in the periodic table, people say that it killed the first two chemists who tried to isolate F_2
 - Chlorine (Cl): part of normal salt, NaCl, it is common in the ocean and in your body
 - Bromine (Br): one of only two elements that are liquid at room temperature, bromine is also found in salts and minerals
 - Iodine (I): a soft, shiny silver solid that easily evaporates to a purple gas, iodine can be used to disinfect cuts and is essential for human brains, suggesting that humans may have evolved to live near the ocean, which provides sources of iodine in fish and seaweed
- Main group solid non-metals: non-conductive and usually soft materials
 - Carbon (C): the element on which biology is based, also found in diamond, graphite, coal, and charcoal
 - Silicon (Si): the basis of the electronics industry; also a main component of sand, glass, and most rocks
 - Sulfur (S): a smelly yellow solid, used to make strong acids and industry, also common in minerals and essential to life
 - Phosphorus (P): first isolated from urine, although common in minerals; essential for life, often glows

2. Metals: soft or hard, light or heavy, usually solid electric conductors

- Alkali metals: soft, light, common soluble positive ions
 - Lithium (Li): the lightest alkali, used in batteries and anti-depressants
 - Sodium (Na, you may know it as natrium): common in the ocean and salt
 - Potassium (K, you may know it as kalium): also common, high concentration inside cells
- Alkaline Earth metals: like alkalis, but less so, less reactive, less soluble, positive ions more common in rocks, but also abundant in ocean
 - Magnesium (Mg): common in rocks, essential for life, especially photosynthesis
 - Calcium (Ca): common in biomaterials such as bone, tooth, and shells, also essential for muscles
- Main group metals
 - Aluminum (Al, also called aluminium): requires lots of energy to produce the metal from the mineral sources, but very common and useful metal
 - Tin (Sn, from Latin stannum): used since ancient times, especially in alloys such as bronze; still used in solder and many other applications
 - Lead (Pb, from Latin plumbum): very heavy, soft, sweet-tasting toxic metal, commonly used since ancient times, now used to shield radiation and in bullets, among many other uses
- Transition Metals: a widely varied group, often characterized by complex chemical properties
 - Iron (Fe, from Latin ferrum): most abundant element on earth, essential in steel, with complex reaction properties essential to life
 - Copper (Cu, from Latin cuprum): less reactive metal, with characteristic colors, commonly used in coins and electronics

- Silver (Ag, from Latin argentum): used in jewelry, coins and other ornaments and utensils since ancient times, it didn't tarnish until after the industrial revolution, and now also used in electronics
- Gold (Au, from Latin aurum): used since ancient times in coins and jewelry, to color stained glass, also in dentistry and other applications
- Mercury (Hg, from Latin hydrargyrum): also called quicksilver, because it is a silver liquid, it is toxic but very important in the history of science; it may be familiar from thermometers

Common Positive Ions (Cations)

"[element name](charge in Roman numerals if needed) ion"

Cation is another word for positive ion. The common positive ions are the ions of the alkali and alkaline earth metals and ammonium, NH_4^+ . The alkali metals form +1 cations, such as Na^+ and K^+ . The alkaline earth metals form +2 cations, such as Ca^{2+} and Mg^{2+} . The hydrogen ion, H^+ is a very common cation. For these cations, you can call them "[element name] ion", such as sodium ion or calcium ion.

You'll also see transition metal cations or main group metal cations, but it is harder to predict what charge they will have, especially because some of them can have different charges, like iron, which is commonly Fe^{2+} or Fe^{3+} . The charge on a transition metal cation can also be indicated using Roman numerals in parentheses, which looks like Fe(II) or Fe(III). The Roman numerals you will need to know for chemistry are:

1	2	3	3	5	6	7	8	9	10
I	II	III	IV	V	VI	VII	VIII	IX	X

For cations that have uncertain charge, you should call them "[element name](charge in Roman numerals) ion." For instance, iron(II) ion or sometimes just Fe(II).

Sometimes people use special names for these ions, in which the higher charge ion is called "[name]-ic ion" and the lower charge ion is called "[name]-ous ion," such as ferrous for Fe(II) and ferric for Fe(III), or cuprous ion for Cu(I) and cupric ion for Cu(II). I think this is most common for Fe, and I've never heard anyone call nickel(II) nickelous ion because that sounds ridiculous.

Table 5.2 Common transition metal cations

Ion	Systematic Name	Older Name
Fe^{3+}	iron(III)	ferric
Fe^{2+}	iron(II)	ferrous
Cu^{2+}	copper(II)	cupric
Cu^+	copper(I)	cuprous
Co^{3+}	cobalt(III)	cobaltic
Co^{2+}	cobalt(II)	cobaltous
Sn^{4+}	tin(IV)	stannic
Sn^{2+}	tin(II)	stannous
Pb^{4+}	lead(IV)	plumbic
Pb^{2+}	lead(II)	plumbous
Hg^{2+}	mercury(II)	mercuric
Hg_2^{2+}	mercury(I)	mercurous

*Mercury(I) ions always occur bound together in pairs to form Hg_2^{2+} .

Here's a list of common cations with less predictable charges:

• Ag^+	• Cu^+	• Cu^{2+}	• Fe^{2+}	• Fe^{3+}	• Hg_2^{2+}	• Hg^{2+}	• Pb^{2+}	• Sn^{2+}	• Al^{3+}
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Elements not on the list above, that you may see soon anyway: zinc(II): Zn^{2+} , cadmium(II): Cd^{2+} , cobalt(II): Co^{2+} , manganese(II): Mn^{2+} , nickel(II): Ni^{2+} , chromium(III): Cr^{3+} .

Common Negative Ions (Anions)

"[base name] + (-ide, -ate, or -ite)"

Anion is another word for negative ion. Common negative ions are the halide ions, formed from the halogen elements: fluoride, F^- ; chloride, Cl^- ; bromide, Br^- ; and iodide, I^- . As you may have noticed, the names of anions have "-ide" at the end when they are formed from elements. Other examples include oxide, O^{2-} , sulfide, S^{2-} , and nitride, N^{3-} .

Common Anions		
Charge	Formula	Name
1 ⁻	H ⁻	Hydride ion
	F ⁻	Fluoride ion
	Cl ⁻	Chloride ion
	Br ⁻	Bromide ion
	I ⁻	Iodide ion
	CN ⁻	Cyanide ion
2 ⁻	OH ⁻	Hydroxide ion
	O ²⁻	Oxide ion
	O ₂ ²⁻	Peroxide ion
3 ⁻	S ²⁻	Sulfide ion
	N ³⁻	Nitride ion

There are also many important polyatomic anions, which means anions that include more than one atom. These include toxic cyanide ion, CN⁻, common hydroxide ion, OH⁻, and peroxide ion, O₂²⁻. Other important anions include acetate ion (C₂H₃O₂⁻), which is in vinegar, the chlorate ion (ClO₃⁻), the perchlorate ion (ClO₄⁻) which is often explosive, the nitrate ion (NO₃⁻), the carbonate ion (CO₃²⁻) found in shells, the sulfate ion (SO₄²⁻), and the phosphate ion (PO₄³⁻). All of these end in "-ate", which means that they have more oxygen. Also, notice that "per-___-ate" means more oxygen than just "-ate", as in perchlorate.

Less common but still important are some "-ite" anions, which have less oxygen, such as nitrite (NO₂⁻), sulfite (SO₃²⁻), chlorite (ClO₂⁻) and hypochlorite (ClO⁻). Notice that "hypo-___-ite" means less oxygen than just "-ite" as in hypochlorite. Sulfite and nitrite are used to preserve foods. Sulfite salts are used in wine, dried fruit and preserved radish (mu). Nitrite salts are used in preserved meats.

One more rule says that if you take an anion like carbonate or sulfate and add one hydrogen ion, then you call that "bicarbonate" (HCO₃⁻) or "bisulfate" (HSO₄⁻). Or you might see it called "hydrogen carbonate" or "hydrogen sulfate." Note that because we added a hydrogen ion, the charge on the bicarbonate ion is one less than the charge on the carbonate ion. Also, note that "disulfate" is S₂O₇²⁻, quite different from bisulfate.



Chemical Nomenclature for Ionic Compounds

"[cation name] + [anion name]"

Ionic compounds are compounds that include at least two components, a positive ion and a negative ion. Often the positive ion is a metal element ion and the negative ion is a non-metal ion. To name an ionic compound, you usually just give the cation followed by the anion, such as "sodium chloride" or "ammonium nitrate." If the cation is the type that could have different charges, then you should say what the charge is, such as "mercury(I) iodide" or "cupric sulfate."



Chemical Nomenclature for Acids

"(hydro if -ide)[anion base name] + (-ic if -ide, -ate; -ous if -ite) + acid"

Acid usually means an anion combined with the hydrogen ion as the cation. For instance, HCl is a common acid, which is the hydrogen ion and the chloride anion. If the anion ends in "-ide" then usually the acid is called "hydro-___-ic acid" such as "hydrochloric acid" for HCl. You'll see this for all the "hydrohalic acids" which are H + a halogen, such as "hydrofluoric acid" or "hydroiodic acid." You might also see "hydrocyanic acid" for HCN. If the anion ends in "-ate" then you call the acid "___-ic acid," such as "sulfuric acid," which is H₂SO₄, or "nitric acid." HNO₃. If the anion ends in "-ite" then the acid name is "___-ous acid," such as "hypochlorous acid" for HClO. Notice that earlier "-ic" and "-ous" meant more and less charge for cations, such as ferric and ferrous ions of iron. Now it also means more and less oxygen in acids.



Chemical Nomenclature for Non-metal Compounds

"(prefix, not mono)[less anion-like atom name] + (prefix)[more anion-like atom name]-ide"

Non-metal compounds are often called covalent compounds. They are named following a different rule from ionic compounds. You will need these "prefixes" which indicate how many of each type of atom are present:

1	2	3	3	5	6	7	8	9	10
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mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca
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The prefixes come from Greek. You will put the element that is more left on the periodic table first, unless it is oxygen, which is always last unless it is in a compound with fluorine. This follows the same pattern as ionic compounds. In ionic compounds, the cation is written first, and you will notice that it is usually more to the left in the periodic table than the anion, which is written last. When you name covalent compounds, the atom that's more like an anion is written last. Fluorine is always most "anionic," and oxygen is next most "anionic," so they will always be last. (Fluorine is actually most electronegative, but we will study this concept much later, which is why right now I'm calling it "anion-like.") If both atoms are in the same group (same column of the periodic table) then the lower one is named first. Notice that the two most "anion-like," F and O, are in the upper right of the periodic table. The atom written second, that's more "anion-like" is named like an anion, with the "-ide" ending. For example, CO: carbon is on the left, so we can write "monocarbon monoxide." Actually people usually just call it "carbon monoxide." You can skip "mono" for the first element. For instance, SO₃ is called "sulfur trioxide" and N₂O₄ is called "dinitrogen tetroxide." XeO₂ is xenon dioxide, even though xenon is more to the right than oxygen, because oxygen is more like an anion than anything except fluorine. If the compound involves hydrogen, then you can leave out the prefixes, such as "hydrogen chloride" for HCl or "hydrogen sulfide" for H₂S, because the numbers of each atom can be predicted as if it were an ionic substance. But actually many compounds of hydrogen have special names, such as "ammonia" for NH₃, "methane" for CH₄, "borane" for BH₃, "silane" for SiH₄ and "phosphine" for PH₃. You should learn the first two of these now.



Summary

Key Info for Common Elements

Element name	Symbol	Atomic number	Commonly found as...
Hydrogen	H	1	H ₂ (g), water (H ₂ O), acid (H ⁺ (aq))
Helium	He	2	He(g), He(l) if you want to make things very cold
Lithium	Li	3	Li ⁺ always, (aq) or in solids with anions, lithium metal Li(s) only in chem class
Carbon	C	6	Covalent compounds, making 4 bonds
Nitrogen	N	7	N ₂ (g) in air, in ammonia (NH ₃ (g or l)), in basic covalent compounds, in proteins
Oxygen	O	8	O ₂ (g) in air, in water, in rock and glass, usually combined with Si
Fluorine	F	9	F ⁻ (aq) or with cations in rock, in covalent compounds with carbon (non-stick pans)
Sodium (Natrium)	Na	11	Na ⁺ (aq) or with anions in salts, sodium metal (Na(s)) only in chem class
Magnesium	Mg	12	Mg ²⁺ (aq) or with anions in salts and rocks

Element name	Symbol	Atomic number	Commonly found as...
Aluminum (Aluminium)	Al	13	Al^{3+} with anions in rocks and salts, industrially made Al(s) metal
Silicon	Si	14	Industrially made Si(s) in computer chips, Si(IV) oxides in sand, glass, most rocks
Phosphorus	P	15	Phosphates: PO_4^{3-} , $\text{P}_2\text{O}_7^{4-}$, etc. in rock, DNA
Sulfur	S	16	$\text{S}_8(\text{s})$, S^{2-} or sulfate (SO_4^{2-}) in salts or rocks
Chlorine	Cl	17	$\text{Cl}^-(\text{aq})$ or with cations in salts, $\text{Cl}_2(\text{g})$ or $\text{ClO}^-(\text{aq})$ in disinfectants
Potassium (kalium)	K	19	$\text{K}^+(\text{aq})$ or with anions in salts, potassium metal (K(s)) only in chem class
Calcium	Ca	20	$\text{Ca}^{2+}(\text{aq})$ or with anions in salts and rocks
Iron	Fe	26	Fe(s) metal industrially made, Fe(II) or Fe(III) oxides or sulfides and other minerals
Copper	Cu	29	Natural Cu(s) metal, Cu(I) or Cu(II) salts or minerals, usually blue or green
Bromine	Br	35	$\text{Br}^-(\text{aq})$ or with cations in salts
Silver	Ag	47	Natural Ag(s) metal, Ag(I) or Ag(II) in salts or sulfide minerals
Tin	Sn	50	Industrially made Sn(s) in alloys, Sn(II) or Sn(IV) salts and oxide or sulfide minerals
Iodine	I	53	$\text{I}^-(\text{aq})$ or with cations in salts
Gold	Au	79	Natural Au(s) metal, rarely Au(I) or Au(III) salts
Mercury	Hg	80	Natural (but rare) metal Hg(l), Hg(II) sulfides and halides, Hg(I) exists as Hg_2^{2+}
Lead	Pb	82	Pb(s) in alloys, Pb(II) sulfide, carbonate and sulfate minerals, sometimes Pb(IV) salts or minerals

Common Polyatomic Ions

Name	Formula	Where you find it
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Name	Formula	Where you find it
Ammonium	NH_4^+	Soluble salts, fertilizer
Cyanide	CN^-	Toxic, in some plant products and dyes
Hydroxide	OH^-	In bases and some minerals
Peroxide	O_2^{2-}	In bleaches and disinfectants
Acetate	$\text{C}_2\text{H}_3\text{O}_2^-$	In vinegar
Perchlorate	ClO_4^-	Soluble salts and explosives, a strong acid
Chlorate	ClO_3^-	Similar to perchlorates but less stable
Chlorite	ClO_2^-	Disinfectants and bleaches, some explosive salts
Hypochlorite	ClO^-	Disinfectants and bleaches, most salts unstable
Nitrate	NO_3^-	Soluble salts, fertilizer, explosives, a strong acid
Nitrite	NO_2^-	Preservatives for food
Carbonate	CO_3^{2-}	In rock, seashells, cement; a base
Bicarbonate	HCO_3^-	A base (baking soda), in soda, in blood
Sulfate	SO_4^{2-}	In salts, plaster, detergent, a strong acid
Bisulfate	HSO_4^-	Food additives
Sulfite	SO_3^{2-}	Salts, food preservatives
Phosphate		Salts, rock, fertilizers, a strong acid, in ATP and DNA

Outside Link

- [CrashCourse Chemistry: How to Speak Chemistrian](#) (11 min)

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- [Emily V Eames](#) (City College of San Francisco)

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