Polyatomic –ates, -ites, per –ates, hypo- ites and other oddities.

All of these ions have oxygen in them and they all have names that end in ate or ite. Let's break these down into smaller groupings.

Consider those made from the halogens (group 7A) and three oxygens. Fluorate, Chlorate, Bromate and Iodate. These all have the formula XO_3^{1-} where X is the halogen atom: F, Cl, Br, or I. Nitrate also has three oxygen atoms and a one minus charge. Carbonate has three oxygen atoms but it is different. It has a two minus charge. Here is the subset of polyatomic ions that have three oxygen atoms connected to a non-metal atom:

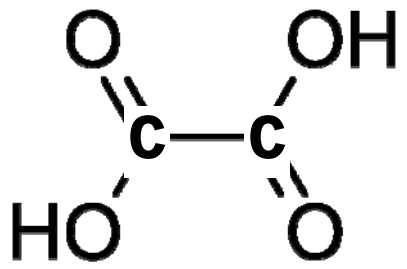
FO_3^{1-} ClO_3^{1-} BrO_3^{1-} IO_3^{1-} NO_3^{1-} CO_3^{2-}

It will help you to remember this group together.

Another subgroup has four oxygen atoms: permanganate, sulfate, chromate, oxalate and phosphate. Here they are:

MnO_4^{1-} SO_4^{2-} CrO_4^{2-} $C_2O_4^{2-}$ PO_4^{3-}

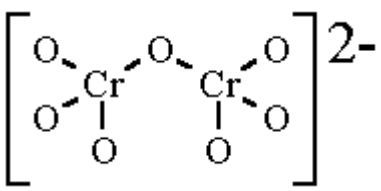
Phosphate is the only polyatomic ion that you are asked to learn with a three minus charge. Oxalate has an odd name. The others have names that tell you what atoms are in them. Sulfate is a combination of sulfur and ate for oxygen. Chromate is a combination of chromium and ate for oxygen. Phosphate is a combination of phosphorus and ate for oxygen. Permanganate is a combination of manganese and oxygen. It has the prefix per. So what about this oxalate? It has an interesting story. It is the ion of the acid oxalic acid.



This is oxalic acid. It is the oxalate ion plus two hydrogens. Oxalic acid and oxalates are present in many plants like parsley, rhubarb, poppy seeds, and spinach. When calcium reacts with oxalic acid an insoluble precipitate forms. This is the primary constituent of kidney stones. Some individuals need to avoid foods high in oxalic acid.

The remaining ions that end in ate are dichromate, acetate and thiocyanate. Let's consider each of these.

Dichromate is a combination of two chromate ions:



Notice that one oxygen atom is shared. This is why the formula has seven oxygen atoms and not eight: $Cr_2O_7^{2-}$

Thiocyanate, SCN^{1-}, is the ONLY ate ion that does not contain oxygen. This is because sulfur is in the same family (same vertical column on the periodic table) and so the combination of thio- and –ate indicate sulfur not oxygen. The thiocyanate ion is often used as a test to detect the presence of iron (III). This will be demonstrated in class.

The last ion in this group is acetate. Acetate is the ion of acetic acid. Acetic acid in water is vinegar. The acetate ion, $C_2H_3O_2^{1-}$, is notable because there are three different atoms in the formula. Thiocyanate also has three different atoms. Most of the polyatomic ions are formed from only two different atoms.

The charges on polyatomic ions are mostly one minus and two minus. Phosphate is the only ion with a three minus charge. Be sure to practice reciting the name of the atom and its formula including the charge. Practicing these formulas and names is the only way to memorize them.

Concentrate on learning all of the –ate ions first. Once you know the –ate ions then follow these rules for the per-ate, ite, and hypo- ite.

- **Per –ate ions have ONE more oxygen than the –ate ions.**
- **-ite ions have ONE less oxygen than the –ate ions.**
- **Hypo –ite ions have ONE less oxygen than the –ite ions, that is, two less oxygen atoms than the -ate ions.**

The ion permanganate, MnO_4^{1-}, is on your list but the manganate ion is not. You may think that the formula of manganate would be MnO_3^{1-} but it is not – ***it is an exception to the rule above***. Maybe this is why it is **not** included in your list. Just remember the formula for permanganate and that will be sufficient.

The last category is the bi- ate ions. There are three of them: bicarbonate, bisulfite and bisulfate. In this instance the bi- indicates the presence of hydrogen. These ions are also called hydrogen carbonate, hydrogen sulfite and hydrogen sulfate. They all have a charge of one minus. Here they are: HCO_3^{1-} , HSO_3^{1-} and HSO_4^{1-}.