

## Polyatomic Ions

**Unit:** Nomenclature & Formulas

**NGSS Standards/MA Curriculum Frameworks (2016):** HS-PS2-6

**Mastery Objective(s):** (Students will be able to...)

- Write chemical formulas that include polyatomic ions.

**Success Criteria:**

- Subscripts are chosen so that positive and negative charges are balanced (equal).
- Formulas for polyatomic ions are in parentheses if more than one is needed.

**Tier 2 Vocabulary:** bond, charge

**Language Objectives:**

- Explain the process and necessity of balancing charges.

**Notes:**

polyatomic ion: a group of atoms that are bonded to each other that behave chemically like a single ion. A polyatomic ion always has a specific name, chemical formula, and charge.

For example: the sulfate ion has the chemical formula  $\text{SO}_4^{2-}$ . It is made of one sulfur atom and 4 oxygen atoms. Chemically, it behaves like a single atom with a  $-2$  charge.

*The formula of a polyatomic ion never changes!*

*I.e.*, the sulfate ion is *always*  $\text{SO}_4^{2-}$ , and the 4 is an important part of the formula. If you wrote  $\text{SO}_2^{2-}$  instead, you would be talking about the hyposulfite ion instead of the sulfate ion—a different polyatomic ion with different chemical properties.

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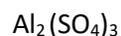
## Polyatomic Ions in Chemical Formulas

If a compound contains a polyatomic ion, you write the formula for the polyatomic ion, *including the subscript numbers*, in the place where the ion goes. For example, a compound with  $\text{Na}^+$  and  $\text{SO}_4^{2-}$  would simply be  $\text{Na}_2\text{SO}_4$ .

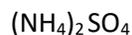
### Balancing Charges with Polyatomic Ions

If you need more than one of a polyatomic ion in a chemical formula, put the entire polyatomic ion, *including any subscript numbers*, in parentheses, and put the number that tells how many ions you need outside the parentheses.

For example, to balance the compound made from  $\text{Al}^{3+}$  and  $\text{SO}_4^{2-}$ , you need 2  $\text{Al}^{3+}$  ions and 3  $\text{SO}_4^{2-}$  ions. The formula is:



Note: there are positive and negative polyatomic ions. A compound can have either, neither, or both kinds. For example, if you had a compound made from the positive ion ammonium ( $\text{NH}_4^+$ ) and the negative ion sulfate ( $\text{SO}_4^{2-}$ ), the compound would have the formula:



### Determining the Number of Atoms in a Formula

The subscripts tell you how many you have of *whatever came immediately before the subscript*. If the thing before the subscript is an element, as in  $\text{CaCl}_2$ , the 2 tells us that we have 2 Cl atoms. There's no subscript after Ca, so this means we have only 1 Ca atom.

If the thing before the subscript is parentheses, as in  $\text{Al}_3(\text{SO}_4)_2$ , the 3 tells us that we have 3 Al atoms, the 2 outside the parentheses tells us that we have 2 entire  $\text{SO}_4$  ions. This means we really have 2 atoms of S and  $2 \times 4 = 8$  atoms of O.

### Sample Problem:

How many hydrogen atoms are in the compound  $(\text{NH}_4)_2\text{HPO}_4$ ?

We have  $2 \times 4 = 8$  from the two  $\text{NH}_4$  ions, plus 1 from the  $\text{HPO}_4$  ion, giving us a total of 9 hydrogen atoms.

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**Table of Polyatomic Ions**

ion	formula	ion	formula	ion	formula
americyl	$\text{AmO}_2^{2+}$	acetate	$\text{CH}_3\text{COO}^-$	tetraborate	$\text{B}_4\text{O}_7^{2-}$
carbonyl	$\text{CO}_2^{2+}$	amide	$\text{NH}_2^-$	carbide	$\text{C}_2^{2-}$
thiocarbonyl	$\text{CS}_2^{2+}$	hydroxylamide	$\text{NHOH}^-$	carbonate	$\text{CO}_3^{2-}$
chromyl	$\text{CrO}_2^{2+}$	azide	$\text{N}_3^-$	chromate	$\text{CrO}_4^{2-}$
neptunyl	$\text{NpO}_2^{2+}$	hydrazide	$\text{N}_2\text{H}_3^-$	dichromate	$\text{Cr}_2\text{O}_7^{2-}$
plutonyl	$\text{PuO}_2^{2+}$	bromate	$\text{BrO}_3^-$	imide	$\text{NH}^{2-}$
seleninyl	$\text{SeO}^{2+}$	chlorate	$\text{ClO}_3^-$	molybdate	$\text{MoO}_4^{2-}$
selenoyl	$\text{SeO}_2^{2+}$	cyanide	$\text{CN}^-$	peroxide	$\text{O}_2^{2-}$
thionyl/sulfinyl	$\text{SO}^{2+}$	cyanate	$\text{OCN}^-$	oxalate	$\text{C}_2\text{O}_4^{2-}$
sulfonyl/sulfuryl	$\text{SO}_2^{2+}$	thiocyanate	$\text{SCN}^-$	phthalate	$\text{C}_8\text{H}_4\text{O}_4^{2-}$
uranyl	$\text{UO}^{2+}$	selenocyanate	$\text{SeCN}^-$	selenite	$\text{SeO}_4^{2-}$
vanadyl	$\text{VO}^{2+}$	tellurocyanate	$\text{CH}_3\text{S}^-$	silicate	$\text{SiO}_3^{2-}$
ammonium	$\text{NH}_4^+$	hydroxide	$\text{OH}^-$	sulfate	$\text{SO}_4^{2-}$
hydronium	$\text{H}_3\text{O}^+$	iodate	$\text{IO}_3^-$	thiosulfate	$\text{S}_2\text{O}_3^{2-}$
iodyl	$\text{IO}_2^+$	methanolate	$\text{CH}_3\text{O}^-$	dithionate	$\text{S}_2\text{O}_4^{2-}$
nitrosyl	$\text{NO}^+$	methanethiolate	$\text{CH}_3\text{S}^-$	silicate	$\text{SiO}_3^{2-}$
thionitrosyl	$\text{NS}^+$	ethanolate	$\text{C}_2\text{H}_5\text{O}^-$	borate	$\text{BO}_3^{3-}$
phosphoryl	$\text{PO}^+$	permanganate	$\text{MnO}_4^-$	arsenate	$\text{AsO}_4^{3-}$
thiophosphoryl	$\text{PS}^+$	nitrate	$\text{NO}_3^-$	phosphate	$\text{PO}_4^{3-}$
phosphor	$\text{PO}_2^+$	superoxide	$\text{O}_2^-$	orthosilicate	$\text{SiO}_4^{4-}$

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