Polyatomic Ions

Unit: Nomenclature & Formulas

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 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* SO_4^{2-}, and the 4 is an important part of the formula. If you wrote 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.

Use this space for summary and/or additional notes:

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 Na^+ and SO_4^{2-} would simply be Na_2SO_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 Al^{3+} and SO_4^{2-}, you need 2 Al^{3+} ions and 3 SO_4^{2-} ions. The formula is:

$$Al_2(SO_4)_3$$

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 (NH_4^+) and the negative ion sulfate (SO_4^{2-}), the compound would have the formula:

$$(NH_4)_2SO_4$$

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 $CaCl_2$, 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 $Al_3(SO_4)_2$, the 3 tells us that we have 3 Al atoms, the 2 outside the parentheses tells us that we have 2 entire 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 $(NH_4)_2HPO_4$?

We have $2 \times 4 = 8$ from the two NH_4 ions, plus 1 from the HPO_4 ion, giving us a total of 9 hydrogen atoms.

Use this space for summary and/or additional notes:

Table of Polyatomic Ions

ion	formula	ion	formula	ion	formula
americyl	AmO_2^{2+}	acetate	CH_3COO^-	tetraborate	$B_4O_7^{2-}$
carbonyl	CO_2^{2+}	amide	NH_2^-	carbide	C_2^{2-}
thiocarbonyl	CS_2^{2+}	hydroxylamide	$NHOH^-$	carbonate	CO_3^{2-}
chromyl	CrO_2^{2+}	azide	N_3^-	chromate	CrO_4^{2-}
neptunyl	NpO_2^{2-}	hydrazide	$N_2H_3^-$	dichromate	$Cr_2O_7^{2-}$
plutoryl	PuO_2^{2+}	bromate	BrO_3^-	imide	NH^{2-}
seleninyl	SeO^{2+}	chlorate	ClO_3^-	molybdate	MoO_4^{2-}
selenoyl	SeO_2^{2+}	cyanide	CN^-	peroxide	O_2^{2-}
thionyl/sulfinyl	SO^{2+}	cyanate	OCN^-	oxalate	$C_2O_4^{2-}$
sulfonyl/sulfuryl	SO_2^{2+}	thiocyanate	SCN^-	phthalate	$C_8H_4O_4^{2-}$
uranyl	UO^{2+}	selenocyanate	$SeCN^-$	selenite	SeO_4^{2-}
vanadyl	VO^{2+}	tellurocyanate	CH_3S^-	silicate	SiO_3^{2-}
ammonium	NH_4^+	hydroxide	OH^-	sulfate	SO_4^{2-}
hydronium	H_3O^+	iodate	IO_3^-	thiosulfate	$S_2O_3^{2-}$
iodyl	IO_2^+	methanolate	CH_3O^-	dithionate	$S_2O_4^{2-}$
nitrosyl	NO^+	methanethiolate	CH_3S^-	silicate	SiO_3^{2-}
thionitrosyl	NS^+	ethanolate	$C_2H_5O^-$	borate	BO_3^{3-}
phosphoryl	PO^+	permanganate	MnO_4^-	arsenate	AsO_4^{3-}
thiophosphoryl	PS^+	nitrate	NO_3^-	phosphate	PO_4^{3-}
phosphor	PO_2^+	superoxide	O_2^-	orthosilicate	SiO_4^{4-}

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