

5.4: Ionic Compounds- Formulas and Names

6.9: Binary Ionic Compounds and Their Properties

6.18: Ionic Compounds Containing Polyatomic Ions

Learning Objectives

- Derive names for common types of inorganic compounds using a systematic approach

Nomenclature, a collection of rules for naming things, is important in science and in many other situations. This module describes an approach that is used to name simple ionic and molecular compounds, such as NaCl , CaCO_3 , and N_2O_4 . The simplest of these are binary compounds, those containing only two elements, but we will also consider how to name ionic compounds containing polyatomic ions, and one specific, very important class of compounds known as acids (subsequent chapters in this text will focus on these compounds in great detail). We will limit our attention here to inorganic compounds, compounds that are composed principally of elements other than carbon, and will follow the nomenclature guidelines proposed by IUPAC. The rules for organic compounds, in which carbon is the principle element, will be treated in a later chapter on organic chemistry.

Ionic Compounds

To name an inorganic compound, we need to consider the answers to several questions. First, is the compound ionic or molecular? If the compound is ionic, does the metal form ions of only one type (fixed charge) or more than one type (variable charge)? Are the ions monatomic or polyatomic? If the compound is molecular, does it contain hydrogen? If so, does it also contain oxygen? From the answers we derive, we place the compound in an appropriate category and then name it accordingly.

Compounds Containing Only Monatomic Ions

The name of a binary compound containing monatomic ions consists of the name of the cation (the name of the metal) followed by the name of the anion (the name of the nonmetallic element with its ending replaced by the suffix *-ide*). Some examples are given in Table 5.4.2.

Table 5.4.1: Names of Some Ionic Compounds

NaCl , sodium chloride	Na_2O , sodium oxide
KBr , potassium bromide	CdS , cadmium sulfide
CaI_2 , calcium iodide	Mg_3N_2 , magnesium nitride
CsF , cesium fluoride	Ca_3P_2 , calcium phosphide
LiCl , lithium chloride	Al_4C_3 , aluminum carbide

Compounds Containing Polyatomic Ions

Compounds containing polyatomic ions are named similarly to those containing only monatomic ions, except there is no need to change to an *-ide* ending, since the suffix is already present in the name of the anion. Examples are shown in Table 5.4.2.

CL, ammonium chloride, C a S O subscript 4 calcium sulfate, and M g subscript 3 (P O subscript 4) subscript 2 magnesium phosphate." data-quail-id="56" data-mt-width="1071">

Table 5.4.2: Names of Some Polyatomic Ionic Compounds

$\text{KC}_2\text{H}_3\text{O}_2$, potassium acetate	$(\text{NH}_4)\text{Cl}$, ammonium chloride
NaHCO_3 , sodium bicarbonate	CaSO_4 , calcium sulfate
$\text{Al}_2(\text{CO}_3)_3$, aluminum carbonate	$\text{Mg}_3(\text{PO}_4)_2$, magnesium phosphate

Ionic Compounds in Your Cabinets

Every day you encounter and use a large number of ionic compounds. Some of these compounds, where they are found, and what they are used for are listed in [Table](#). Look at the label or ingredients list on the various products that you use during the next few days, and see if you run into any of those in this table, or find other ionic compounds that you could now name or write as a formula.

Everyday Ionic Compounds

Ionic Compound	Use
NaCl, sodium chloride	ordinary table salt
KI, potassium iodide	added to “iodized” salt for thyroid health
NaF, sodium fluoride	ingredient in toothpaste
NaHCO ₃ , sodium bicarbonate	baking soda; used in cooking (and as antacid)
Na ₂ CO ₃ , sodium carbonate	washing soda; used in cleaning agents
NaOCl, sodium hypochlorite	active ingredient in household bleach
CaCO ₃ calcium carbonate	ingredient in antacids
Mg(OH) ₂ , magnesium hydroxide	ingredient in antacids
Al(OH) ₃ , aluminum hydroxide	ingredient in antacids
NaOH, sodium hydroxide	lye; used as drain cleaner
K ₃ PO ₄ , potassium phosphate	food additive (many purposes)
MgSO ₄ , magnesium sulfate	added to purified water
Na ₂ HPO ₄ , sodium hydrogen phosphate	anti-caking agent; used in powdered products
Na ₂ SO ₃ , sodium sulfite	preservative

Compounds Containing a Metal Ion with a Variable Charge

Most of the transition metals can form two or more cations with different charges. Compounds of these metals with nonmetals are named with the same method as compounds in the first category, except the charge of the metal ion is specified by a Roman numeral in parentheses after the name of the metal. The charge of the metal ion is determined from the formula of the compound and the charge of the anion. For example, consider binary ionic compounds of iron and chlorine. Iron typically exhibits a charge of either 2+ or 3+ (see [link](#)), and the two corresponding compound formulas are FeCl₂ and FeCl₃. The simplest name, “iron chloride,” will, in this case, be ambiguous, as it does not distinguish between these two compounds. In cases like this, the charge of the metal ion is included as a Roman numeral in parentheses immediately following the metal name. These two compounds are then unambiguously named iron(II) chloride and iron(III) chloride, respectively. Other examples are provided in [Table 5.4.3](#).

Table 5.4.3: Names of Some Transition Metal Ionic Compounds

Transition Metal Ionic Compound	Name
FeCl ₃	iron(III) chloride
Hg ₂ O	mercury(I) oxide
HgO	mercury(II) oxide
Cu ₃ (PO ₄) ₂	copper(II) phosphate

Out-of-date nomenclature used the suffixes *-ic* and *-ous* to designate metals with higher and lower charges, respectively: Iron(III) chloride, FeCl₃, was previously called ferric chloride, and iron(II) chloride, FeCl₂, was known as ferrous chloride. Though this

naming convention has been largely abandoned by the scientific community, it remains in use by some segments of industry. For example, you may see the words *stannous fluoride* on a tube of toothpaste. This represents the formula SnF_2 , which is more properly named tin(II) fluoride. The other fluoride of tin is SnF_4 , which was previously called stannic fluoride but is now named tin(IV) fluoride.

Naming Ionic Compounds

Name the following ionic compounds, which contain a metal that can have more than one ionic charge:

- Fe_2S_3
- CuSe
- GaN
- CrCl_3
- $\text{Ti}_2(\text{SO}_4)_3$

Solution

The anions in these compounds have a fixed negative charge (S^{2-} , Se^{2-} , N^{3-} , Cl^- , and SO_4^{2-}), and the compounds must be neutral. Because the total number of positive charges in each compound must equal the total number of negative charges, the positive ions must be Fe^{3+} , Cu^{2+} , Ga^{3+} , Cr^{4+} , and Ti^{3+} . These charges are used in the names of the metal ions:

- iron(III) sulfide
- copper(II) selenide
- gallium(III) nitride
- chromium(III) chloride
- titanium(III) sulfate

Exercise 5.4.1

Write the formulas of the following ionic compounds:

- (a) chromium(III) phosphide
- (b) mercury(II) sulfide
- (c) manganese(II) phosphate
- (d) copper(I) oxide
- (e) chromium(VI) fluoride

Answer

(a) CrP ; (b) HgS ; (c) $\text{Mn}_3(\text{PO}_4)_2$; (d) Cu_2O ; (e) CrF_6

Summary

Chemists use nomenclature rules to clearly name compounds. Ionic and molecular compounds are named using somewhat-different methods. Binary ionic compounds typically consist of a metal and a nonmetal. The name of the metal is written first, followed by the name of the nonmetal with its ending changed to *-ide*. For example, K_2O is called potassium oxide. If the metal can form ions with different charges, a Roman numeral in parentheses follows the name of the metal to specify its charge. Thus, FeCl_2 is iron(II) chloride and FeCl_3 is iron(III) chloride. Some compounds contain polyatomic ions; the names of common polyatomic ions should be memorized. Molecular compounds can form compounds with different ratios of their elements, so prefixes are used to specify the numbers of atoms of each element in a molecule of the compound. Examples include SF_6 , sulfur hexafluoride, and N_2O_4 , dinitrogen tetroxide. Acids are an important class of compounds containing hydrogen and having special nomenclature rules. Binary acids are named using the prefix *hydro-*, changing the *-ide* suffix to *-ic*, and adding “acid;” HCl is hydrochloric acid. Oxyacids are named by changing the ending of the anion to *-ic*, and adding “acid;” H_2CO_3 is carbonic acid.

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