Experiment 8a. Chemical Nomenclature

Information relating to basic chemical nomenclature that you need to know in General Chemistry appears below. When you perform a chemical experiment, serious problems can result if you use the wrong chemical by accident (because you are not familiar with the names and formulas of the chemicals that you are using). As a result, it is very important that you learn all aspects of chemical nomenclature that appear herein.

I. ELEMENTS

You should know the symbols of the first twenty elements in the periodic table (atomic numbers 1-20), plus those of the following elements:

Br, bromine; Cu, copper; Fe, iron; Ag, silver; Ba, barium; Zn, zinc; Pb, lead; Ni, nickel; I, iodine.

Many non-metals exist in the form of polyatomic molecules. For example, the oxygen in the atmosphere is O_2, not O, because two oxygen atoms have combined to form a stable O_2 molecule. You should know the following: H_2, hydrogen; N_2, nitrogen; O_2, oxygen; O_3, ozone; F_2, fluorine; Cl_2, chlorine; Br_2, bromine; I_2, iodine.

Note: phosphorus is actually P_4, and sulfur is actually S_8, but for simplicity they are often written as simply P and S, respectively.

II. MONOATOMIC IONS WITH ONLY ONE CHARGE

Monoatomic ions have only one atom in them. You can often tell what the charge of such an ion is by looking at the periodic table. The version appearing in Figure 1 at the right has been simplified to show only the representative (A-group) elements. The heavy zig-zag line separates the metals (on the left) from the non-metals (on the right). Semi-metals (metalloids) are shaded.

Please note that hydrogen is classified a non-metal even though it appears on the left-hand side of the periodic table in Group IA.

Metals on the left hand side of the periodic table always *lose* one or more electrons to form positive ions (sometimes called "*cations*.")

Non-metals on the right hand side always *gain* one or more electrons to form negative ions (sometimes called "anions"). The resulting ions always have the same number of electrons as the nearest rare gas.

Simplified Periodic Table of the Elements

	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
	+1	+2	+3*		-3*	-2	-1	
1	1 H						1 H	2 He
2	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra						

* - Refers to Al, N, and P only

Fig. 8.1 - Simplified Periodic Table
(Representative Elements only)

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	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
	+1	+2	+3*		-3*	-2	-1	

* - Refers to Al, N, and P only

1	1 H						1 H	2 He
2	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra						

Fig. 8.1 - Simplified Periodic Table
(Representative Elements only)

The charges of common ions (which you must know) may be calculated using the following equation:

charge of ion = (atomic number of element) − (atomic number of nearest rare gas)

In this equation, "nearest rare gas" means the rare gas whose atomic number is closest to the atomic number of the element in question. For example, aluminum has atomic number 13, and it is located between rare gas neon (atomic number 10) and rare gas argon (atomic number 18). The nearest rare gas (numerically) is therefore neon (atomic number 10), and the charge of an aluminum ion is equal to (13–10), or +3.

We may make the following observations regarding the charges of common ions (memorize this):

All Group IA elements form ions whose charge is +1: H^+, hydrogen ion; Li^+, lithium ion; Na^+, sodium ion; K^+, potassium ion

All Group IIA elements form ions whose charge is +2: Mg^{2+}, magnesium ion; Ca^{2+}, calcium ion; Ba^{2+}, barium ion

Group IIIA: Al^{3+}, aluminum ion (This rule does not apply to other elements in Group IIIA)

Group IVA: No general rule applies. For example, carbon (atomic number 6) neither gains nor loses electrons; instead, it *shares* electrons to form covalent compounds.

Group VA: N^{3-}, nitr***ide*** ion; P^{3-}, phosph***ide*** ion (This rule does not apply to other elements in Group VA)

All Group VIA elements form ions whose charge is –2: O^{2-}, ox***ide*** ion; S^{2-}, sulf***ide*** ion

All Group VIIA elements form ions whose charge is –1: H^-, hydr***ide*** ion; F^-, fluor***ide*** ion; Cl^-, chlor***ide*** ion; Br^-, brom***ide*** ion; I^-, iod***ide*** ion

Hydrogen is the only element listed twice in the periodic table appearing on the previous page to emphasize that hydrogen can form both +1 ions (hydrogen ions) and –1 ions (hydr***ide*** ions).

The names of all of these negatively-charged ions end in ***–ide***; this ending tells you that the ions are *monoatomic*, and that *no* oxygen atoms are present. The two common exceptions to this general rule are hydrox***ide*** ions, OH^-, and cyan***ide*** ions, CN^-.

The charges of ions may be written in several ways. If more than one positive or negative charge is present, textbooks usually write the charges with the number first and the sign last (such as writing 2+ instead of +2, for example). **Other methods of writing these charges are also correct.**

Examples:

1. The magnesium ion, usually written as Mg^{2+}, may also be written as Mg^{++} or Mg^{+2}.
2. The oxide ion, usually written as O^{2-}, may also be written as O^{--}, $O^{=}$, or as O^{-2}.

There are four additional monoatomic ions whose charges you should memorize because they cannot easily be determined from the periodic table. They are:

Ag^+, silver ions; Zn^{2+}, zinc ions; Pb^{2+}, lead ions; Ni^{2+}, nickel ions

III. FORMULAS AND NAMES OF SIMPLE IONIC COMPOUNDS

When naming ionic compounds, ***always write the name of the positive ion first.*** Chemical formulas similarly have the positive ion listed first. For example, sodium ions have a +1 charge and chloride ions have a –1 charge, so we write NaCl (sodium chloride)—not ClNa. The only common exception to this general rule involves *acetate ions*. When writing *formulas*, acetate ions are sometimes written first—as in sodium acetate, CH_3COONa. The more commonly used method of writing the formula of sodium acetate is $NaC_2H_3O_2$.

Furthermore, do *not* include the charges of ions when writing the formulas of ionic compounds. We write the formula of sodium chloride as NaCl, not as Na^+Cl^-.

If the charges of the positive and negative ions are numerically equal but have opposite signs, then the ions are in a 1:1 ratio, and *no* subscripts should be used in the formula. For example, the formula of magnesium oxide (composed of Mg^{2+} and O^{2-} ions) is MgO, not Mg_2O_2. Similarly, the formula of aluminum nitride (consisting of aluminum ions, Al^{3+}, and nitride ions, N^{3-}, is AlN.)

However, subscripts (small numbers written ***below*** the main line) *must* be used whenever the charges of the positive and negative ions do not add up to zero. For example, consider the formula of ***aluminum sulfide.*** An aluminum ion has a charge of +3, and a sulfide ion has a charge of –2. The formula **AlS** would be wrong because if we add up the charges of the ions, the result is: (+3)+(–2) or +1. We cannot write the formula as AlS^+ either, because ***ionic compounds must be electrically neutral and the total charges must add up to zero.***

Instead, we may use the criss-cross rule to obtain the correct formula. Figure 2 at the right shows how it works: the charge of the positive ion becomes the subscript of the negative ion, and the charge of the negative ion becomes the subscript of the positive ion. The formula of aluminum sulfide becomes Al_2S_3, showing that there is a 2:3 ratio of aluminum ions to sulfide ions in the compound.

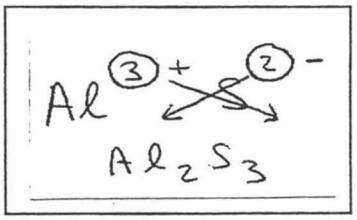

Fig. 2 - Criss-Cross Rule

Two aluminum ions together have a charge of +6; three sulfide ions together have a charge of –6. The total positive charge (+6) added to the total negative charge (–6) adds up to zero and the positive and negative charges cancel each other out. ***Remember that all ionic compounds are electrically neutral and the total positive and negative charges of the constituent ions in the formula must add up to zero.***

IV. MONOATOMIC IONS WITH TWO CHARGES

Many metals, especially transition elements, can form ions with *two* different charges. There are two ways in which such ions may be named:

Method #1: The charge of the ion is written in Roman numerals next to the name of the metal, with the number in parentheses.

Method #2: An –ous ending is added to the stem for the ion with the lower charge, and an –ic ending is applied to the ion with the higher charge.

Examples (which you should know):

Cu^+ - copper (I) ion or cuprous ion; Cu^{2+} - copper (II) ion or cupric ion

Fe^{2+} - iron (II) ion or ferrous ion; Fe^{3+} - iron (III) ion or ferric ion

V. BINARY ACIDS (AQUEOUS [WATER] SOLUTIONS)

When hydrogen is combined with a halogen such as chlorine, the resulting covalent compound is named using the rules appearing in section VII below. Thus, pure HCl is a gas, and its correct name is *hydrogen chloride*. But when this gas is bubbled into water, an acid, called *hydrochloric acid,* is produced. These so-called "binary acids" contain only hydrogen and a non-metal, and they are named *hydro——ic acid* (where the stem of the halogen appears instead of the long dash. ***Examples:***

$HF_{(aq)}$, hydrofluoric acid; $HCl_{(aq)}$, hydrochloric acid; $HBr_{(aq)}$, hydrobromic acid; $HI_{(aq)}$, hydroiodic acid. An exception occurs for $H_2S_{(aq)}$, which is called hydrosulf**ur**ic acid, not hydrosulfic acid.

VI. OXYGEN-CONTAINING ACIDS; POLYATOMIC IONS DERIVED FROM THESE ACIDS

There are five common acids in this group. Each acid dissociates to yield one or more hydrogen ions (H^+). The first two acids are *monoprotic* acids; they dissociate to yield only *one* proton and a *monoatomic* ion (an ion with only one atom in it) is formed.

The three remaining acids are *polyprotic* acids, dissociating to yield *two or more* protons. After dissociation, the related *polyatomic ion* is formed. A polyatomic ion is an ion which has more than one atom in it, such as OH^-, PO_4^{3-}, and CO_3^{2-}.

Monoprotic Acids and their Ions

Neutral Oxygen-Containing Acid	*Related Polyatomic Ion*
1. Nitric acid, HNO_3	Nitr***ate*** ions, NO_3^-
2. Acetic acid, $HC_2H_3O_2$ (sometimes written as CH_3COOH)	Acet***ate*** ions, $C_2H_3O_2^-$ (sometimes written as CH_3COO^-)

Once you know the formula of the free acid on left hand side, you can derive the formula of the polyatomic ion at the right. For example, for nitric acid, the dissociation equation is:

$$\underset{\text{nitric acid}}{HNO_3} \rightarrow H^+ + \underset{\text{nitr}\textbf{\textit{ate}}\text{ ion}}{NO_3^-}$$

Similarly, for acetic acid, the dissociation equation is:

$$\underset{\text{acetic acid}}{HC_2H_3O_2} \rightleftarrows H^+ + \underset{\text{acet}\textbf{\textit{ate}}\text{ ion}}{C_2H_3O_2^-}$$

If acetic acid is written in its alternate form (CH_3COOH), the dissociation equation becomes:

$$\underset{\text{acetic acid}}{CH_3COOH} \rightleftarrows \underset{\text{acet}\textbf{\textit{ate}}\text{ ion}}{CH_3COO^-} + H^+$$

Polyprotic Acids and their Ions

Polyprotic acids dissociate in steps to produce two or more protons. Those polyprotic acids which can dissociate to produce *two* protons (such as H_2SO_4 and H_2CO_3) are often referred to as ***diprotic acids.*** Similarly, polyprotic acids which can dissociate to produce *three* protons (such as H_3PO_4) are often referred to as ***triprotic acids.***

The formula of carbonic acid, H_2CO_3, can easily be remembered if you note that this acid is produced when carbon dioxide gas, CO_2, is dissolved in (and reacts with) water:

$$CO_{2(g)} + H_2O_{(\ell)} \rightarrow H_2CO_{3(aq)}$$

Sulfuric acid (H_2SO_4)

STEP 1: $H_2SO_4 \rightarrow H^+ + HSO_4^-$
Sulfuric acid — Hydrogen sulfate ion (bisulfate ion)

STEP 2: $HSO_4^- \rightleftarrows H^+ + SO_4^{2-}$
Hydrogen sulfate ion (bisulfate ion) — Sulfate ion

Carbonic acid (H_2CO_3)

STEP 1: $H_2CO_3 \rightleftarrows H^+ + HCO_3^-$
Carbonic acid — Hydrogen carbonate ion (bicarbonate ion)

STEP 2: $HCO_3^- \rightleftarrows H^+ + CO_3^{2-}$
Hydrogen carbonate ion (bicarbonate ion) — Carbonate ion

Note that the intermediate ions whose charge is –1 have two different names. The prefix "bi–" is often substituted for the word "hydrogen." For this reason, a HSO_4^- ion may also be called a ***bisulfate ion***, and a HCO_3^- ion may also be called a ***bicarbonate ion***.

Phosphoric acid (H_3PO_4)

For phosphoric acid (H_3PO_4), three such dissociation equations may be written:

STEP 1: $H_3PO_4 \rightleftarrows H^+ + H_2PO_4^-$
Phosphoric acid — Dihydrogen phosphate ion

STEP 2: $H_2PO_4^- \rightleftarrows H^+ + HPO_4^{2-}$
Dihydrogen phosphate ion — Hydrogen phosphate (biphosphate) ion

STEP 3: $HPO_4^{2-} \rightleftarrows H^+ + PO_4^{3-}$
Hydrogen phosphate ion — Phosphate ion

Additional polyatomic ions you need to know:

NH_4^+, ammonium ion; OH^-, hydroxide ion; H_3O^+, hydronium ion; ClO_3^-, chlorate ion

Hints: Ammonium and hydronium ions are formed by adding H^+ to ammonia and water, respectively:

$NH_3 + H^+ \rightarrow NH_4^+$
Ammonia — Ammonium ion

$H_2O + H^+ \rightarrow H_3O^+$
Water — Hydronium ion

Hydroxide ions are formed along with hydrogen ions (H^+) in the dissociation of water:

$H_2O \rightleftarrows H^+ + OH^-$
Water — Hydroxide ion

VII. COVALENT COMPOUNDS CONTAINING TWO NON-METALS

Remember: this section does not apply to ionic compounds that contain positive and negative ions. To name *covalent* compounds containing two different non-metals, which exist in the form of *neutral molecules*, write the more electronegative element *last*. (This is similar to the system of naming ionic compounds with the negative ion written last.) Greek prefixes are used to indicate the number of atoms present.

Prefixes: 1: mono– 2: di– 3: tri– 4: tetra– 5: penta–
6: hexa– 7: hepta– 8: octa– 9: nona– 10: deca–

Examples: $HCl_{(g)}$, hydrogen chloride; $HF_{(g)}$, hydrogen fluoride; CO, carbon monoxide; CO_2, carbon dioxide; SO_2, sulfur dioxide; SO_3, sulfur trioxide; BF_3, boron trifluoride; SiF_4, silicon tetrafluoride; CCl_4, carbon tetrachloride; NCl_3, nitrogen trichloride

Note: the subscript (g) has been added after the formulas of HCl and HF to emphasize that the pure covalent compounds hydrogen chloride and hydrogen fluoride are being named here. These two names change when these substances are dissolved in water. As is noted in section V. above, the names of the aqueous (water) solutions of these two compounds are hydrochloric acid and hydrofluoric acid, respectively.

Also note that the prefix mono– is often omitted, especially in front of the first name of the compound when the subscript is one (as in carbon dioxide, CO_2). Similarly, HCl is called just hydrogen chloride, not monohydrogen monochloride.

VIII. HYDRATES

Hydrates are solid crystalline ionic compounds that contain a definite number of molecules of water that are chemically bound into the crystal structure of the solid. The water that is present in the solid is called the *water of hydration*. When the hydrate is heated to partially decompose it, the water of hydration is driven off, and the *anhydrous salt* (the compound without the water) is left behind. An example is the partial decomposition of cupric sulfate pentahydrate to form cupric sulfate:

$$\underset{\text{Cupric sulfate pentahydrate}}{\underset{\text{HYDRATE}}{CuSO_4 \cdot 5\ H_2O_{(s)}}} \rightarrow \underset{\text{Cupric sulfate}}{\underset{\text{ANHYDROUS SALT}}{CuSO_{4(s)}}} + \underset{\text{Water}}{\underset{\text{WATER}}{5\ H_2O_{(g)}\uparrow}}$$

To name a hydrate, first name the main compound following the usual rules. Then use the Greek prefixes (listed above) to indicate how many water molecules are present. The format is:

[Name of anhydrous salt] ——hydrate

where the Greek prefix is inserted where the dash appears in the above line.

Examples:

$CuSO_4 \cdot 5\ H_2O$ - Copper (II) sulfate pentahydrate or cupric sulfate pentahydrate

$NiCl_2 \cdot 6\ H_2O$ - Nickel chloride hexahydrate

$Fe(C_2H_3O_2)_2 \cdot 4\ H_2O$ - Iron (II) acetate tetrahydrate or ferrous acetate tetrahydrate

The raised dot is used to separate the water of hydration from the rest of the molecule.

IX. EXCEPTIONS - NAMES OF COMMON SUBSTANCES

H_2O is a covalent compound formed by two non-metals and it could technically be called *dihydrogen monoxide* (DHMO). Instead, we find it much more convenient to call this chemical *water*. For some educational fun, visit this web site: **www. dhmo.org .**

Names of some other common substances you should memorize are: H_2O_2, hydrogen peroxide; NH_3, ammonia; and CH_4, methane.

IMPORTANT THINGS TO REMEMBER

1. Remember that negative ions whose names end in —ide are usually *monoatomic* ions (and have only one atom in them). Negative ions whose names end in —ate are *polyatomic* ions (and have several oxygen atoms present in addition). You need to remember how many oxygen atoms there are.

   Examples:

   Sulf**ide** ions are S^{2-}; sulf**ate** ions are SO_4^{2-}
   Nitr**ide** ions are N^{3-}; nitr**ate** ions are NO_3^-
   Phosph**ide** ions are P^{3-}; phosph**ate** ions are PO_4^{3-}
   Chlor**ide** ions are Cl^-; chlor**ate** ions are ClO_3^-

   Exceptions: as was noted previously, the only common negative ions whose names end in —ide and which are *polyatomic* ions are hydroxide ions, OH^-; and cyanide ions, CN^-.

2. Many other ions exist which you do *not* need to memorize at this time. All of this is explained in detail in your textbook, and you are *not* responsible for memorizing those additional ions. For example, hypochlorite ions are ClO^-, chlorite ions are ClO_2^-, and perchlorate ions are ClO_4^-. These ions are not encountered as frequently as the other ions whose names end in —ide or —ate.

3. Remember to use parentheses appropriately when writing formulas of ionic compounds:

   a. ***Parentheses must be used whenever polyatomic ions taken more than once.*** We cannot write magnesium hydroxide as $MgOH_2$, because this would mean one magnesium atom, ***one oxygen atom***, and two hydrogen atoms. Instead, magnesium hydroxide is $Mg(OH)_2$ (one magnesium atom, two oxygen atoms, and two hydrogen atoms). Parentheses need to be used here: if you wrote MgO_2H_2 instead, even though that formula has the correct number of atoms in it, it would not be readily apparent to the reader that you were referring to magnesium hydroxide.

   b. ***No parentheses should be used whenever polyatomic ions need to be taken only once.*** Instead of writing sodium hydroxide as Na(OH), we write NaOH. Parentheses are unnecessary here and should not be used.

   c. ***No parentheses should be used around monoatomic ions under any circumstances.*** Instead of writing sodium sulfide as $(Na)_2S$, we write Na_2S. The use of parentheses in this case is similarly unnecessary.

Examples showing the appropriate use of parentheses when naming ionic compounds that contain polyatomic ions appear in the table that follows.

Name of compound	Positive ion	Negative ion	Formula of compound
Potassium chlorate	K^+	ClO_3^-	$KClO_3$
Aluminum hydroxide	Al^{3+}	OH^-	$Al(OH)_3$
Barium phosphate	Ba^{2+}	PO_4^{3-}	$Ba_3(PO_4)_2$
Ferric bicarbonate	Fe^{3+}	HCO_3^-	$Fe(HCO_3)_3$
Ammonium sulfate	NH_4^+	SO_4^{2-}	$(NH_4)_2SO_4$

4. Remember the relationship between the names of common acids and the negative ions which are produced from those acids. When an acid loses all of its protons, the negative charge is equal to the number of protons lost. ***Examples:***

Formula of Acid	Name of Acid	Formula of Negative Ion	Name of Negative Ion
HCl	hydrochloric acid	Cl^-	chloride ion
HNO_3	nitric acid	NO_3^-	nitrate ion
$HC_2H_3O_2$	acetic acid	$C_2H_3O_2^-$	acetate ion
H_2SO_4	sulfuric acid	SO_4^{2-}	sulfate ion
H_2CO_3	carbonic acid	CO_3^{2-}	carbonate ion
H_3PO_4	phosphoric acid	PO_4^{3-}	phosphate ion

Nomenclature Practice

Two nomenclature grids have been prepared to help you practice writing the names and formulas of ionic compounds. In the first grid, only simple metal and non-metal ions are listed. You may determine the charges of these ions by looking at the periodic table, as is explained in section II.B. In the second grid, polyatomic ions have been added.

In each grid, first write the formulas of the positive and negative ions in the blank spaces provided in the row and column headings. Then, in each rectangle appearing in the main grid, first write the name of the compound and then write its correct chemical formula underneath.

Finally, one additional page is listed containing the names and formulas of many common substances. To test your knowledge of chemical nomenclature, first cover up the second column with a blank sheet of paper. Then write down the formulas of the compounds listed in the first column on the blank paper. Compare your answers with the correct answers and determine why some of your answers were incorrect. Then cover up the names of the compounds in the first column. Start with the formulas of the compounds in the second column and see if you can name all of the compounds listed. Repeat this process going from the third column to the fourth column, and vice-versa.

Nomenclature Grid I - Names and Formulas of Simple Ionic Compounds

First write the formulas of the positive and negative ions in the blank spaces provided in the row and column headings. Then, in each rectangle appearing in the main grid, first write the name of the compound, and then write its correct chemical formula underneath.

	Fluoride ion _____	**Chloride ion** _____	**Oxide ion** _____	**Sulfide ion** _____	**Nitride ion** _____
Sodium ion _____					
Potassium ion _____					
Magnesium ion _____					
Barium ion _____					
Aluminum ion _____					

Please continue to Nomenclature Grid II which is on the following page.

Nomenclature Grid II - Names and Formulas of Ionic Compounds with Polyatomic Ions

First write the formulas of the positive and negative ions in the blank spaces provided in the row and column headings. Then, in each rectangle appearing in the main grid, first write the name of the compound, and then write its correct chemical formula underneath.

	Nitrate ion _____	Acetate ion _____	Carbonate ion _____	Sulfate ion _____	Phosphate ion _____
Ammonium ion _____					
Silver ion _____					
Ferrous ion _____					
Cupric ion _____					
Ferric ion _____					

Please continue to the Nomenclature Assignment which is on the following page.

NOMENCLATURE ASSIGNMENT

The names of various elements, compounds, or ions appear in the first column, and the correct symbols or formulas appear in the second column. First cover up the second column with a blank piece of paper, and practice writing the symbols or formulas, comparing your answers with the correct answers shown. Then cover up the first column and see if you can name the compounds if you are given the formulas.

NAME	FORMULA	NAME	FORMULA
sodium oxide	Na_2O	fluorine	F_2
zinc sulfate heptahydrate	$ZnSO_4 \cdot 7\ H_2O$	magnesium hydrogen sulfate	$Mg(HSO_4)_2$
hydrochloric acid	$HCl_{(aq)}$	potassium hydroxide	KOH
nickel hydroxide	$Ni(OH)_2$	acetic acid	$HC_2H_3O_2$ or CH_3COOH
iodine	I_2	ammonia	NH_3
silver sulfide	Ag_2S	lead chloride	$PbCl_2$
ferric acetate	$Fe(C_2H_3O_2)_3$	aluminum nitride	AlN
hydronium ion	H_3O^+	ferrous bisulfate	$Fe(HSO_4)_2$
cuprous carbonate	Cu_2CO_3	cupric bromide	$CuBr_2$
oxygen	O_2	ammonium carbonate	$(NH_4)_2CO_3$
ammonium phosphate	$(NH_4)_3PO_4$	potassium nitrate	KNO_3
sulfuric acid	H_2SO_4	phosphoric acid	H_3PO_4
ferric phosphate	$FePO_4$	silicon dioxide	SiO_2
potassium nitride	K_3N	sodium acetate	$NaC_2H_3O_2$
magnesium fluoride	MgF_2	iron (II) sulfide	FeS
chlorine dioxide	ClO_2	aluminum hydroxide	$Al(OH)_3$
ferrous chloride	$FeCl_2$	lithium nitrate	$LiNO_3$
barium chloride dihydrate	$BaCl_2 \cdot 2\ H_2O$	calcium hydrogen carbonate	$Ca(HCO_3)_2$
water	H_2O	hydrogen peroxide	H_2O_2
calcium nitrate	$Ca(NO_3)_2$	ozone	O_3
bromine	Br_2	nitrogen triiodide	NI_3
barium acetate	$Ba(C_2H_3O_2)_2$	cuprous sulfate	Cu_2SO_4
carbon disulfide	CS_2	nitrogen	N_2
nitric acid	HNO_3	sodium phosphide	Na_3P
calcium nitride	Ca_3N_2	carbonic acid	H_2CO_3
sodium sulfate	Na_2SO_4	cuprous acetate	$CuC_2H_3O_2$
hydrogen	H_2	ammonium ion	NH_4^+
dinitrogen pentoxide	N_2O_5	ferric iodide	FeI_3
aluminum bicarbonate	$Al(HCO_3)_3$	potassium carbonate	K_2CO_3
barium phosphide	Ba_3P_2	chlorine	Cl_2
hydrobromic acid	$HBr_{(aq)}$	potassium sulfate	K_2SO_4
zinc chloride	$ZnCl_2$	ammonium hydroxide	NH_4OH