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Section: Chemical Names

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7-1 CHEMICAL NAMES

What is in a chemical name? Hopefully, some chemical information and often a historical origin. After Alexander the Great conquered parts of Egypt, the Greeks built a temple dedicated to the god Ammon. Fires built in this temple usually used camel chips as fuel. After years of such practice, it was discovered that a white crystalline material was deposited on the walls of the temple along with the soot from the fires. This white saltlike material became known as sal ammoniac, which meant "salt of Ammon." Today, the compound is named ammonium chloride, but it is sometimes called by the old name of sal ammoniac. In the eighteenth century, sal ammoniac was used to produce a gaseous compound that was given the name ammonia because of its source. This name is still used today as the official name of the compound NH_3.

The ability to name chemical compounds and to deduce the chemical composition from the name is very important to the study of chemistry. Systems of **nomenclature** have been developed for various kinds of compounds. Names that convey information about the composition of compounds are called **systematic names.** The names of many chemical compounds developed historically before any systems of nomenclature had been established. These names generally are not logical and usually do not convey any information concerning the structure of the compound. Such names are called **common** or **trivial names.** Some of these are so familiar that they are almost always used. For example, the name water for H_2O is a common name that is invariably used. Table 7-1 lists the formulas of some important compounds that have common names that are accepted. Table 7-2 lists the trivial and systematic names for a few familiar compounds.

Table 7-1 SOME COMPOUNDS WITH OFFICIALLY ACCEPTED COMMON NAMES

Formula	Name
CH_4	Methane
SiH_4	Silane
GeH_4	Germane
SnH_4	Stannane
C_2H_6	Ethane
C_3H_8	Propane
C_6H_6	Benzene
NH_3	Ammonia
PH_3	Phosphine
AsH_3	Arsine
SbH_3	Stibine
H_2O	Water
H_2S	Hydrogen sulfide
H_2Se	Hydrogen selenide
H_2Te	Hydrogen telluride

Chemical compounds are viewed as either ionic or molecular. There are specific methods used to name ionic compounds and different methods for molecular compounds.

7-2 FORMULAS FROM IONS

The formulas of possible ionic compounds are derived from combinations of ions. An ionic compound will contain the correct number of positive ions and negative ions so that the total positive charge equals the total negative charge. This dictates the formula used to represent ionic compounds. For instance, the formula for the compound containing sodium ion, Na^+, and fluoride ion, F^-, is

$$Na^+ \qquad F^-$$

NaF (one sodium ion for each fluoride ion)

The formula for the compound containing potassium ion, K^+, and sulfide ion, S^{2-}, is shown on the next page.

K^+ S^{2-}

K_2S (two potassium ions for each sulfide ion)

The formula for the compound containing aluminum ion, Al^{3+}, and oxide ion, O^{2-}, is

Al^{3+} O^{2-}

Al_2O_3 (two aluminum ions to three oxide ions)

Formulas for metal polyatomic ion compounds are deduced in the same fashion. The formula for the compound containing sodium ion and nitrate ion, NO_3^-, is

Na^+ NO_3^-

$NaNO_3$

Table 7-2 TRIVIAL AND SYSTEMATIC NAMES FOR SOME COMMON COMPOUNDS

Formula	Trivial Name	Systematic Name
Al_2O_3	Alumina	Aluminum oxide
$NaHCO_3$	Baking soda	Sodium hydrogen carbonate
$Na_2B_4O_7 \cdot 10H_2O$	Borax	Sodium tetraborate 10-water
$CaCO_3$	Calcite or marble	Calcium carbonate
$KHC_4H_4O_6$	Cream of tartar	Potassium hydrogen tartrate
$MgSO_4 \cdot 7H_2O$	Epsom salt	Magnesium sulfate 7-water
$CaSO_4 \cdot 2H_2O$	Gypsum	Calcium sulfate 2-water
C_2H_5OH	Grain alcohol, alcohol	Ethyl alcohol or ethanol
$Na_2S_2O_3$	Hypo	Sodium thiosulfate
N_2O	Laughing gas, nitrous oxide	Dinitrogen oxide
PbO	Litharge	Lead(II) oxide
CaO	Quick lime	Calcium oxide
NaOH	Lye	Sodium hydroxide
$2CaSO_4 \cdot H_2O$	Plaster of paris	Calcium sulfate water (2/1)
K_2CO_3	Potash	Potassium carbonate
NH_4Cl	Sal ammoniac	Ammonium chloride
$NaNO_3$	Chile saltpeter	Sodium nitrate
$Ca(OH)_2$	Slaked lime	Calcium hydroxide
$C_{12}H_{22}O_{11}$	Sugar	Sucrose or α-D-glucopyranosyl β-D-fructofuranoside
NaCl	Salt	Sodium chloride
$Na_2CO_3 \cdot 10H_2O$	Washing soda	Sodium carbonate 10-water
$(CH_3)_2CHOH$	Rubbing alcohol	Isopropyl alcohol

The formula for the compound of calcium ion, Ca^{2+}, and hydroxide ion, OH^-, is

Ca^{2+} OH^-

$Ca(OH)_2$ (Two hydroxide ions are needed for each calcium ion. This is denoted by enclosing the hydroxide in parentheses and using a subscript.)

The formula for the compound of magnesium, Mg^{2+}, and phosphate ion, PO_4^{3-}, is shown below.

Mg^{2+} PO_4^{3-}

$Mg_3(PO_4)_2$

7-3 NOMENCLATURE OF IONIC COMPOUNDS

A tabulation of typical ions appears inside the front cover of this book. Notice that positive simple ions are named by using the name of the metal followed by the word ion (i.e., Na^+ sodium ion). Negative simple ions are named by using the root or first portion of the name of the element with an -ide ending (i.e., O^{2-} oxide ion). See Table 7-5 for a list of roots. Polyatomic ions have unique names, most of which are trivial. All common polyatomic ions are negative except ammonium ion, NH_4^+.

The formula of an ionic compound indicates the ions that compose the compound. To name an ionic compound, simply decide which ions are present. Then give the name of the positive ion, followed by the name of the negative ion. For example, the compound $Al_2(SO_4)_3$ contains the aluminum ion, Al^{3+}, and the sulfate ion, SO_4^{2-}. Thus the name is: aluminum sulfate. Notice that there is no need to indicate that there are two aluminum ions for three sulfate ions because there is only one combination possible. In fact, the known charges of the ions imply this information. Some additional examples are given below.

NaF	sodium fluoride
K_2S	potassium sulfide
Al_2O_3	aluminum oxide
$NaNO_3$	sodium nitrate
$Ca(OH)_2$	calcium hydroxide
$Mg_3(PO_4)_2$	magnesium phosphate

Many combinations of positive and negative ions are possible, and a large number of ionic compounds are found in nature. Numerous ionic compounds have been synthesized in the laboratory by chemists.

Ionic compounds are sometimes grouped according to the negative ion that they share in common. For instance, all compounds that contain the oxide ion, O^{2-}, are called oxides. Tables 7-3 lists some common oxides. Compounds containing chloride ion, Cl^-, are called chlorides (see Table 7-3). Common hydroxides (OH^- containing), carbonates (CO_3^{2-} containing), sulfates (SO_4^{2-} containing), nitrates (NO_3^- containing) and phosphates (PO_4^{3-} containing) are also listed in Table 7-3.

7-4 STOCK AND -OUS/IC NOMENCLATURE

Compounds involving metals that have more than one possible oxidation number are named in a manner that distinguishes one number from

Table 7-3 SOME OXIDES, CHLORIDES, HYDROXIDES, CARBONATES, SULFATES, NITRATES, AND PHOSPHATES

Oxides	
Na_2O	sodium oxide
K_2O	potassium oxide
MgO	magnesium oxide
CaO	calcium oxide
MnO_2	manganese(IV) oxide
FeO	iron(II) oxide
Fe_2O_3	iron(III) oxide
Fe_3O_4	iron(II,III) oxide
CuO	copper(II) oxide
ZnO	zinc oxide
Ag_2O	silver oxide
Al_2O_3	aluminum oxide
Chlorides	
$NaCl$	sodium chloride
KCl	potassium chloride
$MgCl_2$	magnesium chloride
$CaCl_2$	calcium chloride
$BaCl_2$	barium chloride
$FeCl_2$	iron(II) chloride
$FeCl_3$	iron(III) chloride
$AlCl_3$	aluminum chloride
$AgCl$	silver chloride
$ZnCl_2$	zinc chloride
Hg_2Cl_2	mercury(I) chloride
$HgCl_2$	mercury(II) chloride
Hydroxides	
$NaOH$	sodium hydroxide
KOH	potassium hydroxide
$Mg(OH)_2$	magnesium hydroxide
$Ca(OH)_2$	calcium hydroxide
$Ba(OH)_2$	barium hydroxide
$Fe(OH)_3$	iron(III) hydroxide
$Zn(OH)_2$	zinc hydroxide
$Al(OH)_3$	aluminum hydroxide
Carbonates	
Na_2CO_3	sodium carbonate
$NaHCO_3$	sodium hydrogen carbonate
$CaCO_3$	calcium carbonate
$MgCO_3$	magnesium carbonate
$FeCO_3$	iron(II) carbonate
$ZnCO_3$	zinc carbonate
Sulfates	
Na_2SO_4	sodium sulfate
$CaSO_4$	calcium sulfate
$BaSO_4$	barium sulfate
$Al_2(SO_4)_3$	aluminum sulfate
Nitrates	
$NaNO_3$	sodium nitrate
KNO_3	potassium nitrate
$Ca(NO_3)_2$	calcium nitrate
$Fe(NO_3)_3$	iron(III) nitrate
$Zn(NO_3)_2$	zinc nitrate
$AgNO_3$	silver nitrate
$Al(NO_3)_3$	aluminum nitrate
Phosphates	
Na_3PO_4	sodium phosphate
$Ca_3(PO_4)_2$	calcium phosphate
$AlPO_4$	aluminum phosphate

another. For example, the name iron chloride is not meaningful, since iron has the two possible oxidation numbers of +2 and +3. The names of compounds of this type must indicate the oxidation number of the metal. The best method for accomplishing this is called the **Stock system** of nomenclature.

This method is very similar to the one discussed above, except that the name of the metal is followed by a set of parentheses containing its oxidation number (or charge) expressed in Roman numerals. Thus the name of the compound consists of the name of the metal, followed by the oxidation number in parentheses, which is, in turn, followed by the name of the negative ion. As an example, consider the two possible binary compounds involving iron and chlorine. Since iron occurs in either a +2 or +3 oxidation number and chlorine has a −1 oxidation number, the formulas for these two compounds would be $FeCl_2$ and $FeCl_3$. The names of these compounds according to the Stock method would be

$FeCl_2$ iron(II) chloride

and

$FeCl_3$ iron(III) chloride

These names are read iron-two-chloride and iron-three-chloride. The Roman numeral indicates the oxidation number of the iron, and since the oxidation number of chlorine would be −1, the formulas are easily deduced from the names. Keep in mind that the Roman numerals do not refer to the second element but only to the first. The formulas for iron(II) sulfide and iron(III) sulfide would be FeS and Fe_2S_3, respectively, since the oxidation number of sulfur would be −2. The Stock method gives the oxidation number of the first element, and in order to deduce the formula from the name or to obtain the name from the formula, we must know the oxidation number of the second element.

Example 7-1 Name the following compounds using the Stock method of nomenclature:

$CuCl_2$	copper is +2, so the name is copper(II) chloride
CuCl	copper is +1, so the name is copper(I) chloride
SnF_4	tin is +4, so the name is tin(IV) fluoride
SnF_2	tin is +2, so the name is tin(II) fluoride
$Hg(NO_3)_2$	mercury is +2, so the name is mercury(II) nitrate
$Hg_2(NO_3)_2$	mercury is +1, so the name is mercury(I) nitrate

When dealing with compounds involving mercury in the +1 oxidation state, keep in mind that in this state, mercury occurs in compounds as Hg_2^{2+}. Mercury in the +1 oxidation state is unique among the metals in that it occurs as an ion, Hg_2^{2+}, involving two Hg^+ ions joined by a covalent bond. The Hg^+ does not exist as a species. For example, the formula for mercury(I) chloride is Hg_2Cl_2, and the name of the compound Hg_2O is mercury(I) oxide.

A different method is occasionally used to name compounds that involve metals that have at least two different oxidation numbers. This method uses the root of the name of the metal with an -ous ending for the lower oxidation number and an -ic ending for the higher oxidation number of the metal. For example, with this method, the names of $FeCl_2$ and $FeCl_3$ are ferrous chloride and ferric chloride, respectively. The root ferr- is derived from the Latin name for iron, *ferrum*. Table 7-4 lists some metals for which this **-ous/ic** method can be used. Note that in some cases the Latin roots are used and in some cases the normal root is retained. This method is not recommended because it is necessary to know the oxidation number of the metals involved and, sometimes, the Latin names for the metals. That is, the metal name root with an -ous or an -ic ending does not convey the oxidation number of the metal, so it is necessary to know which oxidation number corresponds to each ending. The -ous/ic method should be avoided if possible, but unfortunately, it is still in use and is found in some of the older literature.

Table 7-4 THE ous/ic NAMES OF SOME METALS

Element	Symbol	Oxidation Number	Name
Chromium	Cr	+2	Chromous
		+3	Chromic
Manganese	Mn	+2	Manganous
		+3	Manganic
Iron	Fe	+2	Ferrous
		+3	Ferric
Cobalt	Co	+2	Cobaltous
		+3	Cobaltic
Copper	Cu	+1	Cuprous
		+2	Cupric
Mercury	Hg	+1	Mercurous
		+2	Mercuric
Tin	Sn	+2	Stannous
		+4	Stannic

Example 7-2 Give the -ous/ic names for the following compounds:

$CuCl_2$	copper is +2, so the name is cupric chloride
$CuCl$	copper is +1, so the name is cuprous chloride
SnF_4	tin is +4, so the name is stannic fluoride
SnF_2	tin is +2, so the name is stannous fluoride
$Hg(NO_3)_2$	mercury is +2, so the name is mercuric nitrate
$Hg_2(NO_3)_2$	mercury is +1, so the name is mercurous nitrate

7-5 NAMING NONMETAL-NONMETAL COMPOUNDS

Since the nonmetals usually have several possible oxidation numbers, there is often more than one binary compound involving two different nonmetals in combination. For instance, the common positive oxidation numbers of phosphorus are +3 and +5. Thus the two likely phosphorus-chlorine compounds are

$$\overset{+3}{\mathrm{P}}\ \overset{-1}{\mathrm{Cl}} \quad \text{and} \quad \overset{+5}{\mathrm{P}}\ \overset{-1}{\mathrm{Cl}}$$

$$PCl_3 \qquad\qquad PCl_5$$

Binary nonmetal-nonmetal and metalloid-nonmetal compounds are named by a method that involves stating the name of the first element, followed by the root of the name of the second element with an -ide ending. Table 7-5 lists the roots used for the nonmetals. Each part of the name is preceded by a Greek or Latin prefix indicating the number of combined atoms of that element in the compounds. The prefixes used are given below.

mono-	one (this prefix is usually omitted)
di-	two
tri-	three
tetra-	four
penta-	five
hexa-	six
hepta-	seven
octa-	eight
nona-	nine
deca-	ten

Table 7-5 ROOTS OF THE NAMES OF SOME COMMON ELEMENTS

Element	Root
Hydrogen	hydr-
Boron	bor-
Carbon	carb-
Silicon	silic-
Nitrogen	nitr-
Phosphorus	phosph-
Arsenic	arsen-
Antimony	antimon-
Oxygen	ox-
Sulfur	sulf- or sulfur-
Selenium	selen-
Tellurium	tellur-
Fluroine	fluor-
Chlorine	chlor-
Bromine	brom-
Iodine	iod-

Which nonmetal is named first, and which is given the -ide ending? The preferred order of elements to be named first in nonmetal-nonmetal or metalloid-nonmetal compounds is

B, Ge, Si, C, Sb, As, P, N, H, Te, Se, S, I, Br, Cl, O, and F

Notice that except for hydrogen and oxygen, this order is from bottom to top of each group and from left to right in the periodic table. Naming compounds by this method provides a way in which the formula of the compound is precisely defined by the name. For example, the compound BF_3 would be named boron trifluoride. This name indicates that the compound formula involves one boron in combination with three fluorines. Some additional examples are presented below.

N_2O	dinitrogen oxide
NO_2	nitrogen dioxide
N_2O_5	dinitrogen pentoxide (the "a" of penta is omitted for proper pronunciation)
P_4O_{10}	tetraphosphorus decoxide (the "a" of deca is omitted for proper pronunciation)
OF_2	oxygen difluoride
P_4S_7	tetraphosphorus heptasulfide
PCl_3	phosphorus trichloride
PCl_5	phosphorus pentachloride
CO	carbon monoxide
CO_2	carbon dioxide

7-6 NOMENCLATURE OF ACIDS

The binary compounds involving hydrogen and the VIIA elements are generally named according to the nonmetal-nonmetal nomenclature rules. For example, HCl is hydrogen chloride, and HI is hydrogen iodide. When these compounds are dissolved in water, the resulting solutions display specific properties called acidic properties. Some common properties of acidic solutions are that they taste sour, dissolve some metals, can burn the skin, and turn blue litmus paper red. (See Section 14-1.)

The water solutions of these compounds are called **acids** and are given specific names. We normally give names only to pure compounds. However, since these acid solutions are very important in chemistry, special names are assigned to them. The names are formed by using the prefix hydro- with the root of the name of the element, other than hydrogen, followed by an -ic ending. This part of the name is then followed by the word "acid." The general form for these names is

hydro(root)ic acid

Some examples of this general pattern are given on the next page.

Formula of Pure Compound	Name of Pure Compound	Name of Water Solution
HF	hydrogen fluoride	hydrofluoric acid
HCl	hydrogen chloride	hydrochloric acid
HI	hydrogen iodide	hydroiodic acid

The water solutions of acids are sometimes denoted by giving the formula of the compound followed by a parenthetical "*aq*" to indicate an aqueous or water solution [i.e., HCl (*aq*), HF(*aq*)].

Many of the nonmetals form compounds that include hydrogen and oxygen (i.e., HNO_3, H_2SO_4, $HClO_3$). Most of these compounds and the corresponding water solutions of these compounds have acidic properties. (See Section 14-1.) These compounds are called **oxyacids.** The same name is usually used to refer to both the pure oxyacid and water solutions of the oxyacid.

Most of the nonmetals form more than one oxyacid. For instance, sulfur forms H_2SO_4 and H_2SO_3. The differences between these formulas are that sulfur has a different oxidation number and that there are different numbers of oxygens. They are both oxyacids of sulfur and are distinguished by use of the -ic and -ous endings as is done for some metals. (See Section 7-4.)

		Oxidation Number of Sulfur
H_2SO_4	sulfuric acid	+6
H_2SO_3	sulfurous acid	+4

Table 7-6 lists some common oxyacids of the nonmetals.

Table 7-6 SOME COMMON OXYACIDS

Group VA
- HNO_3 Nitric acid
- HNO_2 Nitrous acid
- H_3PO_4 Phosphoric acid

Group VIA
- H_2SO_4 Sulfuric acid
- H_2SO_3 Sulfurous acid

Group VIIA
- $HClO_3$ Chloric acid
- $HClO_2$ Chlorous acid
- (chlorine also forms perchloric acid, $HClO_4$ and hypochlorous acid, HClO)

7-7 NOMENCLATURE OF OXYANIONS

Oxygen and many of the nonmetals occur in the form of polyatomic ions called **oxyanions.** In fact, the oxyanions are related to the oxyacids in the sense that they can be formed by loss of hydrogen ions (H^+) by the oxyacids. For instance, the sulfate ion, SO_4^{2-}, which is an oxyanion of sulfur, can be formed by the loss of two hydrogen ions from sulfuric acid ($H_2SO_4 \longrightarrow SO_4^{2-} + 2H^+$). Table 7-7 lists some common oxyanions.

Oxyanions are named in a manner related to that of the oxyacids. The formulas of these ions are the same as the oxyacids except that hydrogen is not present, and the ions carry charges that correspond to the absence of hydrogen (one minus charge for every hydrogen that is absent). The names of the oxyanions can be deduced by changing the ending of the name of the corresponding oxyacid and adding the word "ion." The **-ic** ending of the acid name is changed to an **-ate** and the **-ous** ending of the acid name is changed to an **-ite.** Thus, in order to name a given oxyanion, we merely change the ending of the name of the corresponding oxyacid. For example:

H_2SO_4	sulfuric acid	SO_4^{2-}	sulfate ion
H_2SO_3	sulfurous acid	SO_3^{2-}	sulfite ion
H_3PO_4	phosphoric acid	PO_4^{3-}	phosphate ion
HNO_3	nitric acid	NO_3^-	nitrate ion
HNO_2	nitrous acid	NO_2^-	nitrite ion
$HClO_3$	chloric acid	ClO_3^-	chlorate ion
$HClO_2$	chlorous acid	ClO_2^-	chlorite ion

The acids and oxyacids that involve more than one hydrogen can form polyatomic ions that result from the loss of one or more hydrogen ions (H^+) from the parent acid. The charges of these ions correspond to the absence of the hydrogens. These ions are named in the same manner as the acid anions except that the anion name is preceded by the word "hydrogen," which has a prefix indicating the number of combined hydrogens that are associated with the ion. The prefix mono- is usually omitted.

Example 7-3 Name the following ions:

$H_2PO_4^-$	dihydrogen phosphate ion	(H_3PO_4 less one H^+)
HPO_4^{2-}	hydrogen phosphate ion	(H_3PO_4 less two H^+)
HSO_4^-	hydrogen sulfate ion	(H_2SO_4 less one H^+)
HS^-	hydrogen sulfide ion	(H_2S less one H^+)
HCO_3^-	hydrogen carbonate ion	(H_2CO_3 less one H^+)

7-8 NOMENCLATURE OF HYDRATES

Water is a compound that is widely distributed in nature. It is the major component of the natural waters of the earth, and it is intimately involved in the cells and fluids of animals and plants. It is even found incorporated in the minerals and rocks of the earth. In fact, some complex compounds found in the earth actually contain water in loose chemical combination with an ionic solid.

Such compounds that include water are called **hydrates.** They are compounds containing a specific number of moles of water per mole of the original solid, called the parent compound. Since they have definite compositions, hydrates are actually compounds. For example, a certain hydrate of calcium chloride contains two moles of water per mole of the parent compound. The formula of this hydrate is $CaCl_2 \cdot 2H_2O$. Normally, when we write the formula of a hydrate, the formula of the parent compound is preceded by a number indicating the number of moles of this compound associated with a mole of the hydrate. This part of the formula is followed by the formula for water, which is preceded by a

Table 7-7 SOME COMMON OXYANIONS

Group IVA
- CO_3^{2-} Carbonate ion

Group VA
- NO_3^- Nitrate ion
- NO_2^- Nitrite ion
- PO_4^{3-} Phosphate ion

Group VIA
- SO_4^{2-} Sulfate ion
- SO_3^{2-} Sulfite ion

Group VIIA
- ClO_3^- Chlorate ion
- ClO_2^- Chlorite ion
- (chlorine also forms the perchlorate ion, ClO_4^-, and the hypochlorite ion, ClO^-)

number indicating the number of moles of water associated with a mole of the hydrate. The general formula of a hydrate would be

$$yA \cdot xH_2O$$

where A is the formula of the parent compound, sometimes called the anhydrous salt; y is a number indicating the number of moles of A per mole of hydrate; and x is a number indicating the number of moles of water per mole of hydrate. If x or y is absent, a 1 is understood. The dot ($\cdot$) between the formula of the parent and the formula of water denotes a loose chemical bond or association between the parent compound and water.

Hydrates can be named by stating the name of the parent compound followed by the word "water" preceded by a number indicating the number of moles. Alternately, the word "hydrate" is used in place of the word "water," and often a Greek prefix is used to indicate the moles of water. For example $CaCl_2 \cdot 2H_2O$ is named calcium chloride 2-water or calcium chloride dihydrate.

Another nomenclature method involves stating the name of the parent followed by the word water. After the name the ratio of the number of moles of parent to the number of moles of water is indicated in parentheses. Thus $CaCl_2 \cdot 2H_2O$ is named calcium chloride water (1/2).

Example 7-4 Name the following hydrates. (Some substances can form more than one hydrate.)

(a) $CuSO_4 \cdot 5H_2O$	copper(II) sulfate 5-water, copper(II) sulfate pentahydrate, copper(II) sulfate water (1/5)
(b) $CaCl_2 \cdot 6H_2O$	calcium chloride 6-water, calcium chloride hexahydrate, calcium chloride water (1/6)
(c) $CaCl_2 \cdot 3H_2O$	calcium chloride 3-water, calcium chloride trihydrate, calcium chloride water (1/3)
(d) $2CdCl_2 \cdot 5H_2O$	cadmium chloride water (2/5)

The water involved in hydrates is called **water of hydration.** Since water of hydration is contained in hydrates as discrete water molecules, it is often possible to remove the water, or **dehydrate,** by heating. Heating a hydrate produces water and the **anhydrous** (without water) solid compound:

$$\underset{\text{calcium chloride dihydrate}}{CaCl_2 \cdot 2H_2O} \xrightarrow{\text{heat}} \underset{\text{anhydrous calcium chloride}}{CaCl_2} + 2H_2O$$

The **percentage of water by mass** in a hydrate can often be found by dehydrating a known amount of the hydrate and then determining the mass of the resulting anhydrous solid. The mass of water is found by subtracting the mass of the anhydrous solid from the mass of the original sample of hydrate:

$$\text{mass } H_2O = \text{mass hydrate} - \text{mass anhydrous form}$$

Then the percentage of water can be found by dividing the mass of water by the mass of the original sample of hydrate and multiplying by 100:

$$\text{percentage of } H_2O = \left(\frac{\text{mass } H_2O}{\text{mass hydrate}}\right) 100$$

Some anhydrous solids and other substances can become more stable by combining with water in the atmosphere. When these substances are exposed to the atmosphere, they absorb water. A substance displaying such a property is said to be **hygroscopic.** Some substances are so hygroscopic they absorb enough water from the atmosphere to form a solution. Such substances are said to be **deliquescent.** For example, a pellet of solid sodium hydroxide, when exposed to the air, will soon absorb enough water to form a solution. Such deliquescent compounds should not be unnecessarily exposed to the atmosphere.

Some hygroscopic substances, such as calcium chloride and silica gel, are used as drying agents to absorb the moisture in a confined area. Substances like these are called **desiccants.** For example, anhydrous calcium chloride can be used as a desiccant in a container called a desiccator, which is used to keep other chemicals in a dry atmosphere. On the other hand, a few hydrates actually spontaneously lose water of hydration when exposed to the atmosphere. Such a process is known as **efflorescence.** For instance, a sample of $Na_2SO_4 \cdot 10H_2O$ exposed to the atmosphere will soon lose some of the water of hydration as it spontaneously dehydrates.

7-9 NAMES AND FORMULAS

We have considered the nomenclature of several common kinds of compounds. There are other kinds of compounds that are named by specific nomenclature rules, but the nomenclature covered in this chapter applies to those compounds that are important to our discussion of chemistry.

To name a compound given the formula, the compound should be classified into one of the following groups:

metal-nonmetal
metal-polyatomic ion
nonmetal-nonmetal
binary acid or oxyacid
hydrate

Once classified, the compound can be named using the appropriate nomenclature method. For instance, the compound CaS is classified as a metal-nonmetal compound and thus is an ionic compound containing calcium ion and sulfide ion, so it is named:

calcium sulfide

The compound $Zn(OH)_2$ is classified as a metal polyatomic ion compound containing zinc ion and hydroxide ion, so it is named:

zinc hydroxide

The compound Cl_2O_7 is classified as a nonmetal-nonmetal compound and thus is named:

dichlorine heptoxide

The compound HNO_3 is classified as an oxyacid, so it is named:

nitric acid

Example 7-5 Classify and name the following compounds:

H_2SO_3	oxyacid	sulfurous acid
$Ca(NO_3)_2$	metal polyatomic ion	calcium nitrate
K_2O	metal-nonmetal	potassium oxide
PBr_3	nonmetal-nonmetal	phosphorus tribromide
$MgSO_4 \cdot 7H_2O$	hydrate	magnesium sulfate heptahydrate

It is important to consider how a formula can be read. When a formula is encountered in reading, it can be read in one of two ways. First, it is possible to read a formula by just reading the element symbols as letters and the subscripts as numbers. For example, consider the pronunciation of the following formulas:

H_2SO_3	H-two-S-O-three
$Ca(NO_3)_2$	C-A-N-O-three-taken-twice
K_2O	K-two-O
PBr_3	P-B-R-three
$MgSO_4 \cdot 7H_2O$	M-G-S-O-four-dot-seven-H-two-O

The second approach to reading formulas is to translate the formula to the name as it is read. Admittedly, this approach requires some experience on the part of the reader.

PROBLEMS AND QUESTIONS

1 How are simple positive ions named? How are simple negative ions named?

2 How is the formula of an ionic compound written to convey electrical neutrality of the compound?

3 The following formulas contain parentheses. Explain why parentheses are needed in each case.

(a) ammonium sulfate, $(NH_4)_2SO_4$
(b) mercury(I) phosphate, $(Hg_2)_3(PO_4)_2$
(c) iron(II) nitrate, $Fe(NO_3)_2$
(d) tin(IV) chromate, $Sn(CrO_4)_2$

4 Give the correct formulas for the compounds formed by combinations of the positive and negative ions given in the following table (NaCl is given as an example).

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ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης