# Chapter 4: Nonionic Compounds and Their Nomenclature

A ***nonionic compound*** is a substance composed of atoms held together by chemical bonding forces, called ***covalent bonds***. Covalent bonds are formed by sharing a pair of electrons between two atoms, and will be covered in more detail later.

There are two general types of nonionic compounds: organic compounds and inorganic compounds. Organic compounds are molecules composed of predominantly carbon and hydrogen, with relatively small amounts of other elements such as nitrogen, oxygen, sulfur, phosphorous, and others. Organic compounds are numerous and complex. Special rules for naming them have been developed, and organic nomenclature will be covered in your Organic Chemistry class.

Nonionic inorganic compounds are typically small molecules composed two to eight (or so) atoms. There are several types of these nonionic inorganic compounds, and I will discuss the more important types.

Many elements are found in their natural state in the form of molecules. Examples are hydrogen, oxygen, nitrogen, sulfur, and so on. The chemical formulas for these molecules are $H_2$, $O_2$, $N_2$, $S_8$, etc. It is relatively easy to identify a molecule of an element; all of the atoms in the molecular formula will be identical. The proper name for these substances is simply the name of the element – no other descriptive information is required. The proper name for $H_2$ is "hydrogen", not "dihydrogen".

A second type is a ***binary nonionic compound***. These compounds are composed of two different nonmetallic elements, although the number of atoms of the individual elements can vary. Representative binary nonionic compounds are shown in the Table 4.1.

| | | | |
|---|---|---|---|
| $N_2O$ | Dinitrogen oxide | $N_2O_5$ | Dinitrogen pentoxide |
| $PCl_5$ | Phosphorous pentachloride | $SO_3$ | Sulfur trioxide |
| $CO_2$ | Carbon dioxide | CO | Carbon monoxide |
| HCl | Hydrogen chloride | $NI_3$ | Nitrogen triiodide |

Table 4.1. Representative binary nonionic compounds.

Naming binary nonionic compounds is relatively simple. The first element in the chemical formula is named using the full element name. The second element is named as if it were an anion. The prefixes *mono, di, tri, tetra, penta*, etc., are used to indicate 1, 2, 3, 4, 5, etc., atoms of a particular element. The prefix *mono* is never

used to indicate 1 atom of the *first* element: we never call CO monocarbon monoxide.

For certain compounds, such as HCl, extreme care must be used because the substances name changes depending upon specific circumstances. If HCl is dissolved in water, then it is proper to call it *hydrochloric acid*. However, if HCl is present as a pure substance not dissolved in water, its proper name is *hydrogen chloride*. Fortunately, only a few of these kinds of compounds exist.

Many substances have other common or trivial names in addition to their systematic names. Dinitrogen monoxide is also called "nitrous oxide"; these two names are used interchangeably. Unfortunately, these common names must be learned by rote.

Generally, compounds containing hydrogen do not follow the rules for naming binary nonionic compounds. Most hydrogen containing compounds have names that do not specify their composition. Two examples are $H_2O$ and $NH_3$. The proper names for these substances are water and ammonia respectively. You may have heard other students, or sometimes chemistry teachers, call these substances dihydrogen monoxide and nitrogen trihydride. These names are wrong, and no real chemist uses them, unless trying to make some specific point – for example, the point that I just made that the names are wrong.

Compounds containing more than two kinds of elements are almost exclusively organic compounds, or ionic compounds containing complex anions and cations. Examples of these compounds are the oxoanions and the corresponding oxoacids. Table 4.2 shows common oxoanions and their oxoacids. Please notice that many of these ions are complex anions shown in Table 3.2.

| Oxoanion | | Oxoacid | |
|---|---|---|---|
| $CO_3^{-2}$ | carbonate | $H_2CO_3$ | Carbonic acid |
| $HCO_3^-$ | hydrogen carbonate | | |
| $ClO^-$ | hypochlorite | HClO | Hypochlorous acid |
| $ClO_2^-$ | chlorite | $HClO_2$ | Chlorous acid |
| $ClO_3^-$ | chlorate | $HClO_3$ | Chloric acid |
| $ClO_4^-$ | perchlorate | $HClO_4$ | Perchloric acid |
| $SO_4^{-2}$ | sulfate | $H_2SO_4$ | Sulfuric acid |
| $HSO_4^-$ | hydrogen sulfate | | |
| $SO_3^{-2}$ | sulfite | $H_2SO_3$ | Sulfurous acid |
| $HSO_3^-$ | hydrogen sulfite | | |
| $PO_4^{-3}$ | phosphate | $H_3PO_4$ | Phosphoric acid |
| $HPO_4^{-2}$ | hydrogen phosphate | | |
| $H_2PO_4^-$ | dihydrogen phosphate | | |
| $NO_3^-$ | nitrate | $HNO_3$ | Nitric acid |
| $NO_2^-$ | nitrite | $HNO_2$ | Nitrous acid |

Table 4.2. Common oxoanions and oxoacids.

Notice the pattern of acid names; ions with the suffix *-ite* form acids with the suffix *-ous*, while ions with the suffix *-ate* form acids with the suffix *-ic*. These names and suffixes were chosen with this specific pattern to help chemists remember which anion formed which acid (and vice versa).

Chapter 4 Homework:

Vocabulary. The following terms are defined and explained in the text. Make sure that you are familiar with the meanings of the terms as used in chemistry. Understand that you may have been given incomplete or mistaken meanings for these terms in earlier courses. The meanings given in the text are correct and proper.

**Nonionic compound** **Covalent bond** **binary nonionic compound**

Homework: For the following compounds, write the proper, systematic name.

1. $P_2O_5$
2. HI (pure, non-aqueous)
3. $SO_2$
4. $N_2O_4$
5. $SF_6$
6. $P_4O_6$
7. $N_2O$
8. $PCl_5$
9. $SO_3$
10. CO
11. $N_2O_5$
12. $O_2F_2$
13. $NI_3$
14. $SF_2$
15. $N_2F_4$
16. $SiCl_4$
17. $ClF_3$

18. $CF_4$

19. $H_2O$

20. $NH_3$

Answers

1. Diphosphorous pentoxide.
2. Hydrogen iodide.
3. Sulfur dioxide.
4. Dinitrogen tetroxide.
5. Sulfur hexafluoride.
6. Tetraphosphorous hexoxide.
7. Dinitrogen monoxide
8. Phosphorous pentachloride
9. Sulfur trioxide
10. Carbon monoxide
11. Dinitrogen pentoxide
12. Dioxygen difluoride
13. Nitrogen triiodide
14. Sulfur difluoride
15. Dinitrogen tetrafluoride
16. Silicon tetrachloride
17. Chlorine trifluoride
18. Carbon tetrafluoride
19. Water (NOT DIHYDROGEN MONOXIDE!!)
20. Ammonia (NOT NITROGEN TRIHYDRIDE!!)