19.18: Molecular Compounds

Figure 19.18.1(CC by 2.0; Flickr: Timothy Vollmer via Flickr)

The burner on a gas stove burns with a pretty blue flame like the one pictured in the opening image. The fuel burned by most gas stoves is natural gas, which consists mainly of methane. Methane is a compound that contains only carbon and hydrogen. Like many other compounds that consist of just these two elements, methane is used for fuel because it burns very easily. Methane is an example of a covalent compound.

What Are Covalent Compounds?

Compounds that form from two or more nonmetallic elements, such as carbon and hydrogen, are called covalent compounds. In a covalent compound, atoms of the different elements are held together in molecules by covalent bonds. These are chemical bonds in which atoms share valence electrons. The force of attraction between the shared electrons and the positive nuclei of both atoms holds the atoms together in the molecule. A molecule is the smallest particle of a covalent compound that still has the properties of the compound.

The largest, most complex covalent molecules have thousands of atoms. Examples include proteins and carbohydrates, which are compounds in living things. The smallest, simplest covalent compounds have molecules with just two atoms. An example is hydrogen chloride (HCl). It consists of one hydrogen atom and one chlorine atom, as you can see in the figure below.

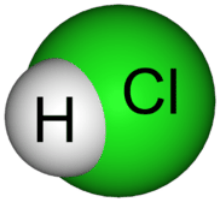

Figure 19.18.2(Public Domain; Ben Mills (Wikimedia: Benjah-bmm27) via Wikipedia)

Naming and Writing Formulas for Covalent Compounds

To name simple covalent compounds, follow these rules:

- Start with the name of the element closer to the left side of the periodic table.
- Follow this with the name of element closer to the right of the periodic table. Give this second name the suffix *–ide*.
- Use prefixes to represent the numbers of the different atoms in each molecule of the compound. The most commonly used prefixes are shown in the Table below.

Table 19.18.1

Naming and Writing Formulas for Covalent Compounds

Number	Prefix
1	*mono-* (or none)
2	*di-*
3	*tri-*
4	*tetra-*
5	*penta-*

Number	Prefix
6	*hexa-*

Q: What is the name of the compound that contains three oxygen atoms and two nitrogen atoms?

A: The compound is named dinitrogen trioxide. Nitrogen is named first because it is farther to the left in the periodic table than oxygen. Oxygen is given the *-ide* suffix because it is the second element named in the compound. The prefix *di-* is added to nitrogen to show that there are two atoms of nitrogen in each molecule of the compound. The prefix *tri-* is added to oxygen to show that there are three atoms of oxygen in each molecule.

In the chemical formula for a covalent compound, the numbers of the different atoms in a molecule are represented by subscripts. For example, the formula for the compound named carbon dioxide is CO_2.

Q: What is the chemical formula for dinitrogen trioxide?

A: The chemical formula is N_2O_3.

Properties of Covalent Compounds

The covalent bonds of covalent compounds are responsible for many of the properties of the compounds. Because valence electrons are shared in covalent compounds, rather than transferred between atoms as they are in ionic compounds, covalent compounds have very different properties than ionic compounds.

- Many covalent compounds, especially those containing carbon and hydrogen, burn easily. In contrast, many ionic compounds do not burn.
- Many covalent compounds do not dissolve in water, whereas most ionic compounds dissolve well in water.
- Unlike ionic compounds, covalent compounds do not have freely moving electrons, so they cannot conduct electricity.
- The individual molecules of covalent compounds are more easily separated than the ions in a crystal, so most covalent compounds have relatively low boiling points. This explains why many of them are liquids or gases at room temperature. You can compare the boiling points of some covalent and ionic compounds in the Table below.

Table 19.18.2

Properties of Covalent Compounds

Name of Compound(Chemical Formula)	Type of Compound	Boiling Point (°C)
Methane (CH4)	covalent	-164
Nitrogen oxide (NO)	covalent	-152
Sodium chloride (NaCl)	ionic	1413
Lithium fluoride (LiF)	ionic	1676

Q: The two covalent compounds in the table are gases at room temperature, which is 20°C. For a compound to be a liquid at room temperature, what does its boiling point have to be?

A: To be a liquid at room temperature, a covalent compound has to have a boiling point higher than 20°C. Water is an example of a covalent compound that is a liquid at room temperature. The boiling point of water is 100°C.

Summary

- Covalent compounds contain two or more nonmetallic elements held together by covalent bonds, in which atoms share pairs of valence electrons. A molecule is the smallest particle of a covalent compound that still has the properties of the compound.
- A few rules can be applied to name simple covalent compounds: name the left-most element in the periodic table first, add *-ide* to the second named element, and use prefixes for the numbers of atoms.
- Covalent bonds are responsible for many of the properties of covalent compounds. Covalent compounds have relatively low boiling points, cannot conduct electricity, and may not dissolve in water.

Review

1. What are covalent compounds? Give two examples.
2. What is the name of the covalent compound that consists of two atoms of silicon and six atoms of bromine? What is its chemical formula?
3. Compare and contrast the properties of ionic and covalent compounds.

Resources