

Compounds and Molecules

Atoms are seldom found alone in nature. They have a tendency to combine with the atoms of other elements. But when they do, how do we know how many atoms of each element are needed to form a compound? Why is table salt (sodium chloride) NaCl ? Why isn't it Na_2Cl or NaCl_2 ? The key is in knowing how the atoms combine.

Combining Capacity

After years of experimenting, scientists found that each element was able to make a specific number of connections with other elements. They called these connections the element's **combining capacity**. Scientists gave a number value to the combining capacity of each metal and nonmetal to explain the compounds they form. The scientists also came up with rules to follow. Table 1 lists the rules for how some elements combine.

For example, both sodium and chlorine were assigned a combining capacity of one. Each element needs to make one connection, so when sodium and chlorine combine their formula is NaCl .

Aluminum, however, has a combining capacity of three. It needs to make three connections. Each chlorine atom needs to make only one connection. When aluminum combines with chlorine, for every atom of aluminum three atoms of chlorine are needed. Therefore, the chemical formula for aluminum chloride is AlCl_3 . Table 2 lists the combining capacities of some metals, and Table 3 lists the combining capacities of some nonmetals.

Both sodium and bromine have a combining capacity of one. Sodium bromide has the formula NaBr , meaning it contains one atom of sodium for each atom of bromine (Figure 1a).

Table 1 How Elements Combine

- Rule 1: Metals combine with nonmetals in many compounds.
 Rule 2: Write the name of the metal first and the nonmetal second.
 Rule 3: Change the ending of the nonmetal to "ide."
 Rule 4: Each atom has its own combining capacity.
 Rule 5: Atoms combine so that each can fill its combining capacity.

Table 2 Combining Capacities of Some Metals

Element	Symbol	Combining capacity
aluminum	Al	3
barium	Ba	2
calcium	Ca	2
magnesium	Mg	2
potassium	K	1
silver	Ag	1
sodium	Na	1
zinc	Zn	2

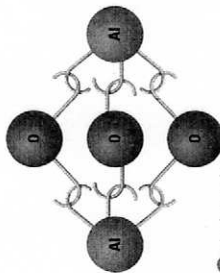
Table 3 Combining Capacities of Some Nonmetals

Element	Symbol	Combining capacity	Combined name
bromine	Br	1	bromide
chlorine	Cl	1	chloride
fluorine	F	1	fluoride
iodine	I	1	iodide
oxygen	O	2	oxide
sulfur	S	2	sulfide

Aluminum has a combining capacity of three, and oxygen has a combining capacity of two. Therefore, in the compound aluminum oxide (Figure 1b), two atoms of aluminum must combine with three oxygen atoms. The chemical formula of aluminum oxide is Al_2O_3 .



a sodium bromide



b aluminum oxide

Figure 1

Some early models pictured atoms with hooks that could attach to the hooks of other atoms.

When Like Atoms Combine

Sometimes chemical formulas represent a molecule of an element instead of a compound. This happens when two or more atoms of the same element join together. A molecule that forms when two atoms of the same element join together is called a **diatomic molecule**. This is not a compound because it contains atoms of only one element. Seven nonmetal elements are found naturally as diatomic molecules of two identical elements: hydrogen (H_2), nitrogen (N_2) (Figure 2a), oxygen (O_2) (Figure 2b), fluorine (F_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2).



a nitrogen molecule

b oxygen molecule

Figure 2

Nitrogen (a) and oxygen (b) molecules in their natural state

Understanding Concepts

- What does the term "combining capacity" mean?
- Elements can be classified as metals or nonmetals. Which elements change their names when they form compounds? Explain, using an example.
- What are the names of the following compounds?
 - CaCl_2 , used in bleaching powder and for melting ice
 - CaO , used in plaster and construction
 - CuCl , used to make red glass
 - AgCl , used in photography
- Use the combining capacities shown in Tables 2 and 3 to write chemical formulas for:
 - sodium fluoride
 - magnesium fluoride
 - potassium bromide
 - silver oxide
 - aluminum sulfide
- Draw "hook-and-ball" diagrams for the compounds in question 4.
- Which of the following is not a compound? Why?
 - CH_4
 - H_2O
 - NH_4
 - N_2

Did You Know?

Somebody who gets a lot of public attention is described as "being in the limelight." This expression refers to calcium oxide or lime, which was used in stage shows decades ago to produce a brilliant white light for footlights.

Work the Web

Learn more about the way that elements bond together to form compounds. Visit www.science.nelson.com and follow the links from Science 9: Concepts and Connections, 1.15.