6.1: Naming Covalent Compounds

Learning Objectives

- Write the chemical names of covalent molecules.
- Nomenclature of alkanes

In the previous section, the process for using a Lewis structure to determine the chemical formula of a covalent molecule was presented and applied. The chemical name of a molecule, in turn, is derived based on the information included in its chemical formula. As stated previously, a chemical name should uniquely correspond to a single chemical formula. In other words, no two chemical formulas should share a common chemical name.

Recall that covalent bonds are produced when unpaired electrons found within two atoms interact to form a shared pair of electrons. As a Lewis structure is the result of correctly executing this sharing process, the chemical formula and the chemical name of the corresponding covalent molecule must accurately reflect the information shown in that Lewis structure. The procedure for writing the chemical name of a covalent molecule is explained in the following paragraphs.

Naming Covalent Molecules

For a covalent molecule, the information represented in its chemical name must be a direct reflection of its Lewis structure. Therefore, the chemical name of a covalent molecule must not only contain information that indicates the identities of its constituent elements, but also must reflect how many of each of those elements are present within the molecule. Note that, if written properly, the chemical formula for a covalent molecule also contains this information and, therefore, can be used as the basis for developing a chemical name. Elemental names are incorporated into a covalent molecule's chemical name in the order in which their corresponding elemental symbols appear in the chemical formula. The suffix on the second elemental term is replaced with "-ide," in order to indicate its secondary placement within the chemical formula. Finally, since the subscripts in a covalent chemical formula are used to indicate how many times each elemental symbol appears in the molecule's Lewis structure, corresponding numerical prefixes, which are listed below in Table $6.1.1$, must be incorporated into the molecule's chemical name.

Table $6.1.1$: Numerical Prefixes Used When Naming Covalent Molecules

Number of Atoms in the Molecule (Indicated by a Subscript)	Numerical Prefix
1	mono-*
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	hepta-
8	octa-
9	nona-
10	deca-

Note that the prefix "mono-" is *never* used to change the first elemental term in a covalent chemical name and should *only* be used as a modifier on the remaining term if the secondary element is oxygen. Finally, an "a" or "o" at the end of a prefix is usually dropped if the name of the element that is being altered begins with a vowel.

These prefix rules are best exemplified when writing the chemical name of "CO," which is the chemical formula of a commonly-known molecule.

This molecule is formed using covalent bonds, as its constituent elements, C (carbon) and O (oxygen), are both non-metals.

Since the elemental symbol "C" appears first in the given chemical formula, "carbon" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is not used to alter the first elemental term in a covalent chemical name. Therefore, the first word in the chemical name of this molecule is "carbon."

Because the elemental symbol "O" is written second in the given chemical formula, "oxide" becomes the basis of the second word in the molecule's chemical name. The suffix on this elemental term is "-ide," as an indicator of its secondary placement within the chemical formula. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." Because the secondary element is oxygen, this prefix is used as a modifier on the term "oxide." Finally, since "oxide" begins with a vowel, the "o" of "mono-" is dropped. Therefore, the second word in the chemical name of this covalent molecule is "monoxide."

The result of combining these words, "**carbon monoxide**," is the chemically-correct name for CO.

Example 6.1.1

Write the chemical name of SF_2, a covalent molecule that is formed when fluorine and sulfur bond with one another.

Solution

Since the elemental symbol "S" appears first in the given chemical formula, "sulfur" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is not used to alter the first elemental term in a covalent chemical name. Therefore, the first word in the chemical name of this molecule is "sulfur."

Because the elemental symbol "F" is written second in the given chemical formula, "fluoride" becomes the basis of the second word in the molecule's chemical name. The suffix on this elemental term is "-ide," as an indicator of its secondary placement within the chemical formula. The subscript on this elemental symbol, a "2," corresponds to prefix of "di-." Therefore, the second word in the chemical name of this covalent molecule is "difluoride."

The result of combining these words, "**sulfur difluoride**," is the chemically-correct name for SF_2.

Exercise 6.1.1

Write the chemical name that corresponds to each of the following chemical formulas.

a. CCl_4, the covalent molecule that is formed when carbon and chlorine bond with one another.
b. PBr_3, a covalent molecule that is formed when bromine and phosphorus bond with one another.
c. N_3P_6, a covalent molecule that is formed when nitrogen and phosphorus bond with one another.
d. I_2O_5, a covalent molecule that is formed when oxygen and iodine bond with one another.
e. HF, the covalent molecule that is formed when hydrogen and fluorine bond with one another.

Answer a

Since the elemental symbol "C" appears first in the given chemical formula, "carbon" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is not used to alter the first elemental term in a covalent chemical name. Therefore, the first word in the chemical name of this molecule is "carbon."

Because the elemental symbol "Cl" is written second in the given chemical formula, "chloride" becomes the basis of the second word in the molecule's chemical name. The suffix on this elemental term is "-ide," as an indicator of its secondary placement within the chemical formula. The subscript on this elemental symbol, a "4," corresponds to prefix of "tetra-." Therefore, the second word in the chemical name of this covalent molecule is "tetrachloride."

The result of combining these words, "**carbon tetrachloride**," is the chemically-correct name for CCl_4.

Answer b

Since the elemental symbol "P" appears first in the given chemical formula, "phosphorus" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is not used to alter the first elemental term in a covalent chemical name. Therefore, the first word in the chemical name of this molecule is "phosphorus."

Because the elemental symbol "Br" is written second in the given chemical formula, "bromide" becomes the basis of the second word in the molecule's chemical name. The suffix on this elemental term is "-ide," as an indicator of its secondary placement within the chemical formula. The subscript on this elemental symbol, a "3," corresponds to prefix of "tri-." Therefore, the second word in the chemical name of this covalent molecule is "tribromide."

The result of combining these words, "**phosphorus tribromide**," is the chemically-correct name for PBr_3.

Answer c

Since the elemental symbol "N" appears first in the given chemical formula, "nitrogen" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, a "3," corresponds to prefix of "tri-." Therefore, the first word in the chemical name of this molecule is "trinitrogen."

Because the elemental symbol "P" is written second in the given chemical formula, "phosphide" becomes the basis of the second word in the molecule's chemical name. The suffix on this elemental term is "-ide," as an indicator of its secondary placement within the chemical formula. The subscript on this elemental symbol, a "6," corresponds to prefix of "hexa-." Therefore, the second word in the chemical name of this covalent molecule is "hexaphosphide."

The result of combining these words, "**trinitrogen hexaphosphide**," is the chemically-correct name for N_3P_6.

Answer d

Since the elemental symbol "I" appears first in the given chemical formula, "iodine" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, a "2," corresponds to prefix of "di-." Therefore, the first word in the chemical name of this molecule is "diiodine."

Because the elemental symbol "O" is written second in the given chemical formula, "oxide" becomes the basis of the second word in the molecule's chemical name. The subscript on this elemental symbol, a "5," corresponds to prefix of "penta-." Since "oxide" begins with a vowel, the "a" of "penta-" is dropped. Therefore, the second word in the chemical name of this covalent molecule is "pentoxide."

The result of combining these words, "**diiodine pentoxide**," is the chemically-correct name for I_2O_5.

Answer e

Since the elemental symbol "H" appears first in the given chemical formula, "hydrogen" is the basis of the first word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is not used to alter the first elemental term in a covalent chemical name. Therefore, the first word in the chemical name of this molecule is "hydrogen."

Because the elemental symbol "F" is written second in the given chemical formula, "fluoride" becomes the basis of the second word in the molecule's chemical name. The subscript on this elemental symbol, an unwritten "1," corresponds to prefix of "mono-." However, this prefix is only used as a modifier on the second term in a covalent chemical name if the secondary element is oxygen. Because the secondary element is fluorine, the "mono-" prefix is not applied. Therefore, the second word in the chemical name of this molecule is "fluoride."

The result of combining these words, "**hydrogen fluoride**," is the chemically-correct name for HF.

Alkanes

Most of the hydrocarbons in petroleum belong to a family of compounds called the **alkanes**, in which all carbon atoms are linked by single bonds. The names of all alkanes end with *-ane*. Whether or not the carbons are linked together end-to-end in a ring (called *cyclic alkanes* or *cycloalkanes*) or whether they contain side chains and branches, the name of every carbon-hydrogen chain that lacks any double bonds or functional groups will end with the suffix *-ane*.

Alkanes with unbranched carbon chains are simply named by the number of carbons in the chain. The first four members of the series (in terms of number of carbon atoms) are named as follows:

1. CH_4 = **methane** = one hydrogen-saturated carbon
2. C_2H_6 = **ethane** = two hydrogen-saturated carbons
3. C_3H_8 = **propane** = three hydrogen-saturated carbons
4. C_4H_{10} = **butane** = four hydrogen-saturated carbons

Alkanes with five or more carbon atoms are named by adding the suffix *-ane* to the appropriate numerical multiplier, except the terminal *-a* is removed from the basic numerical term. Hence, C_5H_{12} is called *pentane*, C_6H_{14} is called *hexane*, C_7H_{16} is called *heptane* and so forth.

Straight-chain alkanes are sometimes indicated by the prefix *n-* (for normal) to distinguish them from branched-chain alkanes having the same number of carbon atoms. Although this is not strictly necessary, the usage is still common in cases where there is an important difference in properties between the straight-chain and branched-chain isomers: e.g. *n-hexane* is a neurotoxin while its branched-chain isomers are not.

IUPAC nomenclature

The IUPAC nomenclature is a system on which most organic chemists have agreed to provide guidelines to allow them to learn from each others' works. Nomenclature, in other words, provides a foundation of language for organic chemistry.

Number of Hydrogen to Carbons

This equation describes the relationship between the number of hydrogen and carbon atoms in alkanes:

$$\mathbf{H = 2C + 2}$$

where "C" and "H" are used to represent the number of carbon and hydrogen atoms present in one molecule. If C = 2, then H = 6.

Many textbooks put this in the following format:

$$\mathbf{C_nH_{2n+2}}$$

where "C_n" and "H_{2n+2}" represent the number of carbon and hydrogen atoms present in one molecule. If $C_n = 3$, then $H_{2n+2} = 2(3) + 2 = 8$. (For this formula look to the "n" for the number, the "C" and the "H" letters themselves do not change.)

Progressively longer hydrocarbon chains can be made and are named systematically, depending on the number of carbons in the longest chain.

The following table contains the systematic names for the first ten straight chain alkanes.

Name	Molecular Formula	Condensed Structural Formula
Methane	CH_4	CH_4
Ethane	C_2H_6	CH_3CH_3
Propane	C_3H_8	$CH_3CH_2CH_3$
Butane	C_4H_{10}	$CH_3(CH_2)_2CH_3$
Pentane	C_5H_{12}	$CH_3(CH_2)_3CH_3$
Hexane	C_6H_{14}	$CH_3(CH_2)_4CH_3$
Heptane	C_7H_{16}	$CH_3(CH_2)_5CH_3$
Octane	C_8H_{18}	$CH_3(CH_2)_6CH_3$

Name	Molecular Formula	Condensed Structural Formula
Nonane	C_9H_{20}	$CH_3(CH_2)_7CH_3$
Decane	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$

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