Molecular Compounds

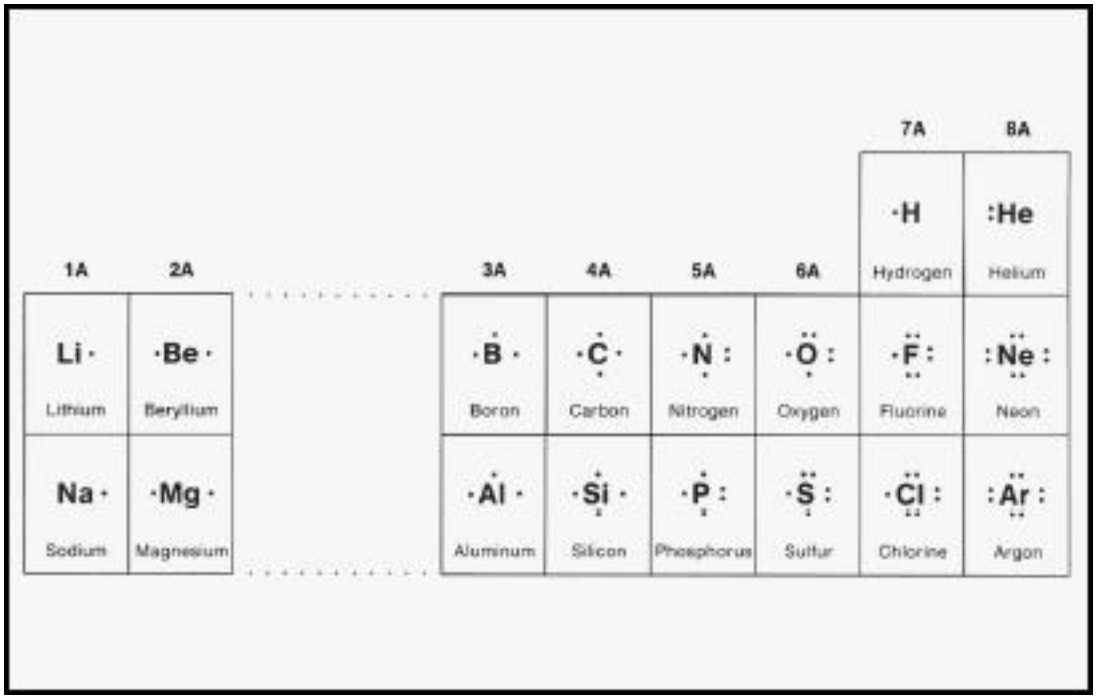
The **octet rule** states that atoms will lose, gain, or share electrons to achieve a stable arrangement of eight valence electrons, called an **octet**. Atoms that transfer (lose or gain) electrons form **ionic bonds**. However, the number of ionic compounds is quite small compared with the total number of known compounds. What type of bonding is found in all of these other compounds that are not ionic?

Atoms that share electrons form **covalent bonds**. In a covalent bond, the shared electrons are considered to be part of the complete outer orbit of both atoms involved. The majority of covalent bonds form between nonmetallic elements.

A **molecule** is formed when two or more atoms bond covalently. Covalently bonded compounds are, therefore, known as **molecular compounds**. Examples of molecular compounds include carbohydrates, proteins, fats, and DNA. The wool, cotton, and synthetic fibers in our clothes also consist of covalently bonded atoms.

Lewis Dot Diagrams

A **Lewis dot diagram** consists of an element's symbol surrounded by dots representing the atom's valence electrons. The dots are placed one at a time on the four sides of the symbol, and then paired up until all are used. Lewis dot diagrams for several elements are shown below:



Diatomic Molecules

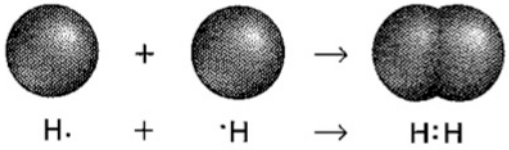
A **diatomic molecule** consists of two atoms of the same element bonded together covalently. This occurs because the resulting molecular compounds are more stable than the individual atoms.

The following elements form diatomic molecules:

Element	Diatomic Molecule	Name
Hydrogen	H_2	Hydrogen gas
Nitrogen	N_2	Nitrogen gas
Oxygen	O_2	Oxygen gas
Fluorine	F_2	Fluorine gas
Chlorine	Cl_2	Chlorine gas
Bromine	Br_2	Bromine gas
Iodine	I_2	Iodine gas

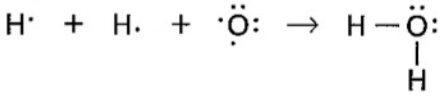
Single Covalent Bonds

When a single pair of electrons is shared, such as in a hydrogen molecule (H_2), a single covalent bond forms. The shared electron pair is represented by a line in the Lewis structure for the molecule. For example, a hydrogen molecule is represented as

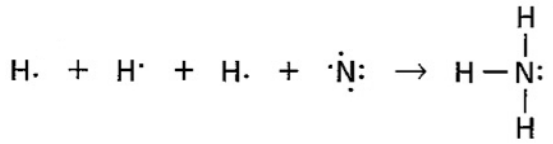


The halogens (group 7A) need one electron to form an octet. Thus, halogens will form single covalent bonds. They will either do this with another identical atom, forming a diatomic molecule, or with another element, such as carbon.

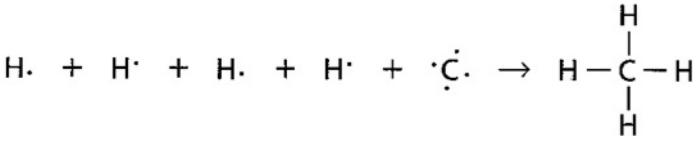
The chalcogens (group 6A) share two electrons to form covalent bonds. They can do this by sharing a single electron with each of two other elements, thus forming two single covalent bonds. Water is an example of a molecular compound containing two single covalent bonds.



Group 5A elements will form three covalent bonds. Ammonia (NH_3) is an example of a molecular compound containing three single covalent bonds.



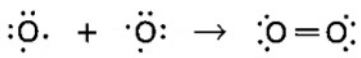
Group 4A elements will form four covalent bonds. A methane molecule (CH_4) is formed when one carbon atom forms four single covalent bonds with four hydrogen atoms.



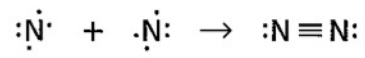
Multiple Covalent Bonds

In many molecules, atoms attain a full octet by sharing more than one pair of electrons between two atoms, forming a multiple covalent bond. Atoms of the elements carbon, nitrogen, oxygen, and sulfur most often form multiple bonds.

A double covalent bond occurs when two pairs of electrons are shared between two atoms. The atoms in an oxygen molecule (O_2) share two electron pairs, forming a double bond.



A triple covalent bond is formed when three pairs of electrons are shared between two atoms. Nitrogen (N_2) shares three electrons pairs, producing a triple bond.



Naming Binary Molecular Compounds

A binary molecular compound consists of two different elements bonded together covalently. Use the following simple rules to name binary molecular compounds.

1. The first element in the formula is always named first, using the entire element name.

2. The second element in the formula is named using the root of the element and adding the suffix –ide.

3. Prefixes are used to indicate the number of atoms of each type that are present in the compound.

Prefix	Number it Represents
mono	1
di	2
tri	3
tetra	4
penta	5
hexa	6

One exception to using these prefixes is that the first element in the formula never uses the prefix *mono–*. Also, to avoid awkward pronunciation, drop the final letter in the prefix when the element name begins with a vowel. For example, CO is carbon monoxide, not monocarbon monooxide.

Example 1
Name the following compounds:

a) P_2O_5

b) CH_4

Many binary molecular compounds were discovered and given common names long before the modern naming system was developed. The table below lists some of these molecules, their common names, and the binary molecular compound names.

Formula	Common Name	Molecular Compound Name
H_2O	water	dihydrogen monoxide
NH_3	ammonia	nitrogen trihydride
N_2H_4	hydrazine	dinitrogen tetrahydride
N_2O	nitrous oxide (laughing gas)	dinitrogen monoxide
NO	nitric oxide	nitrogen monoxide

Writing Formulas from Names

The name of any binary molecule allows you to write the correct formula with ease. Subscripts are determined from the prefixes used in the name because the name indicates the exact number of each atom present in the molecule.

Example 2
Write the formulas for each compound below:

a) disulfur trioxide

b) phosphorous pentachloride

Molecular Compounds

1. What is the difference between an ionic compound and a molecular compound?

2. What kinds of atoms form molecular compounds? How do these atoms form compounds? What type of bond holds the atoms together in a molecular compound?

3. How many valence electrons are there in a fluorine atom? How many electrons does a fluorine atom need to share to have a full outer orbit of electrons? Draw a sketch to show how two fluorine atoms could form a stable molecule.

4. Some elements form diatomic molecules. Where are these elements generally located on the periodic table?

5. Name the following compounds:

   a) CBr_4
   b) NI_3
   c) OF_2
   d) $SiCl_4$
   e) P_2O_5

6. Write chemical formulas for and name the compounds formed from the following pairs of elements.

   a) Silicon and oxygen
   b) Nitrogen and hydrogen
   c) Phosphorus and chlorine
   d) Sulfur and bromine
   e) Carbon and chlorine