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Atoms and Molecules Guided Notes – Teacher Edition

What is an Atom?

Atoms are the simplest building block of matter. Originally, it was thought that atoms were indivisible. However, we now know that an atom can be broken down further, although its chemical properties are not retained. Therefore, an atom can be defined as the smallest particle of a given element that retains the elements chemical properties. For example, a gold coin is made up of a large number of gold atoms molded into the shape of a coin, with small amounts of other elements. Gold atoms cannot be broken down into anything smaller and still retain the properties of gold. A gold atom gets its properties from the tiny subatomic particles from which it is made.

How big are Atoms?

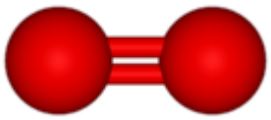
Atoms are very small, measuring 10^{-10} meters in size. They are so small in fact, that when stacked, it would require millions of them to make a layer as thick as a sheet of paper. The table below gives you an idea of the relative sizes of the radius of some everyday objects compared to the radius of a hydrogen atom:

Radius (m)	Object
10^{-10}	An atom of hydrogen
10^{-4}	A grain of sand
10^{-1}	Watermelon
$0.2x10^{-1}$	Cricket ball

The atoms of different elements can vary in size and mass, due to the number of subatomic particles and the number of electron shells they possess.

What are molecules?

Many atoms cannot exist singularly and will, therefore, react with one another to form molecules. A molecule is defined as a collection of two or more atoms of the same or different element in a definite arrangement. The atoms in a molecule are held together by chemical bonds which can only be broken when a chemical reaction takes place. Molecules can be simple, consisting of only a few atoms or complex containing thousands of atoms. For example, the simple molecule oxygen is a gas found in the air we breathe. It consists of two oxygen molecules chemically bonded together (O_2). By contrast, the carbon atoms in a 1-carat diamond weighing 0.2g contain 10^{22} atoms.



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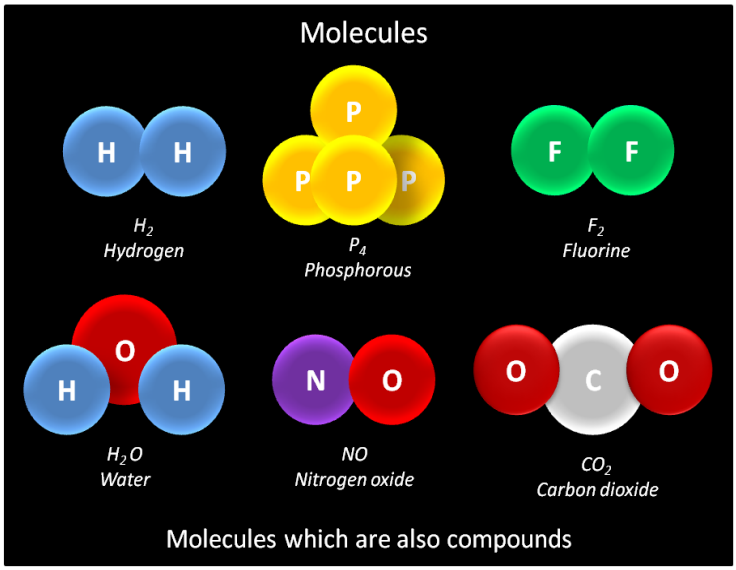
Some other common examples of molecules you will meet in this course are:

- H_2O (water)
- CO_2 (carbon dioxide)
- N_2 (nitrogen gas)
- O_3 (ozone)
- CH_2COOH (ethanoic acid)

What are Compounds?

Molecules which contain different types of atoms are called compounds. All compounds are considered molecules; however, not all molecules are compounds. For example, in the image below, Hydrogen gas (H_2) is a molecule, but not a compound because it is made of only one element. Water, on the other hand, is considered both a molecule and a compound as it contains more than one element - two atoms of hydrogen (H_2) and one of oxygen (O).



Counting atoms in molecules and compounds

When working out how many atoms there are in a compound or molecule there are two numbers that must be considered:

1. Subscripts – the small numbers that tell you how many atoms there are of a specific type in the molecule. For example: In $3H_2O$, the $_2$ is the subscript. The subscript $_2$ in the example

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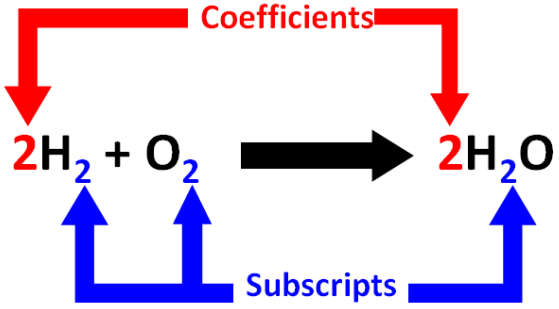
above comes after the H. This means there are two H's (hydrogen atoms) in each molecule of H_2O.

2. Coefficients – the regular-sized numbers that tell you how many molecules you have. For example, in $3H_2O$, the 3 is the coefficient. This shows that there are three H_2O molecules in total.



Therefore the number of hydrogen (H) atoms and the number of oxygen (O) atoms in $3H_2O$ is six hydrogen atoms and three oxygen atoms. To find out the number of atoms, multiply all the subscripts in the molecule by the coefficient. (This will give you the number of atoms of each element.)

To mathematically find the number of elements that make up $3H_2O$, multiply the 2 by the coefficient 3 to find that there are 6 H's. Then we multiply the 1 by the coefficient 3 to find that there are 3 O's.

NOTE:

Although the 1 is usually not written, $3H_2O$ can be written as $3H_2O_1$. (In other words, $3H_2O$ and $3H_2O_1$ is the same thing.)

How to Count Atoms in a Chemical Formula (5 Easy Steps)

Step 1: Write out the chemical formula.

Step 2: List all the atoms present.

Step 3: Count the number of atoms of each element in one molecule.

Step 4: Multiply the number of atoms of each element by the coefficient.

Step 5: Check that your answer makes sense.

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Example Problems:

1. How many atoms in gasoline (C_8H_{18})?

   Carbon (C) = 8 Hydrogen (H) = 18

   8+18 = 26

2. How many oxygen atoms in $C_{10}H_7O$?

   1 oxygen atom

3. Count the number of hydrogen atoms in 2 molecules of vitamin C ($2C_6H_8O_6$).

   H_8 = 8 hydrogen atoms in one molecule

   2 molecules x 8 = 16 hydrogen atoms

4. Give the total number of atoms in 3 molecules of caffeine ($C_8H_{10}N_4O_2$).

   Carbon (C) = 8 Hydrogen (H) = 10 Nitrogen (N) = 4 Oxygen (O) = 2

   Total number of atoms in 1 molecule = 8+10+4+2 = 24

   Total number in 3 molecules = 24 x 3 = 72