

Molecules

A **molecule** is an aggregate of two or more atoms held together by chemical forces, known as chemical bonds. When a molecule is formed the atoms of the same element or different elements are combined in a definite ratio. For example, oxygen gas is a pure element consisting of the same two O (oxygen) atoms. On the other hand, carbon monoxide is a molecule that made up of two different kinds of atoms, one C atom and one O atom. Another common example is the water; a molecular compound created by three atoms, two H atoms and one O atom.

- Like atoms, the molecules also do not carry any charges meaning they are electrically neutral.

Similar to atoms, the molecules also carry symbols to identify them. These symbols are known as **molecular formulas**. These formulas correctly display the type and number of atoms combined in the creation of molecules. The symbol for oxygen molecule is O₂, for carbon monoxide is CO, and for water is H₂O.

If the molecule consists of two atoms, like or unlike, it is known as **diatomic molecule**. The elements that exist in diatomic form including the halogens (7A column elements) are listed below:

Hydrogen gas H₂
Nitrogen gas N₂
Oxygen gas O₂
Fluorine F₂
Chlorine gas Cl₂
Bromine Br₂
Iodine I₂

These diatomic molecules contain two atoms of the same kind. The diatomic molecules can also contain atoms of different elements:

Carbon monoxide CO
Hydrogen fluoride HF
Hydrogen chloride HCl
Hydrogen bromide HBr
Hydrogen iodide HI

As you can see these are the simple molecules. But, the vast majority of molecules contain more than two atoms. These are known as **polyatomic molecules**. They can be atoms of the same element like ozone (O₃) (an allotropic form of oxygen) or atoms of different elements like NH₃ or methane CH₄.

Counting the Number of Atoms

The molecules are formed by the fixed number of atoms of the same or the different elements. The number of atoms in a molecular formula is indicated as a subscript for atoms greater than one, like O₃ (3 oxygen atoms). If only one atom is involved, no subscript is used. For example, CuSO₄ has 1(one) Cu atom, 1 (one) S atom, and 4(four) O atoms.

Know your atomic symbols: It is very important to correctly identify the symbols of the atoms, especially those with two letter symbols.

Example

Find the number of atoms present in (a) K₂Cr₂O₇, (b) C₆H₁₂O₆ (c) Cu (OH)₂, (d) Al₂(SO₄)₃ (e) MgSO₄ · 7H₂O

Answer

- (a) This is a potassium dichromate molecule that has 1 K atom, 2 Cr atoms, and 7 O atoms.
 - (b) This is a glucose molecule that has 6 C atoms, 12 H atoms, and 6 O atoms.
 - (c) This is a copper (II) hydroxide molecule that has 1 Cu atom, 2 O atoms, and 2 H atoms.
 - (d) This is an aluminum sulfate molecule that has 2 Al atoms, 3 S atoms, and 12 O atoms.
 - (e) This is a hydrate known as magnesium sulfate hepta hydrate that has 1 Mg atom, 1 S atom, 5 O atoms, and 14 H atoms.
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Molecular Mass (Weight)

The **molecular mass** is the weight of one molecule expressed in the unit of amu. Like atom, the molecule is also tiny and cannot be seen with naked eye. Thus its mass is expressed in a smaller unit like amu.

To calculate the molecular mass, add all the atomic masses of the atoms involved. For instance, to calculate the molecular mass of NH₃, add the atomic mass of one N atom and atomic masses of three H atoms:

$$\begin{aligned}\text{Molecular mass of NH}_3 &= (1 \times \text{N}) + (3 \times \text{H}) = (1 \times 14.01 \text{ amu}) + (3 \times 1.008 \text{ amu}) \\ &= 17.034 \text{ amu}\end{aligned}$$

Example

Calculate the molecular masses (in amu) of the following compounds.

- (a) Sulfur dioxide (SO₂)
- (b) Table sugar (sucrose) (C₁₂H₂₂O₁₁)

Answer

- (a) In this molecule, there is one S atom and two O atoms.

$$\begin{aligned}\text{Molecular mass of SO}_2 &= (1 \times \text{S}) + (2 \times \text{O}) = (1 \times 32.07 \text{ amu}) + (2 \times 16.0 \text{ amu}) \\ &= 64.07 \text{ amu}\end{aligned}$$

- (b) This molecule has 12 C atoms, 22 H atoms, and 11 O atoms. Hence

$$\begin{aligned}\text{Molecular mass of sucrose} &= (12 \times \text{C}) + (22 \times \text{H}) + (11 \times \text{O}) \\ &= (12 \times 12.01 \text{ amu}) + (22 \times 1.008 \text{ amu}) + (11 \times 16 \text{ amu}) \\ &= 342.296 \text{ amu}\end{aligned}$$

Practice

Calculate the molecular masses of the following compounds.

- (a) Table salt (NaCl)
- (b) Caffeine (C₈H₁₀N₄O₂)
- (c) LSD (C₂₀H₂₅N₃O)