MOLECULES

The particles in elements are made up of atoms or molecules which consist of the same kind of atoms. A molecule is made up of two or more atoms chemically joined together.

Molecules of Elements

The molecules in oxygen gas are made up of two oxygen atoms. The molecules in ozone are made up of three oxygen atoms. In both molecules, the atoms are of the same kind. Thus, we can conclude that molecules of elements are made up of the same kind of atoms.

Molecules of Compounds

In compounds, the molecules are made up of two or more different types of atoms. A molecule of carbon monoxide is made up of one carbon atom and one oxygen atom. In water, each molecule is made up of two hydrogen atoms and one oxygen atom.

RELATIVE ATOMIC MASS

The hydrogen atom is the smallest and lightest atom and the mass of the hydrogen atom was used as the standard unit for comparison with other atoms. Prior to 1961, the relative atomic mass of an element was defined as the number of times one atom of that element was as heavy as one atom of hydrogen.

A carbon atom is twelve times as heavy as a hydrogen atom, so carbon is said to have a relative atomic mass of 12. Similarly, the relative atomic mass of sodium is 23 because one atom of sodium is twenty-three times as heavy as one hydrogen atom.

As hydrogen exists as a mixture of isotopes and also as a gas, scientists found that it was easier and more accurate to use the isotope of carbon called carbon-12, as a standard unit for comparison. Since the mass of a carbon atom is 12 times as heavy as a hydrogen atom, so 1/12 of the mass of a carbon atom will have the same mass as one hydrogen atom. Thus, in 1961, scientists agreed to use carbon-12 as the standard and its relative atomic mass was fixed at 12.000.

We now define the relative atomic mass of an element as the <u>average mass of one atom of the element when compared to 1/12 of the mass of an atom of carbon-12</u>.

Relative atomic mass can be written as a symbol, A_r. We can also use the above definition in the form of a formula as follows:

$$A_r = \frac{Average\ mass\ of\ one\ atom\ of\ element}{Mass\ of\ \frac{1}{12} of\ an\ atom\ of\ carbon-12}$$

If we ignore the existence of small amounts of isotopes (with the exception of chlorine), you will notice that the relative atomic mass of most elements is equal to the mass number.

RELATIVE MOLECULAR MASS

We have used the hydrogen atom originally as the standard unit to compare the masses of atoms. We can also use it to compare the masses of molecules. Since the carbon-12 atom is used as the standard unit for comparing atomic masses, so the definition of the relative molecular mass is as follows:

The relative molecular mass, M_r, of a molecule is the average mass of a molecule of the substance when compared to 1/12 of the mass of an atom of carbon-12.

$$M_r = \frac{Average\ mass\ of\ one\ molecule\ of\ a\ substance}{Mass\ of\ \frac{1}{12} of\ an\ atom\ of\ carbon-12}$$

Since a molecule is made up of atoms, we can calculate the relative molecular mass of a molecule by adding up the relative atomic masses of all the atoms in the molecule.

Example:

Calculate the relative molecular mass of water, H_2O.

M_r of H_2O = (1×2) + (1× 16) = 18

RELATIVE FORMULA MASS

Unlike simple covalent substances, ionic substances are not made of molecules. They are composed of millions of ions joined in a compact lattice. For an ionic compound, we treat it as if it is made up of a formula unit and determine its relative formula mass. However, for simplicity, relative formula mass is often taken to be equivalent to the relative molecular mass. The relative formula mass is obtained by adding up the relative atomic masses of the atoms shown by the formula.

Example:

What is the relative formula mass of magnesium nitrate, $Mg(NO_3)_2$?

Relative formula mass of $Mg(NO_3)_2$ = (24 × 1) + (14 + 16 × 3) × 2 = 24 + 124 = 148

PERCENTAGE COMPOSITION

When we are buying consumer products such as foodstuff and medicine, we often look at the labels for the ingredients and their proportions. The percentage composition of a substance tells us the percentage by mass of each element present in the substance.

Example:

Calculate the percentage composition of calcium sulphate, $CaSO_4$.

$$Relative\ molecular\ mass\ of\ CaSO_4 = 40 + 32 + 16 \times 4 = 136$$

$$Percentage\ of\ calcium, Ca = \frac{40}{136} \times 100 = 29.4\%$$

$$Percentage\ of\ Sulphur, S = \frac{32}{136} \times 100 = 23.5\%$$

$$Percentage\ of\ Oxygen, O = \frac{16 \times 4}{136} \times 100 = 47.1\%$$

Try these:

1. Iron can be obtained from an iron ore called haematite which has the chemical formula, Fe_2O_3.
   a) Calculate the percentage of iron in haematite.
   b) What mass of iron can be obtained from 100 kg of haematite?

2. Potassium chloride and potassium nitrate can be used as fertilizers to increase the potassium content of the soil. Which salt contains a higher percentage of potassium by mass?