Chemistry Study Materials for Class 9

(NCERT based Revision of Mole Concept)

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Molecular Mass and Mole Concept

Molecular Mass

we discussed the concept of atomic mass. This concept can be extended to calculate molecular masses. The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. It is therefore the relative mass of a molecule expressed in atomic mass units (u).

Example 1

(a) Calculate the relative molecular mass of water (H_2O).

Solution: Atomic mass of hydrogen = 1u, oxygen = 16 u

So the molecular mass of water, which contains two atoms of hydrogen and one atom of oxygen is = 2 × 1+ 1 ×16 = 18 u

(b) Calculate the molecular mass of HNO_3.

Solution: The molecular mass of HNO3 = the atomic mass of H + the atomic mass of N+ 3 × the atomic mass of O= 1 + 14 + 48 = 63 u

Formula Unit Mass

The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound.

Formula unit mass is calculated in the same manner as we calculate the molecular mass. The only difference is that we use the word formula unit for those substances whose constituent particles are ions.

For example, sodium chloride as discussed above has a formula unit NaCl. Its formula unit mass can be calculated as: 1 × 23 + 1 × 35.5 = 58.5 u

Mole Concept

Take an example of the reaction of hydrogen and oxygen to form water:

$2H + O \rightarrow 2H_2O$.

The above reaction indicates that

(i) two molecules of hydrogen combine with one molecule of oxygen to form two molecules of water, or

(ii) 4 u of hydrogen molecules combine with 32 u of oxygen molecules to form 36 u of water molecules.

We can infer from the above equation that the quantity of a substance can be characterised by its mass or the number of molecules. But, a chemical reaction equation indicates directly the number of atoms or molecules taking part in the reaction. Therefore, it is more convenient to refer to the quantity of a substance in terms of the number of its molecules or atoms, rather than their masses. So, a new unit “mole” was introduced. One mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams.

The number of particles (atoms, molecules or ions) present in 1 mole of any substance is fixed, with a value of 6.022×10^{23}. This is an experimentally obtained value. This number is called the Avogadro Constant or Avogadro Number (represented by N_0), named in honour of the Italian scientist, Amedeo Avogadro.1 mole (of anything) = 6.022 × 1023 in number,

as, 1 dozen = 12 nos. 1 gross = 144 nos.

Besides being related to a number, a mole has one more advantage over a dozen or a gross. This advantage is that mass of 1 mole of a particular substance is also fixed.

The mass of 1 mole of a substance is equal to its relative atomic or molecular mass in grams. The atomic mass of an element gives us the mass of one atom of that element in atomic mass units (u). To get the mass of 1 mole of atom of that element, that is, molar mass, we have to take the same numerical value but change the units from ‘u’ to ‘g’.

Molar mass of atoms is also known as gram atomic mass. For example, atomic mass of hydrogen=1u. So, gram atomic mass of hydrogen = 1 g.

1 u hydrogen has only 1 atom of hydrogen

1 g hydrogen has 1 mole atoms, that is, 6.022 × 1023 atoms of hydrogen.

Similarly, 16 u oxygen has only 1 atom of oxygen,

16 g oxygen has 1 mole atoms, that is, 6.022 × 1023 atoms of oxygen.

To find the gram molecular mass or molar mass of a molecule, we keep the numerical value the same as the molecular mass, but simply change units as above from u to g. For example, as we have already calculated, molecular mass of water (H O) is 18 u. From here we understand that

18 u water has only 1 molecule of water,

18 g water has 1 mole molecules of water, that is,

6.022 × 1023 molecules of water.

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