Chapter 5

# ATOMS AND MOLECULES

In the chapter "Is matter around us pure?" we used the terms elements and compounds. You learnt about the role of separation techniques in identifying elements. The pure components obtained after separation (or purification) are either elements or compounds.

In this chapter, we can use this knowledge to explain some of observations made in previous classes like the observation of rusting of iron rod kept outside, etc.

- Does the weight of iron rod increase or decrease, on rusting?

We notice that on burning charcoal, it leaves ash at the end ?

- Where does the matter charcoal go?
- Wet clothes dry after some time - where does the water go?

These and other similar questions had also fascinated scientists for many years; in particular, burning or combustion reactions.

Recall the chapter "Metals and non-metals."

- What does happen to Magnesium on burning it in air ?
- What does happen to Sulphur on burning it in air?

Think about the weight of the reactants and products.

## Do you know?

**Antoine Lavoisier** (1743-1794) was a French nobleman. He made many important contributions to chemistry and some call him the **Father of Modern Chemistry**.

Lavoisier studied combustion reactions in detail. For example, during combustion reactions, he not only carefully weighed the solid reactants, but also took into account the gases involved. He perfected chemical apparatus which ensured that gases did not escape during the reactions. This led to the **law of conservation of mass**.

In this chapter, we use the following terms frequently - elements, compounds, reactants and products. Discuss with your friends about meaning of these terms. Think of different examples for each term.

Let us start our investigations by doing a lab activity to see what will happen to weight of reactants and products during a reaction.

## Lab Activity

**Aim:** To understand change in mass before and after a chemical reaction.

**Material required:** Lead nitrate, potassium iodide, distilled water, conical flask, spring balance, test tube, stand, rubber cork, thread etc.

**Procedure**

1. Prepare a solution by dissolving approximately 2 grams of lead nitrate in 100 ml of distilled water.
2. Prepare another solution by dissolving approximately 2 gm of Potassium iodide in 100 ml water.
3. Take 100ml solution of lead nitrate in 250ml conical flask.
4. Also take 4ml solution of potassium iodide in test tube.

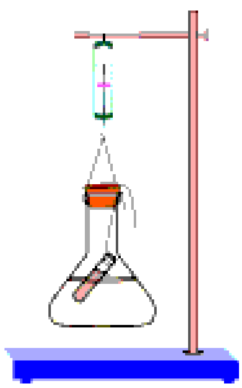


*Fig - 1*

5. Hang the test tube in the flask carefully, without mixing the solutions. Put a cork on the flask.(see figure 1)
6. Weigh the flask with its contents carefully by spring balance.
7. Now tilt and swirl the flask, so that the two solutions mix.

   (see figure 2)

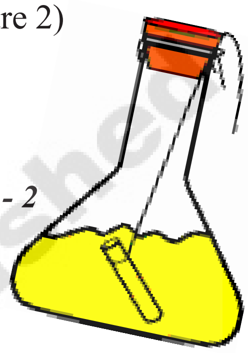


*Fig - 2*

8. Weigh the flask again by the same spring balance as shown in figure 3.

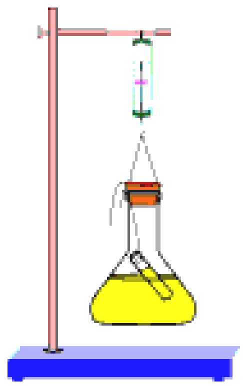


*Fig - 3*

9. Record your observations:

   Weight of flask and contents before mixing =

   Weight of flask and contents after mixing =

Now, try to answer these questions:

- What happens in the reaction flask?
- Do you think that a chemical reaction has taken place? Give reason.

- Does the weight of the flask and its contents change?
- What is your conclusion?

**Result:**

- A chemical reaction took place and the mass remained same before and after chemical reaction. Therefore, mass was neither created nor destroyed in the chemical reaction.

### Think and discuss

- Do you get the same result if the conical flask is not closed?

## Law of conservation of mass

Antoine Lavoisier carried out much experimentation and he established the important law of conservation of mass. It states, **"Matter is neither created nor destroyed during a chemical reaction. More simply, the mass of reactants is equal to the mass of the products of chemical reaction.** Earlier, it was thought that mass is lost during burning of charcoal. But when Lavoisier, carried out the burning in a closed set up, he found no change in weight.

### Think and discuss

- Recall the burning of the Magnesium ribbon in air. Do you think mass is conserved during this reaction?

### Do you know?

Though the law of conservation of mass was proposed by Lavoisier, It was experimentally verfied by Landolt. The experiment carried out by us is a modified form of the experiment done by Landolt.

## Law of constant proportions

From the experiments on law of conservation of mass, we saw that mass does not change during a chemical reaction.

Now let us look at the results of some experiments carried out by the **Joseph L. Proust** between 1798 and 1808.

Proust took two samples of copper carbonate - a compound of copper, carbon and oxygen. He took a sample from nature and another sample prepared in the lab and decomposed it chemically to find percentage of copper, carbon and oxygen in the two samples.

The results obtained are given in table- 1

**Table-1**

| Weight percentage of | Natural sample | Synthetic sample |
|---|---|---|
| Copper | 51.35 | 51.35 |
| Carbon | 38.91 | 38.91 |
| Oxygen | 9.74 | 9.74 |

- What do you observe from the table?

- What difference do you observe in percentage of copper, carbon and oxygen in two samples?

Similarly, Proust took water from different sources, and found that the percentage of oxygen and hydrogen was the same in all samples. There was no relation between the place from where the sample came and its composition.

Based on his experiments, Proust put forward the law of constant (or definite) proportions. It states that, "**a given chemical substance always contains the same elements combined in a fixed proportions by weight**." This means that the relative proportion of elements in a compound is independent of the source or method of preparation.

### Think and discuss

- 100 g of mercuric oxide decompose to give 92.6 g of mercury and 7.4 g of oxygen. Let us assume that 10 g of oxygen reacts completely with 125 g of mercury to give mercuric oxide. Do these values agree with the law of constant proportions?
- Discuss with your friends if the carbon dioxide that you breathe out and the carbon dioxide they breathe out are identical. Is the composition of the carbon dioxide of different sources same?

### Why are the laws valid?

By early 19th century, the scientists knew some laws governing chemical reactions. Why are these laws valid? Why couldn't the elements combine in any proportion ?

Many scientists tried to give appropriate explanations. The English school teacher **John Dalton** proposed the basic theory about the nature of matter. Dalton reasoned his proposals as mentioned below.

1. If mass was to be conserved, then all elements must be made up of extremely small particles, called atoms.
2. If law of constant proportion is to be followed, the particles of same substance couldn't be dissimilar.

Based on the above laws, Dalton proposed A new system of Chemical Philosophy of atomic theory.

## Dalton's atomic theory

The following are the main postulates of the theory:

*Fig - 4*
***John Dalton***

1. Matter consists of indivisible particles called atoms.
2. Atoms are neither created nor destroyed in a chemical reaction.

Chemical reactions involve reorganization of atoms.

3. All the atoms of a given element have identical mass and chemical properties. Atoms of different elements have different masses and chemical properties.

4. Compounds are formed when atoms of different elements combine in simple whole number ratios. That is, chemical change is the union or separation of atoms as a whole.

### Think and discuss

- Which postulate of Dalton's theory is the result of the law of conservation of mass?
- Which postulate of Dalton's theory can explain the law of constant proportions?

### Do you know?

About 2600 years ago, an Indian sage (*Rishi*) called *Kanada* also postulated atoms in his *VAISHESIKA SUTRA*. The actual name of *Kanada* was *Kasyapa* - he was renamed after his *KANA SIDHANTHA*. He proposed that all forms of matter are composed of very small particles known as anu and each anu may be made up of still smaller particles called parmanu.

*The word 'atom' is derived from a Greek word 'a-tomio' (means - indivisible)*

## Atoms and molecules

Very often you may have heard that atoms are the building blocks of all matter. But what does it mean? It means that matter is composed of tiny particles known as atoms.

These atoms are so small that we cannot see them even with a high-powered microscope. The number of atoms present even in a small amount of matter is very large.

### Do you know?

The aluminium foil that we use to pack food might seem thin to you. But it has atoms in thousands.

- Are elements also made of atoms?

We know that substances are made up of - atoms or molecules. Atoms are the most fundamental of all particles that can have an independent existence. Sometimes two or more atoms combine to form a big particle. When atoms combine, they form molecules. When the particles of a substance contain only one type of atoms, that substance is called an **element**. In elements the smallest particle that exist may be atoms or molecules.

There are many elements whose smallest particle is an atom. Iron, copper, zinc, aluminium, silver, gold etc are examples of substances in which the smallest particle is an atom.

Oxygen and nitrogen are examples of substances in which the particles are a combination of two identical atoms.

Atoms of same elements or of different elements can join together to form molecules. If atoms of different elements join together they form a new substance known as compound.

So we can have molecules of elements and molecules of compounds. A molecule can be defined as the smallest particle of matter that is capable of an independent existence and retained all the properties of that substance.

## Why do we name elements?

Do you know what gold is called in your language? But in other languages it would have a different name. There are so many languages in the world so it is not possible to know the different names of each element in different languages. To help scientists communicate without confusion, we must have one name for each element that is accepted by everyone.

### Do you know?

John Berzelius suggested that initial letter of an element written in capitals should represent that particular element, such as 'O' for oxygen, 'H' for Hydrogen and so on.

### Do you know?

How elements like hydrogen and oxygen got their names?

Sometimes elements are named based on their property. For example, the Latin word for water is '**hydro**'. So the element that combined with oxygen to give water was named hydrogen.

At one time people believed that any substance that contained oxygen would be acidic in nature. The Latin word for acid is '**oxy**'. Hence the gas was called oxygen , meaning 'gas that forms acid'. It was later discovered that the acidic property was not related to oxygen. However, by then the name had come into common use so it was not changed.

Place of discovery of element can also play a role in its naming. For example, the gas which was first discovered in the sun (Greek name for Sun is '**helios'**), was named helium.

Can you guess the orgin of names of polonium and californium?

Sometimes elements were named to honour the scientists. For example: Einsteinium, Fermium, Rutherfordium and Mendelevium.

## Symbols of elements

You must have realized that chemistry involves a lot of reactions. It will be a waste of time to write the full name of the elements and compounds every time to describe a reaction. To avoid this we use some shortcuts. Using short forms or symbols for naming the elements is one solution.

Over a 100 elements have been discovered so far. How do we decide their symbols?

**Table-2:** Symbols for some elements

| Element Name | Symbol |
|---|---|
| Hydrogen | H |
| Oxygen | O |
| Nitrogen | N |
| Sulphur | S |
| Carbon | C |
| Calcium | Ca |
| Chlorine | Cl |
| Chromium | Cr |
| Boron | B |
| Barium | Ba |
| Bromine | Br |
| Beryllium | Be |
| Aluminium | Al |
| Iron | Fe |
| Gold | Au |
| Sodium | Na |
| Potassium | K |

Usually, the first letter of the name of the element in English became the symbol of that element and is always written as a capital letter (upper case).

Do you see any problem with this method? We have 26 alphabets in English but there are over 100 known elements. How do we write the symbols for calcium, Chlorine, Chromium?

We have already used the letter 'C' for Carbon. Look at the elements after Carbon and before Aluminium in the table.

Discuss with your teacher and friends how the symbols have been decided for these elements. Notice the following:

- A symbol can have either one or two letters of English.
- The first letter of the symbol is always upper case and the second letter is always lower case.

## Activity-1

Some elements and their possible symbols are given in table-3. Correct them and give reasons for your corrections.

**Table-3**

| Element | Possible symbol |
|---|---|
| Aluminium | al |
| Carbon | c |
| Chromium | Chr |
| Chlorine | CL |
| Beryllium | Be |

## Some unusual symbols

This is not the end of the problem. We observe that symbols for some elements come from their names but some don't. If you are told that certain elements have symbols based on their Latin names (or older names in other languages).

- Would you be able to guess the elements of the table-2, have symbols of this category?

## Activity-2

### Write the symbols for given elements

Look up a periodic table and try to find the symbols for the given elements in table 4 and write them against their names.

**Table-4**

| Element | Sodium | Silver | Tungsten | Potassium | Copper | Gold | Iron | Lead |
|---|---|---|---|---|---|---|---|---|
| Other name | Natrium | Argentum | Wolfram | Kalium | Cuprum | Aurum | Ferrum | Plumbum |
| Symbol | | | | | | | | |



## Elements with more than one atom

Several elements have more than one atom in their smallest constituent particle. Each particle in these elements contains two atoms combined together to form a molecule. Oxygen, hydrogen and nitrogen are examples of such elements.

For example, a molecule of oxygen has two atoms. We need a formula to represent such a molecule in a simple way. The formula for oxygen molecule is $O_2$.

Why did not we write it as 2 O ? Writing a formula in this way indicates two separate atoms of oxygen. Hence first write the symbol for oxygen. and then write 2 as a subscript after the letter O.

Subscript number indicates number of atoms of Oxygen combined to form its molecule.

You may have heard about Ozone gas. This gas is found in large quantities in the upper layers of the earth's atmosphere. It protects us by shielding the earth from some harmful rays of the sun. Every molecule of ozone has three atoms of oxygen. Can you write the formula of ozone?

## Atomicity

Molecules of many elements, such as Argon (Ar), Helium(He) etc are made up of only one atom of that element. But this is not the case with the most of non metals. In non metals the molecules contain more than two atoms of different elements.

The number of atoms constituting a molecule is known as its **atomicity**.

For example, a molecule of hydrogen consists of two atoms of hydrogen. Here the atomicity is two; hence it is known as diatomic molecule. Helium (He), Argon (Ar) exist as single atom. Hence they are known as monoatomic.

Observe the following table to know atomicity of molecules of few elements and try to write the symbol of molecule based on its atomicity.

**Table-5**

| Name of the element | Formula | Atomicity |
|---|---|---|
| Argon | Ar | Monoatomic |
| Helium | | Monoatomic |
| Sodium | Na | Monoatomic |
| Iron | | Monoatomic |
| Aluminum | | Monoatomic |
| Copper | | Monoatomic |
| Hydrogen | $H_2$ | Diatomic |
| Oxygen | | Diatomic |
| Nitrogen | | Diatomic |
| Chlorine | | Diatomic |
| Ozone | $O_3$ | Triatomic |
| Phosphorus | | Tetratomic |
| Sulphur | $S_8$ | Octatomic |



- Why do some elements monatomic?
- Why do some elements form diatomic or triatomic molecules?
- Why do elements have different atomicities

To understand the atomicity of molecules of elements and compounds we need to understand the concept of valency.

- What is valency?

## Valency

There are over 100 elements known now. These elements react with each other to form compounds. Every element has a definite combining capacity, that determines the atomicity of its molecules. Every element reacts with other element according to its combining capacity, which we call as its valency.

**Table-6**

| Element | Valency |
|---|---|
| Hydrogen | 1 |
| Carbon | 4 |
| Oxygen | 2 |
| Chlorine | 1 |
| Helium | 0 |
| Argon | 0 |
| Fluorine | 1 |

So atoms of the elements have power to combine with atoms of other elements. This is known as its valency.

## What is an ion?

Compounds formed by metals and non metals contain charged species. The charged species are known as ions. A negatively charged ion is called anion and the positive charge ion is cation.

For example sodium chloride do not contain discrete molecules as their constituent units. Its constituent particles are positively charged sodium ions ($Na^+$) and negatively charged chloride ions ($Cl^-$).

Ions may be a single charged atoms or a group of atoms (polyatomic) that have a net charge on them.

**Table-7:** Some common, simple and polyatomic ions

| Net Charge | Cation | Symbol | Anion | Symbol |
|---|---|---|---|---|
| 1 unit | Sodium | $Na^+$ | Hydride | $H^-$ |
| | Potassium | $K^+$ | Chloride | $Cl^-$ |
| | Silver | $Ag^+$ | Bromide | $Br^-$ |
| | Copper* | $Cu^+$ | Iodide | $I^-$ |
| | Ammonium | $NH_4^+$ | Hydroxide | $OH^-$ |
| | | | Nitrate | $NO_3^-$ |
| 2 units | Magnesium | $Mg^{+2}$ | Oxide | $O^{2-}$ |
| | Calacium | $Ca^{+2}$ | Sulphide | $S^{2-}$ |
| | Zinc | $Zn^{+2}$ | Sulphate | $SO_4^{2-}$ |
| | Copper* | $Cu^{+2}$ | Carbonate | $CO_3^{2-}$ |
| | Iron* | $Fe^{+2}$ | | |
| 3 units | Aluminium | $Al^{+3}$ | Nitride | $N^{3-}$ |
| | Iron* | $Fe^{+3}$ | Phosphate | $PO_4^{3-}$ |

* elements which show variable valency.

Valency of an ion is equal to the magnitude of its charge. For Example valency of chloride ion ($Cl^-$) is 1. Valency of sulphate ion ($SO_4^{-2}$) is 2.

Now refer the table-7 and try to write the valencies of some other ions.

## Atomic mass

The most remarkable concept that Dalton's atomic theory proposed was that of atomic mass. According to him each element had a characteristic atomic mass.

Since, atoms are extremely light and small, scientists find it difficult to measure their individual masses. Hence, the mass of the atom is compared with a standard atomic mass of other element. In 1961, it was universally accepted that to choose the atomic mass of carbon-12 as a standard reference for measuring atomic masses of other elements.

Observe the following diagram (fig-5). Let us assume the circle in the diagram represents atomic mass of carbon-12. It is divided into 12 equal parts as shown in the figure, and each part represents 1/12 of atomic mass of carbon-12.

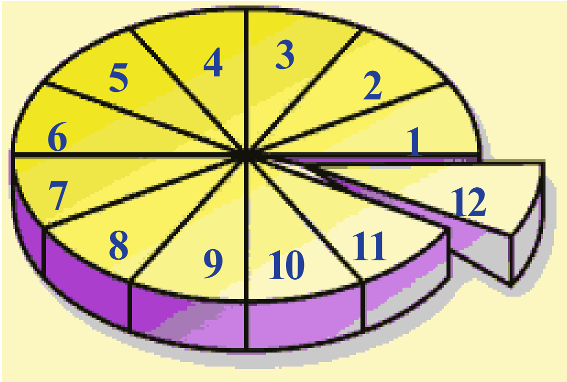


*Fig - 5*

One atomic mass unit is defined a mass exactly one twelfth the atomic mass of Carbon-12 isotope.

The number of times one atom of given element is heavier than 1/12th part of atomic mass of carbon-12 is called its **atomic mass**.

The relative atomic mass of the atom of an element is defined as the average mass of the atom, as compared to $1/12^{th}$ of the mass of one carbon -12 atom.

Atomic mass of an element is a ratio and has no units but expressed in amu according to latest IUPAC recommendations the **amu** has been replaced by '**u**', which is known as **unified mass**.



**Table-8:** Atomic masses of a few elements

| Element | Atomic Mass (in u) | Element | Atomic Mass (in u) |
|---|---|---|---|
| Hydrogen | 1 | Aluminium | 27 |
| Carbon | 12 | Phosphorus | 31 |
| Nitrogen | 14 | Sulphur | 32 |
| Oxygen | 16 | Chlorine | 35.5 |
| Sodium | 23 | Potassium | 39 |
| Magnesium | 24 | Calcium | 40 |

## Do you know?

1. Atomic weights of elements were determined in the beginning with reference to hydrogen by John Dalton.

   While searching various atomic mass units scientists initially took 1/16th of the mass of an atom of naturally occurring oxygen as a unit. This was considered relevant due to two reasons.

   - Oxygen reacted with a large number of elements and formed compounds.
   - This atomic mass unit gave masses of most of the elements as whole numbers.

2. During nineteenth century there were no facilities to determine the mass of an atom. Hence, chemists determined the mass of one atom relative to another by experiments. Today, atomic mass of an atom can be determined very accurately with the help of an instrument called mass spectrometer.

## Molecules of compounds

A molecule is formed by the combination of different kinds of atoms that are chemicelly bonded together by attractive forces. For example, a molecule of water is formed by the combination of atoms of hydrogen and oxygen. All the molecules of water are identical.

Is it possible for any number of atoms of hydrogen to combine with any number of atoms of oxygen to form a molecule of water?

For all the molecules of water to be identical, it is essential that the atoms of hydrogen and oxygen that are present in the molecule must be in fixed numbers. If this number is not fixed, how could all the particles of water be identical?

Each molecule of water contains 2 atoms of hydrogen and 1 atom of oxygen.

## Chemical formulae of compounds

While writing the formula of a compound we must keep two things in mind. First, we must see the elements present in a molecule of the compound. Second, we must see the number of atoms of each element present in that molecule. 2 atoms of hydrogen and one atom of oxygen are present in a molecule of water, its formula is $H_2O$.

Another rule is that if the molecule of a substance contains only one atom subscript need not be written in the formula.

Now look at another example, a molecule of carbon dioxide contains one atom of carbon and two atoms of oxygen. carbon and oxygen also react to form another compound called carbon monoxide. A molecule of carbon monoxide contains one atom of carbon and one atom of oxygen.

- Can you write the formula of carbon dioxide and carbon monoxide? Try to write formula for them as we have done in case of water molecule.

Let us try to write chemical formulae by using valency of elements in criss - cross method.

The following steps should be taken while attempting to write a chemical formula. Take sodium carbonate as an example.

1. Write the symbols of atoms or group of atoms side by side, usually the cation first -Na $CO_3$
2. Write the valency of each atom or group of atoms on the top of its symbol

   $Na^1$ $(CO_3)^2$
3. Divide the valency numbers by their highest common factor if any to get the simple ratio. $Na^1$ $(CO_3)^2$
4. Inter change the valency and write the numbers to the lower right of the constituents as subscript'. $Na_2$ $(CO_3)_1$
5. If any constituent receives the number 1, ignore it while writing the formula. $Na_2CO_3$
6. If a group of atoms receives the number more than 1 encloses it with in brackets

Hence the formula for the sodium carbonate is $Na_2CO_3$.

**Examples**

Formula of hydrogen chloride

$H^1$ $Cl^1$ formula: HCl

Formula of magnesium chloride

$Mg^2$ $Cl^1$ formula: $MgCl_2$

Formula of calcium oxide

$Ca^2$ $O^2$

$Ca^1$ $O^1$ formula: CaO

Formula of aluminium sulphate

$Al^3$ $(SO_4)^2$ formula: $Al_2(SO_4)^3$

Table-9: Formulae of some compounds

| Compound | Formula |
|---|---|
| Sodium Carbonate | $Na_2CO_3$ |
| Sodium bicarbonate | $NaHCO_3$ |
| Sodium hydroxide | NaOH |
| Copper Sulphate | $CuSO_4$ |
| Silver Nitrate | $AgNO_3$ |
| Hydrochloric Acid | HCl |
| Sulphuric Acid | $H_2SO_4$ |
| Nitric Acid | $HNO_3$ |
| Ammonium Chloride | $NH_4Cl$ |

## Molecular mass

We have already discussed the concepts of atomic mass. This concept can be extended to calculate molecular masses.

The molecular mass of substances is the sum of the atomic masses of all the atoms in a molecule of a substance. It is therefore the relative mass of a molecule expressed in unified mass units.(u)

For Example: calculate the molecular mass of $H_2SO_4$

**Solution**

2 (atomic mass of hydrogen) + (atomic mass of sulphur) + (4 x atomic mass of oxygen) = (2x1)+32+(4x16)=98 u

## Formula unit mass

A formula unit, as the name implies ,is one unit of atom, ion or molecule corresponding to a given formula. One formula unit of Nacl, means one $Na^+$ iron and one Cl- iron, similarly one formula unit of $MgBr_2$ means one $Mg^{2+}$ ion and two $Br^-$ ions, and one formula unit of $H_2o$ means one $H_2O$ molecule. The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound. Fermula unit mass is calculated in the same manner as the molecular mass. The only difference is that formula unit is used for the substances whose constituents particles are irons. SodiumChloride has a formula unit Nacl. The formula unit mass can be calculated. as -

1 x 23 + 1 x 35.5 = 58.5(u)

## Mole concept

We have learnt that atoms and molecules are extremely small in size and their number is really very large. Even in small amount of any substance we find very large number of atoms or molecules.

How many molecules are there in 18 grams of water?

How many atoms there are in 12 grams of carbon?

You will be surprised to know that the number of particles in 18 grams of water and 12 grams of carbon is same. This number is very large. To handle such large numbers, a unit called mole is defined. This is a number quantity.

One mole of any species (atoms, molecules, ions or particles) are the quantity which is expressed in a number having a mass equal to its atomic or molecular mass in grams.

The number of particles present in one mole of any substance has a fixed value of $6.022 \times 10^{23}$. This is experimently obtained value. This is called Avogadro constant ($N_A$) named in honour of the Italian scientist, Amedeo Avogadro.

### Do you know?

The word "mole" was introduced by Wilhelm Ostwald, who derived the term from the latin word "moles" meaning a 'heap' or 'pile'. A mole substance may be considered as a heap of atoms or molecules. The unit mole was accepted in 1967 to provide a simple way of reporting a large number-the massive heap of atoms and molecules in a sample.

## Molar mass

Having defined mole, it is easier to know the mass of 1 mole of substance. The mass of 1 mole of a substance which is expressed in grams is called its molar mass.

The molar mass is numerically equal to atomic/molecular /formula mass in unified mass (u) expressed in grams.

For example molecular mass of water ($H_2O$) =18u.

Molar mass of water= 18 g

18 u water has only one molecule of water. But 18 g water has one mole molecules of water that is $6.022 \times 10^{23}$ molecules.

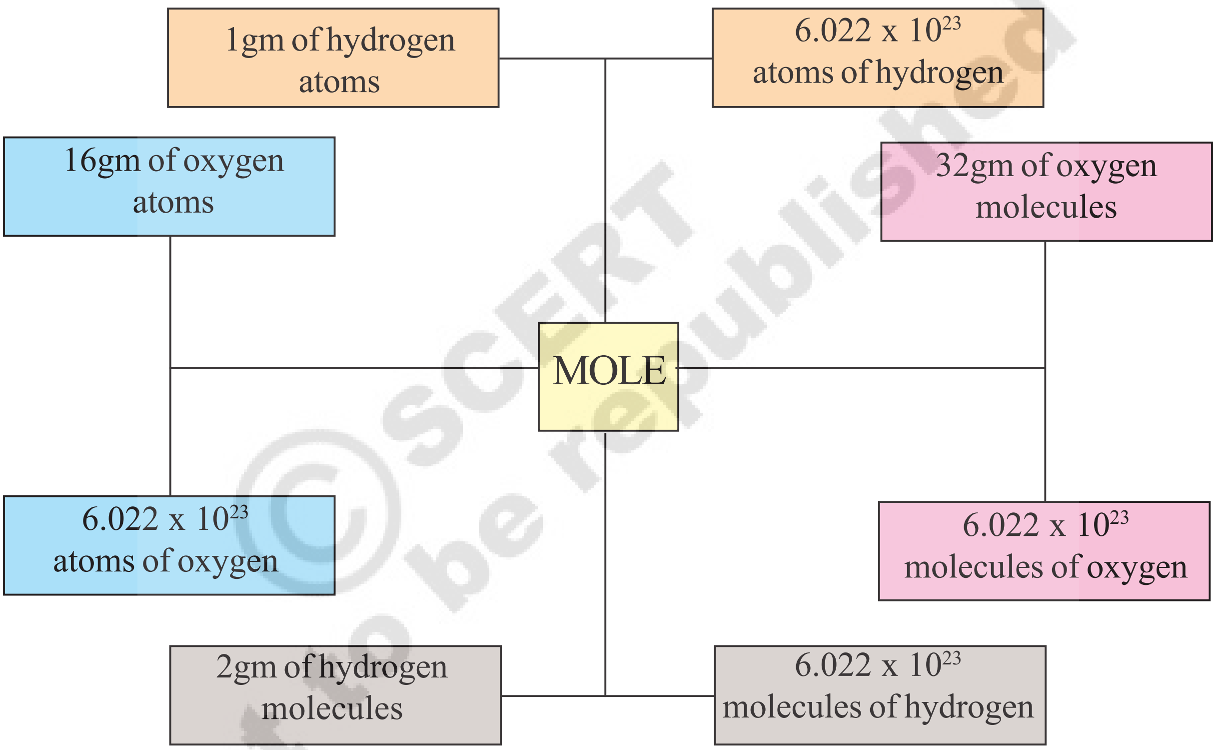



*Fig-6: Diagram on concept of mole*



### Key words

*Law of conservation of mass, Law of constant proportion. Atom, Symbol, Atomic mass, Atomic mass unit (amu), Unified mass (u), Molecule, Molecules of elements, Molecules of compounds, Formula, Ion (cation, anion), Valency, Molecular mass, Formula unit mass, Mole, Avogadro constant, Molar mass.*

## What we have learnt

- The total mass of the products formed in a chemical reaction is exactly equal to the mass of the reactants. This is known as the law of conservation of mass.
- In a chemical substance the elements are always present in fixed proportions by mass. This is known as the law of constant proportion.
- An atom is the smallest particle of an element that can participate in chemical reaction and retain all its properties.
- A molecule is the smallest particle of an element or a compound that is capable of independent existence and retain all the properties of that substance.
- Symbols represents atoms and formula represents molecules and compounds.
- Scientists use the relative atomic mass scale to compare the masses of different atoms of elements.
- The number of times one atom of a given element is heavier than $1/12^{th}$ part of mass of carbon -12 atom is called its atomic mass.
- By using criss - crosss method we can write the chemical formula of a compound.
- The number of particles present in one mole of any substance is called Avogadro constant ($N_A$). It is a fixed a value of $6.022 \times 10^{23}$.
- Mass of one mole of a substance is called its molar mass.



## Improve your learning

1. Draw the digarm to show the experimental setup for the law of conservation of mass. ($AS_5$)
2. Explain the process and precautions in verifying law of conservation of mass. ($AS_1$)
3. 15.9g. of copper sulphate and 10.6g of sodium carbonate react together to give 14.2g of sodium sulphate and 12.3g of copper carbonate. Which law of chemical combination is obeyed? How? ($AS_1$ , $AS_2$)
4. Carbon dioxide is added to 112g of calcium oxide. The product formed is 200g of calcium carbonate. Calculate the mass carbon dioxide used. Which law of chemical combination will govern your answer.($AS_1$ , $AS_2$)

5. 0.24g sample of compound of oxygen and boron was found by analysis to contain 0.144g of oxygen and 0.096g of boron. Calculate the percentage composition of the compound by weight. ($AS_1$)

6. In a class, a teacher asked to write the molecular formula of oxygen Shamita wrote the formula as $O_2$ and Priyanka as O. which one is correct? State the reason.($AS_1$,$AS_2$)

7. Imagine what would happen if we do not have standard symbols for elements?($AS_2$)

8. Mohith said "$H_2$ differs from 2H". Justify. ($AS_1$)

9. Lakshmi gives a statement "CO and Co both represents element". Is it correct? State reason.($AS_1$,$AS_2$)

10. The formula of water molecule is $H_2O$. What information you get from this formula.($AS_1$)

11. How would you write 2 molecules of oxygen and 5 molecules of Nitrogen.($AS_1$)

12. The formula of a metal oxide is MO. Then write the formula of its chloride.($AS_1$)

13. Formula of calcium hydroxide is $Ca(OH)_2$ and zinc phosphate is $Zn_3(PO_4)_2$. Then write the formula to calcium phosphate.($AS_1$)

14. Find out the chemical names and formulae for the following common household substances. ($AS_1$)

    a) common salt b) baking soda c) washing soda d) vinegar

15. Calculate the mass of the following ($AS_1$)

    a) 0.5 mole of $N_2$ gas.
    b) 0.5 mole of N atoms.
    c) 3.011 X $10^{23}$ number of N atoms.
    d) 6.022 X $10^{23}$ number of $N_2$ molecules.

16. Calculate the number of particles in each of the following ($AS_1$)

    a) 46g of Na b) 8g of $O_2$ c) 0.1 mole of hydrogen

17. Convert into mole ($AS_1$)

    a) 12g of $O_2$ gas. b) 20g of water. c) 22g of carbon dioxide.

18. Write the valencies of Fe in $FeCl_2$ and $FeCl_3$($AS_1$)

19. Calculate the molar mass of Sulphuric acid ($H_2SO_4$) and glucose ($C_6H_{12}O_6$)($AS_1$)

20. Which has more number of atoms - 100g of sodium or 100g of iron? Justify your answer. (atomic mass of sodium = 23u, atomic mass of iron = 56u) ($AS_1$)

21. Complete the following table.($AS_1$)

| Anions → ↓ Cations | Chloride | Hydroxide | Nitrate | Sulphate | Carbonate | Phosphate |
|---|---|---|---|---|---|---|
| Sodium | NaCl | | | | | |
| Magnisium | | | | $MgSO_4$ | | |
| Calcium | | | | | | |
| Aluminum | | | | | | |
| Ammonium | | | | | | $(NH_4)_3PO_4$ |

22. Fill the following table($AS_1$)

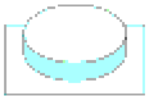
| Sl.No. | Name | Symbol/formula | Molar mass | Number of particles present in molar mass. |
|---|---|---|---|---|
| 1 | Atomic oxygen | | 16g | $6.022 \times 10^{23}$ atoms of oxygen |
| 2 | Molecular oxygen | | | |
| 3 | Sodium | | | |
| 4 | Sodium ion | | 23g | |
| 5 | Sodium chloride | | | $6.022 \times 10^{23}$ units of sodium chloride |
| 6 | water | | | |

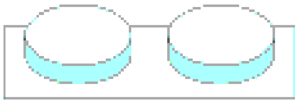


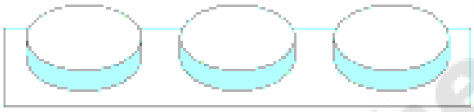
## Group activity ($AS_4$)

1. Make placards with symbols and valencies of the atoms of the elements separately. Each student should hold two placards, one with the symbol in the right hand and the other with the valency in the left hand. Keeping the symbols in place, students should criss-cross their valencies to form the formula of a compound.

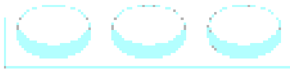
2. Take empty blister packs of medicines. Cut them into pieces having ($AS_4$)

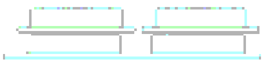
single hallow strip 

double hallow strip 

triple hallow strip 

Divide them into groups according to the valancies. Assume that the number of hallow rounds of strips represents valency of an ion.

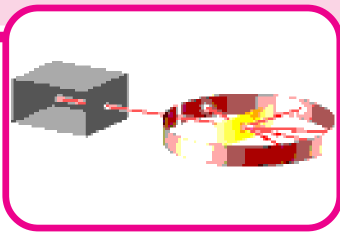
For example  strip represents single valency ions like $Na^+$, $Cl^-$, $H^+$ etc., Simlarly the remaining strips  and  represents double and triple valency ions. (see table 7) Now you can make the formulae by fixing one type of strip into other.

For example two sodium ion strips (Single hallow strips) can be fixed in one carbonate ion strip (double hallow strip) like 

hence the formula of sodium carbonate will be $Na_2 CO_3$

Chapter 6

# WHAT IS INSIDE THE ATOM?



In previous chapters we have learnt that all matter is made of atoms. The first modern atomic theory was proposed by John Dalton. According to Dalton, atoms were indivisible. That means that they could not be divided into further smaller parts. Atoms of an element are all identical to each other and different from the atoms of other elements. This naturally led scientists to ask the following questions :

- Why are the atoms of different elements different?
- Is there anything inside atoms that make them to be same or different?
- Are atoms indivisible?

Atoms are too small to be seen with naked eye. Scientists relied on indirect evidence to prove the existence of atoms. Since they could not see the atoms, they could find its properties on the basis of experiments. Very soon they realized that atoms could gain or lose charges. During electrolysis experiments, Michael Faraday discovered that atoms were accquiring negative charge during process of electrolysis.

Michael Faraday's discovery raised few questions about the indivisibility of atoms.

How could a neutral atom become electrically charged? It is a contradiction to Dalton's theory that the atom was indivisible. This led to an idea that there must exist some tiny particles in atom which are responsible for atom to behave sometimes as a charged particle. As atom is considered as electrically neutral, it probably had some positive constituents and equal number of negative constituents to maintain its electrical neutrality. This gave scope to think about sub-atomic particles.

## Sub-atomic Particles

In science, theories change when scientists discover new facts or clues. Sometimes, an idea or model must be