

## BASIC CONCEPTS OF CHEMISTRY

---

**Chemistry:** Chemistry is the branch of science that deals with the composition, structure and properties of matter. Chemistry is called the science of atoms and molecule.

### **Branches of Chemistry:**

**Inorganic Chemistry**-This branch deals with the study of compounds of all other elements except carbon. It largely concerns itself with the study of minerals found in the Earth's crust.

**Organic Chemistry** -This branch deals with study of carbon compounds especially hydrocarbons and their derivatives.

**Physical Chemistry**-The explanation of fundamental principles governing various chemical phenomena is the main concern of this branch. It is basically concerned with laws and theories of the different branches of chemistry.

**Analytical Chemistry**-This branch deals with the qualitative and quantitative analysis of various substances.

**Industrial Chemistry**-The chemistry involved in industrial processes is studied under this branch.

**Nuclear Chemistry**-Nuclear reactions, such as nuclear fission, nuclear fusion, transmutation processes etc. are studied under this branch.

**Biochemistry**-This branch deals with the chemical changes going on in the bodies of living organisms; plants and animals.

# PROPERTIES OF MATTER AND THEIR MEASUREMENT

Every substance has unique or characteristic properties. These properties can be classified into two categories – **physical properties** and **chemical properties**.

**Physical properties** are those properties which can be measured or observed without changing the identity or the composition of the substance. E.g. colour, odour, melting point, boiling point, density etc.

The measurement or observation of **chemical properties** requires a chemical change to occur. e.g. Burning of Mg-ribbon in air. **Chemical properties** are characteristic reactions of different substances; these include acidity or basicity, combustibility etc. Many properties of matter such as length, area, volume, etc., are quantitative in nature.

**Metric System** was based on the decimal system.

**The International System of Units (SI)** The SI system has seven *base units*

## Prefixes in SI system

Multiple	Prefix	Symbol
$10^{-12}$	pico	p
$10^{-9}$	nano	n
$10^{-6}$	micro	$\mu$
$10^{-3}$	milli	m
$10^{-2}$	centi	c
$10^{-1}$	deci	d
10	deca	da
$10^2$	hecto	h
$10^3$	kilo	k
$10^6$	mega	M
$10^9$	giga	G
$10^{12}$	tera	T

## Mass and Weight—

- **Mass** of a substance is the amount of matter present in it while **weight** is the force exerted by gravity on an object.

- A zero becomes significant in case it comes in between non zero numbers.

For example, 2.003 has four significant figures, 4.02 has three significant figures.

- Zeros at the beginning of a number are not significant.

For example, 0.002 has one significant figure while 0.0045 has two significant figures.

- All zeros placed to the right of a number are significant.

For example, 16.0 has three significant figures, while 16.00 has four significant figures. Zeros at the end of a number without decimal point are ambiguous.

- In exponential notations, the numerical portion represents the number of significant figures.

For example, 0.00045 is expressed as  $4.5 \times 10^{-4}$  in terms of scientific notations. The number of significant figures in this number is 2, while in Avogadro's number ( $6.023 \times 10^{23}$ ) it is four.

- The decimal point does not count towards the number of significant figures.

For example, the number 345601 has six significant figures but can be written in different ways, as 345.601 or 0.345601 or 3.45601 all having same number of significant figures.

### **Retention of Significant Figures - Rounding off Figures**

The rounding off procedure is applied to retain the required number of significant figures.

1. If the digit coming after the desired number of significant figures happens to be more than 5, the preceding significant figure is increased by one, 4.317 is rounded off to 4.32.

2. If the digit involved is less than 5, it is neglected and the preceding significant figure remains unchanged, 4.312 is rounded off to 4.31.

3. If the digit happens to be 5, the last mentioned or preceding significant figure is increased by one only in case it happens to be odd. In case of even figure, the preceding digit remains unchanged. 8.375 is rounded off to 8.38 while 8.365 is rounded off to 8.36.

- The mass of a substance is constant whereas its weight may vary from one place to another due to change in gravity.
- The mass of a substance can be determined very accurately by using an analytical balance

**Volume—** Volume has the units of (length)<sup>3</sup>. So volume has units of m<sup>3</sup> or cm<sup>3</sup> or dm<sup>3</sup>. A common unit, litre (L) is not an SI unit, is used for measurement of volume of liquids. 1 L = 1000 mL, 1000 cm<sup>3</sup> = 1 dm<sup>3</sup>

**Density:** Density of a substance is its amount of mass per unit volume. SI unit of density = SI unit of mass/SI unit of volume = kg/m<sup>3</sup> or kg m<sup>-3</sup>. This unit is quite large and a chemist often expresses density in g cm<sup>-3</sup>.

**Temperature—** There are three common scales to measure temperature — °C (degree Celsius), °F (degree Fahrenheit) and K (kelvin). Here, K is the SI unit.  $K = ^\circ C + 273.15$

**Note—** Temperature below 0 °C (i.e. negative values) are possible in Celsius scale but in Kelvin scale, negative temperature is not possible.

#### Scientific Notation

In which any number can be represented in the form  $N \times 10^n$  (Where n is an exponent having positive or negative values and N can vary between 1 to 10). e.g. We can write 240.508 as  $2.40508 \times 10^2$  in scientific notation. Similarly, 0.00029 can be written as  $2.9 \times 10^{-4}$ .

**Precision** refers to the closeness of various measurements for the same quantity.

**Accuracy** is the agreement of a particular value to the true value of the result

#### Significant Figures

The reliability of a measurement is indicated by the number of digits used to represent it. To express it more accurately we express it with digits that are known with certainty. These are called as Significant figures. They contain all the certain digits plus one doubtful digit in a number.

#### Rules for Determining the Number of Significant Figures

- All non-zero digits are significant.

For example, 6.9 has two significant figures, while 2.16 has three significant figures. The decimal place does not determine the number of significant figures.



**Dimensional Analysis** During calculations generally there is a need to convert units from one system to other. This is called **factor label method** or **unit factor method** or **dimensional analysis**.

For example- 5 feet and 2 inches (height of an Indian female) is to be converted in SI unit 1 inch = 2.54 x 10<sup>-2</sup> m then, 5 feet and 2 inch = 62 inch

Properties	Solid	Liquid	Gas
shape	Definite	Indefinite	Indefinite
Volume	Definite	Definite	Indefinite
Intermolecular force of attraction	Very high	moderate	Negligible
Arrangement of molecules	Orderly arranged	Free to move within the volume	Free to move everywhere
Intermolecular space	Very small	Slightly greater	Very great
Compressibility	Not Compressible	Not Compressible	Highly Compressible
Expansion on heating	Very little	Very little	Highly expand
Rigidity	Very rigid	Not rigid	Not rigid
Fluidity	Can't flow	Can flow	Can flow
Diffusion	Can't diffuse	Can diffuse	diffuse

## Chemical Classification of matter

### Elements

An element is the simplest form of matter that cannot be split into simpler substances or built from simpler substances by any ordinary chemical or physical method. There are 114 elements known to us, out of which 92 are naturally occurring while the rest have been prepared artificially.

Elements are further classified into metals, non-metals and metalloids.

### Compounds

A compound is a pure substance made up of two or more elements combined in a definite proportion by mass, which could be split by suitable chemical methods.

### **Characteristics of compound**

Compounds always contain a definite proportion of the same elements by mass.

The properties of compounds are totally different from the elements from which they are formed.

Compounds are homogeneous.

Compounds are broadly classified into inorganic and organic compounds.

- Organic compounds are those, which occur in living sources such as plants and animals. They all contain carbon. Common organic compounds are oils, wax, fats etc.
- Inorganic compounds are those, which are obtained from non-living sources such as minerals. For example, common salt, marble and limestone.

### **Mixtures**

A mixture is a combination of two or more elements or compounds in any proportions so that the components do not lose their identity. Air is an example of a mixture.

Mixtures are of two types, homogeneous and heterogeneous.

- **Homogeneous mixtures** have the same composition throughout the sample. The components of such mixtures cannot be seen under a powerful microscope. They are also called solutions. Examples of homogeneous mixtures are air, seawater, gasoline, brass etc.
- **Heterogeneous mixtures** consist of two or more parts (phases), which have different compositions. These mixtures have visible boundaries of separation between the different constituents and can be seen with the naked eye e.g., sand and salt, chalk powder in water etc.

## **LAWS OF CHEMICAL COMBINATIONS:**

**Law of Conservation of Mass** (Given by Antoine Lavoisier in 1789).

It states that matter (mass) can neither be created nor destroyed.

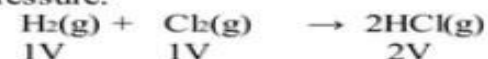
**Law of Definite Proportions or Law of Constant Composition:**

This law was proposed by Louis Proust in 1799, which states that:

'A chemical compound always consists of the same elements combined together in the same ratio, irrespective of the method of preparation or the source from where it is taken'.

**Law of Multiple Proportions** Proposed by Dalton in 1803, this law states that: 'When two elements combine to form two or more compounds, then the different masses of one element, which combine with a fixed mass of the other, bear a simple ratio to one another'.

**Gay Lussac's Law of Gaseous Volumes** (Given by Gay Lussac in 1808.) According to this law when gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.



All reactants and products have simple ratio 1:1:2.

**Avogadro Law** (In 1811, Given by Avogadro) According to this law equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

---

## Dalton's Atomic Theory

---

- All substances are made up of tiny, indivisible particles called atoms.
- Atoms of the same element are identical in shape, size, mass and other properties.
- Atoms of different elements are different in all respects.
- Atom is the smallest unit that takes part in chemical combinations.
- Atoms combine with each other in simple whole number ratios to form compound atoms called molecules.
- Atoms cannot be created, divided or destroyed during any chemical or physical change.

### Atoms and Molecules

The smallest particle of an element, which may or may not have independent existence is called an atom, while the smallest particle of a substance which is capable of independent existence is called a molecule.



Molecules are classified as homoatomic and heteroatomic.

- **Homoatomic molecules** are made up of the atoms of the same element
  - **Heteroatomic molecules** are made up of the atoms of the different element have different atomicity (number of atoms in a molecule of an element) like monoatomic, diatomic, triatomic and polyatomic.
- 

#### **Atomic Mass Unit**

One atomic mass unit is defined as a mass exactly equal to one twelfth the mass of one carbon-12 atom. And  $1 \text{ amu} = 1.66056 \times 10^{-24} \text{ g}$ .

Today, 'amu' has been replaced by 'u' which is known as unified mass.

#### **Atomic Mass**

Atomic mass of an element is defined as the average relative mass of an atom of an element as compared to the mass of an atom of carbon-12 taken as 12.

#### **Gram Atomic Mass**

The quantity of an element whose mass in grams is numerically equal to its atomic mass. In simple terms, atomic mass of an element expressed in grams is the gram atomic mass or gram atom.

For example, the atomic mass of oxygen = 16 amu

Therefore gram atomic mass of oxygen = 16 g

#### **Molecular Mass**

Molecular mass of a substance is defined as the average relative mass of its molecules as compared to the mass of an atom of C-12 taken as 12.

#### **Gram Molecular Mass:**

A quantity of substance whose mass in grams is numerically equal to its molecular mass is called gram molecular mass. In simple terms, molecular mass of a substance expressed in grams is called gram molecular mass.

e.g., the molecular mass of oxygen = 32 amu

Therefore, gram molecular mass of oxygen = 32 g

#### **Formula Mass:**

The sum of atomic masses of the elements present in one formula unit of a compound. It is used for the ionic compounds.



## Mole Concept:

---

Mole is defined as the amount of a substance, which contains the same number of chemical units (atoms, molecules, ions or electrons) as there are atoms in exactly 12 grams of pure carbon-12.

A mole represents a collection of  $6.022 \times 10^{23}$  (Avogadro's number) chemical units..

**The mass of one mole of a substance in grams is called its molar mass.**

### **Molar Volume**

The volume occupied by one mole of any substance is called its molar volume. It is denoted by  $V_m$ . One mole of all gaseous substances at 273 K and 1 atm pressure occupies a volume equal to 22.4 litre or 22,400 mL. The unit of molar volume is litre per mol or millilitre per mol.

---

### **PERCENTAGE COMPOSITION:**

The mass percentage of each constituent element present in any compound is called its percentage composition

Mass % of the element =  $\frac{\text{Mass of element in 1 molecule of the compound}}{\text{Molecular mass of the compound}} \times 100$

### **Empirical Formula and Molecular Formula—**

An **empirical formula** represents the simplest whole number ratio of various atoms present in a compound.

E.g. CH is the empirical formula of benzene.

The **molecular formula** shows the exact number of different types of atoms present in a molecule of a compound.

E.g.  $C_6H_6$  is the molecular formula of benzene.

### **Relationship between empirical and molecular formulae**

The two formulas are related as  $\text{Molecular formula} = n \times \text{empirical formula}$

### **Chemical Equation-**

Shorthand representation of a chemical change in terms of symbols and formulae of the substances involved in the reaction is called chemical equation..

The substances that react among themselves to bring about the chemical changes are known as reactants, whereas the substances that are produced as a result of the chemical change, are known as products.

**Limiting Reagent-** The reactant which gets consumed first or limits the amount of product formed is known as **limiting reagent**

**Reactions in Solutions--** The concentration of a solution can be expressed in any of the following ways.

**1. Mass Percent** is the mass of the solute in grams per 100 grams of the solution.

A 5 % solution of sodium chloride means that 5 g of NaCl is present in 100g of the solution.

**2. Volume percent** is the number of units of volume of the solute per 100 units of the volume of solution.

A 5 % (v/v) solution of ethyl alcohol contains 5 cm<sup>3</sup> of alcohol in 100 cm<sup>3</sup> of the solution

**3. Molarity** of the solution is defined as the number of moles of solute dissolved per litre (dm<sup>3</sup>) of the solution. It is denoted by the symbol M. Measurements in Molarity can change with the change in temperature because solutions expand or contract accordingly.

Molarity of the solution = No. of moles of the solute = n  
Volume of the solution in litre V

The Molarity of the solution can also be expressed in terms of mass and molar mass

Molarity of the solution = Mass of the solute

Molar mass of the solute X volume of the solution in liter.

#### **Molarity equation**

To calculate the volume of a definite solution required to prepare solution of other molarity, the following equation is used:

$$M_1V_1 = M_2V_2,$$

where M<sub>1</sub>= initial molarity, M<sub>2</sub>= molarity of the new solution,

$V_1$ =initial volume and  $V_2$ = volume of the new solution.

**4. Molality-** Molality is defined as the number of moles of solute dissolved per 1000 g , (1 kg) of solvent. Molality is expressed as 'm'.

**5. Mole Fraction** is the ratio of number of moles of one component to the total number of moles (solute and solvents) present in the solution. It is expressed as 'x'.



***Thanks..***