MATTER IN OUR SURRONDING - IX

Matter and its Forms

Matter can be defined as anything that occupies space, (i.e., has a volume), possesses mass, offers resistance and can be felt through one or more of our senses.

Till very recently, it was assumed that matter can neither be created nor destroyed. *Scientists have established that there are two fundamental entities in the universe: Matter and Energy*. They have also come to the conclusion that the total quantity of matter and of energy in the universe is constant. After the discovery of radioactivity, and work done by scientists like Einstein, it was realized that matter and energy are inter-convertible. It is this convertibility of matter into energy that is responsible for construction of atom bombs and nuclear reactors. Keeping these facts in mind, we can broadly define matter as "a condensed form of energy that has mass and extension in space and time.

Particulate Nature of Matter

Intensive investigation by scientists over the years led to the development of a mental model (the minuscule particles couldn't be actually seen at that time) known as 'dynamic particle model'. *All matter is assumed to be made up of particles that are very small, which may be atoms, molecules or ions.*

Characteristics of Particles of Matter

Particles in matter are in a state of continuous motion

The particles present in matter are not stationary, but have a tendency to acquire motion. In fact they are in a state of continuous motion. The rate of movement of the particles is directly proportional to the thermal energy of the particles.

Particles in matter attract one another

The particles in matter attract one another. This attraction is inversely proportional to the distance between the particles. However, the magnitude of these inter-particle forces differs from one substance to another.

Particles in matter have spaces between them

Empty spaces called voids separate the particles from one another. The distance between them ranges from 10^{-8} cm to 10^{-5} cm. Due to these voids matter is able to disperse into one another bringing about diffusion.

In solids,

Atoms or molecules are closely packed and the intermolecular space or void is minimum. The average distance between particles is of the order 10^{-8}cm; consequently, solids are almost incompressible. In addition, the intermolecular attraction in solids is quite high and for that reason the movement of atoms or molecules in solids is restricted. As a result, atoms or molecules in solids have no freedom of mobility; they only vibrate in their fixed positions.

Consequently, a solid will have a definite volume and shape. A solid can form a firm and rigid structure, which allows it to be cut into many shape and sizes. This can result in a solid having any number of free surfaces. *A Solid will also have high density, incompressibility and a high melting and boiling point. A solid may be converted to a liquid when it is given heat energy.*

A solid

- has a definite characteristic shape
- tends to resist deformation of its shape
- is relatively non-compressible Example: Diamond

Solids can be classified as:

Crystalline

A definite well-defined external geometric shape such as cube, octahedron or tetrahedron characterizes the solid. nternally, particles are orderly arranged in a three-dimensional pattern. Example: Common salt and copper sulphate

Amorphous

Amorphous solids (*solids without definite structure*) do not exhibit clear-cut external geometrical shapes. Their internal particle arrangements are less regular; they do not have a defined melting point and display a tendency to deform more easily. Example: Glass and plastic.

Glass does not resist deformation very well. It softens rather than melts when heated and sags and flows on heating over a long period of time.

In liquids

the intermolecular space or the void is slightly more than that of solids while the intermolecular attraction is less. The average distance between particles is of the order 10^{-7} to 10^{-5} cm. When compared to solids, *the particles of liquids are relatively loosely packed. This type of packing leads to a greater mobility of the molecules and liquid particles can move about but cannot separate and so can flow.*

As a result, a *liquid has a definite volume but no definite shape*. It takes the shape of the container in which it is placed. As the intermolecular space is not much, like solids, a liquid cannot be compressed much, even if high pressures are applied. A liquid has only a single free surface the layer that is exposed to the surroundings. The boiling point of a liquid is above room temperature. The liquid state is an intermediate state between solids and gases.

A liquid

- has a definite volume
- no characteristic shape
- takes the shape of the container
- is fluid - is able to flow and change shape without separation
- is essentially non-compressible Example: Water and milk

In gases, the intermolecular attractions are very poor. *The particles are loosely packed at random and the voids between particles are very large*. As a result, a gas does not have a definite shape or a definite volume. It will assume the shape and the volume of the container in which it is placed*Effect*

4TH STATE OF MATTER

A fourth state called plasma refers to the super heated gaseous state. This state is a mixture of electrons and positively charged ions with unusual properties. It is found at extremely high temperatures such as interiors of the sun or stars. *Astronomers reveal that 99% of all matter in the universe is present in the plasma state.*

5TH OF MATTER

A fifth state has recently been revealed that refers to the *super cooled*
In the super cooled state atoms lose their separate identity and get condensed. They behave like a single 'super atom'. *The existence of this state was first envisaged in 1925 by Albert Einstein, who based the idea on the work by Satyendra Nath Bose, the Indian physicist, who had predicted a class of fundamental particles called 'BOSONS' that were named after him*.

A 'Super atom' was actually created on the 5th of June 1995 by the scientists Wieman and Cornell. They chilled atoms of a gas, to the lowest temperature ever achieved, and created a new state of matter called *BOSE-EINSTEIN CONDENSATE.*
Using lasers and an exotic evaporation method, they plunged the temperature of RUBIDIUM gas almost to 'absolute zero' or -273^{o}C. All atomic motions come to a stand still at this temperature.

Inter-conversion of the States of Matter

Depending on the conditions of temperature and pressure, matter can exist in any of the three main states i.e., solid, liquid or gas. Matter can be inter-converted from one state to the other by the addition or removal of heat energy.

When a chemical compound is heated, it may undergo a chemical change called decomposition and as a result, an entirely new compound is formed. For example, when calcium carbonate is heated, it decomposes into calcium oxide and carbon dioxide.

$$CaCO_3 \longrightarrow CaO + CO_2$$

Effect of Temperature on Matter

Fusion or Melting

When we heat a solid, we add energy to the system increasing the vibration of the particles. Eventually these particles break free from their binding forces and fuse. Fusion is the change of state from solid to liquid. This is generally referred to as melting.. *During melting, the temperature of a substance remains constant till the entire substance is converted into liquid due to the latent heat of fusion*. The extra heat is used up in changing the state by overcoming the forces of attraction.

Sublimation

Some solid substances when heated get converted directly to the gaseous or vapour state without first passing through the liquid state is called as sublimation. *When a sublimable solid substance is heated, it is said to 'sublime' into a gaseous state; and when sublimable substances are cooled from their vapour state, the solid obtained is called the 'sublimate*'. Some sublimable substances are: iodine, camphor, naphthalene, dry ice carbon dioxide) etc.

Vaporization and Evaporation

When molecules of a liquid escape from its surface and go into vapour (gaseous) phase, it is called evaporation or vaporization. *Evaporation is a slow change of a liquid into a gas on its surface*. It is process of escaping of molecules spontaneously from the surface of the liquid to vapour state. The greater the surface area of the liquid exposed to atmosphere, greater will be the evaporation. Similarly, at higher temperatures but below boiling point, there will be more evaporation. As the temperature increases, the particles gain more energy and move more rapidly. For this reason the possibility of some particles overcoming the inter-particle forces of attraction and escaping increases. *So, higher the temperature, higher is the rate of evaporation. Low humidity in the atmosphere also raises the rate of evaporation.*

<u>Boiling of a liquid</u> occurs at a point, when it is freely converted into vapour. At this point, called the boiling point, the vapour pressure within the liquid is equal to the external pressure or the atmospheric pressure on the liquid. Thus, molecules escape easily in a gaseous state. At the boiling point, the temperature remains constant till the entire mass of the liquid is converted into gas due to the latent heat of vaporization.

Water boils at 100^{o}C at 1 atmospheric pressure. When dissolved impurities are present in the liquid, the boiling point is increased and the freezing point gets decreased. When you add a small amount of urea or sugar in water, its boiling point will be more than 100^{o}C and its freezing point will be less than 0^{o}C.

Latent heat of vaporization.

The amount of heat required by one kilogram of liquid into gas at atmospheric pressure at its boiling point is known as latent heat of vaporization.

Solidification or Freezing

When the liquid produced by melting a crystal is cooled, it eventually solidifies or freezes. The temperature at which the liquid freezes under one atmospheric pressure is the normal freezing point. The change from liquid state to solid state is called solidification or freezing. Water freezes at 0^{o}C.

Gases On heating gases,

The kinetic energy increases and the inter-molecular forces of attraction decreases. As a result the particle are more spread out with a bigger volume. In other words the gaseous state undergoes expansion on heating

