

# Chapter 1

## MATTER IN OUR SURROUNDINGS

### Matter

Matter is anything that occupies space has mass and can be perceived by our senses. In other words “Matter is used to cover all the substances and the materials from which the universe is made. Everything in this universe is made up of material which scientists have named “matter”.

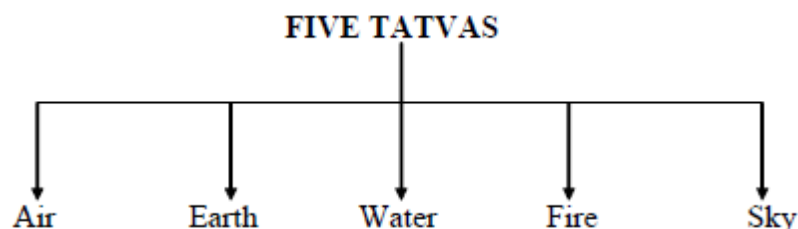
#### Examples:

The air we breathe, the food we eat, stones, clouds, stars, plants and animals, even a small drop of water or a particle of sand– each thing is matter

### Panch Tatva

In early times, human beings have been trying to understand their surroundings. Early Indian philosophers classified matter in the form of five basic elements – the “*Panch Tatva*”– air, earth, fire, sky and water.

According to them everything, living or nonliving, was made up of these five basic elements.



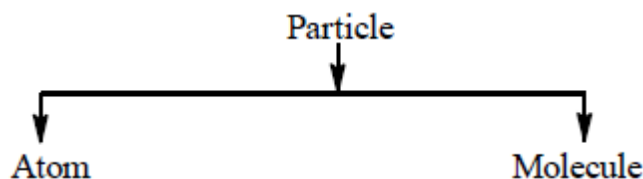
Modern day scientists have evolved two types of classification of matter based on their **physical properties and chemical nature**.

### Physical Nature of Matter

#### Matter is made up of particles

- All matter comprises of very small particles.
- All matter can be broken up in a similar manner to get very small particles.

- Size of these particles is order of  $10^{-8}\text{m}$  to  $10^{-10}\text{m}$ . It cannot be seen with naked eyes.
- Hence we now conclude that all matter is made up of small particles.



## Properties of matter

All matter consists of small particles of matter. These particles have some common characteristics. These characteristics are laid down in a theory called **Kinetic Theory of Matter**. The Kinetic Theory of Matter States

- All matter comprises of small particles.
- These particles have space in between them.
- The particles are continuously moving.
- The particles attract each other.

### A. Particles of matter have space between them

1. Matter is made up of small particles.
2. These particles have small spaces between them.
3. These spaces are invisible to the naked eye.
4. But particles of other matter can get /trap between these spaces without increase in volume.

### B. Particles of matter are continuously moving

Particles present in matter move continuously.

The particles of matter shown three types of motion.

1. **Translatory Motion** – When particles move in straight lines, changing direction without loss of energy on colliding with another particle or the wall of the container, the motion is called **translatory motion**. Translatory motion is maximum in gases and the least in solids when compared to liquids.

2. **Rotational Motion** – When particles move around their own axis, the motion is called rotational motion. This motion is similar to the rotation of earth around its axis. Rotational motion will be high in gases and in liquids.
3. **Vibrational Motion** – When particles have a to and fro motion about a mean position, the motion is called **Vibrational motion**. This motion is maximum in solids as the particles are held in a rigid structure.

### C. Particles of matter attract each other

1. The force with which particles attract to each other varies from matter to matter.
2. In some kinds of matter (waste paper, matchstick) the attraction force is small (as we can tear or break them easily).
3. In other kinds of matter (iron nail) the attraction force is large (as we cannot break the nail easily).
4. This attraction force keeps the particles together.
5. The strength of this force of attraction varies from one kind of matter to another.

## Diffusion

**“The mixing and spreading out of a substance with another substance due to the movement or motion of its particles is called diffusion.”** The diffusion of one substance into another substance goes on until a uniform mixture is formed.

## Diffusion in gases

Diffusion in gases is very fast. This is because the particles in gases move very quickly in all directions.

### Examples – 1

1. The smell of food being cooked in the kitchen reaches us even from a considerable distance.
2. The smell of hot sizzling food reaches us even when we are at a considerable distance but to get the smell of cold food, we have to go close to it.
3. This is due to the fact that the rate of diffusion of hot gases (released by the hot sizzling food) is much faster than the rate of cold gases released by the cold food.

### Example –2

1. When someone opens a bottle of perfume in one corner of a room, its smell spreads in the whole room quickly.

2. When the bottle of perfume is opened, then the liquid perfume quickly changes into vapour (or gas).
3. The perfume vapours move very rapidly in all directions in air, mix with the air particles and hence spread with air in the whole room.

### **Example – 3**

The leakage of cooking gas (LPG) in our homes is detected due to the diffusion of a strong smelling substance present in the cooking gas, into air.

## **Diffusion in liquids**

Diffusion in liquids is slower than that in gases. This is because the particles in liquids move slower as compared to the particles in gases.

### **Solid in liquid**

If a crystal of potassium permanganate is placed at the bottom of water in a beaker, then the purple colour of potassium permanganate spreads into the whole water, slowly.

### **Liquid in liquid**

1. If a drop of ink is put into a beaker of water, then the colour of ink spreads into the whole water of the beaker.
2. The spreading of ink in water, on its own, is due to the diffusion of ink particles into water.

### **Gas in liquid**

*The gases like carbon dioxide and oxygen are essential for the survival of aquatic plants and animals. The carbon dioxide gas and oxygen gas present in air (or atmosphere) diffuse into water (of ponds, lakes, rivers and sea), and dissolve in it. The aquatic plants use the dissolved carbon dioxide for preparing food by photosynthesis and aquatic animals use the dissolved oxygen of water for breathing*

## **Diffusion in solids**

Diffusion in solids is a very, very slow process.

### **Example:**

If we write something on a blackboard and leave it uncleaned for a considerable period of time (say, at least 10 to 15 days), we will find that it becomes quite

difficult to clean the blackboard afterwards. This is due to the fact that some of the particles of chalk have diffused into the surface of backboard.

### **Force of Attraction (or Cohesion)**

1. There is some force of attraction between the particles of the matter which bind them together. This force of attraction between the particles of same substance is known as force of attraction (or cohesion).
2. In general, the force of attraction is maximum in the particles of solid matter and minimum in the particles of gaseous matter.

Solid > Liquid > Gases

### **STATES OF MATTER**

**Solids** have a definite shape and volume. They are harder than liquid and gases. Solids have a definite shape, distinct boundaries and fixed volumes that is, have negligible compressibility. Solids have a tendency to maintain their shape when subjected to outside force. Solids may break under force but it is difficult to change their shape, so they are rigid.

**Liquids** have a definite volume but no definite shape. They take the shape of the container in which they are kept. Liquids flow and change shape, so they are not rigid but can be called fluid.

**Gases** have no definite shape or volume. They occupy the entire space available to them and take the shape of the container in which they are stored.

**Plasma** The state consists of super energetic and super excited particles. These particles are in the form of ionised gases. The fluorescent tube and neon sign bulbs consist of plasma. Inside a neon sign bulb there is neon gas and inside a fluorescent tube there is helium gas or some other gas. The gas gets ionised, that is, gets charged when electrical energy flows through it. This charging up creates a plasma glowing inside the tube or bulb. The plasma glows with a special colour depending on the nature of gas. The Sun and the stars glow because of the presence of plasma in them. The plasma is created in stars because of very high temperature.

**Bose- Einstein Condensate (BEC)** The BEC is formed by cooling a gas of extremely low density, about one-hundred-thousandth the density of normal air, to super low temperatures.

## Comparison of Some Important Characteristics of Solids, Liquid and Gas

| S.No. | Solid                                                                               | Liquid                                                                                                                        | Gas                                                                     |
|-------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| 1.    | Solids have fixed shape and definite volume                                         | Liquids have fixed volume but no definite shape.                                                                              | Gases have no fixed volume and shape.                                   |
| 2.    | Solids have high density                                                            | Liquids have high density but less than solids.                                                                               | Gases have low density.                                                 |
| 3.    | Solids show only slight expansion on heating.                                       | Liquids show slight expansion on heating but more than solids.                                                                | Gases expand considerably on heating.                                   |
| 4.    | They have slight or no compressibility.                                             | They have slight compressibility but more than solids.                                                                        | They have high compressibility.                                         |
| 5.    | Solids do not flow.                                                                 | Liquids generally flow easily.                                                                                                | Gases flow freely.                                                      |
| 6.    | They have their melting and boiling points above room temperature.                  | They have their melting point below room temperature.                                                                         | They have their melting and boiling points both below room temperature. |
| 7.    | Intermolecular forces are very strong and constituent particles are closely packed. | Intermolecular forces are strong enough to keep the particles together but not strong enough to keep them in fixed positions. | Intermolecular forces are very weak and the particles are free to move. |

### Rigid and fluid

Rigid means ‘unbending’ or ‘inflexible’. A stone is rigid because it is unbending or inflexible. Fluid means ‘a material which can flow easily’ and requires a vessel (or container) to keep it.

A solid is a rigid form of matter. Due to their rigidity, solids have a tendency to maintain their shape when subjected to outside force. Thus, the main identifying characteristic of solids is their rigidity. Solids do not require a container to keep them. A brick and a log of wood are two common solids.

A liquid is a fluid form of matter which occupies the lower part of the container. Being fluids, liquids require a container to keep them. A liquid has a well-defined surface, so a liquid can be kept in an open container. The liquid will not escape from the open container by itself. Water and milk are two common liquids around us.

A gas is a fluid form of matter which fills the whole container in which it is kept. Being fluids, gases also require a container to keep them. A gas does not have a free surface, so a gas has to be kept in a closed container. A gas will escape if kept in an open container. **This is why gases are usually kept in air-tight gas cylinders.** For example, cooking gas (LPG) is kept in air-tight metal cylinders. From this discussion we conclude that both, liquids and gases are known as fluids. Characteristic of liquids and gases of ‘flowing’ easily is called ‘fluidity’. Due to fluidity, liquids and gases change their shapes readily when subjected to outside force.

### Inter conversion of the state of matter

Changing temperature, pressure or both can change matter from one physical state to another.

**Changing a solid to a liquid is called melting.**

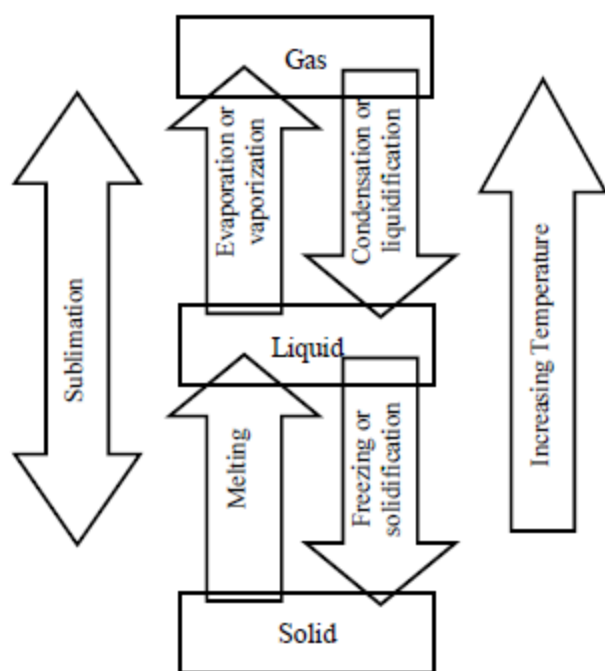
**Changing a liquid to solid is called solidification.**

**Changing a liquid to gas is called vaporization.**

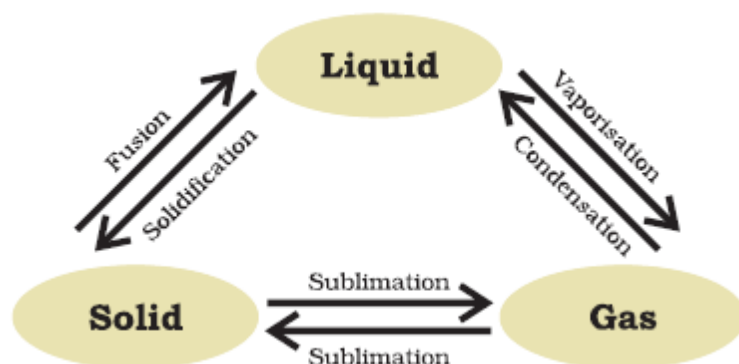
**Changing a gas to liquid is called condensation.**

**Changing a solid to gas directly is called sublimation.**

**Note:** While pressure will not have an effect to change the physical state of a solid but increasing pressure in a gas can bring the particles closer together so as to liquefy the gas. Decreasing pressure over the surface of a liquid helps in vaporizing a liquid.



*Effect of temperature on the physical state of a substance*



## Effect of change of temperature and pressure

We can change the physical state of matter in two ways:

i) By changing the temperature

ii) By changing the pressure

By increasing the temperature, a solid can be converted into liquid state; and liquid can be converted into gaseous state and by decreasing the temperature is vice-versa.

### Melting (fusion)

- The process in which a solid substance changes into a liquid on heating is called **melting** (or **fusion**).
- The point of temperature at which solid melts and changes into a liquid at atmospheric pressure is called melting of the substance.
- When a solid substance is heated the heat energy makes its particles vibrate more vigorously. At the melting point the particles of a solid have sufficient kinetic energy to overcome the strong forces of attraction holding them in fixed positions and break to form small groups of particles. And the solid melts to form a liquid.
- Higher the melting point of a solid substance, greater will be the force of attraction between its particles. For example, the melting point of iron metal is very high ( $1535^{\circ}\text{C}$ ) which tells us that the force of attraction between the particles of iron is very strong.

### Boiling (vaporisation)

- The process in which a liquid substance changes into a gas rapidly on heating is called boiling
- The point of temperature at which a liquid boils and changes rapidly into a gas at atmospheric pressure is known as boiling point of a liquid.

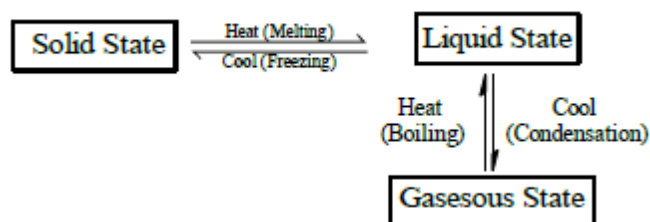
### Condensation

- The process of changing a gas (or vapour) to a liquid by cooling is called condensation where a gas is cooled enough.
- So, when steam (or water vapour) changes into water on cooling, it is called condensation of steam (or condensation of water vapour).
- It is the reverse of vaporization. (Boiling)

### Freezing

- The process of changing a liquid (solidification) into a solid by cooling is called freezing.

- When a liquid is cooled, its particles lose energy due to which they move slowly.
- If the liquid is cooled enough (upto freezing point) its each particle stops moving and vibrates about a fixed position. At this stage the liquid freezes and becomes a solid.
- Freezing is the reverse of melting.
- Freezing means solidification from above discussion, we conclude that state of matter can be changed by changing the temperature.



### Effect of change in pressure on the state of matter

- Matter consists of small particles separated by small distances.
- In the solid state the inter particle distances are very small.
- In the liquid state the inter particles distances are a little more than in solids.
- In the gaseous state the inter particle distances are the largest when compared to liquids or solids.
- It can thus be seen that when pressure is exerted on matter, the effect of the pressure on solids will be negligible as the particles are very close together.
- The effect of pressure in liquids will be small.
- The effect of pressure on gases will be the largest as the inter particle distances are large.
- Thus, whenever pressure is exerted on gases, the particles move closer together.
- As the particles move closer together, the attractive forces between the particles increase.
- This increase in attractive forces helps in the change of state of the gas. If the pressure exerted is sufficiently large the attractive forces increase to such an extent that the physical state changes from gaseous to liquid.
- The reverse can be expected to happen if the pressure on a gas is decreased.

## Latent heat

Heat which required by substance to change its state without rise of its temperature. It is called latent heat (hidden heat) because it becomes hidden in the substance undergoing the change of state and does not show its presence by raising the temperature.

The latent heat is that heat which is used up in overcoming the force of attraction between the particles of substance during the change of state. It does not increase the kinetic energy of the particle of the substance. And since there is no rise in temperature of the substance.

### Latent heat of vapourization and fusion

There are two types of latent heat:

- i) Latent heat of fusion
- ii) Latent heat of vaporization

### Latent heat of vaporisation

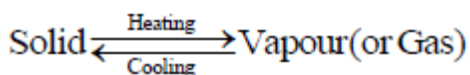
The amount of heat in Joules which is required to convert unit mass or 1 kg liquid in vapours form without rise in temperature is known as latent heat of vaporization. “If the liquid freezes to form a solid and steam condenses to form water, an equal amount of latent heat of fusion and vaporization respectively will be given out by the substance.” Different substances have different Latent Heat of vaporization.

### Latent heat of fusion (solid to liquid)

It is quantity of heat in Joules which is required to convert unit mass or 1 kg solid into liquid form without rise in temperature. Different substances have different **Latent Heat of Fusion.**

## Sublimation

The changing of a solid directly into vapours on heating, and of vapours into solid on cooling is known as sublimation.



- The common substance which undergo sublimation are: Ammonium chloride, Iodine, Camphor, Naphthalene and Anthracene etc.
- Another example of sublimation is provided by solid carbon dioxide (which is commonly known as dry ice).
- Solid carbon dioxide (or dry ice) sublimes to form carbon dioxide gas.

## Evaporation

- **Evaporation** is the phenomenon in which a liquid changes to gaseous state below its boiling point.
- Water molecules are attracted by other water molecules in all directions.
- But at the surface of water, the water molecules are pulled only inward that is below the surface of water.

**Note:** Evaporation is a phenomenon that theoretically takes place in all liquids. But in general when we say evaporation we mean evaporation of water.

**Vapour:** A substance that can exist in the gaseous state at a temperature at which normally it is a solid or liquid is called vapour.

Examples of solids that can exist as vapour: camphor, naphthalene

## Factors Affecting Evaporation

**Evaporation depends on temperature, surface area and weather conditions**

- Evaporation increases if the surface area of the water is large as the number of water molecules at the surface increases. This increases the probability of more water molecules breaking free on acquiring sufficient kinetic energy.
- Evaporation is more as the temperature approaches the boiling point of water. As the temperature increases the kinetic energy of the molecules increases. This decreases the extra kinetic energy the surface molecules require to break free or evaporate. So evaporation increases.
- In highly humid weather, evaporation decreases, as the air is highly-saturated with water molecules.
- As evaporation takes place, the air immediately above the surface of the water becomes saturated with water molecules.

## Cooling effect

### How Does Evaporation Cause Cooling?

- When a liquid evaporates it draws the energy from the liquid itself. Hence it keeps cooling. The liquid draws on the energy lost from the surroundings that in turn become cooler.
- One such usage can be seen in the forced cooling by air coolers during summer.