1 MATTER IN OUR SURROUNDING

INTRODUCTION

- Everything in our surroundings is known as matter. They may be the food we eat, the vehicles, the gadgets, the day-to-day materials that we use, the air we breathe or the water that we drink.
- All these things occupy some space and have mass and volume. For instance, in classrooms the benches that the students use to sit occupy, some space of the classroom. They have mass and volume and hence they can be regarded as matter.
- According to the Indian philosopher's matter can classified into five primitive elements. They are also known as Pancha Tattva - air, soil, fire, sky and water. Every living or non-living is made up these five primitive elements.
- Presently, current researchers have advanced with two kinds of classification. In this chapter, we will find out about the physical and chemical properties of matter, and the difference between physical and chemical changes.

1 MATTER

Matter is anything that has space and volume, or we can say that anything that has mass, occupies space, and can be felt by our one and more sense organs is called matter.

1.1 Classification of Matter

Based on physical properties, matter is classified as solids, liquids, and gases. Based on chemical properties, matter is classified as elements, compounds, and mixtures.

1.2 Physical and Chemical Properties of Matter

Every substance has a unique set of properties that allow us to recognize it and to distinguish it from other substances. The properties of matter can be categorized as physical properties. Physical properties can be measured without changing the identity and composition of the substance. These properties include color, odour, density, melting point, boiling point, and hardness. Chemical properties describe the way a substance may change or react to form other substances. A common chemical property is flammability, the ability of a substance to burn in the presence of oxygen.

1.3 Characteristics of Particles 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. Some important characteristics of particles are as follows:

(1) **All matter comprises of small particles:** Matter composed of very small particles. These particles are so small that we cannot see them with the naked eyes.

(2) **The particles are continuously moving:** Particle of matter are not stationary but in a state of continuous motion. This suggests that they posses some kinetic energy. As the temperature increases, kinetic energy of particles increases and they move faster.

(3) **These particles have space in between them:** Particles of matter have spaces between them. It can be evident from the fact that If we add a drop of ink to the beaker full of water, the ink spreads throughout the water until all the water is coloured. This is because the ink particles take up the spaces in between the water molecules and, as they are in constant random motion, the ink particles spreads evenly throughout the water.

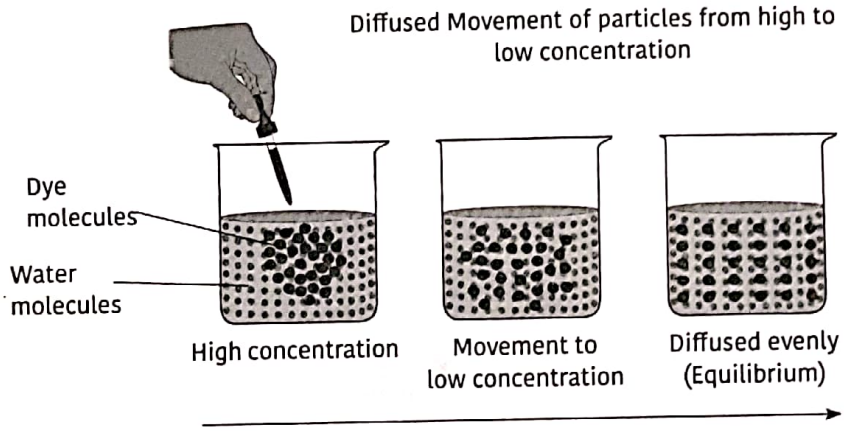
(4) **Particles of matter attract each other:** The particles of substances have certain forces of attraction between them, called **intermolecular forces of attraction.** This keep the particles together. The magnitude of these forces depends upon the nature of the particles which constitute a matter.

(5) **Particles have tendency to diffuse:** The particles have tendency to diffuse. They do so by getting into the spaces between the particles. This phenomenon is called diffusion.

1.4 Evidence for the Existence of Particles in Matter

The evidence for the existence of particles in matter and their motion comes from the experiments on Diffusion and Brownian motion.

(1) **Diffusion:** It is the phenomenon in which the movement of molecules or particles occurs from their higher concentration towards the lower concentration. Intermixing of particles of two different types of matter on their own is called diffusion.

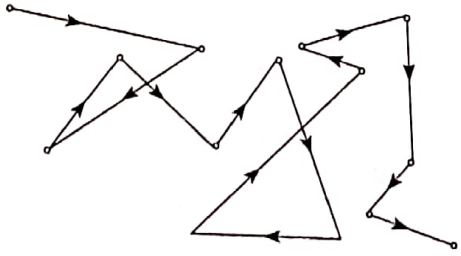


Important Figure. Diffusion

Diffusion in solids, liquids and gases can be defined as:

Diffusion of Gases	Diffusion of Liquids	Diffusion in Solids
Diffusion in gases is very fast. This is because the particles in gases move very quickly in all directions.	Diffusion in liquids is slower than diffusion in gases. This is due to the fact that liquid particles travel more slowly than gas particles.	Diffusion in solids is a very, slow process.
Example: The smell of food being cooked in the kitchen reaches us even from a considerable distance.	Example: A tea bag immersed in a cup of hot water will diffuse into water and changes its colour.	Example: The chalk powder spreads on black board surface.

(2) **Brownian Motion:** Robert Brown was an English botanist who, in the year 1827, observed pollen grains floating on water under a microscope. He observed that pollen grains moved arbitrarily over the surface of water. This arbitrary motion of pollen grains was named Brownian motion and later explained to be caused because of collision of the water molecules with the pollen grains. The water molecules are too small to be seen with any microscope, but it is evident from movement of pollen grains that the water molecules exist and are in constant random motion.



Important Figure. Brownian motion

- Matter is not continuous and is particulate in nature i.e., it is made up of particles.
- Osmosis is a process by which molecules of a solvent tend to pass through a semipermeable membrane from a less concentrated solution into a more concentrated one.

2 STATE OF MATTER

Matter around us exists in three forms. These are called solid, liquid and gas. We can classify the constituents of our body into these three states.

2.1 Solids

Solids have a definite shape and volume. They are harder than liquid and gases. Examples: Iron, wood, stone, sand, gold, ice, pencil, book, needle, piece of thread. Various properties of solid are given below.

(1) **Solids have a definite shape and distinct boundaries:** Due to small inter-particles distances and strong inter-particle forces of attraction, solids have a fixed shape and distinct boundaries like the pen in your hand.

(2) **Solids possess rigidity:** Rigidity means that the solids have the tendency to maintain shape when some outside force is applied. Some solids may change their shape under the influence of a force but regain the same when force is withdrawn.

(3) **Solids have a definite volume:** Due to small inter-particle distances solids cannot be compressed and hence, they have a definite volume. However, some solids can be compressed.

(4) **Solids do not possess the property of diffusion:** Intermixing of particles of different types of matter on their own is called diffusion. Due to small inter-particle distances and strong forces of attraction, the particles of a solid do not move much from their positions. Solids do not have the property of diffusion into other solids.

(5) **Solids have negligible kinetic energy of the particles:** The kinetic energy is linked with movement of particles from one place to other. Since the constituents in the solid state are very closely packed, they have negligible kinetic energy. That is why solid do not flow.

2.2 Liquids

Liquids have a definite volume but no definite shape. They take the shape of the container in which they are kept. Examples: Water, milk, petrol, kerosene oil, alcohol, cooking oil, juice, cold drink etc. Various properties of liquids are given below:

(1) **Liquids do not have a fixed shape but have a fixed volume:** The inter-particle forces of attraction in liquid are strong enough to keep the particles together, therefore, they have a fixed volume. But these forces are not strong enough to keep the particles in fixed positions, therefore, liquids do not have a fixed shape. They take up the shape of the vessel in which they are placed.

(2) **Liquids are not rigid but have the property to flow:** Due to larger inter-particle distances and weaker forces of attraction than in solids, liquids can flow and change shape. Thus, liquids are not rigid but possess fluidity. However, their relative fluidity differs from one liquid to the other.

(3) **Liquids possess the property of diffusion:** Due to larger inter-particle distances in liquids than in solids, the particles of a liquid have more freedom of motion than those of solids. Therefore, solids, liquids and gases all can diffuse into liquids.

(4) **Density of Liquid:** Density of liquid is generally less than that of its solid form. Some exceptions are also there, e.g., solid ice is lighter than water as it floats on water.

(5) **Liquids are Incompressible:** Inter-particle spaces in the liquid state are very small, they cannot be decreased by applying pressure. Therefore, volume of a liquid cannot be compressed.

2.3 Gases

Gases have definite shape or volume. They occupy the entire space available to them and take the shape of the container in which they are stored. Examples: Air, oxygen, nitrogen, hydrogen, ammonia, carbon dioxide, compressed natural gas (CNG). Various properties of gases are given below:

(1) **Gases neither have a definite shape nor a definite volume:** Gases do not have a definite shape but acquire the shape of the vessel in which they are placed. Gases do not have a definite volume.

(2) **Gases have maximum fluidity and least rigidity:** Due to large inter-particle spaces and weak inter-particle forces of attraction, gases have high fluidity and least rigidity.

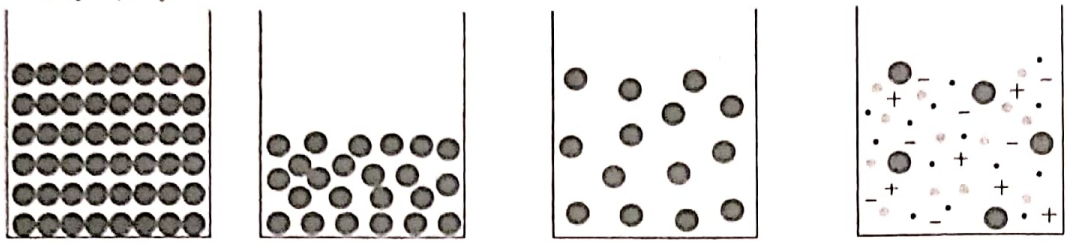
(3) **Gases are highly compressible:** Inter-particle spaces in the gaseous state are very large, they can be decreased by applying pressure. Due to high compressibility, large volume of a gas can be compressed into a small cylinder and transported easily.

(4) **Gases have low density:** This is because, gases have large inter-particle distances. As a result, the particles of a gas are widely separated and the volume of a given mass of a gas is large. Mass per unit volume of a gas is small and hence gases have low density.

(5) **The kinetic energy of the particles in the gaseous state is quite high:** Due to large inter-particle distances and weak forces of attraction, the particles of a gases can move freely and thus have large translational and rotational energy. Due to this, their kinetic energy is quite high. It can be further increased by increasing the temperature of the gas.

(6) **Gases exert pressure:** The particles of a gas are moving continuously in different directions with different speeds. Due to this random motion, the particles of a gas collide with each other and also with the walls of the container. This force per unit area exerted by the particles of the gas on the walls of a container is called the pressure of the gas.

(7) **Gases diffuse very rapidly:** Since inter-particle distances are quite large and inter-particle forces of attraction are very weak. The particles of a gas are moving in different directions with different velocities. The particles of one gas can readily move into the spaces between the particles of the other gas. This spontaneous intermixing of gases is called diffusion. Thus, gases diffuse very rapidly.



Important Figure. Brownian motion

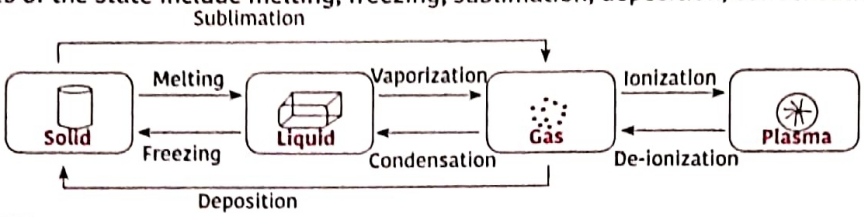
Comparison of General Properties of Solids, Liquids, and Gases

Solid	Liquid	Gas
		
The constituent particles are very closely packed. Inter-particle distances are smallest.	The constituent particles are less closely packed.	The constituent particles are free to move.
Inter-particle distances are the smallest	Inter-particle distances are larger than those in solids but smaller than those in gases.	Inter-particle distances are the largest.
Inter-particle forces of attractions are the strongest	Inter-particle forces of attractions are weaker than those in solids but stronger than those in gases.	Inter-particle forces of attraction are weakest.
They have a definite shape as well as a definite volume.	They have a definite volume but no definite shape.	They have neither a definite shape nor a definite volume.
Solids are completely incompressible	Liquids have little compressibility but liquids are often treated as incompressible	Gases are highly compressible
Solids possess rigidity.	Liquids can flow, therefore, they possess fluidity which is lower than that of gases.	Gases flow more easily than liquids and thus have the highest fluidity
They have high density	Their density is lower than those of solids but much higher than those of gases	They generally have very low densities
They do not show the property of diffusion.	They show the property of diffusion.	They diffuse very rapidly. The rate of diffusion of a gas is, however, inversely proportional to the square root of its density. Thus, lighter gases diffuse more rapidly than the heavier ones.

- Liquids are also called fluids. In summer we suffer from dehydration because of loss of excessive fluids.
- The rate of diffusion of gas is inversely proportional to the square root of its density. Therefore the lighter gases diffuse footer as compared to heavier goes.

3 CHANGE IN STATE OF MATTER

One state of a substance can be converted into the other by changing inter-particle spaces. They are actually change inter-particle forces of attraction. The process can be reversed also under suitable conditions. It is known as "interconversion of states of matter." Common changes of the state include melting, freezing, sublimation, deposition, condensation, and vaporization.



Important Figure. Change of States of Matter or Inter-conversion of states of matter.

3.1 Terms Involved in Change of State

(1) **Melting Point:** The process of conversion of a matter from its solid state to its liquid state at a specific conditions of temperature and pressure is called fusion/melting.
When heat is supplied to a crystalline solid, its temperature increases and hence, the kinetic energy of its constituent particles increases. Due to increase in kinetic energy, the particles start vibrating and the energy supplied in form of heat overcomes the forces of attraction between the particles. At this stage, the particles leave their fixed positions and start flowing. At this temperature, the solid melts, or the solid is converted into a liquid. The temperature at which solid starts to melt is called its melting point.

(2) **Boiling Point/ Vaporization:** The process of conversion of a matter from its liquid state to its gaseous state at a specific conditions of temperature and pressure is called Boiling point/Vaporisation.
If the water is hot enough, it starts to boil. The temperature at which water starts to boil is called its boiling point. When further heat is applied, bubbles of water vapor start forming in the boiling water. This happens as particles of liquid water gain enough energy to completely overcome the force of attraction between them and change to the gaseous state. The bubbles rise through the water and escape from the pot as steam. The process in which a liquid boils and changes to a gas is called vaporization.

(3) **Sublimation:** The process in which solids directly change to gases without going into liquid state is known as sublimation. This occurs when solids absorb enough energy to completely overcome the forces of attraction between them. Dry ice is an example of solids that undergo sublimation.

(4) **Condensation:** The process of conversion of matter from its gaseous state to liquid state at specific temperature and pressure, is called condensation.
When a gas or vapour is cooled by lowering its temperature, the kinetic energy of their constituent particles decreases. Due to decreases in the kinetic energy, the particles start moving slowly. As the temperature is further lowered, the attractive forces pull the particles close together and the gas or vapour starts converting into liquid.

(5) **Freezing:** The process of conversion of matter from its liquid state to solid state at specific temperature is called its Freezing Point.
When the temperature of a solid is raised, it melts to form a liquid. Conversely, if the temperature of a liquid is lowered, the reverse process takes place. The kinetic energy of the particles decreases and the particles start moving slowly. As the temperature is further lowered, the attractive forces pull the particles close together and the substance freezes, i.e. the liquid changes into solid.

(6) **Deposition** is a process in which gases changes directly into the solid. It is opposite to that of sublimation.

- Deposition is a process in which gases changes directly into the solid. It is opposite to that of sublimation.
- Ionisation is a process in which a substances is converted into ions whereas de-ionsation is the reverse process of ionisation.

4 EFFECT OF CHANGE IN TEMPERATURE AND PRESSURE

4.1 Effect of Temperature

On increasing, the temperature of solids, the kinetic energy of the particles increases. Due to the increase in kinetic energy, the particles start vibrating with greater speed. The energy supplied by the heat overcomes the forces of attraction between the particles. As a result, the particles leave their fixed positions and start moving more freely. At a certain temperature, the solid melts and converted into a liquid.
At a certain temperature, a point reached when the particles have enough energy to break free from the forces of attraction and the stage is reached called boiling point. In contrast by changing the temperature, a gas can be converted into the solid state, called freezing point.

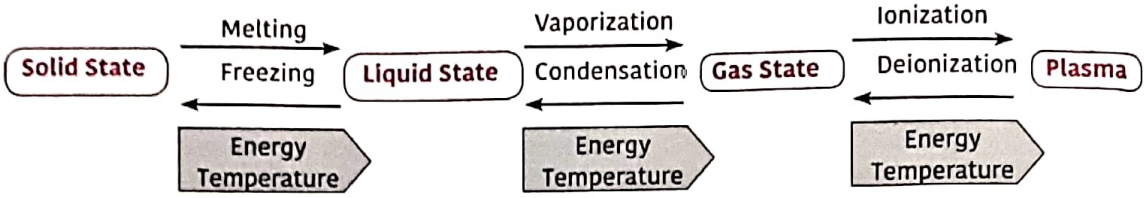


Figure. Effect of Temperature on state of matter.

4.2 Scale for Measuring Temperature

The temperature is generally recorded by a thermometer. There are three scales in which temperature can be measured. These are known as Celsius scale (°C), Fahrenheit scale (°F) and Kelvin scale (K).

(1) Thermometers with Celsius scale are calibrated from 0°C to 100°C.

(2) Thermometers with Fahrenheit scale are calibrated from 32°F to 212°F

(3) Kelvin scale of temperature is S.I. scale and is very common these days. Temperature on this scale is shown by the sign K.

The different scales are related to each other as:

!! Important Formulae:

$$°F = \left(\frac{9}{5}\right)(°C) + 32°$$

$$K = °C + 273.15$$

Temperature Conversion Formula Table

Units	To Celsius	To Fahrenheit	To Kelvin
Celsius	°C	$°C\left(\frac{9}{5}\right) + 32°$	°C + 273.15
Fahrenheit	$(°F - 32°) \times \frac{5}{9}$	°F	$(°F - 32°) \times \frac{5}{9} + 273.15\ °$
Kelvin	K – 273.15°	$K - 273.15° \times \left(\frac{9}{5}\right) + 32°$	K

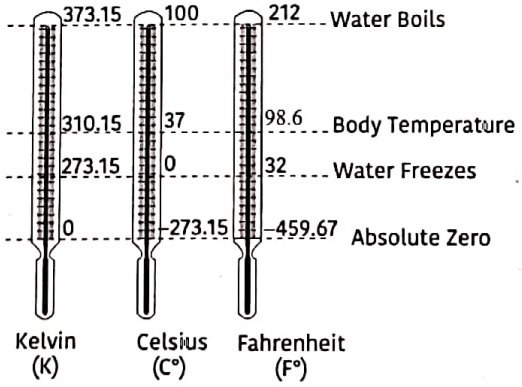


Figure. Different Thermometers for Measuring temperature.

Example 1: The room temperature on Celsius scale is 25° C. Covert it into other two scales of measurement.

Solution. Celsius to Kelvin conversion formula is given by: K = °C +273 = 25 + 273 = 298 K

Example 2: The body temperature of a normal and healthy person is 98.4°F. What is the temperature on the Celsius scale?

Solution. $°F = \frac{9}{5}(°C) + 32°, \frac{9}{5}(°C) = °F - 32° = (98.4° - 32°) = 66.4°C.$ Hence, $°C = 66.4 \times \frac{5}{9} = 36.89°C$

Example 3: Convert 50°C to °F.

Solution. Celsius to Fahrenheit conversion formula is given by:

$$°F = °C + \left(\frac{9}{5}\right)32° = 50° \left(\frac{9}{5}\right) + 32° = 90° + 32° = 122, \text{ therefore, } 50°C = 122°F$$

Example 4: Convert 113°F to Kelvin.

Solution. Fahrenheit to Kelvin conversion formula is given by:

$$K = (F - 32) \times \frac{5}{9} + 273.15 = (113 - 32) \times \left(\frac{5}{9}\right) + 273.15 = 81 \times \left(\frac{5}{9}\right) + 273.15 = 45 + 273.15 = 318.15$$

Therefore, 113°F = 318.15 K

Example 5: Convert 225 K to Celsius.

Solution. Kelvin to Celsius conversion formula is given by:

°C = K – 273.15 = 225 – 273.15 = – 48.15.

Therefore, 225 K = – 48.15°C

4.3 Latent Heat

The amount of heat energy absorbed or released for a phase change is known as latent heat. Latent heat does not raise the temperature But latent heat is always supplied to change the state of a substance. Latent heat is related to a heat property called enthalpy.

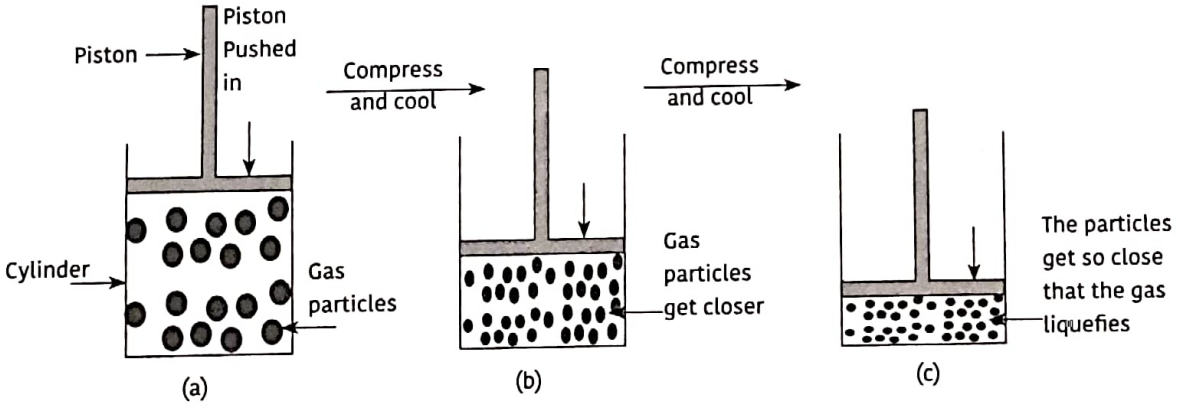
(1) **Latent Heat of Fusion:** The amount of heat energy that is needed to convert one kg of a solid into the liquid state at its melting point is known as latent heat of fusion. Example: latent heat of fusion of ice is 335 kJ/kg. This means that this much amount of heat is absorbed by one kilogram of ice when it changes into water as its melting point temperature (0°C).

(2) **Latent Heat of Vaporisation:** The amount of heat energy that is required to change 1 kg of a liquid into vapours at atmospheric pressure at its boiling point is called latent heat of vaporization. e.g., at 100°C, both water and steam exist together. But the particles of steam at 100°C have more energy as compared to particles of water at the same temperature, since during the change of state from water, heat energy equal to latent heat of vaporization has been absorbed. Steam is more effective than boiling water for heating purpose.

4.4 Effect of Change of Pressure

The physical state of matter can also be changed by increasing or decreasing the pressure to it. e.g., Gases can be liquefied by applying pressure and lowering temperature. When a gas is compressed the intermolecular space between its particles gets decreases and ultimately it will converted into liquid so high pressure and low temperature can liquefy gases.

!! 1 atm = 1.01×10^5 Pa (Pa = Pascal, S.I. unit of Pressure)



!! **Important Figure: Effect of pressure: Inter-particle distances are very large in gases which keeps on decreasing while increasing the temperature.**

4.5 Difference Between Gases and Vapours

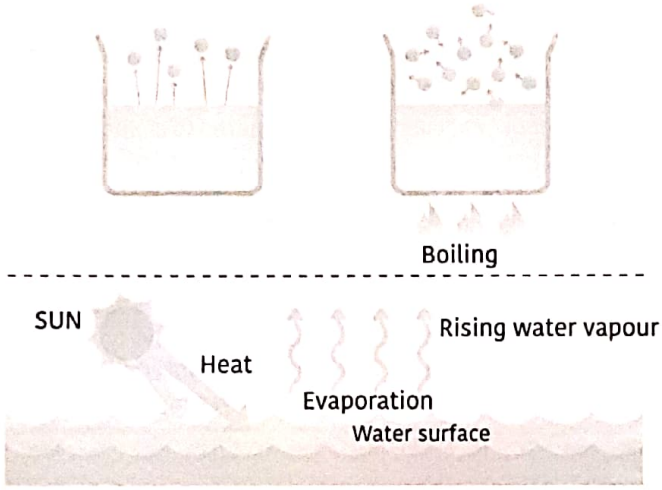
Gases	Vapours
These are the vapors to represent the gaseous state of a substance which is not a liquid at room temperature.	These are the vapours to represent the gaseous state of a substance which is a liquid at room temperature.
Gases are the states of matter.	Vapours are not the states of matter.
Example: ammonia and hydrogen vapor is not correct term because they are not liquids at room temperature. Therefore, we must call these as ammonia gas and hydrogen gas.	**Example:** We can use the terms water vapours and alcohol vapours because both of them are liquids at room temperature,

- A gas above a temperature at which it a gas cannot be liquefied is known as critical temperature (T_c). The corresponding volume and pressure are called critical volume (V_c) and critical pressure (P_c).
- To convert temperature on Celsius scale to Kelvin scale, add 273 to the Celsius temperature i.e., $T(K) = t(°C) + 273$. On the other hand, to convert temperature on Kelvin scale to Celsius scale, subtract 273 from the Kelvin temperature i.e., $t(°C) = T(K) + 273$.

5 EVAPORATION

5.1 Evaporation

The phenomenon of change of a liquid into vapours at any temperature below its boiling point is called evaporation. Some particles in liquid always have more kinetic energy than the others. So, even when a liquid is below its boiling point, some of its particles have enough energy to break the forces of attraction between the particles and escape from the surface of the liquid in the form of vapour. Thus, the fast moving particles of a liquid are constantly escaping from the liquid to form vapours or gas.



Important Figure: Evaporation

5.2 Factors Affecting Evaporation

(1) **Surface area available for evaporation:** Evaporation is a surface phenomena which means that only the particles or molecules of the liquid present on its surface change into vapours. Thus, greater the surface area of the liquid more will be the rate or extent of evaporation. Example Hot milk or tea in a saucer evaporates faster than in cup.

$$\text{Surface area} \propto \text{Rate of evaporation}$$

(2) **Temperature:** The evaporation of water or any other liquid becomes fast if the atmospheric temperature is high. We can say that the evaporation of a liquid is fast in summer as compared to winter. It is because on increasing temperature more number of particles get enough kinetic energy to go into the vapors state. An increase in heat makes things evaporate faster.

$$\text{Temperature} \propto \text{Rate of evaporation}$$

(3) **Humidity:** Humidity represents the amount of water vapours present in air. The air around us cannot hold more than a definite amount of water at a given temperature. If the amount of water in air is already high, the rate of evaporation decreases. That is why, clothes dry up faster in dry day than on a rainy day.

$$\text{Rate of evaporation} \propto \frac{1}{\text{Humidity}}$$

(4) **Speed of wind:** The speed of wind around us has also some effect on evaporation of the liquid. We often notice that the wet clothes dry fast on a windy day. Actually, with the increase in wind speed, the particles of water vapours present in air also move away and the air which replaces it, is comparatively dry. This will enhance or increase the rate of evaporation.

$$\text{Wind Speed} \propto \text{Rate of evaporation}$$

(5) **Nature of liquid:** Another factor which have great importance in the nature of the liquid which is evaporating. We often see that alcohol evaporates at a faster rate than water. In fact, the boiling point alcohol (350 K) is less than that of water (373 K). This means that inter-particles forces of attraction in alcohol are less than in water. Therefore, alcohol will evaporate faster than water., Thus we concluded that lesser the boiling point of a liquid more is its tendency to change into vapours or to evaporate.

5.3 Cooling Effect due to Evaporation

During evaporation, the particles of a liquid absorb energy from the surroundings to overcome the inter-particle forces of attraction and undergo the phase change. The absorption of heat from the surrounding makes the surrounding cool. For example, sweating cools down our body.

5.4 Difference Between Boiling and Evaporation

Boiling	Evaporation
Boiling occurs only when the liquid is heated to a certain temperature called the boiling point of the liquid.	Evaporation occurs when molecules in the liquid phase of a substance gain enough kinetic energy, often from sunlight to more apart and enter the atmosphere as a gas.
Boiling takes place at a specific temperature known as the boiling point of the liquid	Evaporation takes place at all temperatures.
Boiling occurs from the surface as well as from inside the surface of the liquid.	Evaporation is a surface phenomenon and occurs only from the surface of the liquid.
Physical conditions such as change in temperature, surface area, wind speed etc., have no effect on the boiling point of a liquid.	All the physical conditions influences the rate of evaporation of a liquid.
No cooling is caused during boiling.	Cooling is always caused during evaporation.
Boiling is bulk phenomena i.e., the bubble formation occurs even below the surface.	Evaporation is surface phenomena, bubble formation occurs only on the surface of liquid.

- The liquid water has changed to the gaseous state in a process known as vaporization, when this process occurs below the boiling point, is known as evaporation.
- On a hot summer day or after doing heavy exercise, the temperature of our body tends to rise. Due to increase in temperature, our body gives out sweat. When the sweat evaporates, it absorbs heat from our body. By losing heat, our body feels cool.

Chapter at Glance

(1) **Matter** is anything that occupies space, has mass and can be perceived by out senses. All matter comprises of small particles, have space in between them. The particles are continuously moving and attract each other.

(2) Indian philosophers stated that matter is made from five constituents or panch tatvas i.e., Air, Earth, Water, Fire and Sky.

(3) The mixing and spreading out of a substance with another substance due to the movement or motion of its particles is called **diffusion**.

(4) Changing temperature, pressure or both can change matter from one physical state to another. This is called **Interconversion of matter**

(5) The process in which a solid substance changes into a liquid on heating is called **melting (or fusion)**.

(6) The process in which a liquid substance changes into a gas rapidly on heating is **called boiling.**

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

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

(9) We can change the physical state of matter in two ways: (i) By changing the temperature (ii) By changing the pressure.

(10) 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.

(11) The amount of heat in Joules which is required to convert unit mass or 1 kg liquid in vapour form without rise in temperature is known as **latent heat of vaporization.**

(12) The quantity of heat in Joules which is required to convert unit mass or 1 kg solid into liquid form without rise in temperature is known as **latent heat of fusion.**

(13) There are three scales in which temperature can be measured, related to each other as:

$$°F = \left(\frac{9}{5}\right) (°C) + 32°$$

$$K = °C + 273.15$$

(14) For conversion of temperature on Celsius scale to Kelvin scale, add 273 K to the Celsius temperature. On the other hand for conversion of temperature on Kelvin scale to Celsius scale subtract 273 K.

(15) **Evaporation** is the phenomenon in which a liquid changes to gaseous state below its boiling point. Evaporation depends on temperature, surface area and weather conditions. 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.