Chemistry (Class - IX)

Chapter - 1 - Matter in Our Surroundings

Introduction

Anything which occupies space and has mass is called matter. The air we breath, the food we eat, stone, clouds, stars, planets and animals, even a small drop of water or a particle of sand - each things is matter. All the things occupy space that volume and have mass.

[SI unit of volume is m^3, $1m^3 = 1000 L$, $1L = 1 dm^3$
$1L = 1000 mL$, $1mL = 1 cm^3$]

Matters can be classified in a number of ways. Ancient Indian philosopher said that all the matter, living or non-living, was made up of five basic elements : air, fire, earth, sky and water.

Modern day scientists classify matter in two ways : on the basis of its physical properties and the basis of its chemical properties. On the basis of physical properties, matter is classified as - solids, liquids and gases. On basis of chemical properties, matter is classified as - elements, compounds and mixtures.

Physical Nature of Matter

Matter is made up of particles :

Everything around us is made of tiny pieces or particles. A small rain drop (water drop) contains about 10^{21} particles of water in it. Please note that these tiny particles are called atoms or molecules.

Evidence of Particles in Matter

Most of the evidence for the existence of particles in matter and their motion comes from the experiments on diffusion (mixing of different substances on their own) and Brownian motion. Matter is made up of tiny particles which are in motion.

When we dissolve salt in water, the particles of salt get into spaces between particles of water.

When a crystal of potassium permanganate is placed in a beaker of water, the water slowly turns purple on its own, even without stirring. Particles of potassium permanganate get into the spaces between the particles of the water.

The process of diffusion gives us two conclusions about the nature of matter:
(i) that matter is made up of tiny particles and
(ii) that the particles of matter are constantly moving.

Brownian Motion: The zig-zag motion movement of the small particles suspended in a liquid (or gas) is Brownian movement. Brownian motion increases on increasing the temperature.

The existence of Brownian motion gives us two conclusions about the nature of matter:
(i) that matter is made up of tiny particles
(ii) that the particles of matter are constantly moving.

Characteristics of Particles of Matter.

(i) The particles of matter are very, very small
(ii) The particles of matter have spaces between them
(iii) The particles of matter are constantly moving
(iv) The particle of matter attract each other.

(1) How small are these particles of matter?

The very, very small size of the particles of matter can be shown by experiment using potassium permanganate and water.

- Take 2-3 crystals of potassium permanganate and dissolve them in 100mL of water. We will get a deep purple coloured solution of potassium permanganate in water.
- Take out approx. 10mL of this solution and put it into 90 mL of clear water.
- Take out 10mL of this solution and put into another 90 mL of clear water.
- We will notice each time colour of potassium permanganate solution in second beaker becomes a bit lighter.
- Keep diluting the solution like this 5 to 8 time.
- The colour of solution will become still lighter.

This experiment shows that 2 or 3 tiny crystals of potassium permanganate can impart colour to a large volume of water. We conclude that each crystal is made up of million of small particles which keep on spreading.

(2) The particles of Matter have Spaces between them

The spaces between the particles of matter can be shown easily the experiment of dissolving salt in water or sugar in water.

- Take a 100 mL of beaker
- Fill half the beaker with water and mark the level of water
- Dissolve some salt/sugar with the help of a glass rod.
- When all sugar is dissolved we get sugar solution.
- We will find that level of sugar solution is at same mark.

This means that even after dissolving salt / sugar in water, the volume has not increased. This tells us that there are spaces between the particles of water. We can also conclude (say that) the particles (or molecules) in water are not tightly packed, they are somewhat loose, having spaces between them.

(3) The Particles of Matter are Constantly Moving

The best evidence that particles of matter are constantly moving comes from the studies of diffusion and Brownian motion.

(a) When we light (or burn) an incense stick (agarbatti) in one corner of a room, its fragrance (pleasant smell) spreads in the whole room quickly.

b) When a few crystals of copper sulphate are placed at the bottom of a beaker (or a gas jar) containing water, then water in the whole beaker turns blue slowly.

(4) The particles of Matter Attract Each other.

There are some forces of attraction between the particles of matter which bind them together.
The force of attraction between the particles of the same substance is known as cohesion.
The force of attraction (or cohesion) is different in the particles of different kinds of matter.
In general, the force of attraction is maximum in the particle of solid matter and minimum in the particle of gaseous matter.

Q) Give reason : The smell of hot sizzling food reaches you several metres away, but to get the smell from cold food you have to go close.

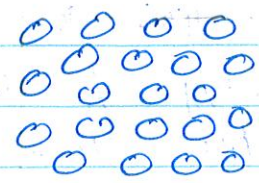
ANS) Solids diffuse at a very slow rate. But, if the temperature of the solid is increased, then the rate of diffusion of the solid particles into air increases. This is due to the increase in the kinetic energy of solid particle. Hence, the smell of hot sizzling food reaches us even at a distance, but to get the smell from cold food we have to go close.

Q) A diver is able to cut through water in a swimming pool. Which property of matter does this observation show.

Ans) This shows that matter is made up of particles.

STATES OF MATTER

Solid, liquids and gases are called the three states of matter.

	SOLID	LIQUID	GAS
1)	Fixed shape and definite volume	Not fixed shape but fixed volume	Neither fixed shape nor fixed volume
2)	Inter particles are smallest	Inter particles distance are larger	Inter particles distance are largest
3)	Incompressible	Almost incompressible	Highly compressible
4)	High density and do not diffuse	Density is lower than solids and diffuse	Density is least and diffuse
5)	Inter particle forces of attraction are strongest	Inter particle forces of attraction are weaker than solids	Inter particle forces of attraction are weakest
6)	Constituent particles are very closely packed.	Constituent particles are less closely packed	Constituent particles are free to move about
7)	Solid do not flow	flow easily	flow easily
8.			

Q) Comment upon the following :
rigidity, compressibility, fluidity, filling a gas container, shape, kinetic energy and density.

Ans: **Rigidity** : can be expressed as the tendency of matter to resist a change in shape.

Compressibility : is the ability to be reduced to a lower volume when force is applied.

Fluidity : is the ability to flow

By filling : a gas container we mean the occupancy of shape of the container by gas.

Shape : defines a definite boundary

Kinetic Energy : is the energy possessed by a particle due to its motion

$KE = \frac{1}{2} mv^2$ m = mass of the particle
v = velocity of the particle.

Density : is mass per unit volume.

Q) Give Reasons :

a) A gas fills completely the vessel in which it is kept.

Ans) There is little attraction between particles of gas. Thus, gas particles move freely in all direction. Therefore, gas completely fills the vessel in which it is kept.

b) A gas exert pressure on the walls of the container.

Ans) The gas particles are in random motion due to weak intermolecular force of attraction. These gaseous molecule continuously collide among themselves and they hit the walls of the container with great force. Therefore, gas exerts pressure on the walls of the container.

c) A wooden table should be called a solid.

Ans) A wooden table has definite shape and volume. It is very rigid and cannot be compressed. It has the characteristics of a solid. Hence, wooden table should be called a solid.

Q) Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water.

Ans) The mass per unit volume of a substance is called density (density = mass/volume). As the volume of a substance increase, it density decrease. Though ice is a solid, it has large number of empty space between its particle. These spaces are larger as compared to the spaces present between the particles of water. Thus volume of ice is greater than that of water. Hence, the density is less than that of water. A substance with lower density than water can float on water. Therefore, ice floats on water.

CHANGE OF STATE OF MATTER

Matter can exist in three physical states : solid, liquid and gaseous state (or vapour state).

For example, water exists as a solid in the form of ice, as liquid in the form of water and as a gas in the form of steam (or water vapours).

We can change the physical state of matter in two ways :
1) By changing the temperature
2) By changing the pressure

Effect of change of temperature

(1) Solid → Liquid — Melting

On increasing the temperature of solids, the K.E. of the particles increases. Due to increase in K.E., the particles start vibrating with greater speed. The energy supplied by heat overcomes the forces of attraction between the particles. The particles leave their fixed positions and start moving more freely. A stage is reached when the solid melts and is converted to a liquid.

"The temperature at which a solid melts to become a liquid at the atmospheric pressure is called its melting point."

> The melting point of a solid is a measure of the force of attraction between its particles (ions or molecules).

Higher the melting point, greater will be the force of attraction between its particle. Melting point of iron metal is very high (1535°C) which tells us that force of attraction between the particles of iron is very strong.

When a solid is heated sufficiently, it changes its physical state and becomes a liquid.

The melting point of ice is 273.15 K (0°C).

Latent heat of fusion: The amount of heat energy that is required to change 1 kg of a solid into liquid at atmospheric pressure at its melting point is known as the latent heat of fusion.

② Liquid to gas Boiling (or Vaporisation)

When we supply heat energy to water, particles start moving even faster. At a certain temperature, a point is reached when the particles have enough energy to break free from the forces of attraction of each other. At this temperature the liquid starts changing into gas.

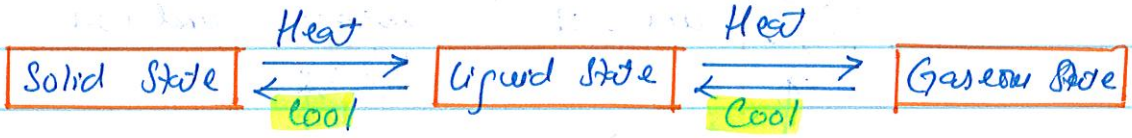
" the temperature at which a liquid starts boiling at atmospheric pressure is known as its boiling point "

For water boiling temperature is 373 K (100°C)

Latent heat of vaporisation :

The amount of heat energy that is required to change 1 kg of liquid into gas at atmospheric pressure at its boiling point is known as the latent heat of vaporisation.

Particles in steam, that is, water vapour at 100°C have more energy than water at the same temperature. This is because particles in steam have absorbed extra energy in the form of latent heat of vaporisation.



(3) Solid to gas - Sublimation

A change of state directly from solid to gas without changing into liquid state (or vice versa) is called sublimation.

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Vapour (or Gas)}$$

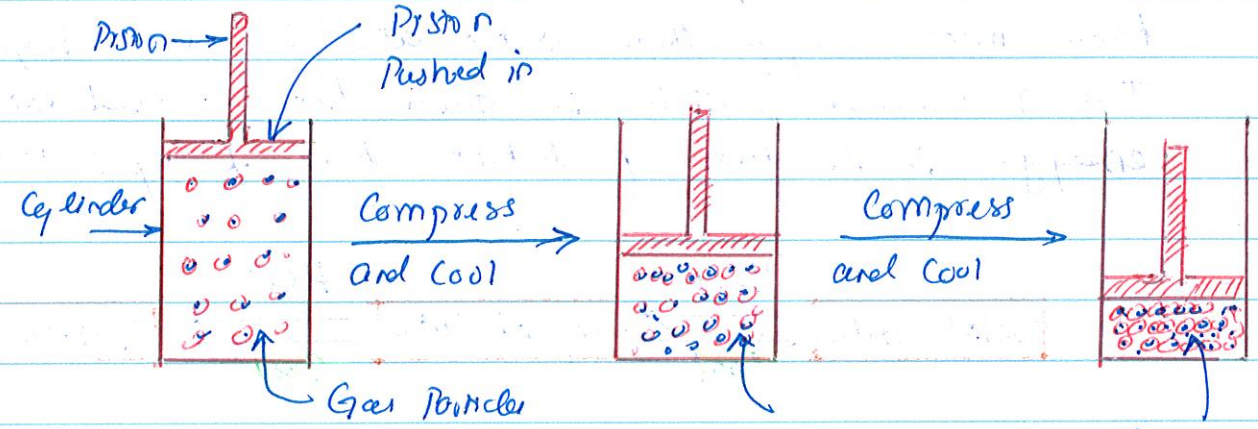
Example, Sublimation of ammonium chloride, Iodine, Camphor, Naphthalene.

Solid carbon dioxide (or dry ice sublimes to form carbon dioxide gas.

Effect of change of pressure

The physical state of matter can also be changed by changing the pressure.

Gas can be liquefied by applying pressure and lowering temperature.



When high pressure is applied to a gas, it gets compressed into a small volume, and when we also lower its temperature, it gets liquefied.

Solid CO_2 gets gets converted directly to gaseous state on decrease of pressure & I can without coming into liquid state. This is the reason that solid CO_2 is also known as dry ice.

Thus, we can say that pressure and temperature determine the state of a substance, whether it will be solid, liquid or gas.

Q) What is the physical state of water at :
a) 250°C (b) 100°C

Ans) a) Water at 250°C exists in gaseous state

b) At 100°C water can exist in both liquid and gaseous form. At this temperature, after getting the heat equal to the latent heat of vaporization, water starts changing from liquid state to gaseous state.

Q) For any substance, why does the temperature remain constant during the change of state?

Ans) During a change of state, the temperature remains constant. This is because all the heat supplied to increase the temperature is utilised in changing the state by overcoming the forces of attraction between the particles. Therefore, this heat does not contribute in increasing the temperature of the substance.

Q) Convert the following temperatures to Kelvin scale.
(a) 25°C (b) 373°C

Ans (a) $K = °C + 273.15$ $K = 25 + 273.15$
$= 298.15\ K$

(b) $K = 373 + 273.15$
$= 646.15\ K$

Q) Give reason for the following :

(a) Napthalene balls disappear with time without leaving any solid

Ans) Napthalene undergoes sublimation easily i.e. the change of state of naphthalene from solid to gas take place easily. Thus, napthalene balls disappear with time without leaving any solid.

(b) We can get the smell of perfume sitting several meters away.

Ans) Gaseous particle possess high speed and large spaces between them. Particles of perfume diffuse into these gaseous particles at a very fast rate and reaches our nostrils. This enables us to smell the perfume from a distance.

Q) Why is ice at 273 K (0°C) more effective in cooling than water at the same temperature.

Ans) Ice at 273 K has less energy than water (although both are at same temperature). Water posses the additional latent heat of fusion. Hence, at 273 K, ice is more effective in cooling than water.

Q) Which produces more severe burns, boiling water or steam.

Ans) Steam ha more energy than boiling water. It posses the additional latent heat of vaporization. Therefore, burn produced by steam are more severe than those produced by boiling water.

Evaporation

The phenomenon (process) of changing of a liquid into vapour at any temperature below its boiling point is called evaporation.

Some particles in a liquid always have more kinetic energy than the others. So, even when a liquid is well below its boiling point, some of its particles have enough kinetic energy to break the force of attraction between the particle and escape from the surface of liquid in the form of vapour (or gas)

Example : a) Wet cloth dry up
b) Evaporation of water from the surface of pond.
c) Evaporation of sea-water to get common-salt.

Factors affecting Evaporation

The evaporation of a liquid depends mainly on the following factors :

(i) Temperature
(ii) Surface Area
(iii) Humidity
(iv) Wind Speed.

1. Temperature :

The rate of evaporation increases with an increase of temperature. With the increase of temperature, more number of particles get enough kinetic energy to go into vapour state.

2. Surface Area

The rate of evaporation increase with an increase of surface area. We know that evaporation is a surface phenomenon. If the surface area is increased, the rate of evaporation increase. For example, while putting clothes for drying we we spread them out.

3. Humidity

The rate of evaporation increase with a decrease in humidity. Humidity is the amount of water vapour 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.

4. Wind Speed

The rate of evaporation increase with an increase in wind speed. It is a common observation that clothes dry faster on a windy day. With increase in wind speed, the particle of water vapour move away with the wind, decreasing the amount of water vapour in the surrounding.

How does Evaporation cause cooling?

The cooling caused by evaporation is based on the fact that when a liquid evaporates, it takes the latent heat of vaporisation from any thing which it touches. By losing heat, 'any thing' gets cooled. The particles of liquid absorb energy from the surrounding to regain the energy lost during evaporation. This absorption of energy from the surrounding make the surrounding cold.

- If we put a little of spirit (ether or petrol) at the back of our hand and wave it around, the spirit evaporates rapidly and our hand feels very cold. The spirit takes the heat of vaporisation from our hand. The hand loses heat and gets cooled.

- During hot summer days, water is usually kept in an earthen pot to keep it cool. The earthen pot has a large number of extremely small pores in its wall. Some water through pores evaporates continuously and takes the latent heat required for vaporisation. The remaining water loses heat and get cooled.

- Perspiration (or sweating) is our body's method of maintaing a constant temperature. When the sweat evaporates, it takes the latent heat of vaporisation from our body. This keeps our body cool.

- We should wear cotton clothe in hot summer days to keep cool and comfortable. Cotton is a good absorber of water, so it absorbs the sweat from our body and exposes it to the air. The evaporation of this sweat cools our body.

- A desert cooler cools better on a hot and dry day. The higher temperature on a hot day increases the rate of evaporation of water and the dryness of air (low humidity) also increases the rate of evaporation of water. Due to increased rate of evaporation of water, a desert room cooler cools better on a hot and dry day.

07 We are able to sip hot tea (or milk) faster from a saucer than from a cup. Saucer has a larger surface area. Due to large surface area, the evaporation of hot tea (or milk) from the saucer is faster. And this faster evaporation cools the hot tea (or milk) more quickly making it convenient for us to drink it.

Why do we see water droplets on the outer surface of a glass containing ice cold water?

The water vapour present in air, on coming in contact with cold glass of water, loss energy and gets converted to liquid state, which we see as water droplets.