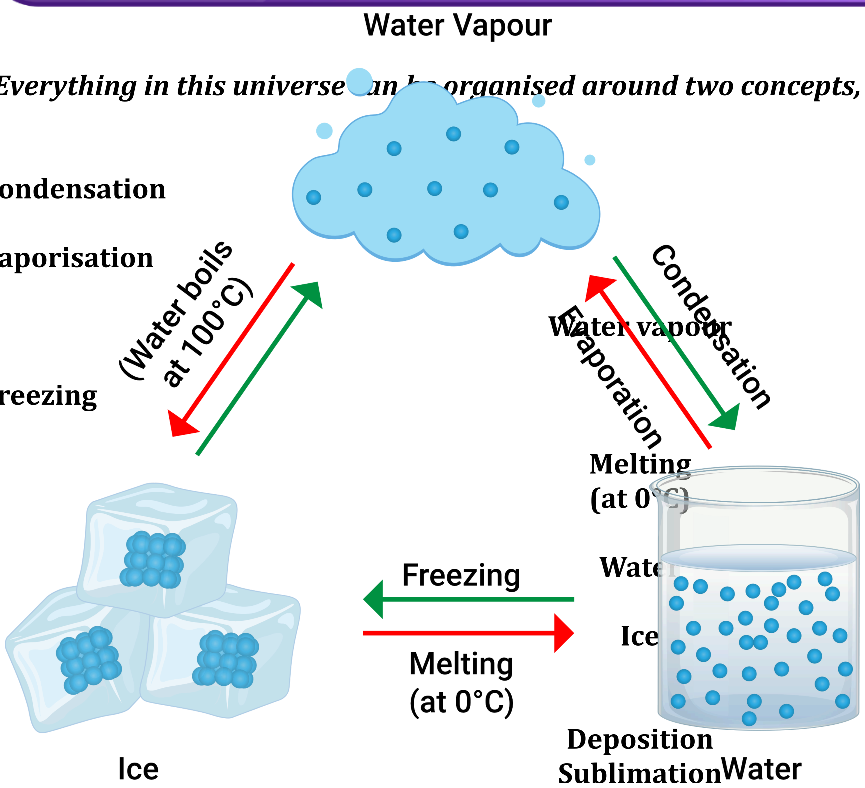
1 Matter in our Surroundings

"Everything in this universe can be organised around two concepts, matter and energy."

Condensation

Vaporisation

Freezing



Do You Remember ?

★ In our surroundings, we see a large variety of things with different shapes, sizes and textures.

★ In earlier classes, we have classified objects on the basis of different properties like- shape, size, solubility, appearance etc.

★ In this chapter, we will classify objects on the basis of physical properties.

1. Introduction

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, everything is **matter.** We can also see, as we look around that all the things mentioned above occupy space and have mass. In other words, they have **both mass and volume**.

Early Indian philosophers classified matter in the form of five basic elements "Panch Tatva" – air, earth, fire, sky and water.

Ancient Greek philosophers also classified matter in similar manner.

Definition

Matter: Anything which occupies space (or have volume) and has mass is called matter.

Some examples of matter are water, air, metals, plants, animals, etc.

The perception of joy, love, hate, thought, cold, hot, pain is not considered as matter.

2. Physical nature of matter

From a long time, there were two views about the physical nature of matter

(i) Continuous nature, like a block of wood or a sheet of glass.

(ii) Particulate nature, that matter is made up of particles like sand.

Matter is made up of particles (Particulate nature)

The particle nature of matter can be demonstrated by a simple activity.

Active Chemistry 1

It is believed that entire universe consists of two components-matter and non-matter. Different forms of energies are regarded as non-matter.

SPOT LIGHT

Aim

To show the particulate nature of matter.

Materials required

Beaker (100 mL), water, glass rod, salt.

Method

(a) Take about 50 mL water in 100 mL beaker.

(b) Mark the level of water.

(c) Add some salt to the beaker.

(d) Stir with the help of a glass rod.

Add

Salt
Stir
Glass rod
Salt solution
Water

Dissolution of salt in water

Now answer

(a) What happened to the common salt initially?

(b) What happened to the common salt on stirring?

(c) What happened to the level of water in the beaker after the activity is over?

(d) Where does the common salt disappear?

Observation and conclusion

(a) The common salt settled at the base of the beaker, it appears like it is a continuous form of matter.

(b) On stirring, the common salt disappeared i.e. it get dissolved in water. This dissolving or disappearance of common salt in water suggests that common salt is not a continuous state of matter. Instead, it is made up of extremely small particles. The water breaks down the common salt into small particles that they are no longer visible to the eye.

(c) The level of water in the beaker does not rise or fall. This suggests that particles of common salt got dispersed in water. This also suggests that there must be some hollow spaces in water. This implies that water by itself is not continuous, but is made of extremely small particles, which are not visible to the eye.

(d) The extremely small particles of common salt positioned themselves in the small spaces between the particles of water. This also accounts for the fact that level of water does not rise, because the particles of common salt do not displace it but occupy the small spaces in between the particles of water.

Size of the particles

The following activity demonstrates that the constituent particles of matter are very small.

Active Chemistry 2

Aim

To show that the constituent particles of matter is very small.

Materials required

Beakers (250 mL), water, glass rod, potassium permanganate.

Method

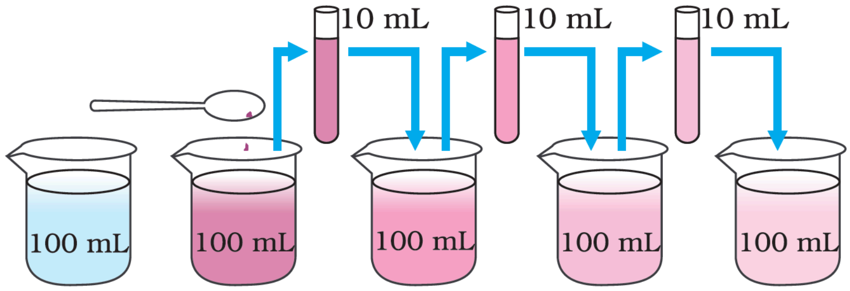
(a) Take a 250 mL beaker and add 100 mL water to it.

(b) Now add 2-3 crystals of potassium permanganate ($KMnO_4$) and stir with a glass rod in order to dissolve the crystals.

(c) Take 10 mL of this solution and add to 90 mL of water taken in another beaker.

(d) Take 10 mL of this diluted solution and put into 90 mL of water taken in another beaker.

(e) Repeat this process two more times. Observe the colour of the solution in the last beaker.



Potassium permanganate colour fades on dilution with water

Observation

This experiment shows that just a few crystals of potassium permanganate can change colour of large volume of water. So, we conclude that there must be millions of tiny particles in just one crystal of potassium permanganate which keep on dividing themselves into smaller and smaller particles with each dilution thereby making the colour lighter and lighter. The same activity can be done using 2 mL of Dettol instead of potassium permanganate. The smell can be detected even on repeated dilution.

The particles of matter are very small, they are small beyond our imagination!!

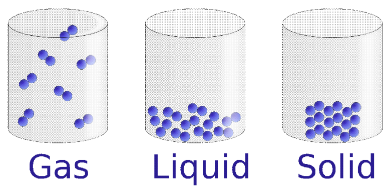
Conclusion

The matter is made up of extremely small particles which cannot be seen even with a powerful microscope what we actually see is an aggregate of tiny particles.

3. Characteristics of particles of matter

(i) Particles of matter have space between them

When sugar is dissolved in water, the volume of the liquid remains unchanged because during dissolution, the particles of sugar get into the spaces between the particles of water.



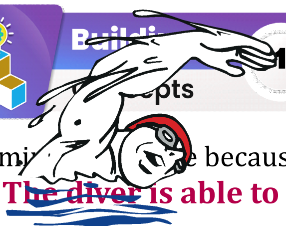
Matter have spaces between the particles

As a result, they get evenly distributed and there is no noticeable change in volume. Similarly, when potassium permanganate is dissolved in water, its particles get evenly distributed throughout the bulk of water. This is indicated by uniform colour of the solution.

This indicates that there are spaces between particles of matter. The particles of potassium permanganate get uniformly distributed in the spaces between water molecules.

Similarly, when we prepare tea, coffee or lemonade (nimbu pani) we observe that particles of one type of matter get into the spaces between particles of other.

Building Concepts 1



Swimmi... because of spaces present between water molecules

The diver is able to cut through water in a swimming pool. Why?

Explanation

The diver is able to cut through water in the swimming pool because matter is not continuous, but it is made up of particles which have vacant spaces between them. Moreover, the attractive forces between molecules of water are not very strong. The diver can easily cut through water by applying force to displace water and occupy its place.

(ii) Particles of matter are continuously moving

We have so far concluded from our discussion that matter is made up of very small particles and these are separated from one another by empty spaces or voids also called interparticle spaces.

A question will immediately come to our mind. Are these particles stationary or in a state of motion? The following activity will illustrate that particles are continuously moving. These are not stationary.

Active Chemistry 3

Diff... burned incense stick shows that particles of matter are in a state of continuous mo...

...particles of matter are in a state of continuous motion.

Materials required

A fresh agarbatti (incense stick), a stand to hold agarbatti, a matchstick.

Method

(a) Take out a fresh incense stick and hold it in a stand.

(b) Place the stand in the corner of a room. You will be able to smell its perfume. Now slowly move away from the incense stick. You will notice that you cannot smell the perfume.

(c) Now light the incense stick and leave the room for a few minutes. On entering the room, you will be able to smell the perfume everywhere in the room.

Building Concepts 2

We can get the smell of perfume sitting several meters away. Why?

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Explanation

This is because perfumes contain volatile solvent which carries pleasant smelling vapours.

They diffuse quite fast and can reach to people sitting several meters away.

> Diffusion of gas through small holes is called effusion. For example,
> (a) Slowly escaping of air from a tyre pinhole.
> (b) Deflating of balloon over time due to mini holes on the balloon.
>
> **SPOT LIGHT**

Now answer

a. Why can you smell the perfume of the incense stick when you were close to the stick?

b. Why can you not smell perfume at a short distance when the incense stick is not lighted?

c. Why does the smell of perfume of the incense stick fills the whole room in few minutes, when lighted?

Observation

a. The particles of perfume(matter) are not stationary, but are continuously moving. They drift through the air for a small distance when its not lighted and hence we can smell the perfume.

b. The particles of perfume(matter) do not have sufficient energy to drift through the air. Thus, a few steps away from the incense stick, we cannot smell it.

c. When the incense stick is lighted, the heat energy makes the particles of perfume move rapidly. Thus, they easily drift through the air in the room and hence we can smell it anywhere in the room.

Conclusion

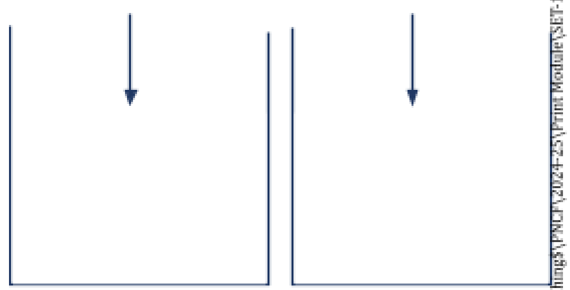
a. Particles of matter are in continuous state of motion and hence have some energy.

b. When the temperature of matter rises, the particles of matter move faster.

Active Chemistry 4

Aim

Light purple colour
$KMnO_4$ crystal
(Cold water)
Fast purple colour
$KMnO_4$ crystal
(Hot water)



Temperature $\propto$ Kinetic energy energy

To demonstrate that the Kinetic Energy of particles increases with increase in temperature.

Materials required

Beakers, water (hot and cold), potassium permanganate crystals.

Method

(a) Take two beakers. To one beaker, add 100 mL of cold water and to the other beaker, add 100 mL of hot water.

(b) Now add a crystal of potassium permanganate to both the beakers.

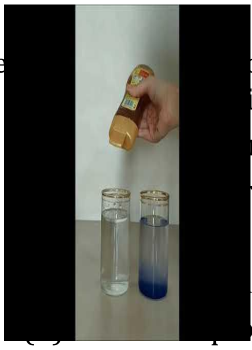
Observation

It is observed that purple colour of potassium permanganate starts spreading and after sometime, the entire solution becomes purple. The rate of mixing is faster in case of hot water.

Conclusion

This experiment demonstrates that the particles of matter possess motion and the kinetic energy of the particles increases with increase in temperature.

Active Chemistry 5



Diffe… on by ink and honey

…ifferent rates of diffusion by different substances.

…red

…ed ink, honey, water.

…sses filled with water.

(…) …f blue or red ink slowly and carefully along the sides of the first glass and honey in the same way in the second glass.

(c) Leave them undisturbed. Record your observations.

Now answer

a. What do you observe immediately after adding the ink drop?

b. What do you observe immediately after adding a drop of honey?

c. How many hours or days does it take for the colour of ink to spread evenly throughout the water?

Observation

a. As the drop of ink trickles along the sides of the beaker, the blue colour of the ink starts diffusing in water, which appears like wavy blue streaks in water.

b. The honey drop continues travelling along the side of beaker and there is no visible diffusion of it in water.

c. The ink spreads evenly in the water in about two hours.

Conclusion

a. Rate of diffusion depends upon the nature of substances.

b. More viscous substances which have particles with less kinetic energy, takes more time to get diffused.

Diffusion

"The spontaneous intermixing of particles of two or more different substances is called diffusion." The rate of diffusion becomes faster with increase in temperature because at higher temperature, the particles have more energy and hence move faster.

Diffusion is,

(i) Fastest between two different gases.

(ii) Slower between two different liquids or a solid and a liquid.

(iii) Slowest (or almost negligible) in case of two different solids.

> Rate of diffusion increases with temperature. Thus, punctured tyre becomes flat more quickly in summer than in winter.
>
> **SPOT LIGHT**

(iii) Particles of matter attract each other

Some forces of attraction between the particles of matter which bind them together. Force of attraction between particles of matter are of two types:

Cohesion force: The force of attraction between the particles of same kind of substances. For example, water-water molecules.

Adhesion force: The force of attraction between the particles of different kind of substances. For example, between water and glass molecules.

The following activity may be carried out to demonstrate the attractive forces between particles of matter.

Active Chemistry 6

Aim

To demonstrate the strength of attractive forces between particles of different kinds of matter.

Method

Play this game in the field. Make four groups and form human chains.

hold each other from the back and lock arms like Bihu dancers.

Bihu Dancers

(b) The second group should hold hands to form a human chain.

(c) The third group should form a chain by touching each other with only their fingertips.

(d) Now, the fourth group of students should run around and try to break the three human chains one by one into as many small groups as possible.

Now answer

a. Which group was the easiest to break? Why?

b. If we consider each student as a particle of matter, then in which group the particles held each other with the maximum force?

Answers

a. Third group, because they were weakly bonded with each other.

b. Ist group

If particles are bonded tightly, it is difficult to separate them.

Conclusion

Particles of matter attract each other.

Active Chemistry 7

Aim

To show that particles of different matter have different force of attraction.

Materials required

Iron wire, chalk, rubber band, hammer, knife.

Method

(a) Take a piece of iron wire, a piece of chalk and a rubber band.

(b) Try to break them by hammering, cutting or stretching.

Now answer

In which of the above three substances do you think the particles are held together with greater force?

Observation

It is observed that the piece of iron wire is most difficult to break. This indicates that particles in iron wire are held by stronger force of attraction as compared to particles in piece of chalk or rubber band.

Conclusion

This shows that different kind of matter possess different forces of attraction.

Active Chemistry 8

Aim

To show that particles of matter attract each other.

Method

Open a water tap, try breaking the stream of water with your fingers.

Now answer

(a) Were you able to cut the stream of water?

(b) What could be the reason behind the stream of water remaining together?

Observations

(a) Yes, stream of water can be cut.

(b) Water molecules exert a force of attraction on each other, therefore as soon as we remove fingers, they will try to unite again and will remain together forming a continuous stream again.

Conclusion

Since energy is required to break crystals of matter into particles. It indicates that particles in matter are held together by some attractive forces, the strength of these attractive forces varies from one matter to another.

Building Concepts 3

We can easily move our hand in the air but to do the same through a solid block of wood, we need a karate expert. Why?

Explanation

In air, the interparticle attractive forces are negligible and hence, it is easy to separate the particles in air and we can easily move our hand through it. In a solid block of wood, the interparticle forces are very strong and hence, it is not easy to separate the particles. Therefore, it is not easy to move our hand through a solid block of wood (only a karate expert can do it).

Check your Concepts 1

1. Which of the following are matter?
Chair, air, love, smell, hole, almonds, thoughts, cold, cold drink.

2. Give reason for the following.

(i) It is commonly observed that if a bottle of ammonia is opened in one corner of the laboratory, its smell can be felt in the other corner of the laboratory after some time.

(ii) The smell of hot sizzling food reaches you several meters away, but to get the smell from cold food you have to go close.

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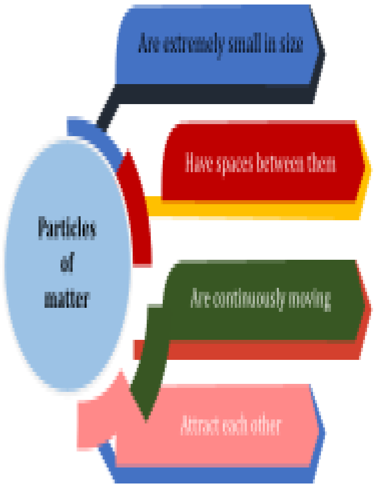
Quick Tips

★ Some important characteristics of particles of matter-



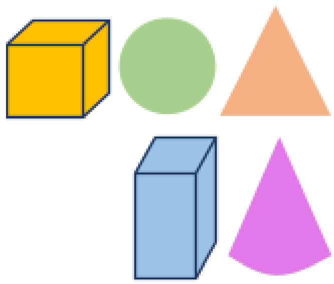
4. States of matter

Matter around us exists in three different states:

(i) solids (ii) liquids (iii) gases

These states of matter arise due to the variation in the characteristics of the particles of matter. Now, let us study about the properties of these three states of matter in detail.

The Solid State



Different shapes of solids

Solids are known for their hardness and rigid nature.

Characteristics of the solid state

(1) Solids have fixed shapes.

(2) Some solids can change their shape.

(3) Solids keep their volume.

(4) Solids can be hardly compressed on applying pressure.

(5) Solids have negligible kinetic energy of the particles.

(6) Solids do not have the property of diffusion.

Wooden block, a solid has fixed shape

Why a wooden block should be called a solid?

Explanation

A wooden block has a fixed shape and is rigid and follows all properties of a solid. Hence, it should be called a solid.

Building Concepts 5

A rubber band undergoes a change in shape on stretching, still we call it a solid. Why?

Explanation

A rubber band is called a solid because although it undergoes a change in shape on stretching yet it regains the same shape when the force is removed.

1

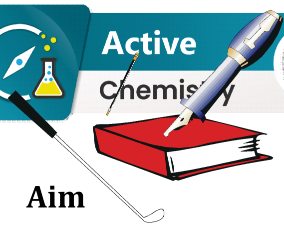
Inter ber band is like that of spring, that's why it is stretchable.

1. ls, cold drink.

2. (i) It is due to the reason that particles of ammonia gas intermix with particles of air spontaneously and reaches every corner due to diffusion. Hence, its smell is felt.

(ii) The smell of hot sizzling food reaches us more quickly as compared to smell of cold food. This is because rate of diffusion is faster at higher temperature than at lower temperature.

Active Chemistry 9



Pen, Book, Needle and wooden stick

Aim

To study the properties of solids.

Method

Collect the following articles: a pen, a book, a needle and a wooden stick.

Now answer

a. Do all these have a definite shape, distinct boundaries and a fixed volume?

b. Are these capable of diffusing into each other?

c. Try compressing them by applying force. Are you able to compress them?

Ans. a. Yes b. No c. No

Conclusion

This shows different properties of solids.

Check your Concepts 2

1. When salt or sugar are poured into different kinds of vessels, why do they take the shape of vessel?
2. Sponge is a solid, yet we are able to compress it. Why?

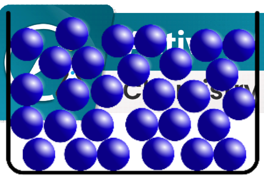
The Liquid State

The liquids have fluidity and the molecular motion is comparatively more than solids. Both these characteristics in the liquid state are because of the presence of weaker interparticle forces.

> Liquids are called fluids. We generally suffer from dehydration in extreme hot weather due to the excessive loss of fluids.
>
> **SPOT LIGHT**

Characteristics of the liquid state

(1) Liquids do not have fixed shapes.



Arrangement of molecules in a liquid

Aim

To show that liquids take the shape of the container.

Materials required

A liquid(water), beaker, conical flask, flat bottomed flask.

Method

volume of a liquid (say water) first in a glass beaker then transfer water into nd finally into a flat-bottomed flask.

Containers of different shapes

We observe that the water has acquired the shape of all the three containers.

Conclusion

This shows that liquids take the shape of the container.

(2) Liquids occupy definite volume or keep their volume.

(3) Liquids have fluidity and not rigidity.

Active Chemistry 11

Aim

To show that liquids flow.

Method

Collect water, cooking oil, milk, juice, a cold drink, containers of different shapes.

Now answer

When you pour the liquid from one container into another, does it flow easily?

Observation

Yes, it flows easily.

Conclusion

This shows that liquids flow and change shape, so they are not rigid but can be called fluid.

(4) Liquids have lesser density as compared to solids.

(5) The kinetic energy of the particles in the liquid state is more than in the solid state.

(6) Particles in the liquid state can easily diffuse.

Active Chemistry 12

Aim

To study diffusion of gases in water.

Materials required

200 mL beaker half filled with tap water, wire gauze, tripod stand, spirit lamp or Bunsen burner.

Method

Place the wire gauze over tripod stand and then the beaker containing water. Heat the beaker by a spirit lamp or a bunsen burner on low flame. Do not allow the water to boil. Make your observations as the water is being heated.

Now answer

a. What do you observe on the sides of glass beaker?

b. Give an explanation to your above observation.

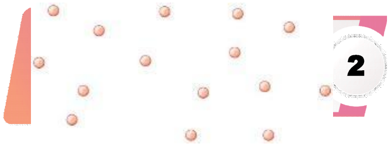
Observation

a. Tiny bubbles of gas cling to the sides of beaker.

b. The tiny bubbles are of air (especially carbon dioxide and oxygen) which got dissolved in water naturally. These gases are expelled out when water is warmed.

Conclusion

The gases like oxygen and carbon dioxide diffuse and hence dissolve in water. The dissolved oxygen in water is essential for the respiration of water animals. The dissolved carbon dioxide helps the aquatic plants to synthesize their food by the process of photosynthesis.



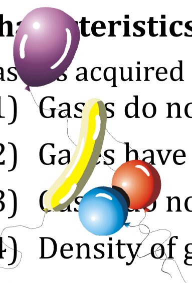
Arrangement of
molecules in a gas

1. Salt or sugar takes the shape of containing vessel, but does not change its individual shape. For example, sugar crystals are cubical and they remain cubical in any vessel.
2. Sponge has very small holes throughout its structure. These holes are filled with air. When it is compressed, the air in the holes is squeezed out. Thus, we are able to compress it.

The Gaseous State

Out of the three states of matter, the interparticle spaces are the maximum in the gaseous state. The interparticle forces which hold the different particles in the gaseous state together are the minimum. As a result, rigidity is the minimum while fluidity is the maximum.

Characteristics of gaseous state



Same gas has acquired different shapes depending on the shape of balloon.

(1) Gases do not have fixed shape.

(2) Gases have maximum fluidity and least rigidity.

(3) Gases do not have fixed volume and are highly compressible.

(4) Density of gases is very less.

(5) The kinetic energy of the particles in the gaseous state is very high.

(6) Gases exert pressure.

(7) Gases diffuse very rapidly.

Please note that even the heavier gases can rise upwards and lighter gases can move downwards. This means that the diffusion of the gases is not influenced by gravity. For example, invert a cylinder containing hydrogen gas (colourless) over a cylinder containing nitrogen dioxide (reddish brown) and separate the two cylinders by a lid.

Now, remove the lid. What will you observe? Both the cylinders will acquire the same colour i.e., light brown. This means that hydrogen gas has moved downwards and nitrogen dioxide upwards. Both the cylinders contain a uniform mixture of these two gases and are light brown in colour.

For example, Air is the common example of the gaseous state. It is a mixture of number of gases like nitrogen, oxygen, carbon dioxide, inert gases, etc. A few other examples are hydrogen, ammonia, sulphur dioxide, chlorine, etc.

Rate of diffusion is inversely proportional to square root of density RD $\propto 1/\sqrt{d}$. Thus, less dense gases diffuse faster than the heavier (more density)

More examples

(i) CNG (Compressed natural gas) is used as fuel in internal combustion engines.

(ii) Oxygen in compressed form is supplied to hospitals for serious patients in cylinders.

(iii) LPG (Liquefied petroleum gas) which is used in home for cooking.

(iv) Cooking gas (LPG) is obtained by compressing petroleum gas into cylinders. Its major constituent is butane(C_4H_{10}).

Active Chemistry 13

Aim

To study the compressibility of solids, liquids and gases.

Materials required

100 mL syringes, chalk pieces, water, rubber corks.

Method

(a) Take three 100 mL syringes and close their nozzles by inserting them in a rubber cork. Remove the pistons from all the syringes.

(b) Fill chalk pieces in the first, water in the second and leave third syringe as such. It already contains air.

(c) Insert the pistons back into the syringes.

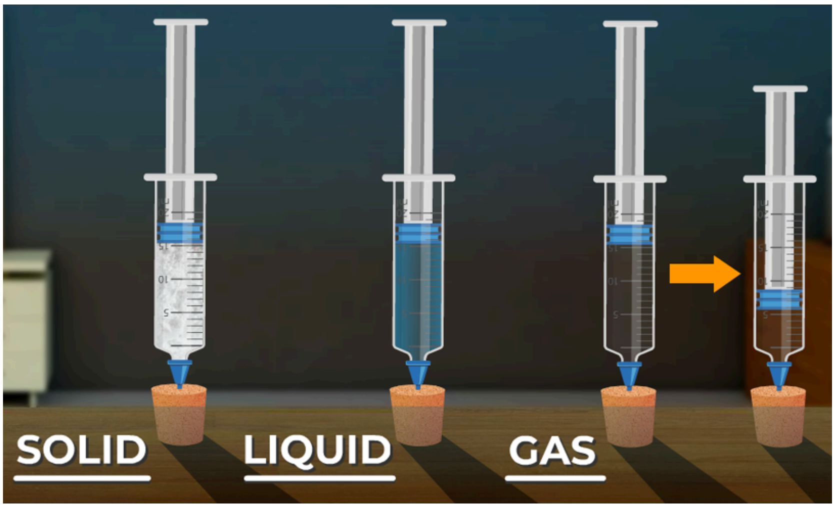
(d) Compress all the syringes by pushing the pistons.

Observation

It is observed that when the syringe containing air, is compressed by applying pressure, the piston can move downward easily and it can be compressed to a larger extent. But when the second syringe containing water is compressed, it is not compressed easily and it can be compressed to much lesser extent than that of air. The first syringe containing chalk pieces (solid) is compressed with most difficulty.

Conclusion

This shows that gases are more compressible than solids and liquids.



Gases are compressible
Liquids are hardly compressible
Solids are not compressible

Compressibility of solid, liquid and gas

Building Concepts 6

Explain why a gas fills completely the vessel, in which it is kept?

Explanation

The molecules of a gas have large intermolecular spaces and kinetic energy, but extremely small intermolecular forces. Thus, the molecules of the gas spread in the entire space of the containing vessel on account of high kinetic energy and practically low intermolecular forces, hence fill entire space of the vessel.

Check your Concepts 3

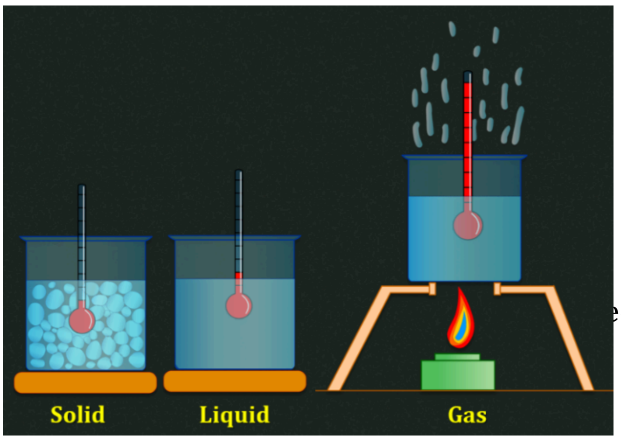
1. (Density = Mass / Volume). Arrange the following in the order of increasing density.
Air, exhaust from chimneys, honey, water, chalk, cotton and iron.

Comparison of characteristic properties of solids, liquids and gases

Property	Solids	Liquids	Gases
Shape	Definite	Not Definite. Take the shape of the container, but do not necessarily occupy all of it	Not Definite. Take the shape of the container by occupying whole of the space available to them.
Volume	Definite	Definite	Not Definite. Takes the volume of the container.
Compressibility	Almost nil	Very very less	Very large
Fluidity or Rigidity	Rigid	Fluid	Fluid
Density	High	Low	Very low
Diffusion	Generally, do not diffuse	Diffuse slowly	Diffuse rapidly
Intermolecular space	Negligible	More than solids	Maximum
Intermolecular force	Maximum	Less than solids	Minimum
Kinetic energy of particles	Negligible	More than solids	Maximum

5. Can matter change its state?

We all know from our observation that water can exist in three states of matter: solid as ice, liquid as the familiar water and gas as water vapour. A substance may exist in three states of matter i.e. solid, liquid or gas, depending upon the conditions of temperature and pressure. By changing the conditions of temperature and pressure, all three states could be obtained (solid, liquid, gas). On heating, a solid change into a liquid which on further heating changes into gas.



ee states of matter

If a solid is to be converted into liquid, the interparticle spaces have to be increased. Similarly, if a liquid is to be converted into gas, these spaces must be further increased. In other words, we can say that one state of a substance can be converted into another by changing interparticle spaces and interparticle forces of attraction.

Please note that the process can be reversed also under suitable conditions. This is known as interconversion of states of matter and this can be brought about by two ways

(i) By changing the temperature

(ii) By changing the pressure

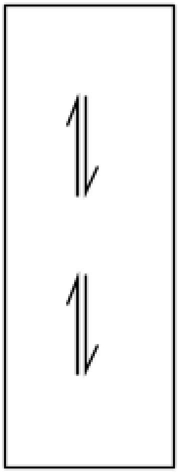
Temperature affects the phase of matter by breaking the bonds between the molecules of a substance, leading it to change its state.

SPOT LIGHT

Effect of change of temperature

Change in state
of water

Ice
(solid)
Water
(liquid)
Heat
Cool
Steam
(gas)
Heat



Cool

The effect of temperature on three states of matter could be seen by performing the following activity.

Active Chemistry 14

Aim

To show that temperature remains constant during the change of state.

Materials required

Beakers, ice, thermometers, burner, glass rod, tripod stand.

Method

(a) Take a piece of about 100–150 g of ice in a beaker.

(b) Hang a thermometer in it so that its bulb is in contact with ice.

(c) Start heating the beaker slowly on a low flame.

The kelvin scale is an absolute thermodynamic temperature scale which works on the basis of absolute zero temperature. It is the temperature at which molecules would

(d) Note down the temperature when ice starts changing to water and ice has been converted to water.

(e) Record all observations for the conversion of solid ice into liquid water.

(f) Now, place a glass rod in the beaker and slowly heat the beaker with constant stirring with help of a glass rod.

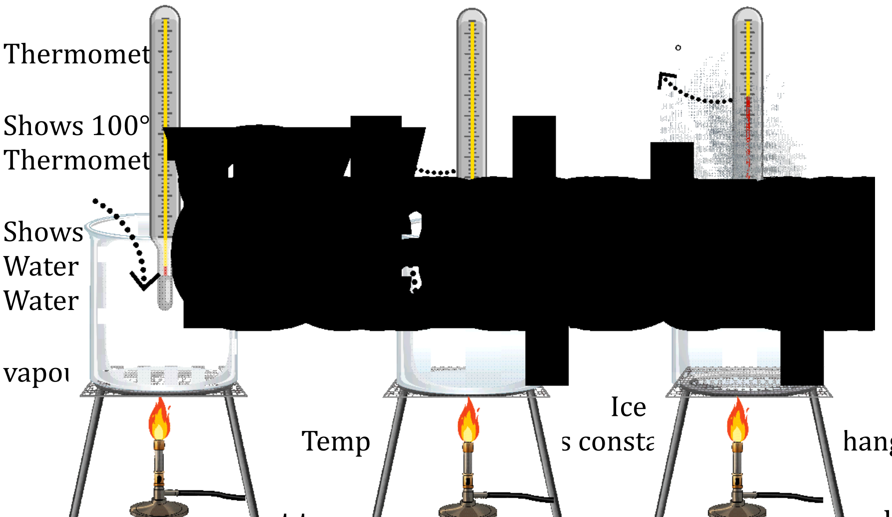
(g) Note the temperature when water starts changing into water vapour.

(h) Record all observations for the conversion of water in the liquid state to vapour state.

Observation

It is observed that as temperature increases, the ice starts changing into water. This change is called **"Melting"**. The temperature remains same till all the ice changes into water. The thermometer shows 0°C until all the ice has melted.

On further heating, the temperature starts rising. At 373 K (or 100°C), water starts boiling. As the water continues boiling, the temperature remains constant.



This shows that temperature remains constant during the change of state.

Explanation about interconversion of different states of matter

(i) Change of state from solid to liquid - Melting

Ice is a solid. In solids, the particles are tightly packed together. When we heat a solid, its particles become more energetic and kinetic energy of the particles increases. Due to the increase in kinetic energy, the particles start vibrating more strongly with greater speed. The energy supplied by heat overcomes the intermolecular forces of attraction between the particles. As a result, the particles leave their mean position and break away from each other. After this, solid melts and a liquid is formed.

"The temperature at which a solid melts to become a liquid at the atmospheric pressure is called its **melting point**". The melting point of ice is 0°C. It may also be written as 273.15 K or 273 K.

°C + 273 = K

Conversion of temperature on Celsius scale to Kelvin scale

For example, 0°C = 0 + 273 = 273 K

100°C = 100 + 273 = 373 K

Conversion of temperature on Kelvin scale to Celsius scale

For example, 373 K = 373 – 273 = 100°C

273 K = (273 – 273) = 0°C

Quick Tips

★ In Kelvin temperature, the symbol (°) is not used.

★ Temperature conversion formulas-

(i) The temperature conversion formula from Celsius to Kelvin is: K = C + 273.15

(ii) The temperature conversion formula from Kelvin to Celsius is: C = K – 273.15

(iii) The temperature conversion formula from Fahrenheit to Celsius is: 9/5 (°C) = °F – 32

Numerical Ability 1

1. Convert the following temperatures to the Celsius scale.

(a) 300 K (b) 573 K

Ans. (a) (300 – 273) = 27°C. (b) (573 – 273) = 300°C.

2. Convert the following temperature to the Kelvin scale.

(a) 27°C (b) 378°C

Ans. (a) 27 + 273 = 300 K (b) 378 + 273 = 651 K

Latent heat (hidden heat)

It is observed that the temperature of the system does not change after melting point is achieved till all the ice melts, though we continue to heat the beaker. This happens because the heat supplied is used up in changing the state by breaking the intermolecular forces of attraction which hold them in solid state. As a result, there is no change in temperature till all the ice melts. This energy required to change solid into liquid is called **"latent heat"**.

The word **"latent"** means **"hidden"** because this energy is hidden into the contents of the beaker.

Latent heat is of two types

(a) Latent heat of fusion (b) Latent heat of vaporization

Latent heat of fusion

Latent heat of fusion is defined as the amount of heat energy required to change 1 kg of a solid into a liquid at atmospheric pressure without any change in temperature at its melting point. The latent heat of fusion of ice is 3.34×10^5 J/kg.

(ii) Change of state from liquid to solid - Freezing

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. Thus, the temperature at which a liquid freezes to become a solid at atmospheric pressure is called the **freezing point**.

(iii) Change of state from liquid to gas - Boiling

In a liquid most of the particles are close together. When we supply heat energy to the liquid, the particles of water start vibrating even faster. Some of the particles become so energetic that they can overcome the attractive forces of the particles around them. Therefore, they become free to move and escape from the liquid. Thus, the liquid evaporates i.e. starts changing into gas. "The temperature at which a liquid changes into a gas or vapour at the atmospheric pressure is called its **boiling point**."

For example, the boiling point of water is 100°C or 373 K.

> Melting point and boiling point are measures of strength of forces of attraction between constituent particles. Higher the melting point, stronger is the force of attraction.
>
> SPOT LIGHT

Latent heat of vaporization

The latent heat of vaporization of a liquid is the quantity of heat in joules required to convert 1 kilogram of the liquid (at its boiling point) to vapour or gas, without any change in temperature. The latent heat of vaporization of water is 22.5×10^5 joules per kilogram (or 22.5×10^5 J/kg).

Building Concepts 7

Why it takes much longer to cook food in the hills (mountains) than in the plains (Sea level)?

Explanation

The boiling point of a liquid depends upon the pressure acting on it. It increases, if the pressure is increased or decreases if the pressure acting on it is decreased. For example, water boils at 373 K at sea level where the pressure is 1 atmosphere. However, on mountains, it boils at a lower temperature where the pressure is less than 1 atmosphere. Because water boils at a lower temperature at hills food will cook at a lower temperature and it will take longer to get enough heat for cooking. It is because of this reason that cooking of food takes longer time on mountains and lesser time in plains.

(iv) Change of state from gas to liquid - Condensation

Drop ... e outer surface of the glass containing ice cold water.

... s or vapour is cooled by lowering its temperature, the kinetic energy of their ... particles decreases. Due to decrease in the kinetic energy, the particles ... ng slowly. As the temperature is further lowered, the attractive forces pull ... es close together and the gas or vapour condenses i.e. gas or vapour changes

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into liquid. Thus, the process of changing a gas (or vapour) to liquid by cooling is called **condensation**.

For example, We see water droplets on the outer surface of a glass containing ice-cold water.

Take some ice-cold water in a glass. Soon we will see water droplets on the outer surface of the glass. The water vapour present in air, on coming in contact with the cold glass of water loses energy and gets converted to liquid state, which we see as water droplets.

Check your Answers 3

1. Air, exhaust from chimneys, cotton, water, honey, chalk and iron.

(v) Sublimation

The process of conversion of a solid into gas without undergoing into liquid state is known as sublimation. The process of conversion of a gas into solid state is known as deposition or desublimation.

For example, Ammonium chloride, camphor, iodine, naphthalene, solid carbon dioxide (dry ice), anthracene undergoes sublimation.

Sublimation can be represented as

$$\text{Solid} \underset{\text{Cooling}}{\overset{\text{Heating}}{\rightleftharpoons}} \text{Gas}$$

Sublime: A gaseous form, directly formed from a solid on heating, is known as sublime.

Sublimate: A solid state of matter formed directly from its gaseous state on cooling, is called sublimate.

Process of sublimation can be illustrated by following activity.

> The process of melting is also called Fusion. The process of freezing is also called solidification. Boiling is also called vaporization. Condensation is also known as liquefaction.
>
> **SPOT LIGHT**

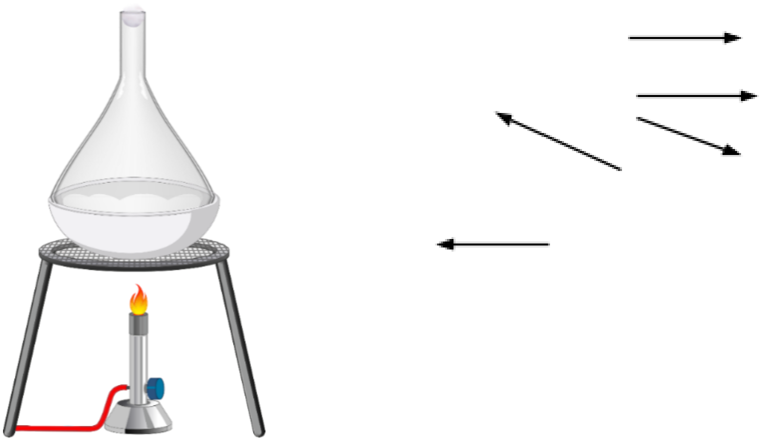
Active Chemistry 15

Aim

To demonstrate the process of sublimation.

Materials required

China dish, ammonium chloride, funnel, cotton plug, burner, tripod stand, wire gauze.



Cotton plug
Inverted funnel
Solidified ammonium chloride
Vapours of ammonium chloride

Ammonium chloride

Method

(a) Take some ammonium chloride.

(b) Powder it and put in a china dish.

(c) Place an inverted funnel over the china dish.

(d) Put a cotton plug on the stem of the funnel.

(e) Heat the china dish slowly.

Observation

We observe that solid Ammonium chloride on heating gets converted into vapour which gets condensed on the funnel. Solid state is directly converted into gaseous state.

Conclusion

This experiment shows sublimation process.

More examples of sublimation

(i) In very cold places, the snow does not melt but sublimes directly to vapours.

(ii) In frost-free refrigerators, ice on the walls of the freezer sublimes when warm air is circulated through the compartment during the defrost cycle.

Effect of change of pressure

To convert a gas into a liquid or to convert a liquid into a solid, the interparticle distances must by decreased and the interparticle forces of attraction must be made stronger. This can be done in the following ways

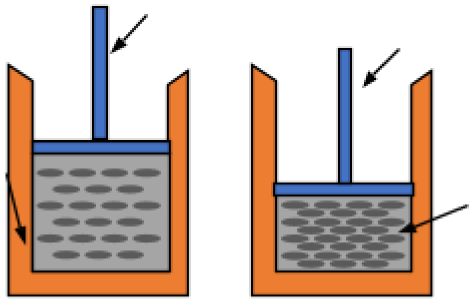
(i) By applying pressure

(ii) By lowering temperature or

(iii) By combination of both the factors discussed above.

(i) By applying pressure

Gases are compressible because on applying pressure, the spaces between the gaseous particles decrease. Therefore, gases can be compressed readily.



Piston
Piston

Gas particles
Gas particles

By applying pressure particles of gas can be brought close together.

(ii) By lowering temperature

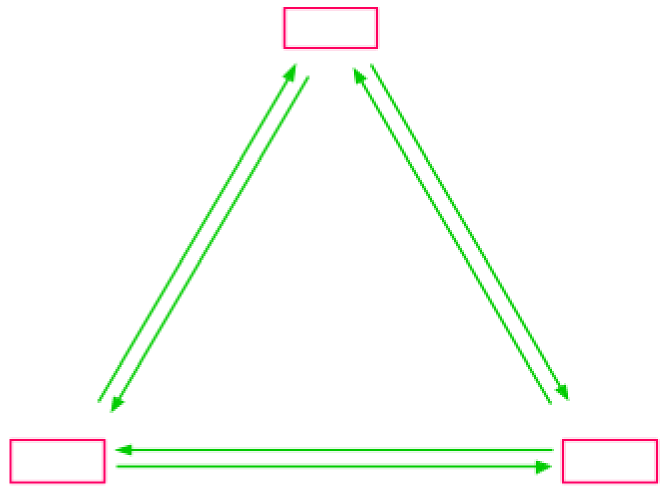
If we cool the gas, the kinetic energy decreases and the particles slow down. As a result, interparticle distances decrease and interparticle forces of attraction increase which pull the gas particles close to form a liquid.

(iii) By combination of both the factors discussed above

From the above discussion, it is evident that a gas can be liquefied either by increasing the pressure or by lowering the temperature. However, in most of cases, a combination of both these factors is used to liquefy the gases. If the pressure on the liquefied gas is further increased and the temperature further lowered, the liquefied gas may change into the solid state.

Quick Tips

★ Interchange between different states –

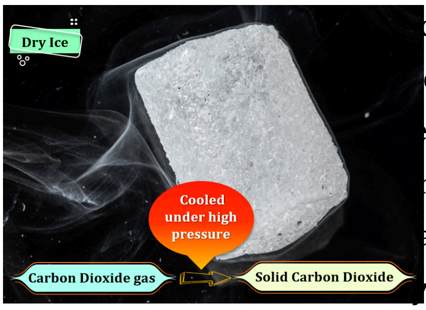


Liquid
Gas
Solid
Boiling/Vaporization
Liquefaction/Condensation
Melting/Fusion
Freezing/Solidification
Sublimation
Deposition/De-sublimation

Building Concepts 8

Why solid CO_2 is also known as dry ice?

Explanation



d under high pressure, it can be directly converted into solid ce. If the pressure on dry ice is decreased to one atmosphere, it ts converted into the gaseous state (i.e. carbon dioxide gas) he intervening liquid state. As a result, unlike ordinary ice, dry ace on which it is kept. It is because of this reason that solid ice. It is used as a refrigerant under the name **dricold**.

Solid CO_2

Three conditions of temperature and pressure which decide the state of matter.

- If the melting point of a substance is above the room temperature at the atmospheric pressure, it is classified as **solid**.
- If the boiling point of a substance is above room temperature under atmospheric pressure, it is classified as **liquid**.
- If the boiling point of the substance is below the room temperature at the atmospheric pressure, it is classified as **gas**.

6. Evaporation

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

Whatever be the temperature at which evaporation takes place, the latent heat of vaporization must be supplied whenever a liquid changes into vapour (or gas).

For example,

(i) Water in ponds changes from liquid to vapour without reaching the boiling point.

(ii) Water when left uncovered slowly changes into vapour.

(iii) When we put wet clothes for drying, the water from the clothes goes to the atmosphere.

Quick Tips

★ Differences between Evaporation and Boiling –

	Evaporation	Boiling
1	Evaporation process takes place spontaneously at all temperatures.	Boiling takes place only at definite temperature (boiling point) at which the vapour pressure of the liquid is equal to atmospheric pressure.
2	Evaporation takes place only at the surface of the liquid. Evaporation is a surface phenomenon.	Boiling takes place even below the surface of the liquid in the form of bubbles. Boiling is a bulk phenomenon.
3	It always causes cooling.	It does not cause cooling.

Factors affecting evaporation

Let us understand this with an activity.

Active Chemistry 16

Aim

To study the factors affecting evaporation.

Materials required

Water, test tube, china dish.

Acetone is a volatile liquid

5 mL of water in a test tube and keep it near a window or under a fan.

5 mL of water in an open china dish and keep it near a window or under a fan.

(c) Take 5 mL of water in an open china dish and keep it inside a cupboard or on a shelf in your class.

(d) Record the room temperature.

(e) Record the time of days taken for the evaporation process in the above cases.

(f) Repeat the above three steps of activity on a rainy day and record your observations.

What do you infer about the effect of temperature, surface area and wind velocity (speed) on evaporation?

Conclusion

There are five factors which affects the rate of evaporation.

(i) Nature of liquid

Different liquids have different rates of evaporation. A liquid having weaker interparticle attractive forces evaporates at faster rate because less energy is required to overcome the attractive forces.

For example, Acetone evaporates faster than water.

liquid

Well spread clothes dry faster

pends upon the surface area. If the surface area is increased, the rate of evaporation increases because the high energy particles from liquid can go into gas phase only through surface.

For example,

(a) The rate of evaporation increases when we put kerosene or petrol in an open china dish than in a test tube.

(b) Clothes dry faster when they are well spread because the surface area for evaporation increases.

(iii) Temperature

Rate of evaporation increases with increase in temperature. This is because with the increase in temperature more number of particles get enough kinetic energy to go into the vapour state (or gaseous state).

For example,

Clothes dry faster in summers than in winters.

(iv) Humidity in the air

The air around us contains water vapour or moisture. The amount of water present in the air is referred as humidity.

The air cannot hold more than a definite amount of water vapour at a given temperature. If the humidity is more, the rate of evaporation decreases. The rate of evaporation is more if the air is dry.

For example, clothes do not dry easily during rainy season because the rate of evaporation is less due to high moisture content(humidity) in the air.

(v) Wind speed

The rate of evaporation also increases with increase in speed of the wind. This is because with increase in speed of wind, the particles of water vapour move away with wind, resulting in decrease in the amount of vapour in the atmosphere.

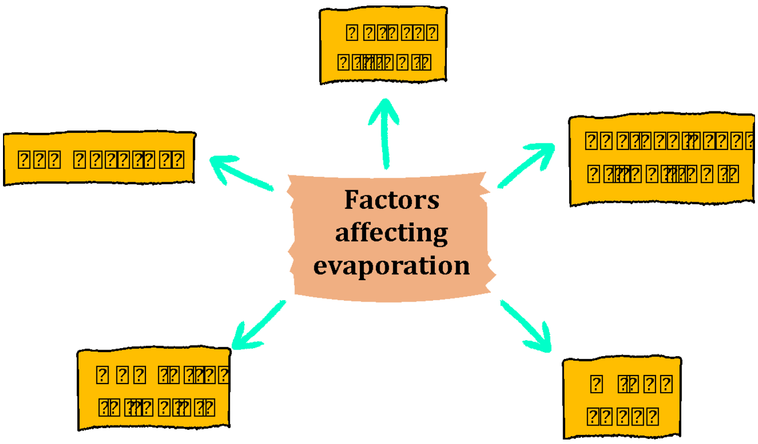
For example,

(a) Clothes dry faster on a windy day.

(b) In a desert cooler, an exhaust fan sucks the moist air from the cooler chamber which results in greater rate of evaporation of water and hence greater cooling.

Quick Tips

★ Factors affecting evaporation –



Building Concepts 9

Why evaporation causes cooling?

Explanation

During evaporation, cooling is always caused. This is because evaporation is a phenomenon in which only the high energy particles leave the liquid surface. As a result, the particles having low energy are left behind. Therefore, the average molecular energy of the remaining particles left in the liquid state is lowered. As a result, there is decrease in temperature on the part of the liquid that is left. Thus, evaporation causes cooling.

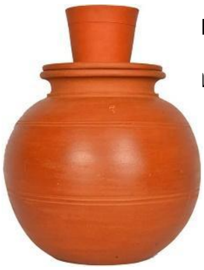
Desert cooler

ur some acetone (nail polish remover) on our palm, we feel cold. This is

particles gain energy from our palm or surroundings and leave the palm

(b) We sprinkle water on the roof or open ground after a sunny hot day. This cools the roof or open ground. This is because the large latent heat of vaporization of water helps to cool the hot surface.

Some other examples of evaporation



ld wear cotton clothes in hot summer days to keep us cool and ble.

Water cools because of evaporation.

lot of sweat on our body in hot summer days. Cotton is a good absorber of it absorbs the sweat from our body and exposes it to the air for evaporation. The evaporation of this sweat cools our body. The synthetic clothes (made of polyester, etc) do not absorb much of sweat, so they fail to keep our body cool in summer.

(ii) Water stays cool in the earthen pot(matki) during summer.

vater oozes out of the pores of an earthen pot, during hot summer, it rapidly. As the cooling is caused by evaporation, therefore, the e of water within the pot falls and hence it becomes cool.

Tea cools because of evaporation

ng of hot tea.

If tea is too hot to sip, we pour it in the saucer. In doing so, we increase the surface area and the rate of evaporation increases. This, in turn, causes cooling and the tea attains a desired temperature for sipping.

(iv) A wet handkerchief is placed on the forehead of a person suffering from high fever.

The logic behind placing wet cloth is that as the water from the wet cloth evaporates, it takes heat from the forehead. This, in turn, lowers the temperature of head and protects brain from any damage due to high temperature.

(vi) We often sprinkle water on the road in summer.

The water evaporates rapidly from the hot surface of the road, there by taking heat away from it. Thus, the road becomes cool.

7. Plasma

Definition: Plasma is the fourth phase of matter, apart from the traditional solids, liquids, and gases. It is a most common state of matter made from a gas that has lost its electrons due to heat.

Plasma was first identified as "radiant matter" by Sir William Crookes in 1879. Irving Langmuir assigned the term "Plasma" in 1928.

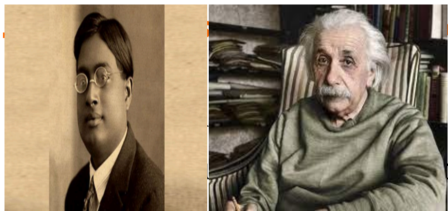
Composition: Plasma may be formed by heating and ionizing a gas. It is a collection of charged particles that respond strongly and collectively to electromagnetic fields, taking the form of gas like clouds or ion beams.

- Plasma is distinct from a gas because it possesses unique properties.
- Plasma has neither a definite volume nor a definite shape.
- Free electrical charges (not bound to atoms or ions) cause plasma to be electrically conductive.

For example, Flame, interstellar nebulae, aurora borealis, lightning stars, and even the empty vastness of space are all examples of the plasma state of matter. You can find plasma inside fluorescent lights and neon signs.

Since the particles in plasma are electrically charged (generally by being stripped of electrons), it is frequently described as an "ionized gas".

8. e-BEC (5th state of matter)



Bose and A.Einstein

is a **gaseous superfluid phase** formed by **atoms** cooled to **solute zero**.

Satyendra Bose and **Albert Einstein**, had predicted it in the 1920. They didn't have the equipment and facilities to make it happen in the 20s. The first such condensate was produced by **Eric Cornell, Ketterle** and **Carl Wieman** in **1995**, using a gas of **rubidium** atoms cooled at 170 **nanokelvins** (nK).

As in plasma, atoms are super-hot and super excited, the atoms in a Bose Einstein condensate (BEC) are total opposites. They are super-unexcited and super-cold atoms.

The BEC forms at super low temperatures. At zero Kelvin, all molecular motion stops.

When you get to a temperature near absolute zero, atoms begin to clump. The result of this clumping is the BEC. A group of atoms takes up the same place, creating a "super atom". There are no longer thousands of separate atoms. They all take on the same qualities and become one blob.

Some important quantities and the units

Quantity	Unit	Symbol
Mass	Kilogram	kg
Length	Meter	m

Temperature	Kelvin	K
Weight/Force	Newton	N
Volume	Cubic meter	m^3
Density	Kilogram /Cubic meter	kg/m^3
Pressure	Pascal	Pa

Some Important Relations
1kg = 1000g
1m = 100 cm
$1m^3 = 10^6\ cm^3$ or 10^3 L (litre)
$10^3 cm^3 = 1L$

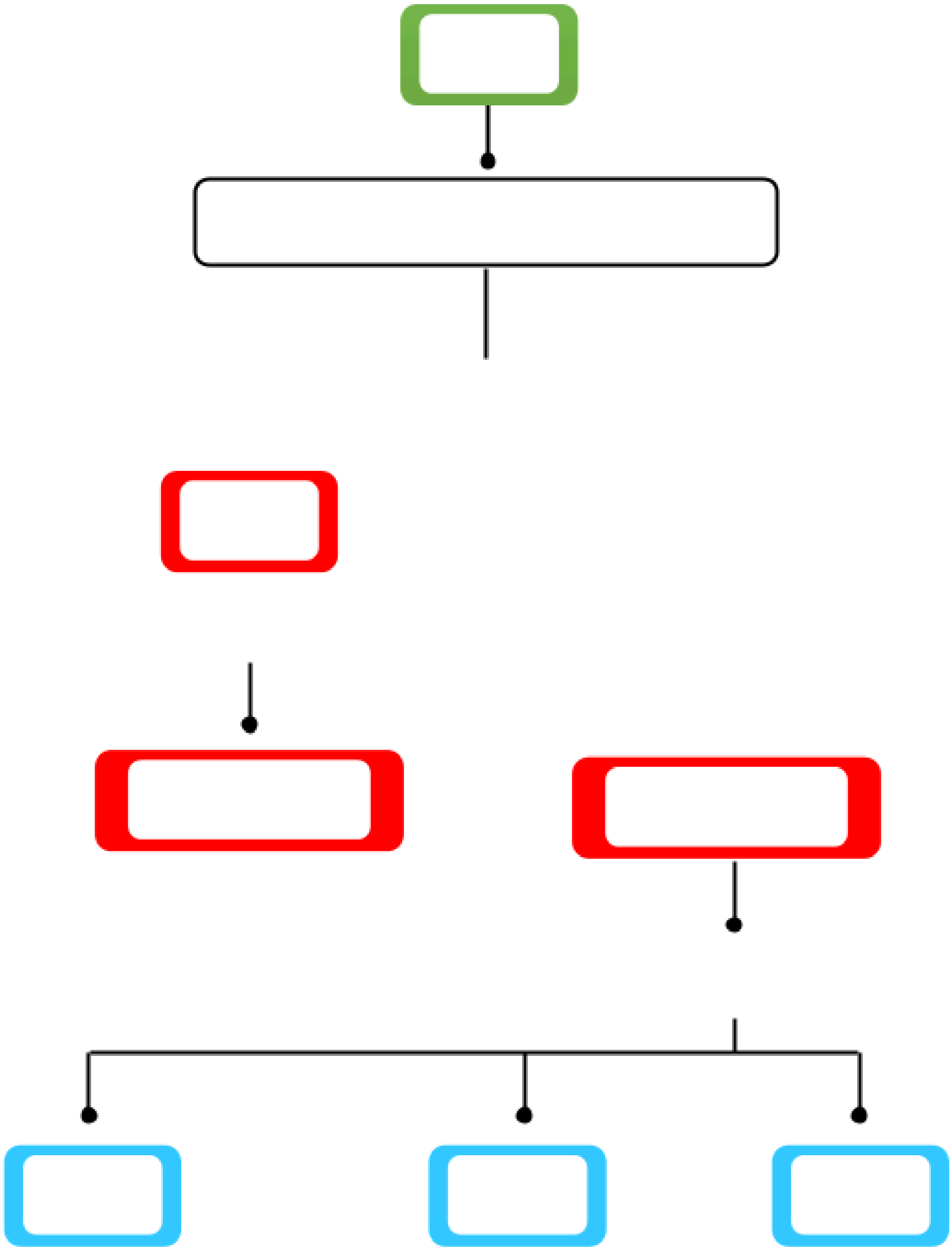
Basic terminology

1. **Fluidity -** Property to flow.
2. **Rigidity -** Inflexibility, opposite of fluidity.
3. **Compressibility -** Property to be compressed.
4. **Volatility -** Property of forming vapours.
5. **Humidity -** Amount of water vapour in air.
6. **Diffuse -** To spread.
7. **Interparticle -** Between two particles.
8. **Thermometer-** Device used to measure temperature
9. **Incense stick -** Agarbatti
10. **Dilution –** Addition of water to a liquid.
11. **Viscous -** Thick and sticky.
12. **Density-** Mass per volume.
13. **Constituent particles -** Particle that cannot be broken into smaller pieces.

In plasma, electrons are away from their nuclei, forming an electron "sea". This gives it the ability to conduct electricity.

SPOT LIGHT

Memory Map



Anything that possesses mass,
occupies space

Classification based on Physical properties
Composition of matter

- Particles are very small in size.
- Particles have mass.
- Particles have space between them.
- Particles are continuously moving.
- Particles attract each other.

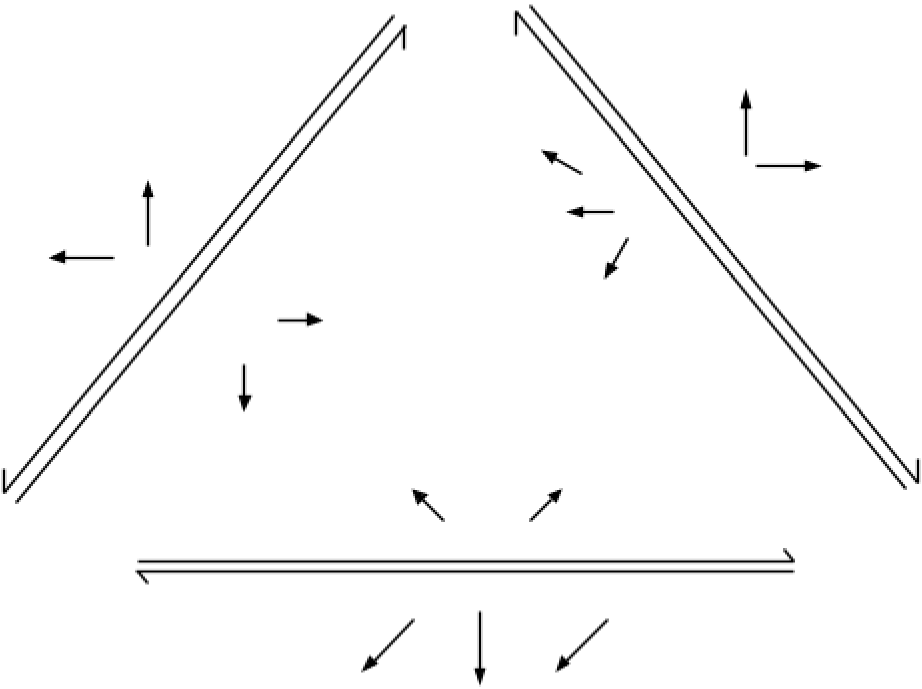
States of matter

Arise due to variation in characteristics of particles

- Have definite shape, distinct and fixed boundaries.
- Maintain their shapes.
- They are rigid and have negligible compressibility.
- Have no fixed shape but have a fixed volume
- Take up the shape of the container in which they are kept
- They are not rigid and change shape
- Particles move randomly in high speed
- Diffuse very fast into other gases
- Highly compressible

Matter
Particles
Characteristics

Solids
Liquids
Gas



(Intermediate energy of particles)
Liquid

Solid
(Lowest energy of particles)
Gas
(Highest energy of particles)
Deposition
Pressure increased
Latent heat evolved
Temperature decreased
Freezing
Temperature decreased
Latent heat evolved
Melting (Fusion)
Temperature increased

Latent heat
absorbed
Sublimation
Temperature
increased
Latent heat
absorbed
Vaporization (Boiling)
Condensation (Liquefaction)
Temperature
increases
Latent heat
absorbed
Temperature
decreased
Pressure
increases
Latent heat
evolved