

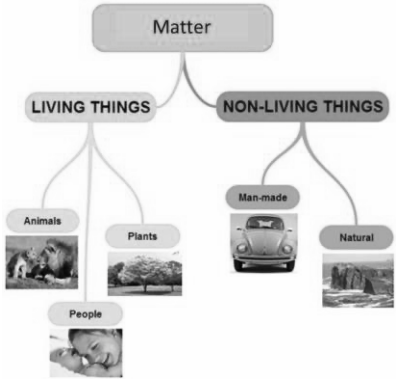
MATTER IN OUR SURROUNDINGS

Concepts Covered

- Matter and its Classification, States of Matter, Effect of Change of Pressure & Temperature, Evaporation, Five States of Matter.

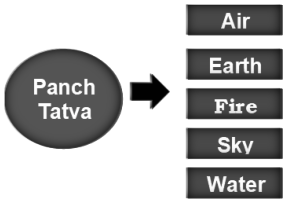
Matter

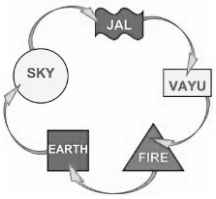
Air, water, stones, sand, clouds, pencils, books – Everything is made up of matter. Matter is anything in this universe that occupies space and has mass.



Constituents of Matter

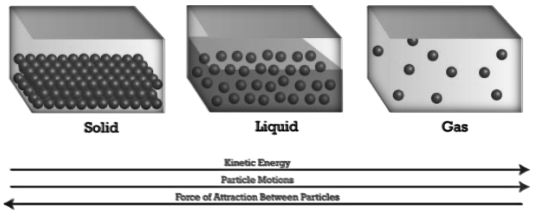
According to the early Indian philosophers, every living and non-living thing is made of five basic elements called- the *Panchtatva* – Air, Water, Earth, Sky, and Fire. Therefore, matter is a composition of these five constituents.



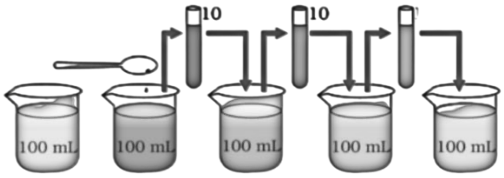


Physical Nature of Matter

Is matter continuous or particulate?



Matter is particulate in nature. This means that matter consists of particles as you can see in the microscopic image of a cube above.



Example:

- The size of the particles of matter is very small.
- They can be broken into further particles as well.

Example:

On dilution of a colourful solution, as shown in the figure below, we can still see the colour. This means there are millions of particles present in the colour which just divide themselves on dilution.

- **Which of these is matter – happiness, air, sandwich, thoughts, juice, and eraser?**

Air, sandwich, juice, and eraser as they have mass, They occupy space and can be broken into further particles.

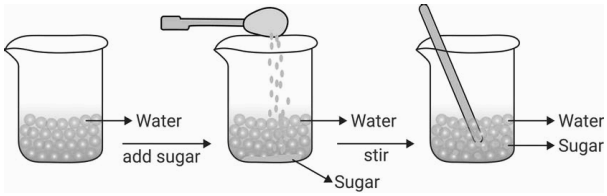
Characteristics of Particles of Matter

Particles of matter have three characteristics:

1. Particles of matter have spaces between them
2. Particles of matter are moving all the time
3. Particles of matter attract each other

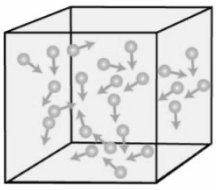
Particles of Matter Have Spaces Between Them

- Have you ever wondered what causes salt to get dissolved in water?
- Salt gets dissolved in water because particles have spaces between them. The particles of the salt get in between the spaces between the particles of water and a mixture is formed.
- We cannot see these particles through naked eyes.



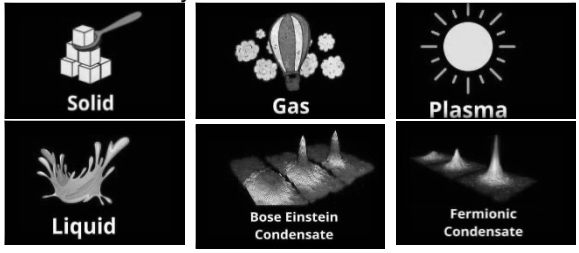
Particles of Matter Are Continuously Moving

- Particles of matter are in motion all the time. Hence, they possess kinetic energy.
- Kinetic Energy – Energy due to motion
- The particles of a matter intermix on their own with other particles of a matter. Examples: Salt in water, Various gases in the air, Ink in water.
- Diffusion – The process of mixing two different types of particles together is called diffusion. Diffusion becomes faster on heating.
- The kinetic energy of particles also increases on heating.



Particles of Matter Attract Each Other

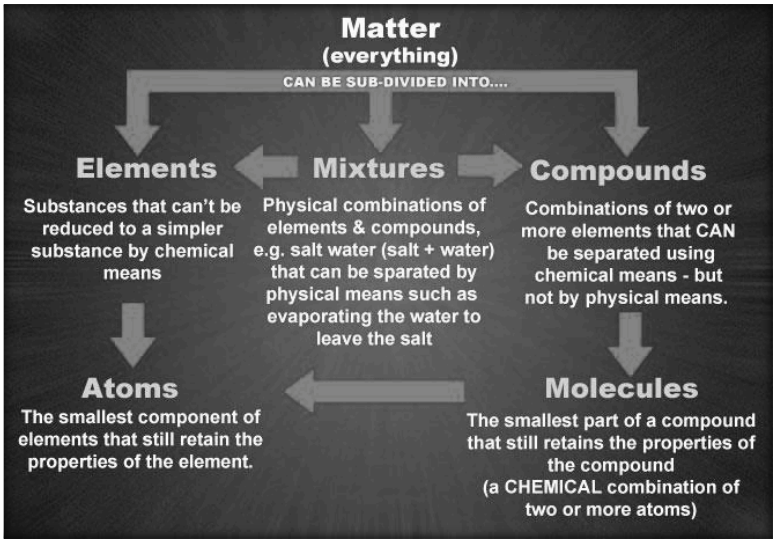
- The particles of matter are always held together because of a force of attraction between them.
- The amount of this force between the particles varies in different forms of matter, as shown in the figure below:
- Solids have the highest force of attraction. That is why we cannot move our hands through a solid object. The particles are so tightly bound.
- Similarly, particles of gases have the least force of attraction in them. We can move our hands easily in the air, can't we? This is because the particles of air are loosely bound.
- We can arrange the force of attraction between different types of matter (solids, liquids, and gases) in increasing order as.
- We can also move our hands through water or liquid matter but not as freely as we can in the air.
- This means that they are also loosely bound to some extent. **Gas < Liquid < Solids**



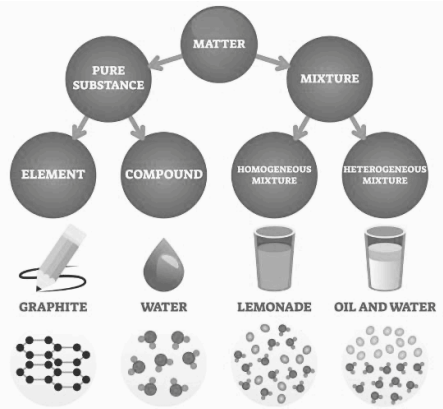
States of Matter

Now we know that particles of matter have a force of attraction between them. Based on this criterion, we can say that matter is present in three different states: solid state, liquid state, and gaseous state. But in reality, states of matter exist in multiple ways which depend on properties of temperature.

Anatomy of Matter



Classification States of Matter



Plasma and BEC

- Plasma (This state consists of super energetic and super excited particles. These particles are in the form of ionized gases. The fluorescent tube and neon sign bulbs consist of plasma.)
- BEC (Bose Einstein Condensate) The BEC is formed by cooling a gas of extremely low density, about one hundred-thousandth the density of normal air, to super low temperatures.

The Solid State

Solids are the objects that have the following properties:

- They have a specific shape.
- They have distinct boundaries.
- They have a volume.
- There is less kinetic energy among the particles in solids. They are generally arranged in an order. Thus, they possess a fixed shape. They cannot be compressed.
- The force of attraction is the maximum among the particles of solids. There is not much space between the particles. Therefore, they cannot be compressed.

Characteristics of solid state

- They have definite shape due to strong Intermolecular forces of attraction.
- They have distinct boundaries.
- They have a fixed volume.
- They cannot flow.
- They have negligible compressibility due to negligible distance between the neighbouring molecules.
- They possess a tendency to uphold their shape when exposed to external force.
- They break under force but it is difficult to change their shape so they are rigid.
- They have high density and do not diffuse at all.

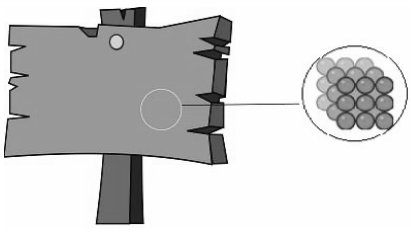


Fig: Particles of Solid (Wooden Plank) Are Compact Together and Have Less Space

Liquid State

Liquids have the following properties:

- Liquids have a fixed volume
- Liquids do not have a fixed shape.
- The force of attraction in liquid particles is less than solids. Therefore, there is a space between the particles of liquids and they can flow easily. They cannot be compressed. That is why they are also called fluids.
- You might have seen that liquids take the shape of the container in which we put them. This is because the particles of liquids have a high kinetic energy, they always keep on moving.

Can other matter diffuse into liquids?

- Yes, other matter can diffuse into liquids whether it is solids, liquids, or gases. This is so because there is a space between the particles of liquid so particles of other matter can slip into those spaces.
- Diffusing solids into liquids: Mixing sugar in tea
- Diffusing liquids into liquids: Mixing ink in water
- Diffusing gases into liquids: The Presence of oxygen and carbon dioxide in water.

The Gaseous State

Gases have the following properties:

- They do not have a fixed volume.
- They do not have a fixed shape.
- The particles of gases have the least or almost no force of attraction between them. Therefore, the particles have a large number of spaces between them and they can freely move in any direction.
- Also, They can be easily compressed and put into a small container, unlike solids and liquids.
- Since there is a lot of space between the particles, different gases can diffuse into each other easily.
- The kinetic energy between the particles is the maximum in the case of gases. Therefore, the particles move around freely at high speed and there is no fixed shape of gases.

(i) Mass: Mass in gm = Moles Molecular mass.
(ii) Volume: Volume of the gas is the volume of container in which they are filled in.
(iii) Temperature: Temperature of a gas is the measure of kinetic energy of gas.
(iv) Pressure: Pressure of gas is defined as the force exerted by the gas on the walls of its container.

It is often assumed that pressure is isotropic, i.e. it is the same in all the three directions.

$$\textbf{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\mathbf{Mg}}{\mathbf{A}} = \frac{\mathbf{v} \times \mathbf{d} \times \mathbf{g}}{\mathbf{A}} = \frac{\mathbf{A} \times \mathbf{h} \times \mathbf{d} \times \mathbf{g}}{\mathbf{A}} = \text{hdg}$$

Where….
h = height of the mercury column supported by the barometer,
d = density of mercury,
g = acceleration due to gravity.

Difference in the Characteristics of States of Matter

Solid	Liquid	Gas
Definite shape	Indefinite shape	Indefinite shape
Definite volume	Definite volume	Indefinite volume
Maximum force of attraction between particles	Less forces of attraction between particles compare to solid	Negligible force of attraction between particles
Cannot be compressed	Cannot be compressed	Can be compressed
Kinetic energy of particles is minimum	Kinetic energy of particles is more than solid	Kinetic energy of particles is maximum
Particles can't move rather they vibrate only at their fixed position	Particles can slide over one another	Particles can move freely
Highest density	Density is lower than solid	Lowest density
Cannot flow	Flow	Flow

Can Matter Change Their States?

Water exists in three states:

- Ice – solid
- Water – liquid
- Water Vapor – Gas

This is an indication that matter can change its states.

Effect of Change of Temperature

What happens to matter when we heat it?

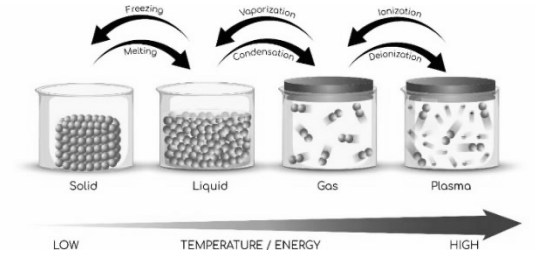
Solids

- As we heat solids, the kinetic energy between the particles of solids increases which decreases the force of attraction between them.
- They start vibrating and changing their positions. Slowly, due to heat the particles become free and a solid convert into its liquid state.
- Melting Point – The temperature at which a solid melt to become a liquid at atmospheric pressure.

Example:

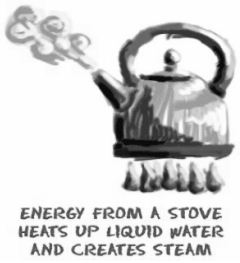
The melting point of ice is 273.16 Kelvin.

- Fusion – The process of melting of a solid into liquid is called fusion.
- In the melting process, once a solid reaches its melting point, its temperature does not increase further. So where does all the heat go? The heat present in the solid at time of melting is used by the particles to diminish the force of attraction between each other. The heat energy is therefore considered as hidden.
- Latent Heat – The heat energy which is used to break the force of attraction between the particles of matter is known as latent heat. Since the heat is hidden therefore it is called as latent Heat.
- Latent Heat of Fusion – The amount of heat energy 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.
- Atmospheric Pressure – Pressure exerted by the weight of the atmosphere.



Liquids

- Just like in solids, the kinetic energy of particles of liquid increases, the force of attraction among them decreases and they start moving freely.
- As we keep on supplying the heat, a point comes when the particles overcome the forces of attraction completely.
- This is when a liquid starts changing into gas.
- Boiling Point - The temperature at which a liquid starts boiling at the atmospheric pressure is known as its boiling point.



Example:

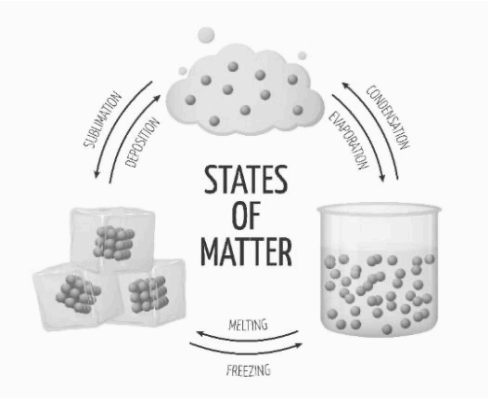
The boiling point of water is 373 Kelvin.

- Latent Heat of Vaporization – The amount of heat energy required to change 1 kg of a liquid into a gas at atmospheric pressure at its boiling point is known as latent heat of vaporization.

What happens when we decrease the temperature?

1. Gases

- The kinetic energy between the particles decreases and they turn into a liquid state.
- Condensation / Liquefaction – The process of converting a gas into a liquid by cooling down its temperature. Example, the formation of clouds is due to condensation of water vapor from Earth.

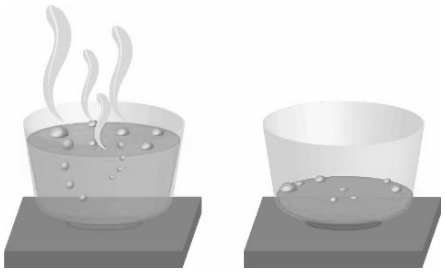


2. Liquids

- The kinetic energy between the particles decreases and they turn into a solid state. For Example, The formation of ice.
- Sublimation – change of state of a gas directly into solid and vice-versa is known as sublimation. For Example, Camphor is a solid that directly evaporates into the air without changing to a liquid state.
- Therefore, by increasing or decreasing the temperature we can change the states of matter into one another. Here is a diagram that sums this up.

Effect of change of Pressure

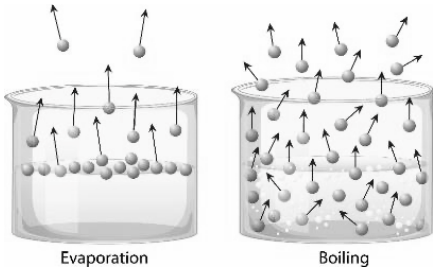
- By applying pressure, we can bring the particles of matter close to each other thereby, increasing the force of attraction among the particles.
- When we compress and decrease the temperature of a gas, the gas changes into a liquid.
- Dry Ice – Carbon dioxide in solid form is known as dry Ice. It can directly turn into gas by decreasing the pressure to 1 atmosphere.



We already know that

- Particles of matter are never at rest.
- Particles of matter possess different amounts of kinetic energy.

- The particles of liquids have more kinetic energy. Therefore, they are able to overcome the forces of attraction and convert into vapor without any external forces.



Evaporation

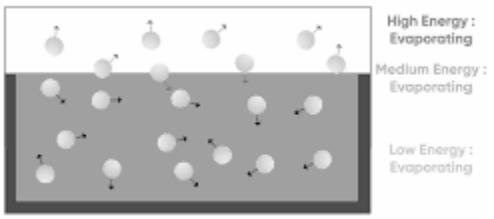
The phenomenon of change of a liquid into vapors at any given temperature below its boiling point is called evaporation. Evaporation is different from boiling, as shown in the figure.

Factors Affecting Evaporation

Condition	Rate of Evaporation	Reason
Increase in Surface Area	Increases	Particles have more space and thus can evaporate easily.
Increase in Temperature	Increases	Kinetic energy among the particles increases.
Increase in Humidity	Decreases	Water content in air increases and so evaporation decreases.
Increase in Wind speed	Increases	Water vapours are blown away by winds allowing more evaporation.

How does evaporation cause cooling?

The process of evaporation uses the energy of the liquid particles. Therefore, the particles absorb energy from the surroundings to compensate for the energy that is being lost in the process of evaporation. This results in cooling of the surrounding area.



Example:

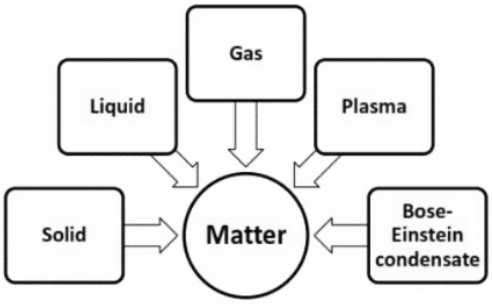
- Our palms feel cool when we put some acetone (nail paint remover) on it.
- People sprinkle water on their roofs or ground on sunny days to cool the area.
- We are able to sip hot tea faster in a saucer than in a cup.

Why do people wear cotton clothes in summer?
We perspire more in summer. As the sweat evaporates it takes energy from our body surface and keeps our body cool. Cotton can absorb the sweat easily and expose it to the atmosphere causing evaporation to take place easily. This, in turn, keeps us cool in summer days.

Why do water droplets appear on the surroundings of a glass with ice-cold water?
There are water vapours present in the air. When they come in contact with the walls of the glass that has ice-cold water in it they condense. As a result, their state changes from gaseous state to liquid state, thus forming tiny water droplets on the walls of the glass.

Five States of Matter

- By far we have discussed the three states of matter – Solid, Liquid, Gas.
- But, scientists have discovered that there are two more states of matter
  - Plasma
  - Bose-Einstein Condensate



Plasma

- It is a state of matter in which the particles are super excited and super energetic. They are in the form of ionized gases.
- For Example – Fluorescent tubes and neon light bulbs consist of plasma
- The neon bulbs contain neon gas and there is another gas such as helium in the fluorescent tube. As electricity is passed in the tube or the bulb, these gases get ionized and this creates the plasma inside them that glows.
- In fact, the Sun and the stars glow because plasma is present in them. Here are some examples of plasma:

Bose-Einstein Condensate (BEC)

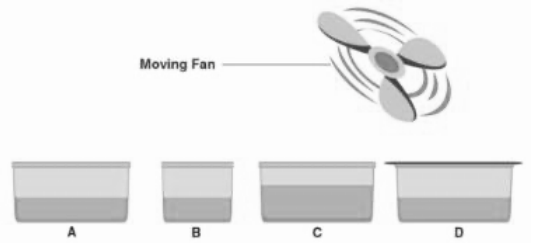
- It is the fifth state of matter discovered by Albert Einstein on the basis of the studies conducted by an Indian scientist Satyendra Nath Bose.
- BEC is formed by condensing gases of extremely low densities to much lower temperatures.

Solved Examples

(1) **Water as ice has a cooling effect, whereas water as steam may cause severe burns. Explain these observations.**

Answer: Water as ice has less energy and water molecules absorb energy from our body to give cooling effect, whereas steam has high energy and transfers high energy into our body which transforms as heat to cause burns.

(2) **Look at Fig. 1.3 and suggest in which of the vessels A, B, C or D, the rate of evaporation will be the highest? Explain.**



Answer: (C) because evaporation increases with increase in the surface area. With increase in wind speed particles of water vapour will move away hence and the rate of evaporation will be the highest.

(3) **Alka was making tea in a kettle. Suddenly she felt intense heat from the puff of steam gushing out of the spout of the kettle. She wondered whether the temperature of the steam was higher than that of the water boiling in the kettle. Comment.**

Answer: Steam and the water temperature boiling in the kettle is the same. But the particles of steam have more energy in the form of latent heat of vaporization than the particles of water. This energy is released when the steam condenses to water. Therefore, steam is hotter than the boiling water.

(4) **(a) Conversion of solid to vapour is called sublimation. Name the term used to denote the conversion of vapour to solid.**
(b) Conversion of solid state to liquid state is called fusion; what is meant by latent heat of fusion?

Answer: (a) Freezing is the term used to denote the conversion of vapour to solid.
(b) The amount of heat energy released or absorbed when a solid change to liquid at atmospheric pressure at its melting point is known as the latent heat of fusion.

(5) **A sample of water under study was found to boil at $102^{\circ}C$ at normal temperature and pressure. Is the water pure? Will this water freeze at $0^{\circ}C$? Comment.**

Answer: Boiling point of pure water is $100^{\circ}C$ and melting point is $0^{\circ}C$ at 1 atmospheric pressure. Here the water boils at $102^{\circ}C$. it is not a pure water and freezes at temperature below $0^{\circ}C$.

(6) **'Osmosis is a special kind of diffusion'. Comment.**

Answer: Diffusion in liquids and gases is the movement of particles from low concentration to high concentration. Osmosis is the movement of particles from the low concentration to high concentration through the semi-permeable membrane. This movement happens due to diffusion. Hence, Osmosis is a special kind of diffusion.

(7) **You want to wear your favorite shirt to a party, but the problem is that it is still wet after a wash. What steps would you take to dry it faster?**

Answer:

- Drying of clothes is due to the process of evaporation, hence, the following steps should be taken to dry the shirt faster.
- Dry the shirt under fan with high speed. With increase in speed of fan water vapour moves away with wind. This decreases water vapour in the surroundings which will increase the evaporation and the shirt gets dried faster.
- Spread the shirt on a hanger which will increase surface area. Increase in surface area makes the shirt dry quickly.
- Dry the shirt in sunlight. Because of high temperature more water vapour gets kinetic energy to get converted to vapour. This will fasten the process of evaporation and the shirt will dry easily.
- Iron the shirt. Heat increases the speed of vaporization and evaporation. This will make the shirt will dry faster.

(8) **Why does the temperature of a substance remain constant during its melting point or boiling point?**

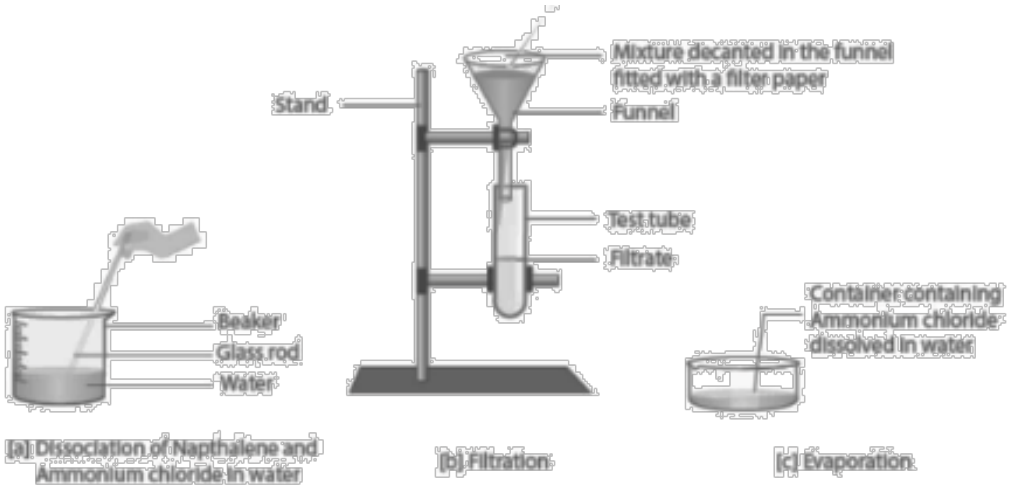
Answer: The temperature of a substance remains constant during melting and boiling points till the completion of melting and boiling because of latent heat of fusion used by the substances. Latent heat of fusion helps to overcome the force of attraction between particles of solid to change into liquid when they melt. Hence temperature remains constant.
Similarly, during formation of vapours latent heat helps solid substances to convert into gaseous state. Hence temperature of a substance remains constant at boiling point.

(9) **It is a hot summer day. Priyanshi and Ali are wearing cotton and nylon clothes respectively. Who do you think would be more comfortable and why?**

Answer: Hot summer leads to a lot of sweating. Cotton will absorb moisture whereas Nylon will not absorb moisture as efficiently as cotton. Hence cotton absorbs the sweat faster that Nylon does. Evaporation of moisture from the cotton cloth will give a cool feeling, especially when wind flows. Hence, It can be concluded that Priyanshi will be more comfortable in summer days.

(10) **You are provided with a mixture of naphthalene and ammonium chloride by your teacher. Suggest an activity to separate them with a well-labelled diagram.**

Answer: Naphthalene is a non-polar compound which will not dissolve in water. Similarly, ammonium chloride is a polar compound which is soluble in water. Naphthalene is volatile at a room temperature whereas ammonium chloride is volatile at high temperature. The mixture of naphthalene and ammonium chloride can be separated by decantation of an aqueous mixture. Naphthalene remains undissolved in water and can be taken out in a funnel. The filtrate of ammonium chloride can be evaporated to obtain dry ammonium chloride.



Exercise

OBJECTIVE TYPE QUESTIONS

(1) The quantity of matter present in an object is called its:
(A) Weight (B) Gram
(C) Mass (D) Density

(2) In which phase of matter would you expect compound (alcohol exists) at room temperature?
(A) Solid (B) Liquid
(C) Gas (D) Plasma

(3) As of the 1990s, scientists have proved the existence of how many states of matter?
(A) Two (B) Three
(C) Four (D) Five

(4) Rate of diffusion of a gas is:
(A) Directly proportional to its density
(B) Directly proportional to its molecular mass
(C) Inversely proportional to the square root of its density
(D) Inversely proportional to the square root of its molecular mass

(5) Equal volumes of all gases under similar conditions of temperature and pressure contain equal numbers of molecules. This statement was made by:
(A) Gay- lussac (B) Avogadro
(C) Berzilius (D) John Dalton

(6) Which of the following phenomena would increase on raising the temperature?
(A) Diffusion, evaporation, compression of gases
(B) Evaporation, compression of gases, solubility
(C) Evaporation, diffusion, expansion of gases
(D) Evaporation, solubility, diffusion, compression of gases

(7) Seema visited a Natural Gas Compressing unit and found that the gas can be liquefied under specific conditions of temperature and pressure. While sharing her experience with friends she got confused. Help her to identify the correct set of conditions.
(A) Low temperature, low pressure
(B) High temperature, low pressure
(C) Low temperature, high pressure
(D) High temperature, high pressure

(8) The property of flow is unique to fluids. Which one of the following statements is correct?
(A) Only gases behave like fluids
(B) Gases and solids behave like fluids
(C) Gases and liquids behave like fluids
(D) Only liquids are fluids

(9) During summer, water kept in an earthen pot becomes cool because of the phenomenon of
(A) Diffusion (B) Transpiration
(C) Osmosis (D) Evaporation

(10) A few substances are arranged in the increasing order of 'forces of attraction' between their particles. Which one of the following represents a correct arrangement?
(A) Water, air, wind (B) Air, sugar, oil
(C) Oxygen, water, sugar (D) Salt, juice, air

Answer Key

OBJECTIVE TYPE QUESTIONS

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(C)	(B)	(D)	(D)	(B)	(C)	(C)	(C)	(D)	(C)