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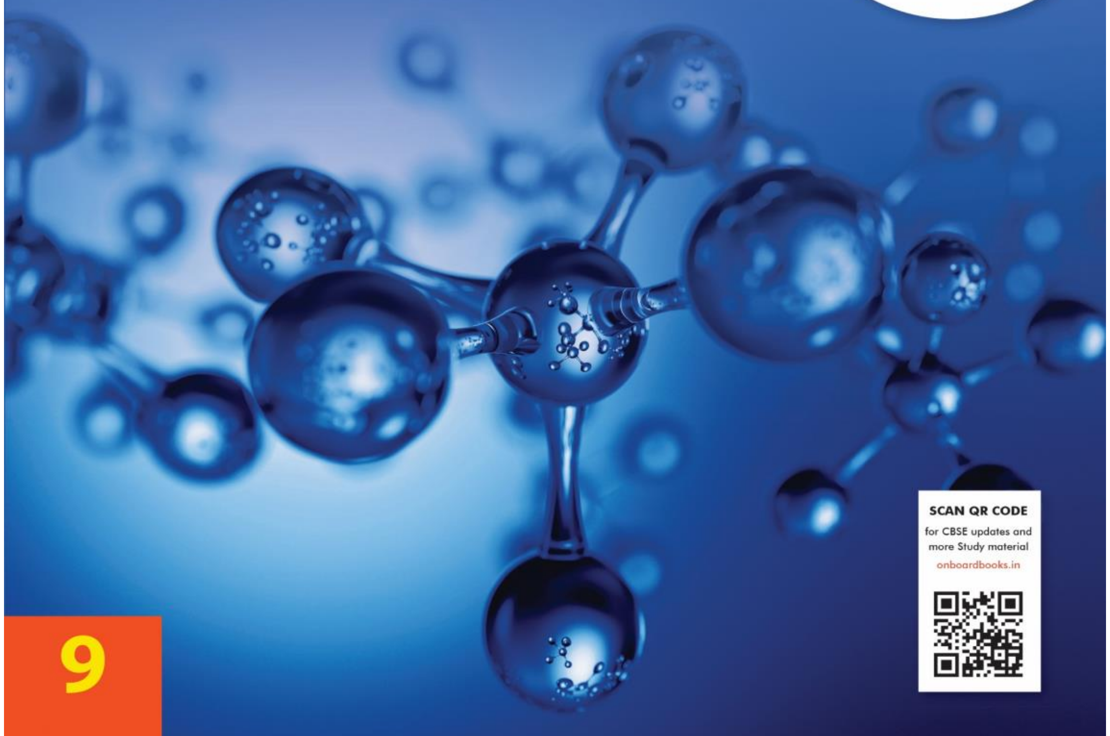

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CBSE LIVING SCIENCE CHEMISTRY

CLASS 9

Chapter 1

Matter in Our Surroundings

Learning Objectives

- ❖ Matter
- ❖ Definition of matter
- ❖ Characteristics of matter
- ❖ Classification of matter
- ❖ Solids, liquids and gases
- ❖ Change of state – melting, boiling, evaporation, condensation, sublimation
- ❖ Cooling by evaporation
- ❖ Absorption of heat by materials

INTRODUCTION

Everything in this universe is made up of materials. Scientifically, the term ‘matter’ is used for material. Material or matter exists in different shapes, sizes and textures. For example, fabric, wood, water, rock, plastic, rubber, leather, food, etc.

While the transformation of matter to energy can be seen, the transformation of energy to matter cannot be seen. The discovery of relationship between energy and matter ($E = mc^2$), and of interaction between energy and matter has been of lasting importance.

These processes occur in nature and in our daily life at every moment. In order to know more about these interrelationships and the proper utilisation of energy for the benefit of mankind, and to know the world around us, we need to know about the matter in greater detail.

MATTER

Matter is defined as something which occupies space, possesses mass and offers resistance to any stress applied on it. Some examples of matter are sugar, wood, plastic, rubber, clothes, air, petrol, vegetable oil, etc.

Particulate Nature of Matter

All forms of matter consist of small particles. The particles of matter have space between them and they move continuously.

How Small are the Particles of Matter?

Matter is made up of extremely small particles known as atoms, which cannot be seen even with a powerful microscope. With a microscope, we can actually see an aggregate of tiny particles. The smallest particle of a matter which is capable of independent existence and exhibits the properties of matter is called molecule.
The diameter of the molecules of matter, in general, is of the order of 10^{-9} m.

Characteristics of Particles of Matter

1. The particles of matter are moving continuously, thus, they possess kinetic energy. Also, they can intermix on their own with each other. With the increase in temperature, the kinetic energy of particles of matter increases and hence, they move even faster.

The average speed of particles of matter at any particular temperature depends on the intermolecular forces of attraction between them. The stronger the intermolecular attractive forces, the lower is the average speed of the particles.

2. The particles of matter attract each other and they are held together by strong intermolecular forces of attraction. The strength of attractive forces differs from one kind of matter to another.

3. The particles of matter have minute space between them. These empty spaces are called voids.

Diffusion of Matter

The phenomenon of intermixing of particles of two or more different types of substances on their own is called diffusion. Some examples of diffusion are:

- The fragrance of perfumes can be felt from a distance because of the diffusion of vapours of perfumes in the air.
- The aroma of burning incense sticks can be felt from a distance because of the diffusion of smoke particles in the air.

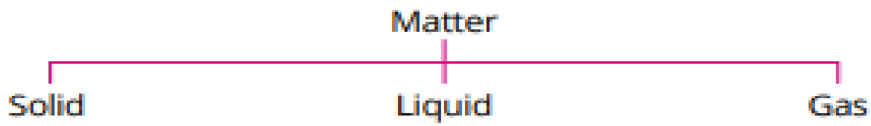
Rate of Diffusion

In gases, the rate of diffusion is very high, as the particles of gases travel with high speed. The rate of diffusion increases with increase in temperature. This is because, with increase in temperature, the kinetic energy of the particles increases and they move faster. Diffusion of a solid into another solid substance is negligible due to the immobility of particles in solids.

Diffusion of a liquid into another liquid and that of a solid into a liquid is much slower than the diffusion of a gas into another gas.
Osmosis is the process in which the particles move from lower concentration to higher concentration through a semipermeable membrane.

CLASSIFICATION OF MATTER

On the basis of physical properties of matter, it is classified into three states, namely, solid, liquid and gaseous states.



Solid State

In solids, the particles are bound together by strong attractive forces and are closely packed which makes them hard and rigid. Solids have very low compressibility, and possess definite volume and definite shape. Examples of solids are iron, wood, glass, cane sugar, common salt, pencil, sponge, etc.

Liquid State

In liquids, the particles are bound to each other with the forces weaker than those in solids and are loosely packed. Liquids are relatively more compressible.

They have a tendency to flow but their fluidity is less than that of gases due to the stronger interparticle attractive forces. Liquids possess definite volume but no definite shape, i.e., a liquid takes the shape of the container in which it is kept. Examples of liquids are water, milk, petrol, benzene, etc.

Gaseous State

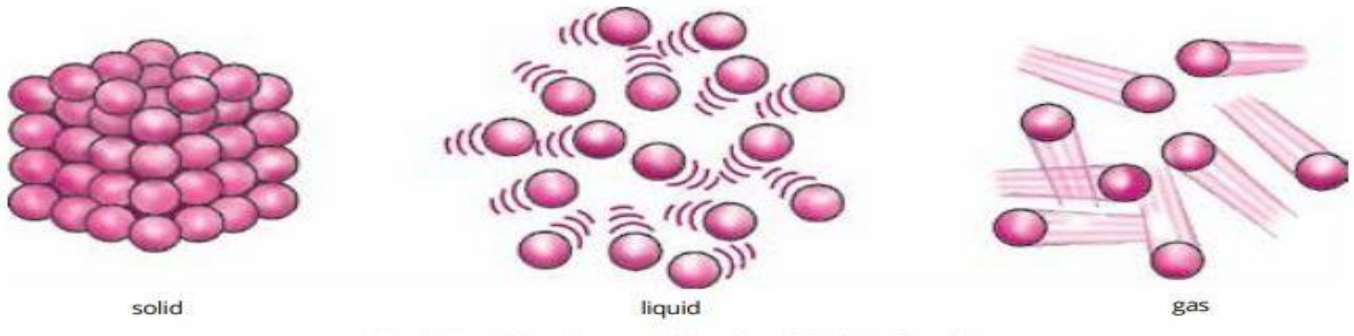
In gases, there are no interparticle attractive forces and the particles are separated from each other by much greater distances. Gases do not have a definite shape and volume. A gas occupies the volume of the container in which it is kept. The particles in the gases are very loosely packed and they can move around freely. The gaseous particles move randomly in different directions until they collide with one another or with the walls of the container. This makes gases shapeless and highly compressible. Compressed natural gas (CNG) is used as a fuel in vehicles as it is highly compressible and lighter than air. Liquefied petroleum gas (LPG) which is used in our houses for cooking is another example of compressed gas.

Gases have high fluidity and less rigidity due to the presence of large interparticle empty spaces and weak interparticle forces of attraction. Some common examples of gases are hydrogen, nitrogen, oxygen, carbon dioxide, sulphur dioxide, nitrogen dioxide, etc.

A comparison of the properties of solids, liquids and gases is given in the table below.

Property	Solid	Liquid	Gas
1. Shape and volume	Solids have a definite shape and volume.	Liquids do not have a definite shape but have a definite volume.	Gases do not have definite shape and volume.
2. Compressibility and hardness	Solids are hard, rigid and have very low compressibility.	Liquids are relatively more compressible than solids.	Gases have high compressibility.
3. Density (mass per unit volume)	Solids possess high density.	Liquids are less dense than solids.	Gases possess very low density in comparison to liquids and solids.
4. Diffusion (free mixing of molecules)	Due to close-packed structure the particles in solids are immobile and do not diffuse.	Liquids undergo slow diffusion.	Gases undergo diffusion freely.
5. Kinetic energy	Solid particles exhibit least kinetic energy.	Liquid particles exhibit lower kinetic energy than gas particles.	Gas particles exhibit the highest kinetic energy.
6. Rigidity/fluidity	Solids possess rigidity.	Liquids possess fluidity which is less than that of gases.	Gases possess highest fluidity.
7. Motion of particles	Particles do not exhibit freedom of motion. They only vibrate about their mean positions.	Particles exhibit greater freedom of motion. They possess translational, rotational and vibrational motions.	Particles exhibit maximum freedom of motion. They possess large translational, rotational and vibrational motions.
8. Interparticle attractive forces	Interparticle attractive forces are the strongest.	Interparticle attractive forces are weaker than solids but stronger than gases.	Interparticle attractive forces are the weakest.

Molecular Arrangements of Different States of Matter



Molecular arrangements in solid, liquid and gas

- Solids have the most orderly arrangement of molecules because the molecules are held together by strong intermolecular attractive forces. This is why, solids are rigid, incompressible, have high density, fixed volume and do not possess the ability to flow. The molecules of a solid cannot move freely and can only vibrate about their mean positions.

- In liquids, due to the presence of relatively weaker intermolecular forces, molecules are somewhat loosely packed. In liquids, layers of molecules can slip and slide over each other. Hence, liquids have a slightly disordered arrangement of molecules.

- In case of gases, due to the presence of extremely weak intermolecular forces, molecules are wide apart from one another and free to move randomly in any direction with high speed. This is why, in gases there is no order in the arrangement of molecules.

Factors governing the states of matter

The intermolecular attractive forces are responsible for bringing the molecules closer while the motions of the molecules tend to move them away from each other. The physical state of a matter depends on the net effect of these two opposing factors. When the intermolecular attractive forces are very strong and kinetic energy is very small, the matter exists as a solid. When the intermolecular attractive forces are strong and the kinetic energy is large enough for the molecules to move to-and-fro, the matter exists as a liquid. When the intermolecular attractive forces are negligible and the kinetic energy is very large, the matter exists as gas.

Scales of measuring temperature

There are three scales on which the temperature of a system is measured. These are:

a. Celsius scale (°C), b. Fahrenheit scale (°F) and c. Kelvin scale (K).

Celsius scale: In the Celsius scale, the freezing point of water is taken as 0 °C while the boiling point of water is taken 100 °C.

Fahrenheit scale: In the Fahrenheit scale, the freezing point of water is taken as 32 °F while the boiling point of water is taken as 212 °F. The Celsius and Fahrenheit scales are related to each other by the following relation:

$°F = 9/5\ (°C) + 32$

Kelvin scale is the best scale for measuring temperature because it has no negative sign

INTERCONVERSION OF STATES OF MATTER

In solids, liquids and gases, the intermolecular forces of attraction are strong, moderate and negligible, respectively. The increasing order of intermolecular attractive forces in some solids, liquids and gases is as follows:

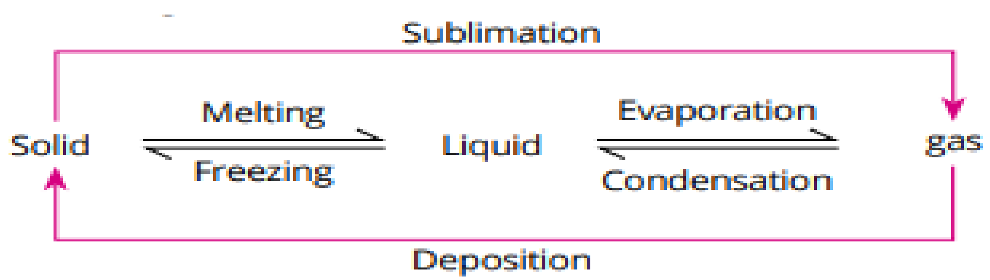
Carbon dioxide(g) < alcohol(l) < water(l) < sugar(s) < sodium chloride(s)

weakest **strongest**

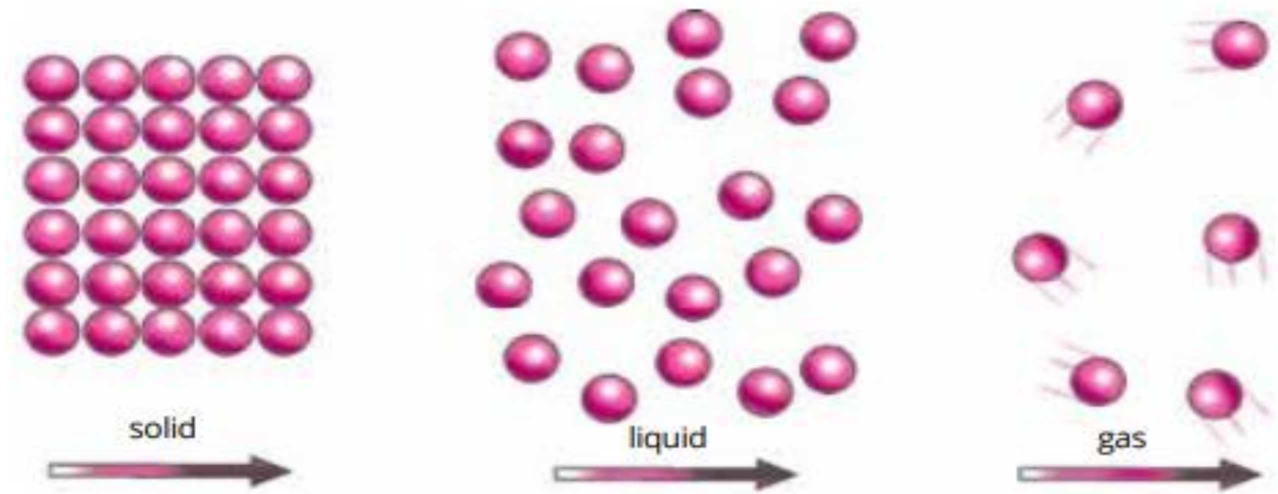
Effect of change of temperature

On increasing the temperature (or heating), the speed of particles increases which results in change of state of matter.

The interconversion of the three states of matter is shown in the figure below.



The effect of heat on the interparticle spacing and physical states of matter is shown in the figure below.



Effect of heat on the interparticle spacing in different physical states of matter

Melting and Boiling Points

The temperature at which a solid changes into a liquid is called the **melting point** of the solid. The strength of intermolecular forces of attraction present in a solid can be predicted by its melting point. Ice melts at 0 °C (273 K).

On further increase in temperature, a stage is reached when the molecules have enough kinetic energy to overcome the intermolecular forces of attraction. At this temperature, the liquid gets converted into gas.

The temperature at which a liquid changes into a gas (or vapour) is called the **boiling point** of the liquid.
As the particles from the bulk of a liquid gain enough energy to change into vapour state, boiling is considered as a bulk phenomenon. Water boils at 100 °C (373 K).
The process in which vapour on cooling get converted into liquid is called **condensation** or **liquefaction**.

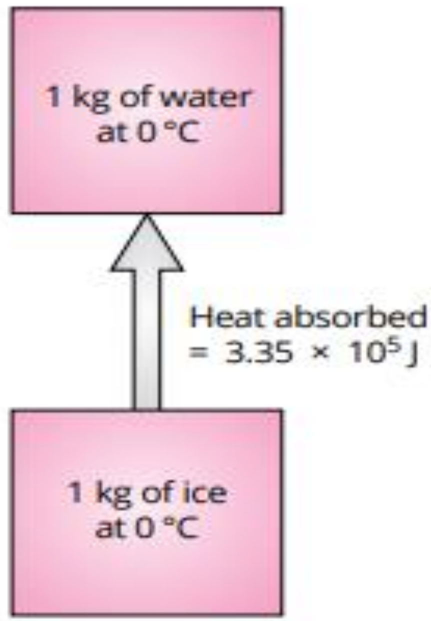
Now, the heat supplied to the substance during melting and boiling is used up in changing the state by overcoming the intermolecular forces of attraction between the molecules and hence it does not cause a rise in temperature. Hence, temperature remains constant during melting or boiling. The heat supplied during melting and boiling remains hidden in the contents in the apparatus and is called the latent heat (latent means hidden).

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 without any change of temperature is called the **latent heat of fusion**. The SI unit of latent heat of fusion is J kg^{-1}.

Latent heat of fusion of ice: The quantity of heat energy required to change 1 kg of ice into water at atmospheric pressure at its melting point (0°C) without any change of temperature is called the latent heat of fusion of ice. The value of latent heat of fusion of ice is 3.35×10^5 J kg^{-1}. Thus, the energy of 1 kg of water at 0 °C is 3.35×10^5 J more than that of ice at the same temperature.

In the process of fusion, 1 kg of ice at 0°C is able to withdraw from the surroundings 3.35×10^5 J more heat energy than 1 kg of water at the same temperature (0°C) could do. Hence, at 0 °C, ice is more effective in cooling than the same quantity of water at the same temperature (0°C).



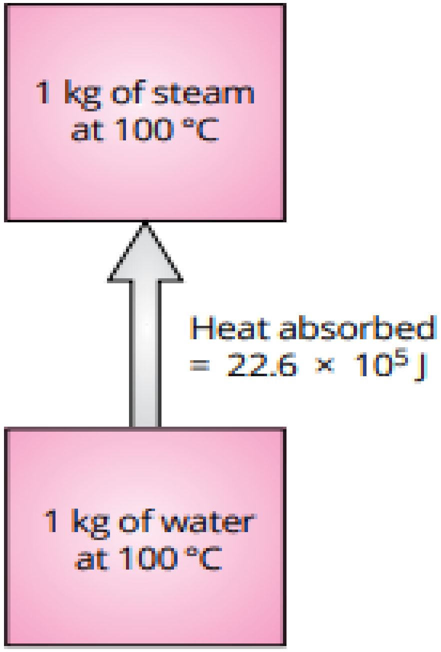
Latent heat of vaporisation

The amount of heat energy required to change 1 kg of a liquid into vapour at atmospheric pressure at its boiling point without any change in temperature is called the latent heat of vaporisation. The SI unit of latent heat of vaporisation is J kg^{-1}.

Latent heat of vaporisation of water: Latent heat of vaporisation of water is the amount of heat energy required to change 1 kg of water into vapour at atmospheric pressure at the boiling point of water without any change of temperature. The value of latent heat of vaporisation of water is 22.6×10^5 J kg^{-1}. Thus, the energy of 1 kg of steam at 100 °C is 22.6×10^5 J more than that of water at the same temperature (100 °C).

This means that steam at 100 °C is a more effective heating agent than water at the same temperature (100 °C). It also means that when 1 kg of steam at 100 °C is condensed to 1 kg of water at 100 °C heat energy equal to 22.6×10^5 J is given out.

The latent heat of vaporisation of ethanol, diethyl ether and mercury is 8.5×10^5 J kg^{-1}, 3.9×10^5 J kg^{-1} and 2.8×10^5 J kg^{-1} respectively.



Sublimation

Sublimation is defined as a process in which a solid on heating, changes directly into the vapour phase without passing through the intermediate liquid state.
Some examples of sublimable solids are naphthalene, dry ice (solid CO_2), ammonium chloride, etc.

Effect of change of pressure

On increasing the pressure, the particles of matter come closer and the distance between the particles decreases while the force of attraction between them increases. Hence, increase or decrease in pressure can change the state of matter.

Dry ice (solid CO_2) gets directly converted to gaseous CO_2 when pressure is decreased to 1 atm. This is the reason why dry ice is stored under high pressure. Gases can be liquefied by increasing the pressure and decreasing the temperature.

EVAPORATION

The phenomenon of change of a liquid into vapour at any temperature below the boiling point of the liquid is called evaporation. It is an endothermic process.
The examples of evaporation are:
1. Drying of wet clothes
2. Change of liquid water into water vapour when left uncovered

Factors affecting the rate of evaporation

Some of the factors that affect the rate of evaporation are:

1. **Surface area:** Evaporation, being a surface phenomenon, increases with increase in surface area. For example, wet clothes dry faster on spreading than when folded.
2. **Temperature:** Rate of evaporation increases with increase in temperature. We know that, increase in temperature increases the kinetic energy of the molecules, facilitating them to change into the vapour state.
3. **Humidity:** Humidity is defined as the amount of water vapour present in the air. At a particular temperature, the air cannot hold more than a definite amount of water vapour. Hence, a higher humidity in the air decreases the rate of evaporation.
4. **Speed of Wind:** An increase in the speed of wind causes vapour particles to move away. It decreases the amount of water vapour in the surroundings. This results in increase in the rate of evaporation. For example, on a windy day, wet clothes dry faster.

Cooling by evaporation

Evaporation is a cooling process because when vaporisation occurs, the evaporating vapours carry away the heat. The liquid particles absorb energy from the surroundings in order to regain the energy lost during evaporation. As a result, the surrounding becomes cooler. During summer, water kept in an earthen pot becomes cool due to evaporation through tiny pores on its surface.

Evaporation of sweat from our body also causes cooling. When sweat evaporates, it absorbs energy from our body equal to the latent heat of vaporisation of water. This keeps our body cool.
The human body undergoes evaporative cooling by perspiration even when surrounded by a temperature higher than the body temperature. You might have observed that when you perspire it feels cool. Perspiration is the insensate loss of moisture from the skin due to evaporation.

Why do people sprinkle water on the open ground or roof after a hot sunny day?

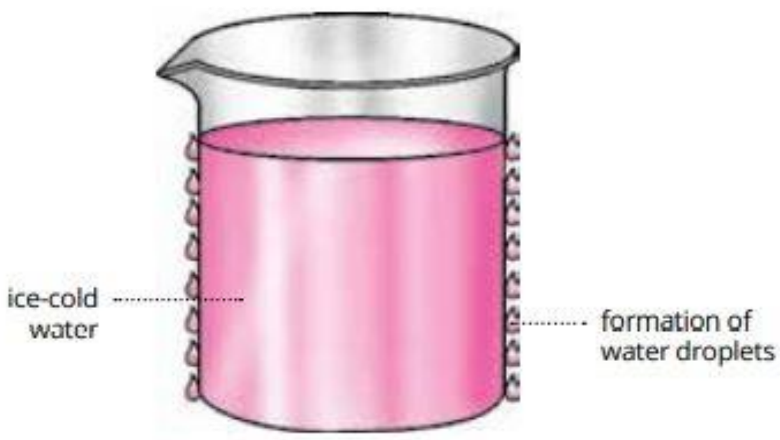
The sprinkling of water on the open ground or roof causes the water molecules to absorb energy from the open ground, roof and surroundings and to get evaporated. The evaporation of water causes a cooling effect since it makes use of the very large latent heat of vaporisationof water (22.6×10^5 J kg^{-1}).

Why does our palm feel cold when we put some acetone, ethyl alcohol, petrol or perfume on it?

The particles present in acetone (nail polish remover), ethyl alcohol, petrol or perfume absorb energy from our palm or surroundings and evaporate causing the palm to feel cold.

Formation of water droplets on the outer surface of beaker containing ice-cold water

When ice-cold water is kept in a beaker for a few minutes, water droplets are formed on the outer surface of the beaker. This is because the water vapours present in air come in contact with the cold outer surface of glass, lose energy and are condensed into water droplets on the outer surface of the beaker.



Formation of water droplets on the outer surface of a beaker containing ice-cold water

SUMMARY

1. **Matter:** Matter is something which occupies space, possesses mass and offers resistance to any stress applied on it. Matter exists in three physical states such as solid, liquid and gas.
2. **Solids:** Solids have definite shape and volume and are rigid and incompressible. Solids have any number of surfaces. Due to the presence of strong intermolecular attractive forces, the constituent particles in solids are held closely in fixed positions.
3. **Liquids:** Liquids have definite volume but no definite shape. Liquids have only one upper surface. In liquids, the constituent particles are packed loosely.
4. **Gases:** Gases neither have a fixed shape nor a fixed volume. Gases have no surface. In gases, the constituent particles are far away from each other and are free to move randomly with high speeds in all directions.
5. **Change of state:** The states of matter are interconvertible. The states of matter are changed by changing pressure or temperature or by changing both temperature and pressure.
6. **Evaporation:** The phenomenon of change of a liquid into vapours at any temperature below the boiling point of the liquid is called **evaporation**. Evaporation is a surface phenomenon. Evaporation causes cooling.
7. **Sublimation:** The process during which a solid on heating changes directly into vapour without passing through the intermediate liquid state is called **sublimation**.
8. **Boiling point:** The temperature at which a liquid changes into vapour at the atmospheric pressure is called the **boiling point** of the liquid. Boiling is a bulk phenomenon.
9. **Melting point:** The temperature at which a solid changes into a liquid is called the **melting point** of the solid.
10. **Latent heat of vaporisation:** The amount of heat energy required to change 1 kg of a liquid into gas at atmospheric pressure at its boiling point is called **latent heat of vaporisation**. The SI unit of latent heat of vaporisation is J kg^{-1}. The value of latent heat of vaporisation of water is 22.6×10^5 J kg^{-1}.
11. **Latent heat of fusion:** The amount of heat energy required to change 1 kg of solid into liquid at atmospheric pressure at its melting point is called **latent heat of fusion**. The SI unit of latent heat of fusion is J kg^{-1}. The value of latent heat of fusion of ice is 3.35×10^5 J kg^{-1}.

MIND MAP

MATTER IN OUR SURROUNDINGS

MATTER

- occupies space and possesses mass
- offers resistance to any force applied
- made up of particles

CHARACTERISTICS OF PARTICLES OF MATTER

- they are continuously moving
- they have space between them
- they attract each other

STATES OF MATTER

Solids

- have definite shape and volume
- hard to compress and rigid
- closely packed arrangement of particles
- strong interparticle attractive forces

Liquids

- have no definite shape but have definite volume
- low compressibility and possess fluidity
- loosely packed arrangement of particles
- weak interparticle attractive forces

Gases

- have no definite shape and volume
- high compressibility and highest fluidity
- particles are free to move
- weakest interparticle attractive forces

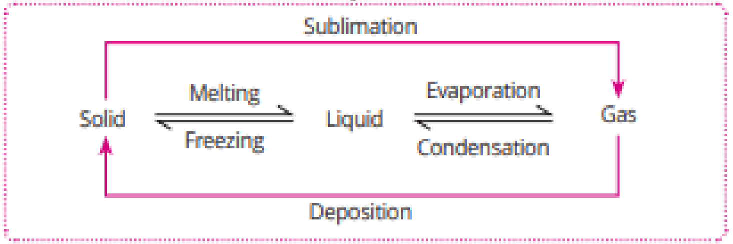
Plasma

- matter consists of a gas carrying electrical charge
- form in stars due to very high temperature

Bose – Einstein Condensate

- created by cooling a gas with very low density to super low temperatures

INTERCONVERSION OF STATES OF MATTER



FACTORS AFFECTING THE RATE OF EVAPORATION

- surface area
- temperature
- humidity
- wind