Matter: - Anything which occupies space and has mass is called matter, so everything in the universe is "matter".

Physical nature of matter :-

(1) Matter is made up of particles

(2) The constituent particles of matter are extremely small in size

Characteristics of particles of matter :-

1) **Particles of matter have space between them**
2) **Particles of matter are continuously moving:** They possess the kinetic energy. As the temperature rises, particles move faster. So, with increase in temperature the kinetic energy of the particles also increases. When two different forms of matter are brought in contact, they intermix spontaneously. This intermixing is possible due to motion of the particles of matter and also due to the spaces between them. This intermixing of particles of two different types of matter on their own is called diffusion. On heating diffusion becomes faster.
3) **Particles of matter attract each other:** There are some forces of attraction between the particles of matter which bind them together. The force of attraction between the particles of the same substance is known as **cohesion.** The force of attraction (or cohesion) keeps the particles together. The strength of this force of attraction varies from one kind of matter to another.

Diffusion: This spontaneous intermixing of particles of two different types of matter is called diffusion

- This intermixing is possible due to
  - motion of the particles of matter
  - the spaces between them
- The rate of diffusion becomes faster with increase in temperature because at higher temperature, the particles have more kinetic energy and hence move faster.
- Diffusion occurs fastest in gases because the particles in gases move very rapidly. The diffusion is slowest in solid because the particles in solids do not move much. Diffusion in liquids is however faster than solid and slower than that in gases.

Kinetic Molecular Theory of Matter

The kinetic theory of matter explains the behaviour of the atoms and molecules in solids, liquids and gases. The kinetic molecular theory of matter states that:

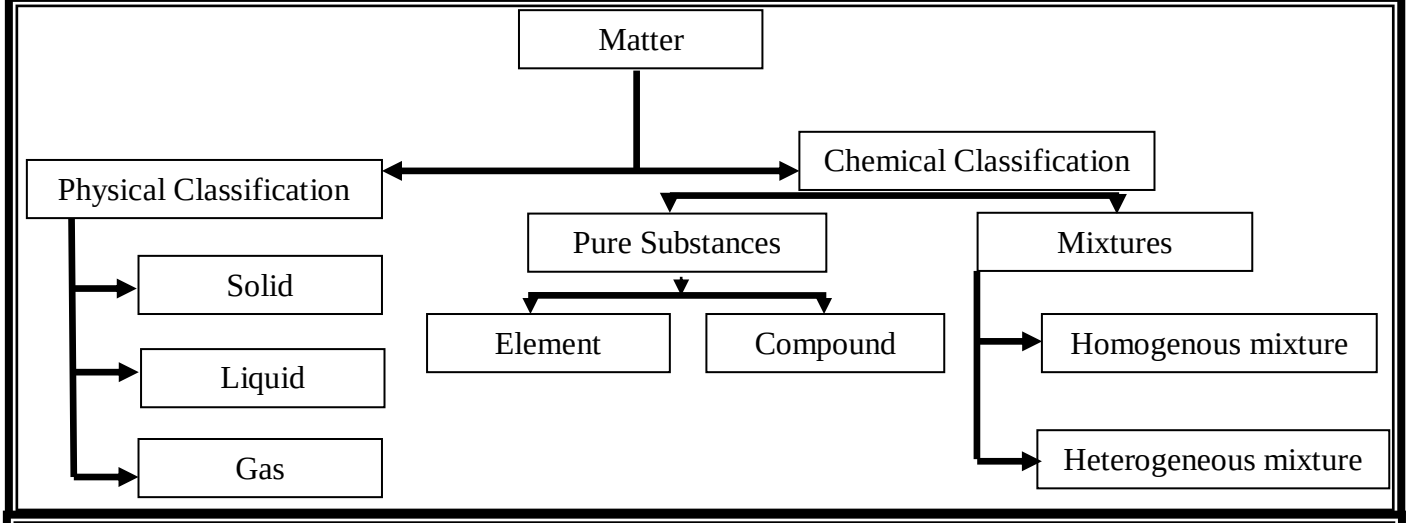
- Matter is made up of particles that are constantly moving.
- All particles have energy. Particles in the solid phase have the least amount of energy, while gas particles have the greatest amount of energy.
- The temperature of a substance is a measure of the average kinetic energy of the particles.
- A change in phase may occur when the energy of the particles is changed.
- There are spaces between particles of matter. Particles in the gas have a high amount of space, while solids molecules have the least amount of space
- There are attractive forces between atoms/molecules, and these become stronger as the particles move closer together. These attractive forces are called intermolecular forces.

Basis of Classification of Types of Matter

- Based upon particle
- Based upon energy of particles
- Based upon distance between particles

Five states of matter

- Solid
- Liquid
- Gas
- Plasma
- Bose-Einstein condensate



Basis of Molecular structure of Solid, Liquid and Gas

	Solid	Liquid	Gas
Intermolecular force of attraction	Solid have very strong Intermolecular force of attraction so the particles are closely packed and makes solid strong, hard and rigid	Intermolecular force of attraction are strong enough to keep molecules of particle together but not strong enough to keep them in fixed positions	Negligible intermolecular force of attraction and particles are
Intermolecular Space	Very less or negligible intermolecular spaces between the particles	Moderate intermolecular space (More than solid) between the particles	Maximum intermolecular spaces are available between the particles.
Kinetic energy	Posses very low kinetic energy	High kinetic energy, more than that of solid	KE of molecules of gases is maximum and move randomly at a high speed

Different states of matter and their properties

Rigidity: Rigidity means inflexible. A solid is rigid form of matter, hence it does not require container to keep it.

Fluidity: Material which can flow easily and requires a vessel to keep it. A liquid is a fluid form of matter which takes shape of container while a gas fills the container.

Property	Solids	Liquids	Gases
Mass	Definite mass	Definite mass	Definite mass
Volume	Definite volume	Definite volume	No definite volume
Shape	Definite shape	No definite shape, takes the shape of the container	No definite shape
Density	High density	Lesser density than solid	least density
Compressibility	Incompressible	Almost incompressible	Highly compressible
Nature	Very hard and Rigid	Fluid (can flow)	Highly fluid
Free surface	Any number of free surfaces	One free surface i.e only the upper surface	No free surface
Thermal Expansion	Very low	Higher than solids	Maximum
Diffusion	Negligible	Some liquid can diffuse spontaneously into other eg. water and alcohol while others do not diffuse eg. Oil and water	Gases diffuses spontaneously and rapidly

Plasma

- The state consists of super energetic and super excited particles.
- These particles are in the form of ionised gases and free electrons.
- A plasma is a very good conductor of electricity and is affected by magnetic fields.
- Plasma, like gases have an indefinite shape and an indefinite volume. Ex. Ionized gas

Eg: 1. Atom of gases in helium and neon bulb break into charged electron and ions, consequently plasma is formed which glows with a specific colour.
2. The sun and star glows due to presence of plasma created by high temperature.

Bose-Einstein condensate

- Fifth state of matter and is the main work Satyendra Nath Bose and Albert Einstein.
- **BEC** is a state of matter that can arise at very low temperatures.
- The BEC is all about molecules that are really close to each other (even closer than atoms in a solid).
- BEC was actually shown by Eric A. Cornell, Wolfgang Ketterle and Carl E. Wieman, three American scientists, in 2011 by cooling certain gases of extremely low density to a very low temperature called super low temperature.

Microscopic Explanation for Properties of Solids

Solids have a definite shape and a definite volume because the particles are closely packed	Solids do not flow easily because the particles cannot move/slide past one another	Solids are not easily compressible because there is little free space between particles

Microscopic Explanation for Properties of Liquids

Liquids are not easily compressible and have a definite volume because there is little free space between particles.	Liquids have an indefinite shape because the particles can slide past one another.	Liquids flow easily because the particles can move/slide past one another.

Microscopic Explanation for Properties of Gases

Gases are easily compressible because there is a great deal of free space between particles	Gases flow very easily because the particles randomly move past one another.	Gases have an indefinite shape and an indefinite volume because the particles can move past one another.

Microscopic Explanation for Properties of Plasmas

Plasmas have an indefinite shape and an indefinite volume because the particles can move past one another.	Plasmas are easily compressible because there is a great deal of free space between particles	Plasmas are good conductors of electricity & are affected by magnetic fields because they are composed of ions

Microscopic Explanation for Properties of BEC

Particles are less energetic than solids because Exist at very low temperature .	Particles are literally indistinguishable because they are locked into same space .	BEC shows super fluidity because Particles can flow without friction.

Interchange in states of matter

Matter can exist in three form which are interchangeable

- Solid, as ice ,
- Liquid, as the familiar water, and
- Gas, as water vapour.

Interconversion of states of matter can be achieved

- By changing the temperature
- By changing the pressure

Interconversion of state of matter

Physical behaviour of matter depends on molecular arrangement which can be changed by changing the condition of temperature and pressure, thus matter can be converted from one state to another state under suitable condition. His is also called as **phase transition**.

Effect of change in temperature on States

$$Solid \xrightarrow[(Increase\ in\ temperature)]{Melting} liquid \xrightarrow[(increase\ in\ temperature)]{Vaporization} Gas$$

$$Gas \xrightarrow[(Decrease\ in\ temperature)]{Condensation} Liquid \xrightarrow[(Decrease\ in\ temperature)]{Freezing} Solid$$

Solid to liquid change

Melting or Fusion: The process of conversion of solid state to liquid state is called melting or fusion. Melting is carried out by supplying heat energy to the solid state.

- Temperature at which a solid changes into liquid at atmospheric pressure is called **melting point** of substance.
- On increasing the temperature of solids, the kinetic energy of the particles increases. Due to the increase in kinetic energy, the particles start vibrating with greater speed. The energy supplied by heat overcomes the forces of attraction between the particles. The particles leave their fixed positions and start moving more freely. A stage is reached when the solid melts and is converted to a liquid.
- The melting point of a solid is an indication of the strength of the force of attraction between its particles. Higher the melting point, stronger is the force of attraction between the particles.

Factor effecting melting point

(i) Effect of pressure: The effect of pressure on the melting point of solid depends upon the nature of solid.

- Solid which expands on melting: The melting point increases with increases in pressure because an increase in pressure opposes expansion eg: Paraffin wax, Gold, Silver
- Solid which contracts on melting: The melting point decreases with increases in pressure because an increase in pressure favours contraction eg: Ice, Brass

Principle of regelation: Since ice is a solid which contracts on melting, its melting point decreases on increasing pressure. When two ice are pressed together, the ice at the interface melts due to application of pressure. When pressure is removed it solidifies again thereby joining to ice cubes. This Principle is called **regelation.**

(ii) Effect of impurities: Addition of impurities to a solid decreases the melting point of solid thereby allowing the substance to melt

Liquid to gas Change

Boiling or Vaporisation: The process in which a liquid substance changes into a gas on heating is called Boiling or Vapourisation.

- The temperature at which liquid boils and changes into a gas on heating at atmospheric pressure is called **Boiling point** of liquid.
- Boiling point of substance is the measurement force of attraction between the particles of the substance. The greater the force of attraction greater will be the boiling point.

Causes of conversion: When a liquid substance is heated, the heat energy make the particles vibrate vigorously. At boiling point the particles have sufficient kinetic energy to overcome the strong force of attraction which holds the particles of liquid together. This kinetic energy breaks the particles in individual units and thus the liquid evaporates to form gas.

Factor effecting boiling point

Effect of pressure: Boiling point of water increases with increase in pressure and decreases with decrease in pressure. Water boils at lower temperature than 100^{o}C at higher altitudes.

Effect of impurities: Impurities increases the boiling point of liquids. Eg: Sea water boils at temperature above 100^{o}C.

Gas to liquid Change: Condensation

The process of conversion of gas to liquid is called **condensation**

Condensation is reverse of vapourisation.

Causes of conversion: When the temperature decreases, molecules of gas lose its kinetic energy and become slower, when the speed of molecules decreases, the force of attraction between the molecules increases and molecules come closer to each other and gets converted into liquid.

Liquid to Solid Change: Freezing or Solidification

Freezing: The process of conversion of liquid state to solid state is called freezing. Freezing is carried out by extracting heat from the liquid substance.

The temperature at which a liquid freezes to become a solid at atmospheric pressure is called **freezing point.** Water freezes to form ice at 0^{o} C (273K), so 0^{o} C is the freezing point of water.

Causes of conversion: When a liquid substance is cooled by lowering the temperature, the particles lose energy due to which they start moving slowly. When liquid is cooled enough till its freezing point, its each particle stop moving and vibrate about a fixed point. This is the point when liquid change and become solid.

Effect of impurities: Impurities lowers the freezing point of liquids.

Sublimation: The process of converting a solid substance directly into gaseous state on heating, without passing through the liquid state and the gaseous state, directly change into solid state on cooling, is known as "Sublimation"

Example :- Ammonium chloride, camphor, iodine, naphthalene, solid carbon dioxide (dry Ice)

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.

The process due to which the gaseous state, directly change into solid state on cooling is called **deposition**

Causes of conversion: The solid having weak intermolecular force of attraction, when heated are directly converted into vapours (gaseous state) without being converted into liquid.
Small amount of energy is sufficient to make the intermolecular force of attraction negligible. It increases intermolecular distance to a very large extent making molecular arrangement like that in gases.

Application of Sublimation:

- Process of sublimation is helpful in purification of solids which sublime on heating and contain non-volatile impurities
- Freeze-dried foods prepared by sublimation can be stored for long time

Effect of change of pressure :-

Solid –There is no effect of pressure on solids.

- Solids are non compressible, i.e. solids cannot be compressed as there is no space between their particles which could allow compression.
- When the pressure is increased on a solid, it is deformed and finally broken.

Liquid – There is no effect on pressure on liquid.

- Liquids are non compressible, i.e. liquids cannot be compressed since there is not enough space between their particles to get compressed.

Gas – The volume of gas decreases with increase in pressure.

- Gases are compressible because on applying pressure, the space between the gaseous particles decreases. Therefore gases can be compressed readily.
- By applying pressure and reducing temperature, the gases can be converted into liquids i.e. gases will be liquefied.
- **This process of conversion of a gas into a liquid by increasing pressure and decreasing temperature is called Liquefication.**
- On applying pressure, intermolecular space in the gases decreases and molecules come closer.
- Solid carbon dioxide which also called **dry ice** is converted directly to carbon dioxide gas by decreasing its pressure upto 1 atm without coming into liquid state.
- **Factors affecting liquefaction of gas:** Liquefaction of gas depends on two factors:
  - **Pressure:** On increasing the pressure, gas molecules come closer to each other and hence increasing the intermolecular forces and thus converting into the liquid state.
  - **Temperature:** On decreasing the temperature kinetic energy of gas molecules decreases, movement of gas molecules slows down. The slow-moving molecule comes closer to each other due to the intermolecular forces thus aggregating and converting into the liquid form.

The liquefaction of gas: To liquefy a gas, the molecules must be brought closer together. When the pressure on a gas is increased, the molecules get closer and closer until they merge to create liquids at a specific pressure.
When the temperature of a gas is lowered, however, the molecules lose kinetic energy, resulting in a decrease in velocity. Slow-moving molecules can't resist the force of attraction, so they get closer together to from a liquid.
The liquefaction of gases is caused by a decrease in temperature and an increase in pressure.
The **critical temperature** is the temperature at which a gas changes into liquid. The critical temperature of a gas is the temperature above which it is impossible to liquefy it with any amount of pressure. This temperature was the highest temperature at which a gas appears in the form of a liquid. It is the critical temperature or T_C.
The pressure required to liquefy the gas at critical temperature is called as the Critical pressure (P_C).

Latent Heat:

Latent heat is the energy required to change the state of a substance from solid to liquid and vice-versa as well as from liquid to gas and vice-versa, and from the solid state to the gaseous state and vice-versa without changing the temperature of the substance.

- Latent heat does not change the temperature of substance instead this temperature is used up to change the state of matter.
- The latent heat is used in changing the state by breaking the intermolecular force of attraction hence there is no increase in temperature till one states changes to another *completely*.
- There are two types of latent heat:
  1. Latent heat of fusion
  2. Latent heat of vaporisation

Why latent heat only change the state but not the temperature?

Every substance solid or liquid has some force of attraction between its particles which hold them together. When the substance changes its state (from solid to liquid, from liquid to gas) it has to break these attractive forces and so that the particles can move.

Basically, when heat is provided some heat break the attractive force and some heat is utilized in increasing the kinetic energy of particles. Latent heat is used to break the attractive force between particles and not to increase the kinetic energy so the state change but not the temperature.

Latent heat of fusion (solid to liquid change):It is the heat energy used in converting a substance from solid state to liquid state.

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".

- Latent heat of fusion of ice is 3.34×10^5 J/kg. 1 kg of ice at 0^o C will need 3.34×10^5 J to melt and become ice.
- When water at 0^o C converts in ice on freezing it gives out 3.34×10^5 J of energy.

Latent heat of vaporisation: It is the heat energy used in converting a substance from liquid state to gaseous state.

The latent heat of vaporization of a liquid is the quantity of heat in joule 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)

- 22.5×10^5 J energy is required to convert 1 kilogram of water into vapour. Hence gives out heat equivalent the latent heat of water (22.5×10^5 J/kg) when condenses to liquid.

Evaporation

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

Evaporation of a liquid can take place even at room temperature, though it is faster at higher temperatures. It is **surface phenomenon** because it occurs at surface of a liquid only.

Process of Evaporation: Some particles in a liquid always have more kinetic energy than the others. So even when a liquid is well below its boiling point, some of its particles have enough energy to break the force of attraction between the particles and escape from the surface of the liquid in the form of vapour (or gas). Thus, the fast moving particles (or molecule) of a liquid are constantly escaping from the liquid to from vapour (or gas).

Molecules at the surface of water posses higher kinetic energy than the molecules in the bulk of liquid. Because of increase in kinetic energy those molecules become able to overcome the force of attraction between the particles of liquid. After getting required kinetic energy and decrease in force of attraction, they escape in the air in the form of vapour. Additionally those kinetic energy get some of the required kinetic energy from their neighbouring molecules also because of which the temperature of the adjacent molecules decrease, which finally result in decrease of the temperature of surface of liquid.

Factors affecting the Evaporation:

- Temperature
- Surface area
- Humidity in air
- Wind speed
- Nature of liquids

Temperature: Evaporation increases with increase in temperature and decreases with decrease in temperature. This means rate of evaporation is directly proportional to the temperature.

With increase in temperature the particles of liquid at surface get required kinetic energy to overcome the force of attraction and escape in air quickly. Hence, the increase in temperature increases the rate of evaporation.

Surface Area: Evaporation increases with increase in surface area and decreases with decrease in surface area.

Since evaporation takes place at the surface of liquid only, hence if the more surface of liquid is exposed to atmosphere more particles will receive the required temperature to get the required kinetic energy to escape in air. Therefore, evaporation takes place more rapidly with larger surface area. This means rate of evaporation increases with increase in surface area and decreases with decrease in surface area.

Humidity in air: Evaporation decreases with increase in humidity and increases with decrease in humidity present in air. This means rate of evaporation is indirectly proportional to the humidity present in air.

Humidity is the amount of water vapour present in air. Because of more water vapour present in air the water holding capacity of atmosphere decreases which decrease the rate of evaporation. If air is dry then it can holds more water and thus in dry air rate of evaporation increases.

Nature of liquid: Some of the liquids such as alcohol, acetone, petrol etc evaporate faster than water. This is because intermolecular forces are weak in these liquids than in water. Such type of liquid are called volatile liquids and these have small latent het of vapourisation.