Matter in Our Surroundings

Matter

Matter is anything that has mass and occupies space. Examples of matter are iron, wood, oil, kerosene, petrol, rock, minerals, water, air, coal, etc. Matters are classified on the basis of physical and chemical properties. On the basis of physical properties, matter is classified as solid, liquid and gas. On the basis of chemical properties, matter is classified as elements, compounds and mixtures. Matter is made up of particles.

Characteristics of Particles of Matter

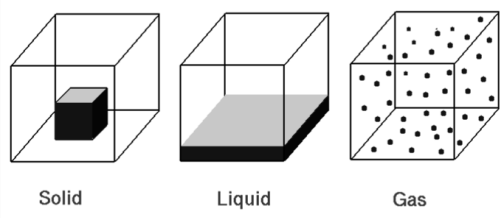
The various characteristics of particles of matter are:

- ❖ They are extremely small in size.
- ❖ They have spaces between them.
- ❖ They are constantly moving.
- ❖ They attract each other. The force of attraction between particles of same substance is known as cohesion. Particles of different matter exert different amount of force of attraction.

Classification of Matter on the Basis of Their Physical Properties

On the basis of physical properties, all the matters are classified into three groups namely solid, liquid and gas. In other words, it can be said that matter exists in three physical states namely solid, liquid and gas.

States of Matter



States of Matter

The following are the properties of three states of matter:

Solid

The various properties of solids are:

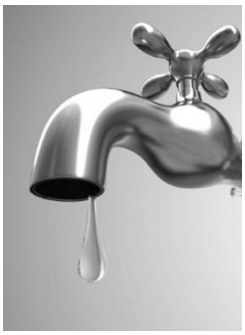
- ❖ They have fixed shape and fixed volume.
- ❖ They have closely packed particles. There is a strong force of attraction between the particles that holds them together in fixed position.
- ❖ They cannot be compressed.
- ❖ They have high density.
- ❖ They do not flow.

Stone (Solid)

Liquid

The various properties of liquids are:

- ❖ They have fixed volume but not fixed shape.
- ❖ They cannot be compressed much.
- ❖ They have closely packed particles, but not as closely packed as in solids.
- ❖ They have moderate to high density. Liquids are usually less dense than solids.
- ❖ The force of attraction between the particles is strong enough to hold the particles together, but not strong enough to hold them in fixed position.
- ❖ They generally flow easily.



Water (Liquid)

Gas

The various properties of gases are:

- ❖ They neither have fixed shape nor fixed volume. Gases take the shape and volume of the container in which they are kept.
- ❖ They have particles that are much farther apart from one another as compared to solid and liquids. The force of attraction between particles of gas is negligible, therefore; the particles can freely move in any direction.
- ❖ They can be compressed easily.
- ❖ They have very low densities. Gases are very light in weight.
- ❖ They flow easily. They move from higher concentration to lower concentration and this movement is called diffusion.

Air (gas) balloon

Changing the State of Matter

The three physical states of matter can be changed by changing the temperature and pressure.

Changing the State of Matter by Changing Temperature

The temperature can be increased by heating to change solid into liquid and liquid into gas. The temperature can be decreased by cooling to change gas into liquid and liquid into solid.

- **Changing solid state of matter to liquid state (Melting):** When a solid is heated sufficiently, it changes its physical state and becomes a liquid. The process, in which a solid substance changes into liquid on heating is called melting or fusion. For example, when ice is heated it changes into water.
  The temperature at which a solid substance melts at atmospheric pressure is called melting point of the substance. The higher the force of attraction between particles of a solid substance, the greater is the melting point of that substance. On heating solid substance, the particles of substance vibrate vigorously. When the melting point is reached, the particles of a solid have sufficient amount of kinetic energy to overcome the force of attraction holding the particles at fixed position. Therefore, the solid melts and turns into liquid state.

- **Changing liquid state of matter to gaseous state (Vapourisation):** When a liquid is heated sufficiently, it changes its physical state and becomes gas. The process, in which a liquid substance changes into a gas is called evaporation. For example, when water is heated it changes into water vapour.

  The temperature, at which a liquid changes its state to vapours at atmospheric pressure, is called boiling point of the liquid. On heating liquid substance, the particles of substance vibrate vigorously. When the boiling point is reached, the particles of a liquid have sufficient amount of kinetic energy to overcome the force of attraction holding the particles at its position. Therefore, the liquid boils and turns into gaseous state.

- **Changing gaseous state of matter to liquid state (Condensation):** When a gas or vapour is cooled sufficiently, it changes its physical state and becomes a liquid. For example, when steam or water vapour is cooled, it is converted into liquid water.
  On cooling, particles of gaseous substance lose kinetic energy, therefore; they vibrate slowly and move closer until the particles become attracted towards each other and form a liquid.

- **Changing liquid state of matter to solid state (Freezing):** When a liquid is cooled sufficiently, it changes its physical state and becomes a solid. For example, when water is cooled, it is converted into ice.

  On cooling particles of liquid substance lose kinetic energy, therefore; they stop moving and move closer until the particles become attracted towards each other and acquires a fixed position to turn into a solid.

  The heat given to a substance to change its physical state is called latent heat. Normally heat given to a substance rises the temperature of the substance, but in case when change in physical state of substance is involved, there is no rise in the temperature of the substance. The amount of heat energy required to change the state of a substance is called its latent heat. The latent heat does not increase the temperature of a substance because this heat is consumed for overcoming the forces of attraction between the particles of a substance during the change of state. Therefore, the kinetic energy of the particles of the substance is not increased. The latent heat can be of two types. They are:

Latent Heat of Fusion

The latent heat of fusion or melting of a solid is the amount of heat in joules required to convert 1 kilogram of solid to liquid without causing any change in temperature. For example, the latent heat of fusion of ice is 334 KJ per kg. Which is the amount of heat that converts ice into water without causing any increase in temperature.

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 liquid to vapour or gas without causing any change in temperature. For example, the latent heat of

vapourisation of water is 2258 KJ per kg which is the amount of heat that converts water into vapours without causing any increase in temperature.

Sublimation

When a solid directly changes into gas or vapour on heating and vapours changes directly to solid substance, on cooling, is called sublimation. For example, ammonium chloride undergoes sublimation. On heating, ammonium chloride changes directly into ammonium chloride vapour. When solids that undergo sublimation are heated, their particles move very quickly that they separate completely to form vapour or gas. When the vapour or gas is cooled, the particles of gas slow down very quickly and acquire fixed position to from a solid. Solid carbon dioxide or dry ice also undergoes sublimation. When dry ice is heated, it sublimes to form carbon dioxide gas. Another common example of substance that undergoes sublimation is naphthalene balls. Naphthalene balls disappear with time without leaving any residue behind. Few substances that undergo sublimation are ammonium chloride, iodine, camphor, naphthalene and anthracene.

Changing State of Matter by Changing Pressure

The physical state of matter can also be changed by changing the pressure. Gases can be changed into liquids by increasing pressure along with decreasing temperature. Similarly some solids such as solid carbon dioxide can be changed into gases on decreasing the pressure and increasing the temperature.

Classification of Matter on the Basis of Chemical Properties

On the basis of chemical properties the matter is classified into two Types namely pure substances and mixtures. The pure substances can be of two type namely elements and compounds.

Pure Substance

Pure substances are made of only one kind of particles. The particles can be atoms or molecules. For example, water is made up of only water molecule and therefore, water is a pure substance. Another example is sodium element which is made up of only sodium atom and therefore, is a pure substance. All elements and compounds are pure substances because they contain only one kind of particles. Thus, all the elements such as hydrogen, nitrogen, bromine, iodine, silver, etc. are pure substances. Similarly, all compounds such as water, carbon dioxide, hydrochloric acid, camphor, etc. are pure substances.

An element is made up of only one kind of atom. An element is a substance that cannot be broken down into two or more-simpler substances by the usual chemical methods of applying heat, light or electric energy. The elements can be in solid, liquid or gaseous state at room temperature.

On the basis of the properties of elements, they can be classified as:

Metals

Metals are elements that are malleable, ductile and conduct electricity. Metals have tendency to lose electrons. Some of the metals are zinc, silver, iron, potassium, mercury, uranium, etc. All metals are solids except mercury, which is a liquid.

The properties of metals are:

- **Malleable:** Metals can be beaten into thin sheets with a hammer. Gold and silver are some of the best malleable metals.

- **Ductile:** Metals can be drawn into thin wires. All metals are not equally ductile. Some metals are more ductile than the other metals. Copper and aluminium are also very ductile and can be drawn into thin wires that are used in electrical wiring.

- **Good conductor of heat and electricity:** Metals allow heat and electricity to pass through them easily. Metals are good conductors of heat. Silver metal is the best conductor of heat. Copper and aluminium metals are also very good conductors of heat. The poorest conductor of heat among metals is lead. Mercury metal is also a poor conductor of heat.

- **Lustrous:** Metals have shiny surface and can be polished. Shining surface of metals makes them good reflectors of light. Silver metal is an excellent reflector of light. Shiny appearance of metals makes them suitable for making jewellery and decorative pieces.

- **Hard:** Metals are hard except sodium and potassium, which are soft metals and can be cut with knife. The hardness varies from metal to metal. Metals such as iron. Copper and aluminium are very hard.

- **Strong:** Metals have high tensile strength. Metals can hold large weights without breaking. For example, iron metal in the form of steel is very strong and is used in the construction of bridges, machines, vehicles, etc. Sodium and potassium are metals that have low tensile strength.

- **Solid at room temperature:** All metals, except mercury, are solid at room temperature.

- **High melting and boiling point:** Most of the metals melt and vapourise at high temperatures. For example, iron has a high melting point of $1535^{o}C$ and copper has a melting point of $1083^{o}C$. However, few metals such as sodium and potassium have low melting point. Another metal gallium has an extremely low melting point, such that it starts melting in hand.

- **High density:** Metals have high densities and are heavy. Metals such as sodium and potassium are exception and have low densities and are light in weight.

- **Metals are sonorous:** Metals when hit make sound. This property makes them suitable for making bells, wires for stringed musical instruments such as violin, guitar.

Non Metals

Non-metals are elements that are neither malleable nor ductile and do not conduct electricity. Non-metals have tendency to gain electrons. All non-metals exist in solid or gaseous state except bromine which exists in liquid state at room temperature. Some examples of non-metals are neon, argon, krypton, xenon, etc.

The properties of mm metals are:

- **Non-metals are non-malleable:** Non-metals are brittle. They cannot be beaten into thin sheets and tend to break when hammered. Sulphur and phosphorous are solid non-metals that breaks when hammered.

- **Non-metals are non-ductile:** Non-metals cannot be drawn into wires. They break when stretched.

- **Non-metals are bad conductors of heat and electricity:** Non-metals do not allow heat and electricity to pass through them.

- **Non-metals are non-lustrous:** Non-metals have dull appearance. Iodine is an exception and has lustrous appearance.

- **Non-metals are generally soft:** Most of the non-metals are soft and can be easily cut with knife. Carbon in the form of diamond is the only exception which is very hard.

- **Non-metals are non-strong:** Non-metals have low tensile strength. They cannot be used for holding large weights.

- **Non-metals may be solid, liquid or gases at room temperature:** Non-metals can exist in all three states. For example, carbon and sulphur are solid, bromine is liquid and hydrogen and oxygen are gases.

- **Non-metals have low melting points and boiling points:** All non-metals have comparatively low melting point except graphite, which has high melting point. Most of the non-metals have very low boiling points, which is the reason they exist as gases at room temperature.

- **Non-metals have low densities:** Non-metals have low densities and are light in weight. Iodine is an exception, which has high density.

- **Non-metals are non-sonorous:** Non-metals when hit do not make sound.

- **Non-metals have different colours:** Non-metals have different colours. For example, sulphur is yellow, phosphorous is white or red, graphite is black, chlorine is yellowish-green.

Metalloids

Few elements have some properties of metals and non-metals. For example, few elements have appearance similar to metals but are brittle like non-metals. These elements are neither conductors of electricity like metals nor insulators like non-metals, instead they are semiconductors. These elements that show properties of both metals and non-metals are called metalloids. They have properties that are intermediate between the properties of metals and non-metals. They are sometimes called semi metals. Examples of metalloids are boron (B), silicon (Si), germanium (Ge).

Compounds

Compounds are the substances made up of two or more elements chemically combined in a fixed proportion by mass. For example, water (H_2O) is a compound made up of two elements hydrogen and oxygen, chemically combined in fixed proportion of $1:8$ by mass (Atomic masses: $H = 1u$, $O = 16u$, therefore $H_2 : O = 2u : 16u$ or $1:8$). Other compounds are salt or sodium chloride $(NaCl)$, ammonium chloride (NH_4Cl).

Mixtures

A mixture consists of two or more elements or compounds that are not chemically combined together. For example, sugar solution, air and milk are examples of mixture. In sugar solution, the sugar and water are physically mixed without any chemical reaction between sugar and water. Similarly air constitutes mixture of different gases and milk consists of fat, water and proteins.

Mixtures can be of two types:

- **Homogeneous mixtures -** in homogeneous mixtures, the substances are completely mixed together and are indistinguishable from one another. For example, salt solution, copper sulphate solution, sea water, milk, soil, soap solution, petrol, etc. All the homogeneous mixtures are called solutions.

- **Heterogeneous mixtures -** a heterogeneous mixture does not have a uniform composition throughout its mass. For example, mixtures of sugar and salt, chalk and water.

Solution

Solution is a homogeneous mixture of two or more substances. Some common examples of solutions are salt solution, vinegar, metal alloys, air, etc.

Properties of solution are:

(i) A solution is a homogeneous mixture.
(ii) A solution has solute particle, which is extremely small in size. It is less than $10^{-9} m$ in diameter.
(iii) The particles of a solution cannot be seen even with a microscope.
(iv) The particles of a solution pass through the filter paper. Therefore, different particles of solution cannot be separated by filtration.
(v) The particles of solution do not get separated, even after the solution is kept for some time.
(vi) A true solution does not scatter light, due to the very small size of its particles.

Different types of solutions are:

Suspension

Suspension is a heterogeneous mixture in which the small particles of solute are spread throughout a liquid without dissolving in it. For example, chalk and water mixture, Paints, sand and water mixture.

Properties of suspension are:

(i) A suspension is a heterogeneous mixture.
(ii) Size of solute particles of suspension is in the range of 10^{-7} to $10^{-5} m$ diameter.
(iii) The particles of a suspension can be seen easily.
(iv) The particles of suspension can be separated by filtration.
(v) The particles of suspension separate, after the solution is kept for some time. Therefore, suspensions are unstable.
(vi) Suspension scatters beam of light passing through it due to quite larger size of its particles.

Colloids

Colloids consist of particles whose size is intermediate between those in true solutions and those in suspensions. When seen with naked eye colloids appear homogeneous, but are found heterogeneous when observed through a high power microscope. Some of the examples of colloids are soap solution, starch solution, blood, milk, etc.

The properties of colloids are:

(i) A colloid appears to be homogeneous, but it is heterogeneous.
(ii) The size of particles in a colloid is bigger than those in a true solution but smaller than those in a suspension. It is between 10^{-9} to $10^{-7} m$ diameter.
(iii) The particles of most of the colloids are visible under powerful microscope.
(iv) The particles of colloids cannot be separated by normal filtration.
(v) The particles of colloids do not separate out if the colloid is kept for some time.
(vi) The colloid scatters a beam of light passing through it.