Physical and Chemical Changes

You must have observed that when ice melts, it changes to water. Similarly, when we burn paper, it changes to ash. Thus, in both cases, a change is taking place. There are many changes taking place all around us. **Can we classify these changes?** All the changes can be broadly classified into two types:

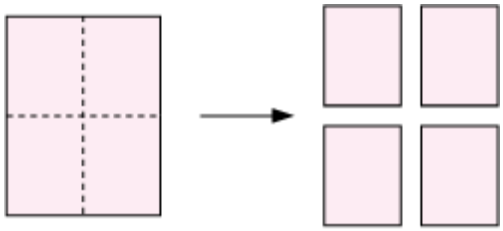
1. Physical changes

2. Chemical changes

Let us differentiate between physical changes and chemical changes.

We know that the shape, size, colour, and state of a substance are its physical properties. Physical changes usually involve changes in these properties of a substance. A change in any one of these physical properties is called a **physical change**.

For example, if you cut a piece of paper into 4 equal squares, then the shape of the paper changes, but there is no change in the properties of the paper. Also, no new substance gets formed in the process. Hence, the cutting of paper is a physical change.



Paper Papers

In this case, we cannot join back the pieces to form the original paper. Hence, the cutting of paper is irreversible in nature. Let us now discuss a physical change, which is reversible in nature that is evaporation. **Evaporation is the process in which a liquid gets converted into its vapours**. This process depends on various factors such as,

- **Nature of liquids:** There are some liquids which evaporate quickly, such as petrol and kerosene, while there are other liquids which take some time to evaporate, such as water.
- **Surface area:** Evaporation of a liquid depends on the surface of the liquid. If surface area of the liquid increases, then evaporation increases.
- **Humidity:** It is the amount of water vapour present in the environment. If humidity or water vapour in air is high, evaporation will be slow and if air is free of water vapour then evaporation takes place rapidly.
- **Temperature:** As the temperature rises, the evaporation takes place more quickly.

Let's understand the evaporation process with the help of an illustration:

If we add a spoon of common salt in some water and stir the mixture for sometime, then the salt disappears. Now, if we place the salt solution in a china dish over a hot plate, then it will be observed that the water evaporates after sometime, leaving behind a white solid (as shown in the figure).

Evaporating salt solution

The white solid that is left after all the water is boiled is nothing but salt. This proves that when salt dissolves in water, no new substance is formed. However, this process is reversible. Thus, dissolution of salt in water is a physical change.

Hence, it can be concluded that in a physical change,

- a change in the physical properties of a substance such as state, shape, size, and colour takes place
- no new substances are formed

For example,

Ice → Water → Steam (They are all still water!)

- The original substance can generally be recovered again

Now, you know what physical changes are. **Do you know the characteristics of chemical changes?**

A chemical change is the one in which the formation of one or more new substances takes place. The new substance formed has different chemical properties from that of the substance that formed it.

Now, watch the following animation to see an example of chemical change.

Let us add more to our knowledge by performing the next activity.

When lime is added to water, the temperature of water increases and water almost starts boiling. A substance called slaked lime is produced during this change. Hence, it is a chemical change. The following chemical equation can be used to represent the chemical change.

$CaO + H_2O \rightarrow Ca(OH)_2 + Energy$

Lime Water Slaked lime

Thus, it can be concluded that in a chemical change,

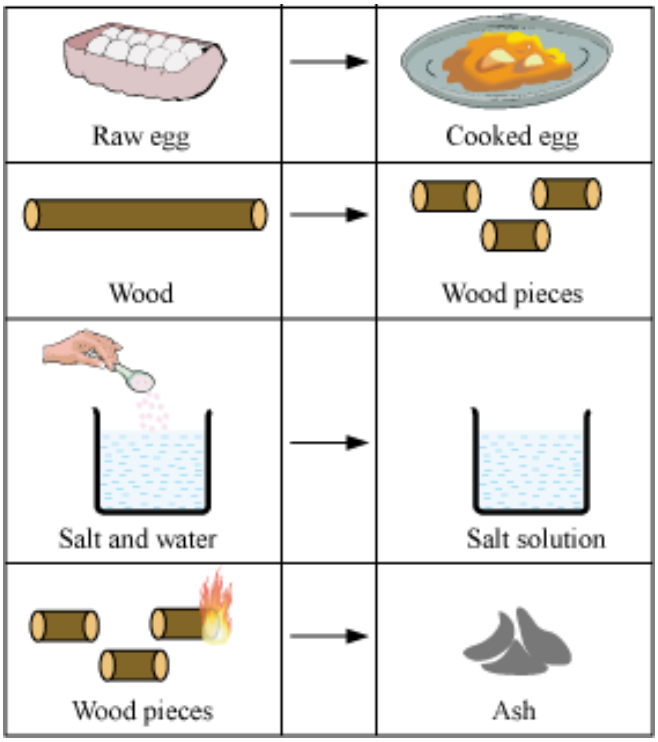
- one or more new substance(s) are formed
- the chemical properties of the new substance(s) are different from those of the starting material
- the original material cannot be recovered easily

For example, magnesium oxide and calcium hydroxide (formed in the above activities) cannot be converted back into their original substances.

Hence, we can summarize the differences between physical and chemical changes as given in the table below.

Physical Change	**Chemical Change**
1. The chemical composition of a substance does not change.	1. The chemical composition of a substance changes.
2. Most changes are reversible.	2. Most changes are irreversible.
3. No new substances are formed. For example, Ice → Water → Steam	3. New substances are formed. For example, Paper → Ashes

Can you specify the type of changes given in the table?



Some other examples of physical changes

- Melting of butter
- Boiling of water
- Condensation of water vapours
- Making of fruit salad with raw fruits
- Expansion or contraction of metals on heating or cooling
- Freezing of water
- Beating of metals into sheets
- Mixing of sugar and sand
- Crystallisation of salts from their solutions

Some other examples of chemical changes

- Digestion of food
- Cooking of food
- Rusting of iron
- Decaying of wood
- Burning of paper
- Souring of milk
- Ripening of mangoes
- Burning of candle

Burning a candle: We now understand the difference between physical change and chemical change. But there are a few changes in which simultaneous physical and chemical changes occur. Let us study about those changes.

When we burn a candle, heat and light is produced, which melts the candle. This process is a physical change. But at the same time, two new products, which are carbon dioxide and water vapours, are formed, making it a chemical change.

Thus, burning a candle is a combination of physical and chemical change.

- **Sublimation of ammonium chloride**

Sublimation of an element is a change from the solid directly to gas phase with no intermediate liquid stage. For example, when ammonium chloride is heated, it goes directly into the vapour state. When these vapours are cooled, ammonium chloride is obtained back.

Since we obtain the original substance back at the end, it is a physical change. **But do you know why does it sublime?**

Ammonium chloride sublimes because of dissociation of ammonium chloride into ammonia and hydrogen chloride in the vapour state. On cooling, ammonia and hydrogen chloride recombine to form ammonium chloride again.

Thus, the physical change taking place is the result of chemical dissociation and combination.

- **Cooking rice**

  Do you know what happens when we cook rice?

  While cooking rice, water molecules pierce the walls of the cells of the starch present in rice. Thus, some of the starch is decomposed. Therefore, this change is physical to a major extent since the composition of rice remains the same.

Allotropic Changes

Evaporating salt solution

Allotropy is exhibited by certain chemical elements, which can exist in two or more different forms, known as allotropes of that element. For example, carbon has graphite and diamond as its allotropes. Oxygen has ozone as its allotrope.

In each allotrope, the element's atoms are bonded together in a different manner. Also, they may differ in number of atoms forming the unit.

In oxygen gas, there are two atoms in a molecule. On the other hand, in ozone, three atoms are present in a molecule. Also, oxygen and ozone are different in some of their chemical properties.

Hence, we conclude that allotropic changes are chemical changes.

Changes in the Properties of a Substance on Heating and Cooling

You may have observed many changes that take place around us. Some of these changes can be reversed and some cannot be reversed. There are many changes that occur when the temperature of a substance is increased or decreased. For example, when water is kept in a freezer, the temperature of the water decreases and it freezes to form ice.

So, can you tell what will happen to a substance when it is heated or cooled? And, is it possible to re-obtain the substance by reversing the change?

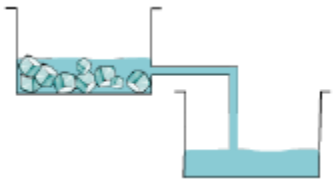
When a substance is heated, it may melt or evaporate. When it is cooled, it may condense or freeze. In some cases it might contract.

Do you know what the terms expansion and contraction mean? How are these terms related to changes in heat energy?

All metals expand when heated and contract when cooled. When heated, there is an increase in the volume of a substance and the process is known as expansion. Again, when cooled, there is a decrease in the volume of a substance and the process is called contraction.

The given animation shows an application of expansion and contraction.

You must have seen the tools that are used to dig soil. The iron blade of such a tool has a ring that attaches it to the wooden handle. Here again, the processes of expansion and contraction are used.



When ice-cubes are kept at room temperature for some time, they form water. If the tray containing water is kept in a freezer, then the water again changes into ice cubes. The formation of water when ice cubes are heated (or when the temperature of the ice cubes is increased) is called melting.

Melting is the process in which the physical state of a substance changes from solid to liquid at its melting point.

Have you observed that when water is sprinkled on a roof during a hot summer afternoon, it soon disappears? When a substance is present in liquid state, a part of it keeps changing into gaseous state by absorbing heat energy from the surroundings and eventually evaporates. This is a temperature dependent process; as temperature increases, the rate of evaporation also increases.

Take a small amount of water and dissolve some salt in it. Keep the solution in sunlight for a few hours. You will observe after some time that all the water evaporates, leaving behind a white powder. This white powder is nothing but salt. Salt is obtained in a similar manner from seawater.

Reversible and Irreversible Changes

Take a rubber band. Stretch it and then release it.

What happens to the rubber band?

Does the stretched band recover its original shape and size on releasing or does its shape change permanently when it is stretched?

It will be observed that the rubber band regains its shape when it is released. Thus, the change that the rubber band undergoes on stretching is a reversible change.

A change is called reversible if a substance that is undergoing the change can be re-obtained. All other changes are called irreversible changes. We will now discuss these changes in detail along with their examples.

Reversible change

A reversible change is the one in which a substance that is undergoing the change can be recovered in its original form.

For example, when ice cubes are kept at room temperature for some time, they melt to give water. If the same tray containing water is kept in a freezer, then the water turns

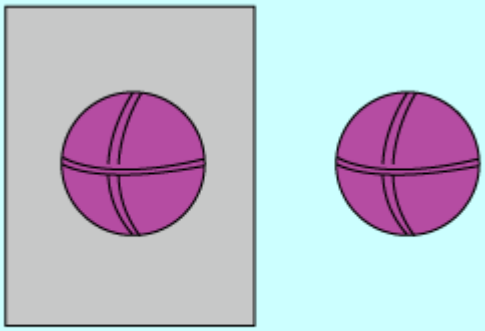
into ice. As the ice cubes are re-obtained when the tray is kept in the freezer, the change is reversible.

Let us watch the following animation to understand reversible changes in a better manner.

Irreversible change

The change in which a substance that is undergoing the change cannot be re-obtained is known as an irreversible change. Hence, it can be said that an irreversible change is the one in which a substance that is undergoing the change cannot be recovered in its original form.

The following animation explains an example of irreversible change.



A ball cut out of paper

Take a piece of paper and draw a ball on it and then cut along its outline, as shown in the figure.

Can this change be reversed?

Take two raw eggs and boil one of them. Compare the raw egg with the boiled egg.

What kind of change does the egg undergo on boiling?

The given table classifies a few changes as reversible and irreversible.

Reversible change	Irreversible change
Boiling of water	Cooking of food
Dissolution of sugar in water	Burning of wood
Melting of ice-cubes	Ripening of fruits
Melting of butter	Chopping of wood

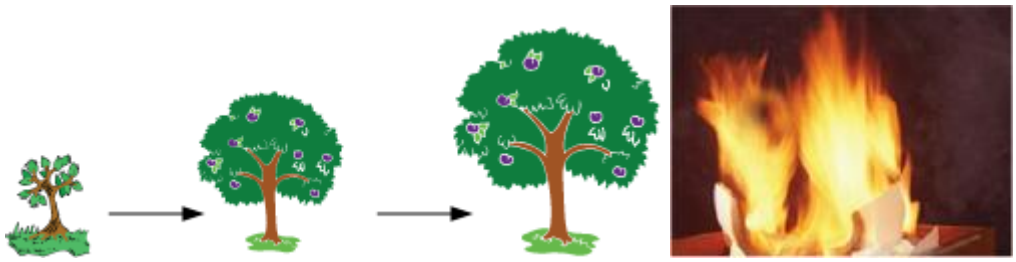
Some Other Criteria of Classifying Changes

Slow and fast changes

Slow changes are those which occur very slowly. On the other hand, fast changes are those which occur very fast.

The given table classifies a few changes as slow and fast.

Slow change	Fast change
Rusting of iron	Bursting of a balloon
Growth of plants	Burning of paper
Curdling of milk	Lighting of electric bulb



Desirable and undesirable changes

Change brought about by a person or the nature, which is useful, is called a desirable change. On the other hand, change brought about by a person or the nature, which is harmful, is called an undesirable change.

Some examples of desirable changes

- Formation of manure from animal dung and dead leaves is a desirable change as these waste materials are converted to useful manure.
- Formation of curd is a desirable change as it is more easily digestible than milk.
- Cooking of food is a desirable change.

Some examples of undesirable changes

- Spoiling of food in summer is an undesirable change as spoiled food is not edible.
- Flooding of rivers during rainy season is an example of undesirable change. This is because floods not only damage property and endanger the lives of humans and animals, but also have other detrimental effects.
- Breaking of glass particles is an undesirable change as broken glass cannot be rejoined.

Natural and man-made changes

Changes that take place on their own in nature and are never ending are called natural

changes.

Examples of this type are:

- formation of coal from dead and decaying plants
- change of day and night
- growth in living things

Changes that take place due to the efforts made by the human beings are called man-made changes.

Examples of this type are:

- cooking of food
- making paper from wood
- making a kite from a piece of paper

Periodic and non-periodic changes

Changes that occur again and again after a fixed interval of time are called periodic changes. On the other hand, changes that do not occur repeatedly after regular intervals of time are called non-periodic changes.

Beating of heart occurs repeatedly after a fixed interval of time. Therefore, it is a periodic change. On the other hand, falling of leaves is a non-periodic change as leaves do not fall repeatedly after regular intervals of time.

The given table classifies a few changes as periodic and non-periodic.

Periodic change	Non-periodic change
Phases of moon	Landslides
Change of seasons	Rusting of iron
Swinging of pendulum	Earthquakes
Occurrence of day and night	Freezing of water