Changes in energy are always accompanied by a particular ***chemical change or physical change.***

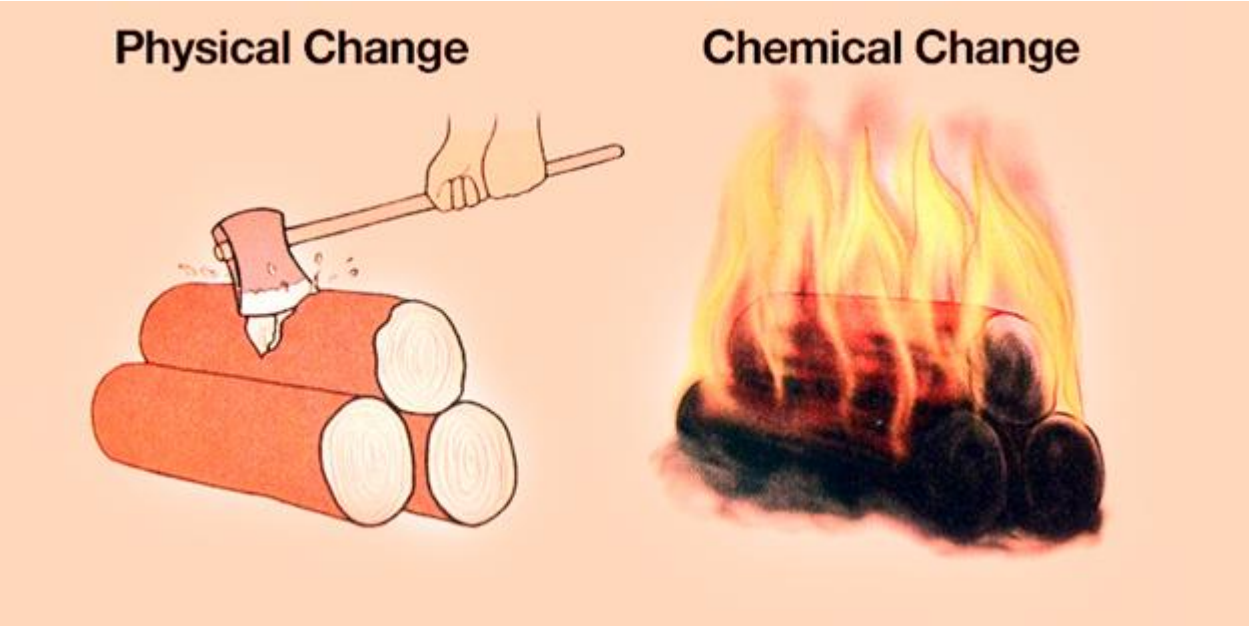
Many changes happen in a natural environment such as evaporation of water, condensation, rainfall, etc. The change in state is involved in all these changes. During some reaction, the old bonds in the reactants break and new bonds are created in the products.

What is Chemical Change?

- The change in which the molecular composition is completely altered and a ***new product is formed*** is called a chemical change.
- Chemical changes create a new product.
- The changes in Chemical ***change are irreversible and permanent***.
- It reveals that chemical change cannot be reversed by changing or altering the experimental changes.
- The mass of the substance is altered during a chemical change. Either the mass is added or removed.
- During a chemical change, the energy changes occur. There is an energy difference in the ***breaking of old bonds in reactants and the formation of new bonds*** in products.
- The reaction is called an exothermic reaction if the energy is released and as an endothermic reaction when the energy is absorbed.

Examples of Chemical Change

1. Burning of wood or paper
2. Burning of camphor
3. Souring of milk
4. Burning of candle
5. Digestion of food



Chemical Changes and Physical Change

There is a difference in energy during the breaking and making of bonds. The energy is given out to the surroundings if the energy required to break the bonds is higher than the energy required to make the bonds.

These changes or reactions are called exothermic. But, the energy is absorbed from the environment when the energy needed to break the bond is lower than the energy required to make the bonds. Such reactions are called endothermic reactions.

Recommended Videos

What is Physical Change?

- During the physical change, the ***arrangement of molecules is altered leading to change in state***. No new products are formed, and the molecular composition remains totally the same. For example, the molecular composition of ice and water is not altered.
- No energy changes occur when as a result of a physical change. The energy needed to bring a physical change is equal to the amount of energy required to reverse the change. There is no change in energy.
- The changes are reversible and temporary. The reaction gets reversed if the cause of producing the change is removed. For example, water on freezing forms ice and ice on melting forms water.
- During the physical change, the mass of the substance remains the same. Only energy is added or removed, and mass is not involved in a physical change.

Examples of Physical Change

1. Dissolution of sugar in water
2. Melting of ice
3. Freezing of water
4. Boiling of water
5. Melting of wax

Everything around us is undergoing a process of change. Our hair and nails keep growing. Leaves die and new leaves take their place. While some changes in our environment are temporary and can change back to their original positions, other changes are relatively permanent.

On this basis, changes around us can be classified into two broad categories:

1. **Reversible changes**
2. **Irreversible changes**

Reversible changes can be described as changes that can be reversed by reversing the action or changing the conditions. Example: freezing of water, rolling of a chapati from dough etc.

Irreversible changes can be described as changes that cannot be reversed even after bringing about changes in the conditions. Example: rusting of iron, cooking of vegetables etc.

Figure 1 Closing and opening of mimosa leaves represent a reversible change

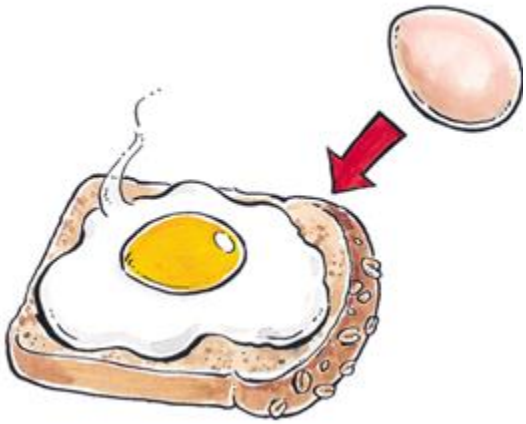


Figure 2 Cooking of an egg into an omelette represents an irreversible change

Substances and materials usually undergo two major types of changes:

- **Physical change:** This represents a change not in the chemical identity but the physical form of a substance. When substances undergo a physical change, there is no formation of a new substance and more or less these changes can be reversed. Example: boiling of water and melting of ice represent reversible physical changes while growing of height is an irreversible physical change.

Physical Change

- **Chemical change:** This represents a change in the chemical identity of a substance. These are irreversible changes because the original substance gets converted into a new substance and cannot be brought back. Example: cooking of rice, burning of matchstick etc.

Figure 4 Chemical Change

Difference between physical and chemical changes:

Physical Change	Chemical Change
A change in matter which occurs without causing any change in the composition of the matter is known as physical change	While a chemical change is defined as the change in the chemical composition of matter
Usually, physical changes are reversible in nature	While chemical changes are often irreversible
No new products are formed when an object undergoes physical change	Chemical changes often lead to formation of new products
These changes have no impact on the molecular composition of the substance	Chemical changes have a direct impact on the chemical bonds and molecular composition of a substance
A few changes occur when cooling or heating is done	These changes involve absorption or release of energy

There are other ways to bring about changes in substances:

- **Mixing two substances together:** A small amount of curd is added to warm milk which leads to conversion of that milk into curd. This is an irreversible change.

When we add a salt to water it becomes salty but this is a reversible change.

- **Expansion and Contraction:** In order to make tools like an axe, the ring of its iron blade is heated which allows it to expand i.e. become larger in size and then is allowed to cool down which makes it contract again i.e. become smaller in size leading to a tight fit of the handle.

Figure 5 Curd is added to milk to allow it to set into curd

Physical Changes

- **Physical Properties** of a substance are those characteristic of a substance that describes its physical nature.
- For Example colour, density, shape, size and volume are some physical properties.
- **Physical Change** is a change which occurs when there is an alteration in the physical properties of a substance.
- The physical change does not result in the formation of any new substance but can alter the shape and size of the existing substance.

Chemical Changes

- The **chemical property** of a substance are those characteristic of a substance that describes its chemical nature.
- For Example toxicity of a substance or how a substance reacts with other substances is its chemical property.
- A **chemical change** or chemical reaction is any change in the chemical properties of a substance.
- Whenever a substance undergoes a chemical change, a new substance is formed.
- Examples of Chemical Changes:
  - Rusting of iron occurs when iron gets in contact with moisture
  - When a magnesium ribbon is burnt it radiates white light and converts into ashes
  - Formation of Medicines
  - Extracting of iron from the iron ore
  - Formation of plastic

A chemical change is always accompanied by any one or all of the following way:

- Radiation or absorption of heat
- Production of sound
- Change in the colour of the substance
- Change in the smell of the substance
- Formation of a gas

- Formation of a solid as residue

Change in Property	Example
Radiation or absorption of heat	Burning of a substance such as coal, wood or candle results in production of heat and hence is a chemical change. Similarly, melting of ice results in absorption of heat and therefore it is a chemical change.
Production of sound	Bursting of fireworks is a chemical change. It results in production of sound, heat, radiation as well as gas.
Change in the colour of the substance	Raw fruits and vegetables when cut and left in open air start acquiring brown color due to a chemical change. Similarly, rusting of iron results in change of color of iron to reddish brown is also a chemical change.
Formation of a gas	When antacids are mixed in water bubbles are formed indicating the production of a gas and therefore it is a chemical change.
Change in the smell of the substance	When food gets spoiled, it produces foul smell. This is because of a chemical change in food. Rotten eggs often produce a bad odour due to production of sulphur.
Formation of Solids	Two liquids combine with each other and form a solid called precipitate. For Example, shells of animals are precipitates formed by chemical changes.

Figure 4: Chemical Changes

Rusting of Iron

When the iron comes in contact with oxygen and water, reacts and forms a red colored substance over it. It is called **Rust**.

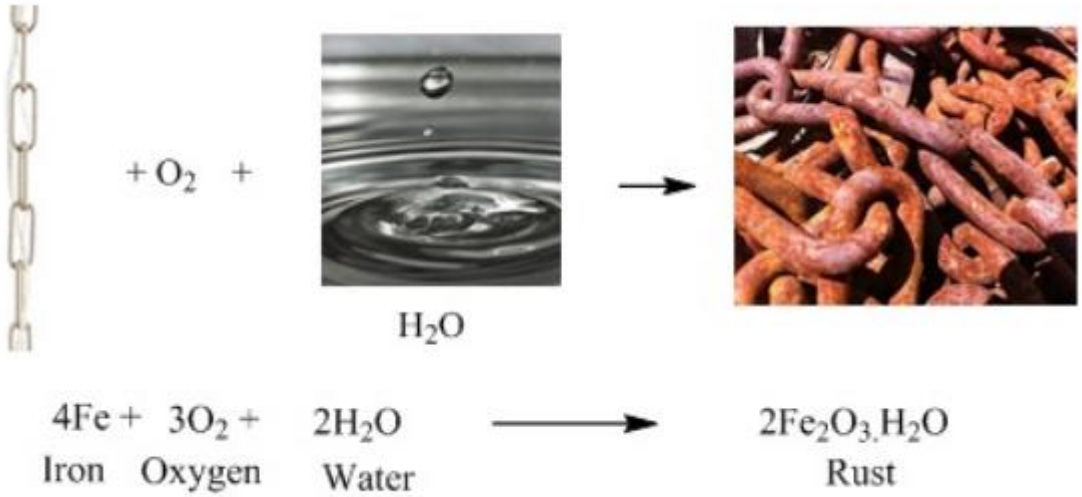


Figure 5: Formation of Rust

How to prevent rusting of iron

- By applying paint on iron objects so that they cannot come in contact with oxygen and moisture in the environment
- **Galvanization** of iron which means applying a layer of zinc or chromium metals on the iron
  -

In Chemical change, one or more substances are formed. A chemical change generally involves chemical reactions and the results in the formation of new products. A chemical change is not a reversible process.
For example: rusting of iron, digestion of food, curdling of milk, etc.

Experiments Showing Change

1. When Magnesium ribbon is burnt it forms oxides of Magnesium. This Magnesium oxide is a new substance.
   So, this is an example of Chemical change. Its equation is as follows:

Magnesium (Mg) + Oxygen (O2) Magnesium Oxide (MgO)

If Magnesium Oxide is added in water it results in the formation of a new substance which is Magnesium Hydroxide. The new substance is basic in nature and it will turn red litmus paper blue.

Magnesium oxide (MgO) + Water (H2O) Magnesium Hydroxide (Mg(OH2))

2. Another example of chemical change is the reaction between Copper Sulphate and Iron. The colour of Copper Sulphate solution changes from blue to green colour and a new substance, Iron Sulphate is formed. The iron which is put in this solution develops some brown deposits. This brown deposit is copper.
3. When a pinch of baking soda is added to Vinegar, then carbon dioxide is released with a hissing sound.

Vinegar (Acetic acid) + Baking soda (Sodium bicarbonate) Carbon dioxide + other products.

This Carbon dioxide which is formed by the above reaction, when passed through lime water will produce Calcium Carbonate. And it will turn lime water milky.

CO_2 + $Ca(OH)_2$ (lime water) Calcium Carbonate ($CaCO_3$) +H_2O

4. When iron objects are left open for some time, it forms a brownish layer due to the oxygen and moisture present in the atmosphere. This brownish layer is known as rust and the whole process of rust formation is called rusting.

Iron (Fe) + Oxygen (O_2) + Water (H_2O) Rust (iron oxide Fe_2O_3)

The process to prevent rusting of iron is called Galvanization. In this process, a layer of zinc is deposited on the surface of iron objects. The water pipes of iron are galvanized. Crystallization refers to the process by which solids are obtained from their solutions. It is a kind of purification method. Crystallization is a physical change.

- ***Alloying***

Homogeneous mixture of two or more metals, or a metal and a non-metal to change the properties of the pure state metals and protect them from rust.

1. For instance, Iron is used widely for different purposes but it is never used in pure state. It is due to the fact that pure iron is very soft and stretches in hot state. But mixing with small amount of carbon (about 0.05%) makes it strong and tough. Mixing nickel and chromium with iron gives stainless steel, which is hard and does not rust.

Fig. Stainless steel

1. Another vital property of alloy is that electrical conductivity and melting point of an alloy is less than that of pure metals. For instance, brass is an alloy of copper and zinc (Cu and Zn), and bronze is an alloy of copper and tin (Cu and Sn), possessing poor conductivity towards electricity. On the other hand copper in pure state is used for making electrical circuits.


Fig. Musical instrument made of Brass (left) and bronze statue (right)
Solder is an alloy of lead and tin (Pb and Sn) possessing low melting point and is used for welding electrical wires together

Chemical reaction:

A chemical change occurs when chemicals react with each other. Thus, a chemical change is also called a chemical reaction.

Some of the properties of a chemical change or chemical reaction are:

- Change in energy
- Change in color
- Evolution of gas
- Formation of precipitate

Change in energy: Almost all chemical reactions involved energy change. Some chemical reactions produce heat while some take away heat.
A change or reaction in which heat is released is called an **exothermic reaction.**

For example; In a reaction between carbon and oxygen, carbon dioxide is formed with the generation of heat.
Carbon + Oxygen ……. Carbon dioxide + Heat

A change or reaction in which heat is absorbed from the surrounding is called an **endothermic reaction.**
For example in a reaction between carbon and sulphur, carbon disulphide is formed with the absorption of heat.
Carbon + Sulphur + Heat …….. Carbon disulphide

Change in colour: The colour of the product may differ from that of the reactants. For example; copper sulphate is blue in colour, but after reacting with iron, the product formed (iron sulphate) is of green colour.

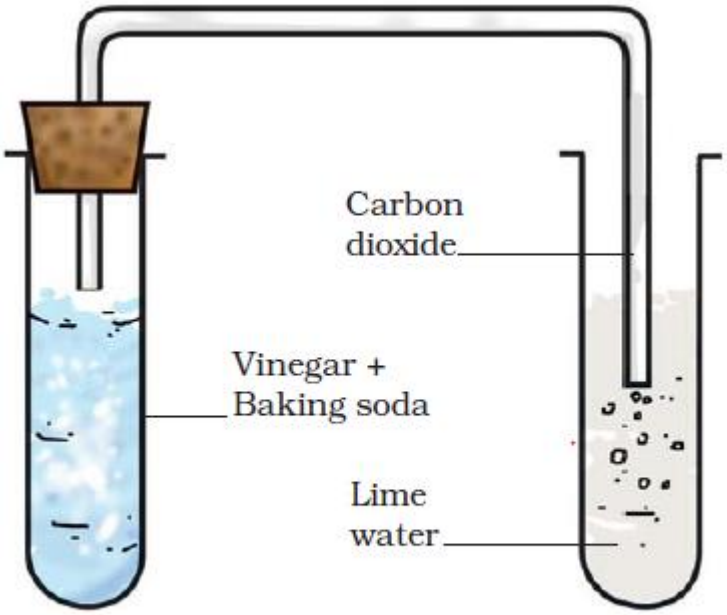
Evolution of gas: Some chemical changes also produce gases. Generally the gases produced can be carbon dioxide, hydrogen, ammonia etc. The presence of carbon dioxide can be confirmed as it turns lime water milky.

Activity:

Reaction between vinegar and baking soda:

Take vinegar (acetic acid) in a glass beaker and add a pinch of baking soda (sodium hydrogen carbonate) to it. We will observe gas bubbles coming out of the beaker. This is due to the release of carbon dioxide. This can be confirmed by making the gas produced pass through freshly prepared lime water. The lime water turns milky when

carbon dioxide is passed through it due to the formation of calcium carbonate.



Set up to pass gas through lime water

Carbon dioxide (CO_2) + Lime water [$Ca(OH)_2$] -> Calcium Carbonate ($CaCO_3$) + Water (H_2O)

Formation of precipitate: In some chemical changes, the product formed separates from the solution and form a different mass of layer. This insoluble solid is called a precipitate. For example; in a reaction between copper sulphate and hydrogen sulphide, copper sulphide and sulfuric acid are formed. The copper sulphide formed is given out as a precipitate.

Chemical Changes in Our Daily Life

- An explosion of a firework (or crackers) is also a chemical change which produces heat, light, sound and unpleasant gases that pollute the atmosphere.
- When food gets spoiled, it produces a foul smell. This shows that new substances have been formed in the spoiled food which has a foul smell. So, the spoilage of food is a chemical change.
- If we cut an apple into slices and kept in the open for some time, we will find that the cut surface of apple acquires a brown colour. This change in colour is due to the formation of the new substance by the action of oxygen (or air). So, this change in colour is a chemical change.
- Similarly, the cut surface of potato or brinjal turns black on keeping in air for some time due to the chemical change.

- When an acid reacts with a base, then a neutralisation reaction takes place in which two new substances, salt and water, are formed. So, neutralisation is a chemical change.

- During photosynthesis, the plants intake carbon dioxide and water in the presence of chlorophyll and sunlight to form two new substances, glucose (food) and oxygen. So, photosynthesis is a chemical change.
- In the process of digestion, the various food materials break down to form new substances which can be absorbed by the body, so the process of digestion is a chemical change.

Changes occurring in a chemical change

Chemical changes occurring in our day to day life involves following changes.

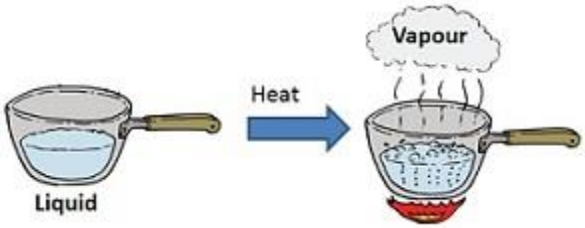
- **Change in colour**

During rusting the iron articles undergoes change in colour. We have also observed that silver gets tarnished when kept for a long time. The metallic silver reacts with hydrogen sulphide or sulphur present in air and gets tarnished.

$$4Ag + 2H_2S + O_2 \longrightarrow 2Ag_2S + 2H_2O$$

- **Change in state**

On heating liquid changes its state and converts to vapour due to reaction within the particles caused by heat.



- In case of rusting of copper, the metallic copper reacts with oxygen, carbon-dioxide and atmospheric moisture and develops a green coloured coating of copper hydroxide and copper carbonate.

$$2Cu + H_2O + CO_2 + O_2 \longrightarrow Cu(OH)_2 + CuCO_3$$

Fig. Copper developing green coloured rust on exposure to moist air

-
- **PHYSICAL CHANGE**
  -
  - **Crystallisation**
    Seawater contains salts dissolved in it which makes it salty. We have learnt in Class VI that salt can be obtained from seawater by the process of evaporation. The salt obtained in this manner is not pure and its crystals are small. The shape of the crystals cannot be seen clearly. Large crystals of pure substances can, however, be obtained from their solutions by the process of crystallisation. It is an example of a physical change. The process of cooling a hot concentrated solution of a substance to obtain crystals is called crystallisation. The process of crystallisation is used to obtain crystals of a pure solid substance from the impure solid substance.
  - Impure copper sulphate powder can be purified by the process of crystallisation to obtain large crystals of pure copper sulphate.

Crystallization

It is a process of obtaining crystals of a pure substance from its solution. For Example, we can obtain the crystals of copper sulphate by boiling copper sulphate solution.

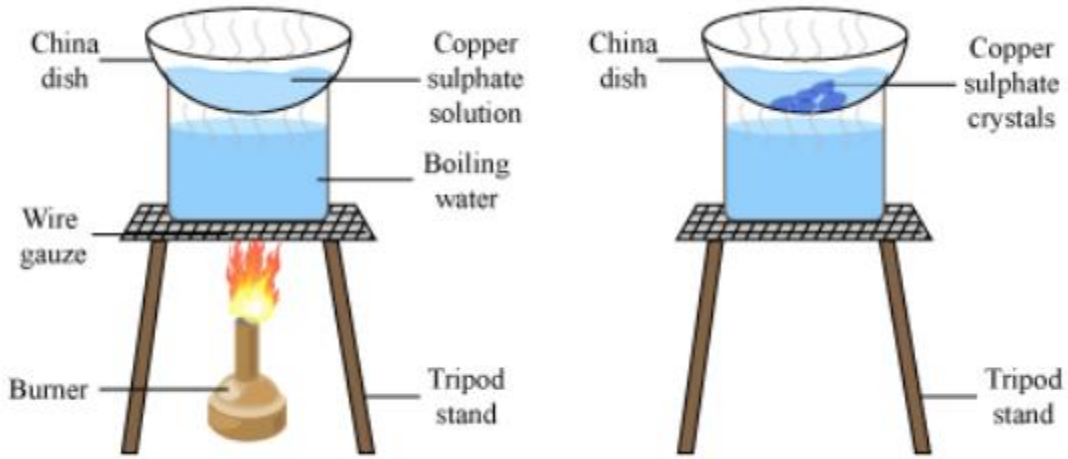


Figure 7: Crystallization of Copper Sulphate

Crystallization

It is a process of obtaining crystals of a pure substance from its solution. For Example, we can obtain the crystals of copper sulphate by boiling copper sulphate solution.

Figure 7: Crystallization of Copper Sulphate

Physical change

Physical changes refer to the changes in the physical properties of the substances such as shape, size, colour and state. These changes are reversible in nature. In a physical change no new substance is formed.

Tearing a piece of paper changes its shape and size.

Similarly kneading of flour to dough changes its state.

Melting of ice is also a physical change where the matter is changing its state from solid to liquid.

As an ice cube melts, its shape changes as it acquires the ability to flow. However, its composition does not change. Melting is an example of a physical change. A physical change is a change to a sample of matter in which some properties of the material change, but the identity of the matter does not. When we heat the liquid water, it changes to water vapor. But even though the physical properties have changed, the molecules are exactly the same as before. We still have each water molecule containing two hydrogen atoms and one oxygen atom covalently bonded. When you have a jar containing a mixture of pennies and nickels and you sort the mixture so that you have one pile of pennies and another pile of nickels, you have not altered the identity of either the pennies or the nickels - you've merely separated them into two groups. This would be an example of a physical change. Similarly, if you have a piece of paper, you don't change it into something other than a piece of paper by ripping it up. What was paper before you started tearing is still paper when you're done. Again, this is an example of a physical change.

Rolling of chapati/roti

Crushed can

Physical changes can further be classified as reversible or irreversible. The melted ice cube may be refrozen, so melting is a reversible physical change. Physical changes that involve a change of state are all reversible. Other changes of state include **vaporization** (liquid to gas), **freezing** (liquid to solid), and **condensation** (gas to liquid). Dissolving is also a reversible physical change. When salt is dissolved into water, the salt is said to have entered the aqueous state. The salt may be regained by boiling off the water, leaving the salt behind.

When a candle burns, both physical and chemical changes take place. Identify these changes. Give another example of familiar process in which both the chemical and physical changes take plac

Physical changes in burning candle On heating, candle's wax melts, it is a physical change. Since, it again turns into solid wax on cooling. The change is reversible. Chemical changes in burning candle The wax near to flame burns and gives new substances like carbon dioxide, carbon soot, water vapours, heat and light. Cooking of food, boiling of eggs are examples of both physical and chemical changes. In both cases, the physical appearance of the substances change and new substances are formed.

Matter and Its Nature

What is Matter?

Anything which has mass and occupies some space is called matter. Each and everything which we see around us is matter.

What about air? Neither we can see it nor has it mass!! Is it also matter?

The answer is yes! Air is a matter. We can't see it but it occupies space. That is why only a limited amount of air can be filled in a balloon. Further, air has mass too. But the problem is that, its molecules move with such a high speed and the space between them is so large that we don't feel the mass of air.

Remember when the molecules of gas collide with the wall of container they exert some force on it which is the cause of pressure of gas. Colliding molecule exerts force; this means it has some momentum. And if it has momentum, it must have mass too.

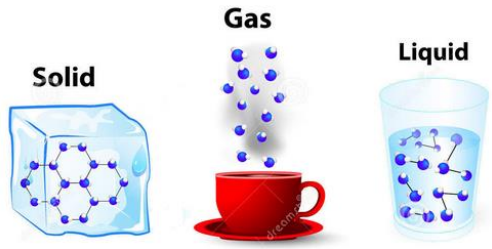
So, air is a matter.

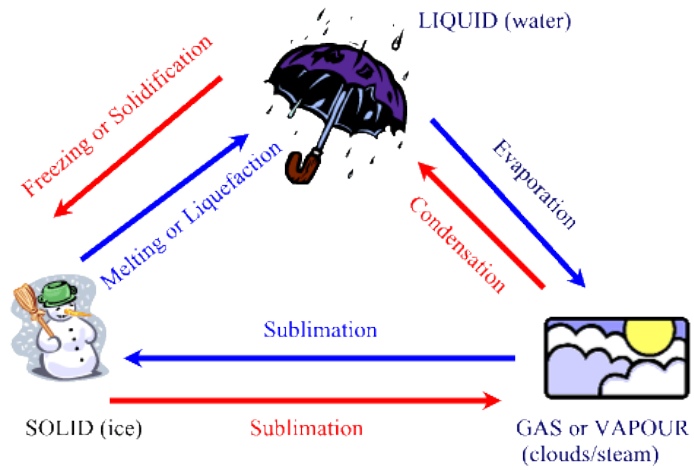
Classification of Matter

Matter is classified at microscopic and macroscopic levels.

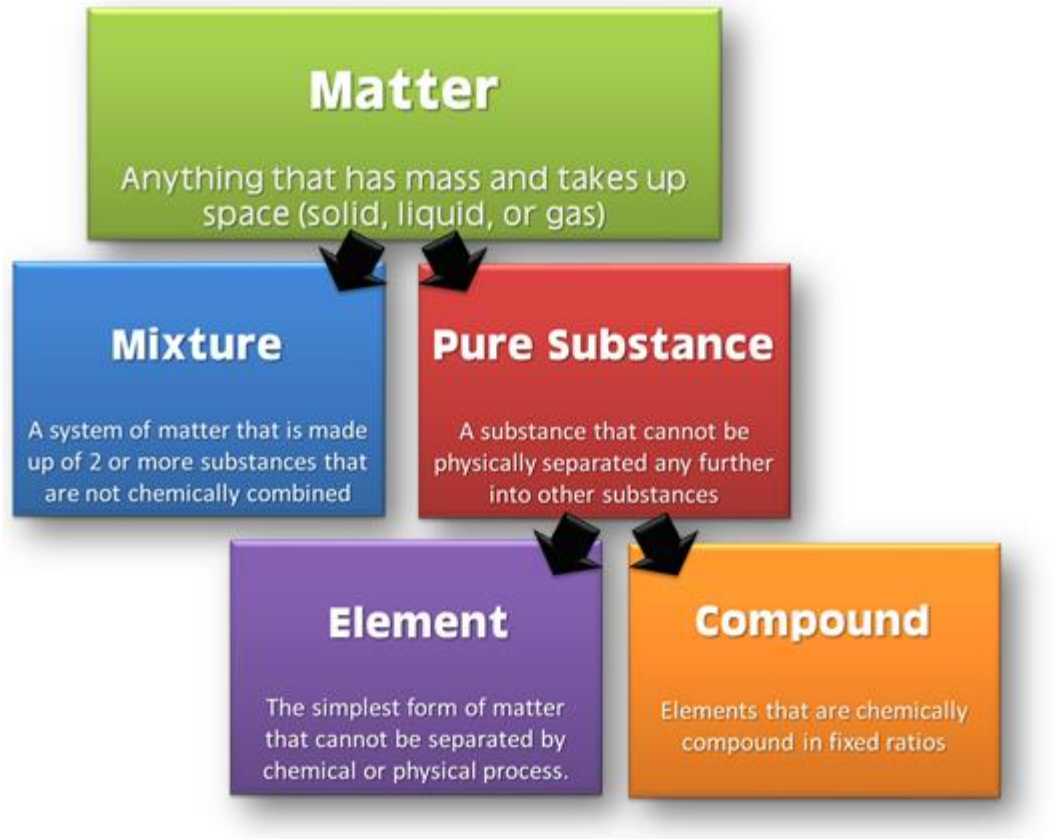
At microscopic level, it can be classified as solid, liquid and gas. These are the three physical states of matter.

These three states of matter and interconvertable by changing the conditions of temperature and pressure

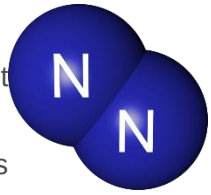




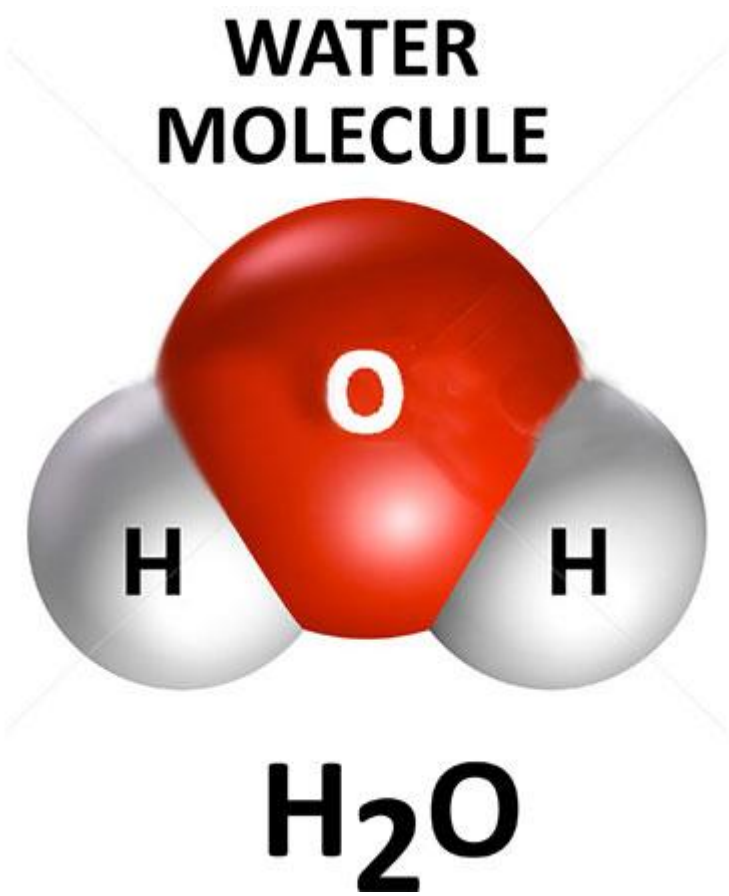
At macroscopic level, matter can be classified as pure substances and mixtures. This classification of matter is based upon chemical composition of various substances. Pure substances can further be classified into elements and compounds



Elements:



- The primary stuff present in all the substance is known as element, whose smallest unit is known as atom.
- Total 112 elements are known till date of which 92 are naturally occurring elements rest are results of artificial transmutation.
- There are 88 metals, 18 non metals and 6 metalloids.
- For example. Nitrogen, Hydrogen, Oxygen, Carbon etc.

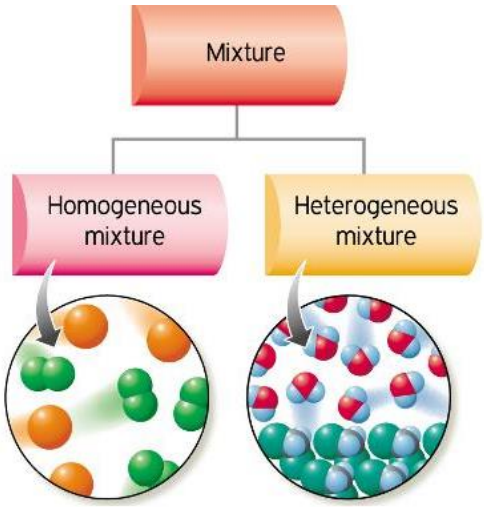


Compound:

- A non elemental pure substance is called a compound in which more than one atom of elements are linked by chemical bonds formed due to chemical reaction.
- The resulting molecule is a electrically neutral particle of constant continuous composition.
- For example: Water is a compound which is formed by combination of two elements hydrogen and oxygen.

Mixture:

- Mixtures are the aggregate of more than one type of pure substance whose chemical identity remains maintained even in mixtures. Their constituent ratio may vary unlike compound.
- For example sugar syrup is mixture of water and sugar. Gun-powder contains 75 % KNO_3, 10% sulphur and 15% carbon
- There are two types of mixture (a) homogeneous (b) heterogeneous
- Homogeneous mixtures are those whose composition for each part remains constant. For example aqueous and gaseous solution.



- Heterogeneous mixtures are those whose composition may vary for each and every part. For example soil, concrete mixtures.

Physical and Chemical Properties of Matter

- **Physical Property:** The property which can be measured without changing the chemical composition of the substance is known as physical property like mass, volume, density, refractive index etc.
- **Chemical Property:** The property which can be evaluated at the cost of matter itself is known as chemical property. For example combustible nature of hydrogen gas can be verified by burning of hydrogen. The sweet taste of sugar by consuming it.
- **Physical Quantities :** Many physical properties of substances are quantitative in nature. Such properties are called physical properties.
- The measurement of any physical quantity consists of two parts:
  - The number and
  - The unit
- Accuracy of the number is expressed using concepts of significant figures
- The units of measurement are expressed in S.I. units
- The units of any physical quantity are derived using the concept of dimensional analysis.

Example 1:

Question:

What is the difference between homogeneous and heterogeneous mixtures?

Solution:

A homogeneous mixture is a mixture which has uniform composition throughout the mixture. For example, mixtures have uniform compositions throughout the mixtures.

A heterogeneous mixture is a mixture which has a non-uniform composition throughout the mixture. For example, Mixture of s all examples of heterogeneous mixtures

Units for Measurement

All physical quantities have to be measured. The value of a physical quantity is expressed as the product of the numerical value and the unit in which it is expressed.

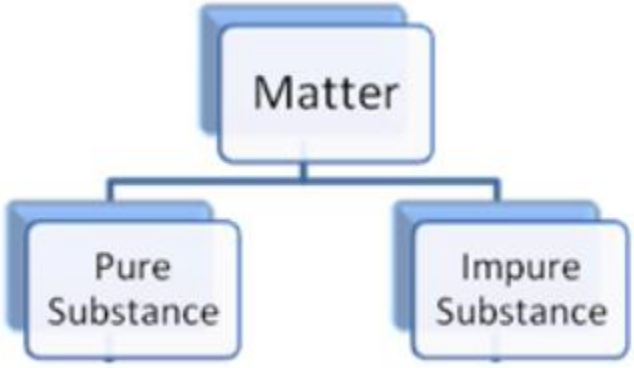
Fundamental Units:

Fundamental units are those units which can neither be derived from one another nor they can be further resolved into any other units. The seven fundamental units of measurement in S.I. system.

Quantity	Name of unit
Mass	Kilogram
Length	Meter
Temperature	Kelvin
Amount of substance	Mole
Time	Second
Electric current	Ampere
Luminous intensity	Candela

What is a substance?

- Anything that cannot be broken into further particles by applying any physical processes is called a **Substance**.
- Matter can be classified into two types of substances – Pure substances and Mixtures



What is a pure substance?

A substance that consists of only one type of particle is called a **Pure Substance**. **For Example**, Diamond, Salt, Sulfur, Tin.

What is a mixture?

- When we combine different substances into each other a mixture is formed. **For Example**, Lemonade is a mixture of three substances, Lemon Juice, Sugar and Water.
- Which of these is a mixture or a pure substance?

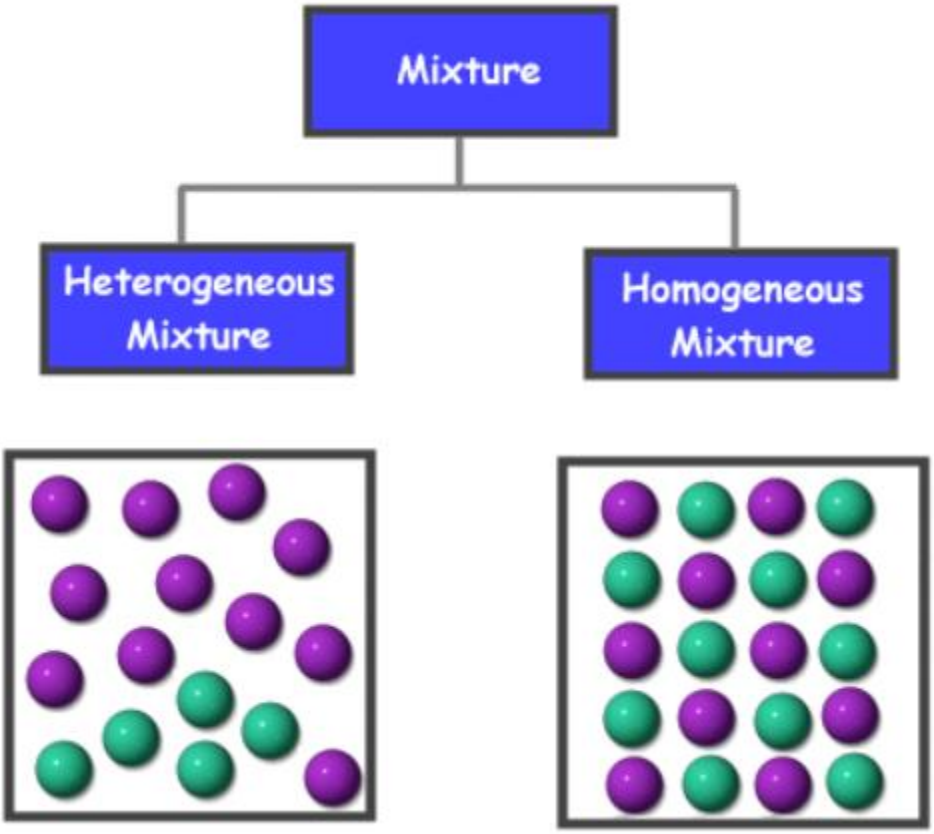
  Water, Copper, Chocolate cake, Hydrogen, Soil, Air

  Mixture – Chocolate cake, Soil, Air

  Pure substance – Water, Copper, Hydrogen

Types of Mixtures

There are two categories of mixtures: Homogeneous Mixtures and Heterogeneous Mixtures



Homogenous Mixtures

- When we add sugar, water and lemon juice together they all uniformly mix with each other. Now it is no possible to separate these substances from the mixture. Such mixtures in which the components mix with each other uniformly are called **Homogenous Mixtures**.
- The ratio of compositions of homogeneous mixtures can be different. **For Example**, one may add two spoons of sugar in lemonade while someone else may add only one spoon of sugar in their lemonade. Still, lemonade is a homogeneous mixture.

Heterogeneous Mixtures

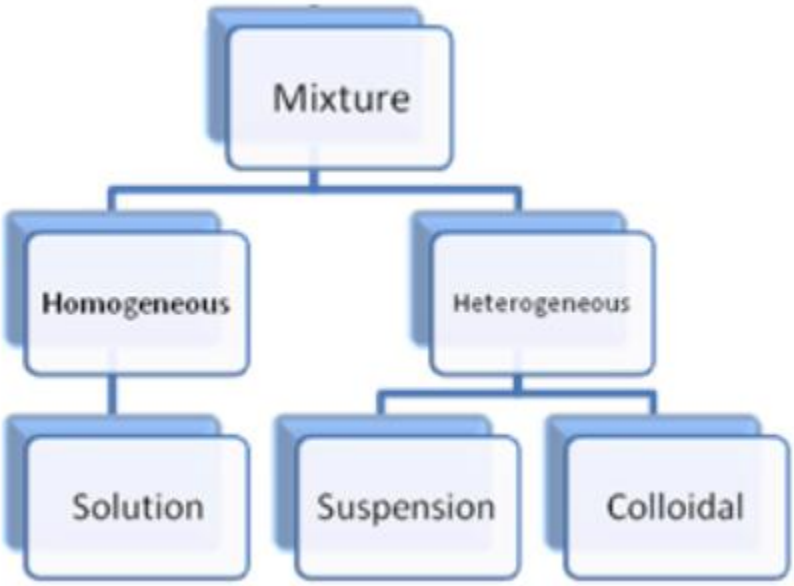
- The components in a heterogeneous mixture do not completely dissolve in each other and we can separate them by physical means. In other words, the composition of such mixtures is not uniform.
- **For Example**, If we mix sand in water the sand settles down in water after some time and we can separate it by filtration.

Here are a few differences between homogeneous and heterogeneous mixtures –

Homogenous Mixtures	Heterogeneous Mixtures
They have a uniform composition throughout	They have a non-uniform composition

We cannot separate the components of the mixture through physical processes	We can separate the components through physical processes
Components cannot be seen through naked eyes	Components can easily be seen through naked eyes
The mixture is in single phase throughout	The substances can be of two different phases and we may see separate layers of the substances
Example: A mixture of water and milk	**Example**: A mixture of oil in water

What is a solution?



A solution is nothing but a uniform mixture of two or more substances. Homogenous Mixtures are solutions.

Solution of -

- **Liquid into liquid:** Water and Ink
- **Solid into solid:** Alloys
- **Gas into gas:** Air
- **Solid into liquid:** Sugar and Water
- **Solid into gas:** Hydrogen and Metals
- **Liquid into gas:** Carbon Dioxide and Water

What is an alloy?

An alloy is a mixture of different metals or non-metals and metals that cannot be separated from each other using physical methods. **For Example:**

Brass – Copper with up to 50% zinc

Bronze – Copper with up to 12% tin

BRONZE WAS ONE OF THE FIRST ALLOYS CREATED BY HUMANS.

Solution constitutes of two types of substances, a solute and a solvent.

Solution = Solute + Solvent

Solvent – The substance in which another substance is mixed is called the **Solvent**. **For Example**, Water is a solvent in which we can mix different substances such as salt or sugar.

Solute – The substance that is added to the solvent to form a solution is called a **Solute**. **For Example**, Salt, when mixed in water, acts as a solute for the mixture.

Properties of a Solution:

- A solution is a homogenous mixture.
- We cannot see the particles of a solution through naked eyes as they as are small as 1 nanometer in diameter.
- The path of light is not visible through the solution. The particles of a solution do not scatter light through them as they are extremely small.
- We cannot separate the particles of a solution by methods of filtration.

What is a stable solution?

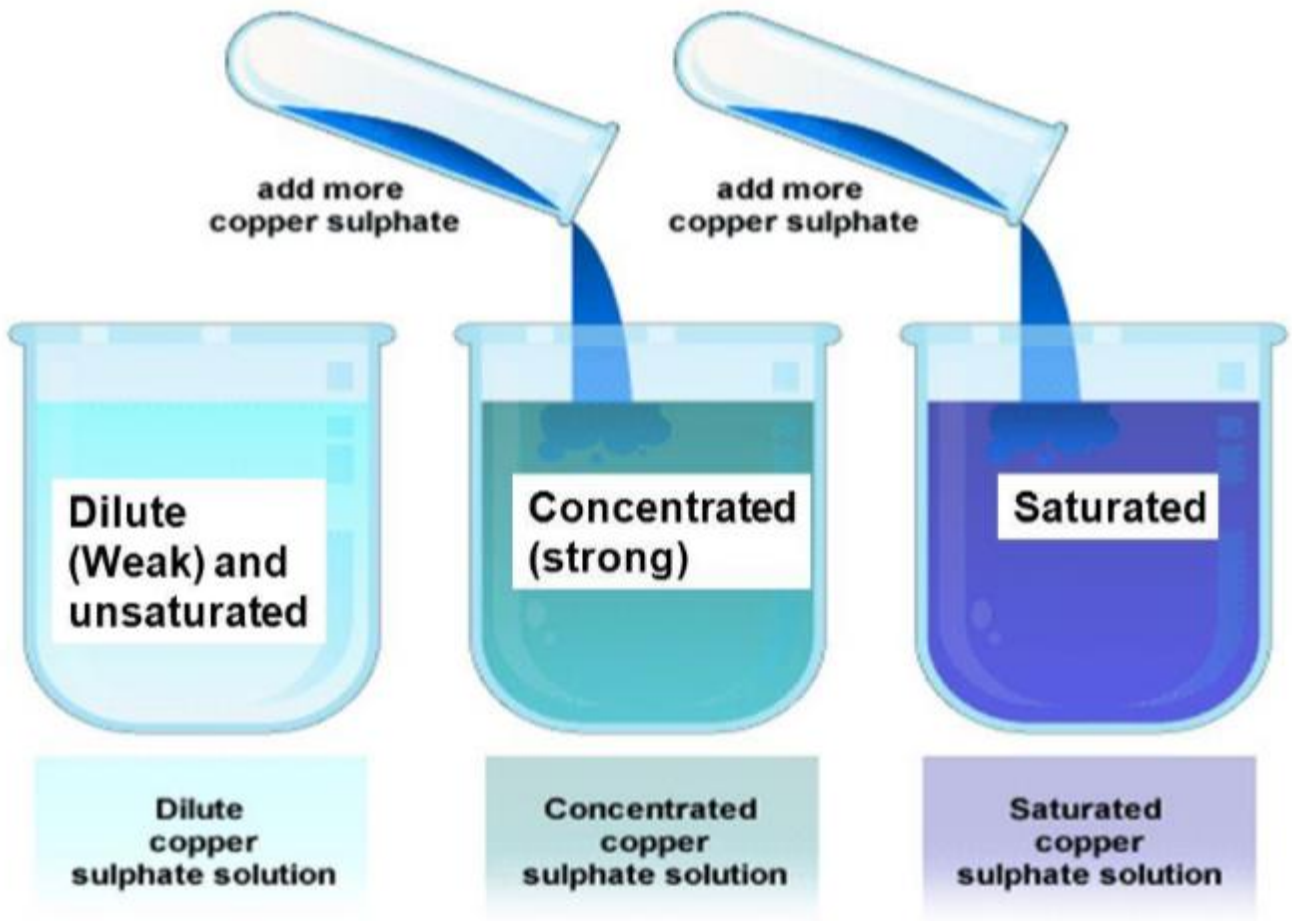
A stable solution is a solution in whose particles do not settle down if we leave the solution undisturbed for some time. This is because the particles of a stable solution are homogeneously spread.

Different Types of Solutions

- **Dilute** – A solution in which the concentration of the solute is much less than that of the solvent. **For Example**, If we mix 1gm of salt in 500 ml of water, the salt solution thus obtained will be diluted. If

we keep on adding the solute in a solution there comes a point when no more solute dissolves in the solution. This is called the **Saturation Point of a Solution**.

- **Unsaturated Solution** – A solution, in which we can add more amount of solute as it has not achieved its saturation level yet, is called an Unsaturated Solution. A dilute solution can be called as an **Unsaturated Solution**.
- **Concentrated Solution** – A solution with a large amount of solvent is called a **Concentrated Solution**.
- **Saturated Solution** – A solution in which no more solute can be added since it has already dissolved the maximum amount of solute it can is called a **Saturated Solution**.



What is concentration?

C**oncentration** refers to the amount of a substance per defined space or can be defined as the ratio of solute in a solution to either solvent or total solution.

To calculate the concentration consider the formulae below:

- **Percent by Mass** = (Mass of solute / Mass of solution) X 100
- **Percent by Volume** = (Volume of solute / Volume of solution) X 100
- **Molarity (M)** = Number of moles of solute / Volume of Solution in litres

Where, Moles of solute = Given mass / molar mass

- **Molality (m)** = Moles of solute / weight of solvent in kg
- **Normality (N)** = Number of mole equivalents/ volume of solution in litres

  = Mass of solute / (equivalent mass * volume of solution in Litres)

- **ppm (Parts Per Million)** = (Mass of Solute / Mass of Solvent) * 10^6
- **Mole Fraction**$_{SOLUTE}$ = Moles of Solute / Total Moles of Solution
- **Mole Fraction**$_{SOLVENT}$ = Moles of Solvent / Total Moles of Solution
- **Mole Fraction**$_{SOLUTE}$ + Mole Fraction$_{SOLVENT}$ = 1

What is a suspension?

A suspension is formed when two or more substances are mix in a non-uniform manner. Heterogeneous mixtures are suspensions. The solute does not mix with the solvent and can be viewed through naked eyes.

Properties of Suspensions:

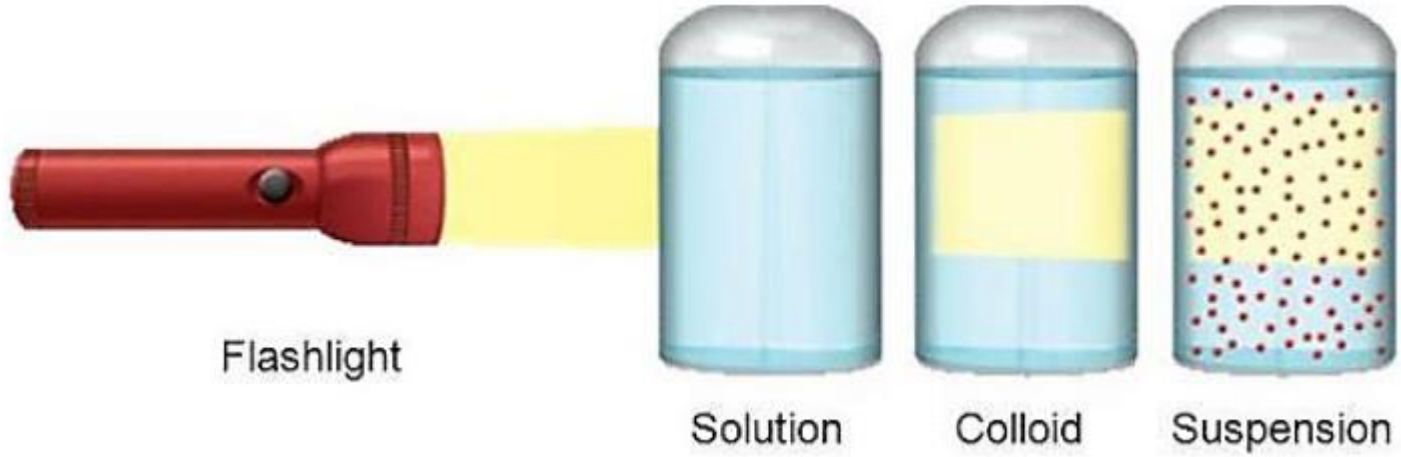
- A suspension is a heterogeneous mixture.
- We can see the particles of suspensions through naked eyes.
- We can see the path of light through the particles of a suspension.
- The particles of suspension tend to settle down when left undisturbed. Then, they can be separated using filtration.

What are colloids or colloidal solutions?

A colloidal solution or a colloid is a uniform solution of two or more substances. The particles are relatively very small that the solution appears as a homogeneous mixture but it is not.

Properties of colloids:

- Colloids are heterogeneous in nature.
- The particles of a colloid cannot be seen through naked eyes.
- The particles scatter a beam of light passed through a colloid and produce Tyndall effect.
- Colloids are stable in nature. The particles of colloids do not settle down if left uninterrupted.
- We cannot separate the particles of a colloid through filtration. We use a method called **Centrifugation** to separate the particles of a colloid.



What is the Tyndall Effect?

When a beam of light is passed through a colloid the particles of the colloid scatter the beam of light and we can see the path of light in the solution. **For Example**, when a ray of light enters a dark room it is scattered by the dust particles present in the air and we can see the path of light clearly.


Classification of Colloids

Dispersed Phase – The dispersed particles or the solute-like components in a colloid
Dispersing Medium – The substance in which these solute-like particles are added

Based on the state of the dispersing medium colloids are classified as:

Types of Colloids

Example	Dispersing Medium	Dispersed Substance	Colloid Type
Fog, Aerosol sprays	Gas	Liquid	Aerosol
Smoke, Airborne bacteria	Gas	Liquid	Aerosol
Whipped cream, Soap suds	Liquid	Gas	Foam

Milk, Mayonnaise	Liquid	Liquid	Emulsion
Paints, Clays, Gelatin	Liquid	Solid	Sol
Marshmallow, Styrofoam	Solid	Gas	Solid foam
Butter, cheese	Solid	Liquid	Solid emulsion
Ruby glass	Solid	Solid	Solid sol

How to separate components of a mixture?

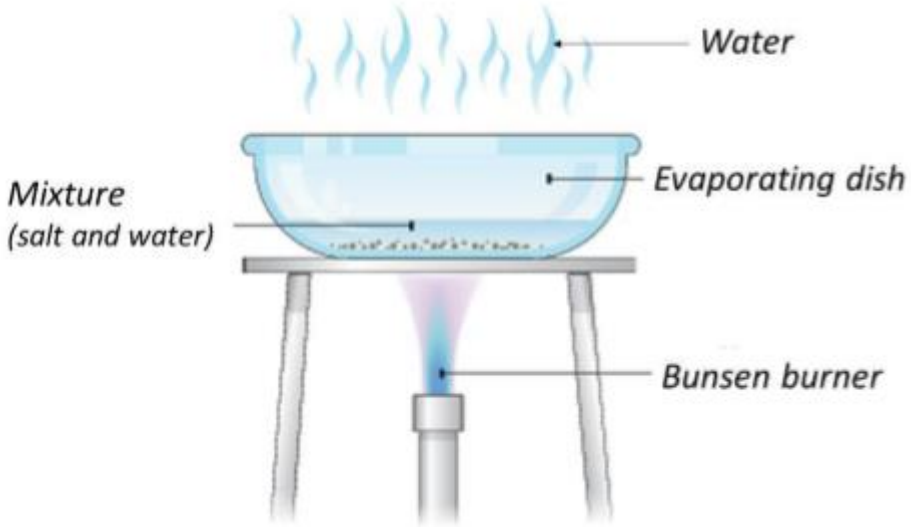
We can separate the heterogeneous mixtures into their constituents by means of physical methods like:

- Filtration
- Hand-picking
- Sieving

The components of a mixture can be separated from each other using several other techniques like:

- Evaporation
- Centrifugation
- Sublimation
- Chromatography
- Distillation

1. Evaporation – For separating a mixture of a non-volatile and a volatile substance



- **Applications:**

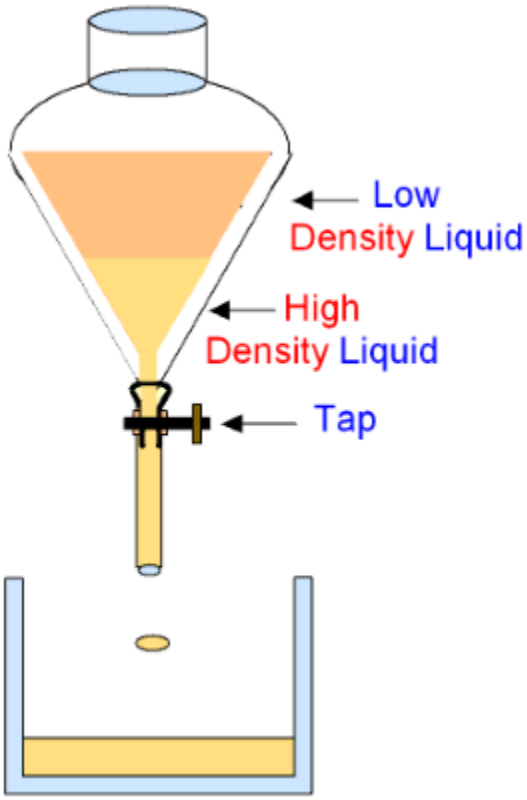
- Separating coloured component from the ink
- Salt from water
- Sugar from Water

- **Method:**
  - Mix some ink into water and heat it. After some time the water will evaporate leaving behind the coloured substance.

2. Centrifugation – Separating dense particles from lighter particles

- **Applications:**
  - Separating milk from cream
  - Separating butter from cream
  - Squeezing out water from wet clothes
- **Method:**
  - Milk is put in a centrifuging machine or milk churner and the cream thus separates from milk.

3. Using a Separating funnel – To separate two immiscible liquids

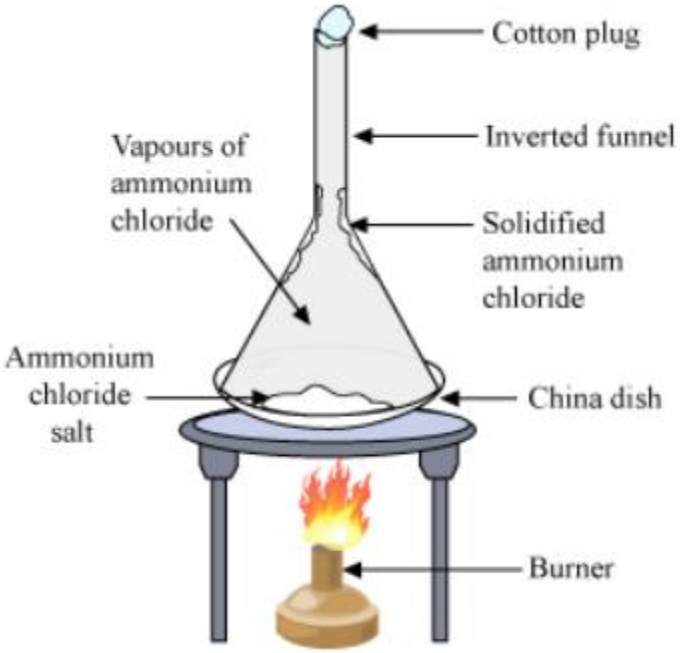


- **Applications:**
  - Oil from water

- Iron and iron ore

- **Method:**
  - The immiscible liquids are allowed to settle in the funnel. They soon form separate layers due to varying densities. The first liquid is allowed to flow out of the funnel and as soon as it is completely poured out, the stopcock is closed thereby separating the two liquids from each other.

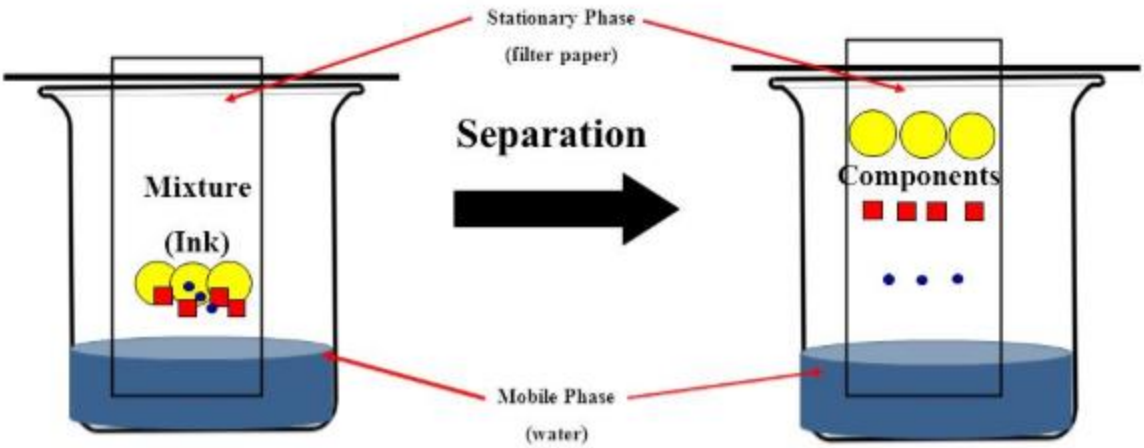
4. Sublimation – To separate a sublimable component from a non-sublimable component



- **Applications:**
  - Ammonium chloride / camphor / naphthalene and salt

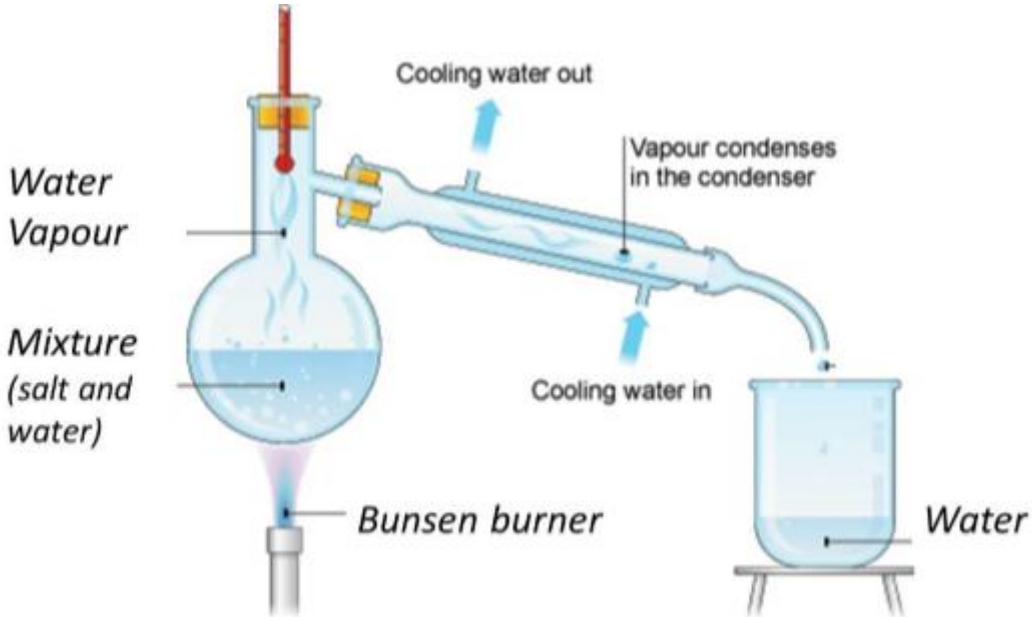
- **Method:**
  - Heat the mixture in an inverted funnel so that the sublimable component sublimes in the air and settles over the walls of the funnel and the non-sublimable component, on the other hand, is left behind.

5. Chromatography – To separate solutes that can dissolve in the same solvent



- **Applications:**
  - Separating colour components of a dye
  - Drugs from blood
- **Method:**
  - Take a filter paper or a blotting paper and place a drop of ink at the rear end. Dip the end in water. Since ink is a mixture of two or more colors, the component of ink which is soluble in water mixes into it and then separates quickly from the other components that are less soluble in water.

6. Distillation – To separate miscible liquids (the boiling points of the liquids must be sufficiently different)



- **Applications:**
  - Acetone and water
- **Method:**
  - The mixture is heated in a distillation apparatus. The one substance with lower boiling point evaporates first, condenses and gets separated from the one with a higher boiling point.
  - **Simple Distillation** – when the miscible liquids have a satisfactory difference in their boiling points
  - **Fractional Distillation** – when the difference between the boiling points of the liquids is less than 25 K

Separating different Gases from the Air

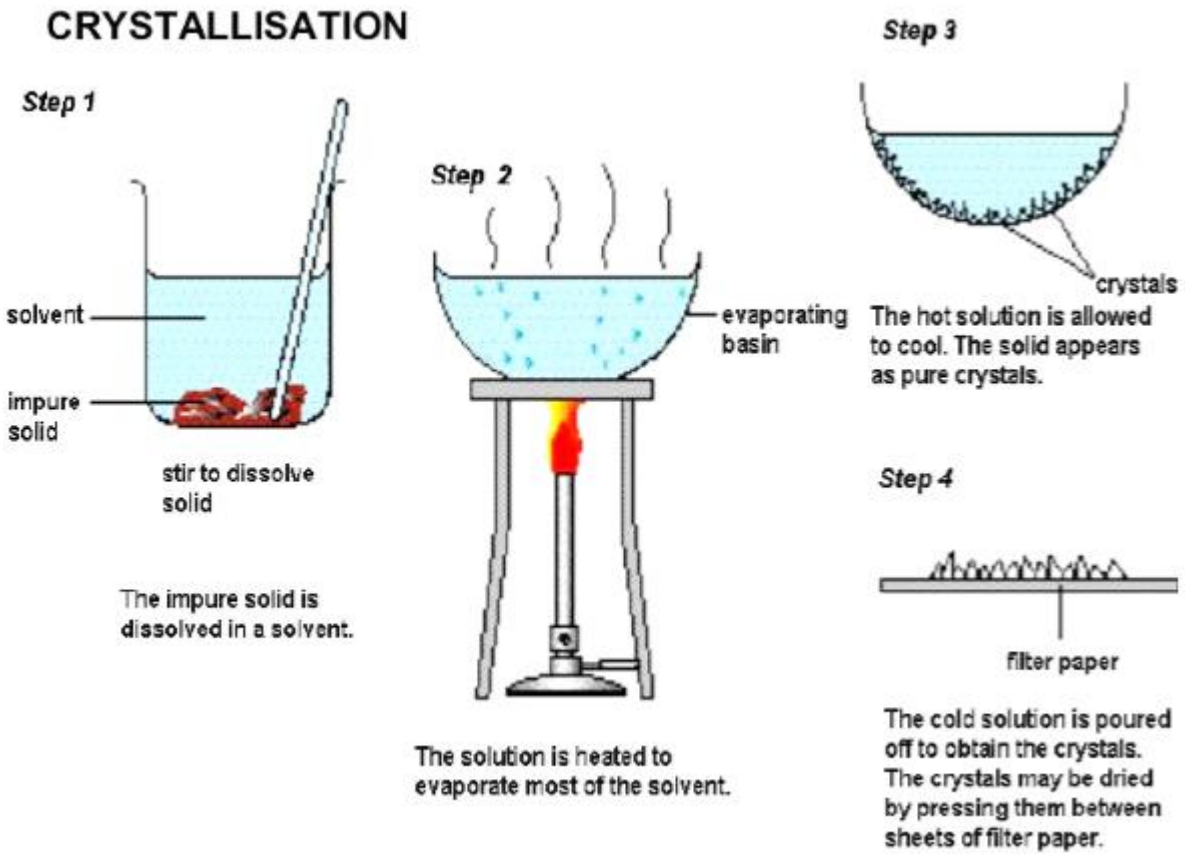
Method – Fractional Distillation

- Compress and cool the air by increasing the temperature and decreasing the pressure. The air turns to liquid air.
- Liquid air is warmed up slowly in a fractional distillation apparatus
- The several components of air get separated and are collected at various heights on the basis of their boiling points

Purifying Solids

Method used – Crystallization

In the crystallization method, we can obtain a pure solid in the form of crystals from its solution



- **Applications:**
  - Salt from sea water
  - Purification of copper sulphate
- **Method:**
  - The impurities of a substance are filtered out.
  - Water is evaporated to obtain a saturated solution.
  - The solution is covered with filter paper and left as it is.
  - After some time, the crystals of pure solid are formed.
- **Is evaporation better than crystallization?**

Simple evaporation is not better than crystallization because:

1. Some solid substances decompose because of excess heat. **For Example**, Sugar gets charred on extra heating.

2. If after filtration some impurities remain in the solution they can contaminate the solid and therefore we would not obtain a pure substance.

Physical Change and Chemical Change

Physical Property of a Substance:

Properties of a substance such as rigidity, colour, fluidity, boiling point, melting point, density and hardness which we can observe are called as **Physical Properties**.

Physical Change:

When physical properties of a substance change it is known as a **Physical Change**. When we convert a substance from one state to another, such as a solid into a liquid or vice-versa, it is also a physical change as only the physical nature of the substance changes without affecting its chemical nature.

For Example, Change of ice into water. The chemical properties of water remain the same.

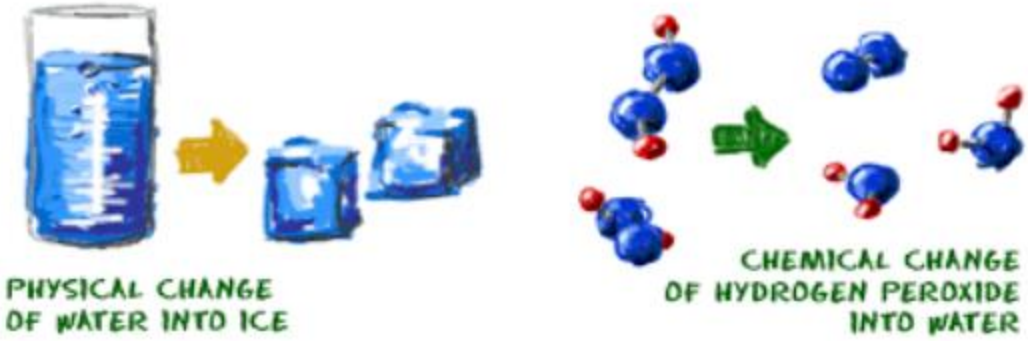
Chemical Property of a Substance:

The chemical nature of a substance is known as its **Chemical Property** such as its odour or its chemical composition.

Chemical Change:

When the chemical properties or chemical composition of a substance gets altered it is called a chemical change. It is also called as a **Chemical Reaction**.

For Example, Burning of paper



Types of Pure Substances

Pure substances are classified as elements and compounds

Elements

An element is the simplest form of matter. Elements cannot be broken down into further elements by chemical reactions. Elements are further characterized as Metals, Non-Metals and Metalloids

Metals – Silver, Mercury, Copper, Gold

1. Metals are lustrous (shiny)

2. Metals conduct heat and electricity

3. Metals have a silver-grey or gold-yellow colour

4. We can hammer metals and form thin sheets (Malleability)

5. We can convert metals into wires (Ductility)

6. Metals always produce a ringing sound if they are hit (Sonorous)

Non-Metals – Carbon, Iodine, Chlorine, Oxygen, Hydrogen

1. Non-Metals do not conduct heat and electricity

2. Non-Metals are not sonorous, lustrous or ductile

3. Non-Metals have varied colours

Metalloids – Silicon, Germanium

They show some properties of metals and some of the non-metals.

Quick Facts –

1. There are 100 elements known to us

2. 92 elements out of them occur naturally

3. Rest, 8 are man-made elements

4. Most of the elements are solid in nature

5. At room temperature, 11 elements exist in the gaseous state

6. At room temperature, 2 elements exist in the liquid state – bromine and mercury

7. At a temperature slightly higher than room temperature, 2 elements exist in the liquid state – calcium and gallium

Compounds

It is a substance that consists of two or more substances. These substances are combined chemically with each other in fixed proportions. The properties of a compound are different than that of its constituents. **For Example**, Ammonium Sulphate, Sulphur Chloride, Water.

Mixtures vs. Compounds

Mixtures	*Compounds*
Properties of a mixture Reflect the properties of the materials it contians.	Different properties from that of the elements that make up the compounds.
No uniform composition	Definite composition. Definite ratio/formula
Can be separated by physical means.	Cannot be separated by physical means.

Chemical symbols:
The representation of an element using the short form or abbreviation of its name is known as its chemical symbol. The name is based on English name or Latin name. For

example; the name Copper and its symbol 'Cu' came from the Latin word cuprum.
All the names and symbols of the elements are approved by the International Union of Pure and Applied Chemistry (IUPAC).

Element (Latin Name)	Symbol	Element (Latin Name)	Symbol	Element (Latin Name)	Symbol
Hydrogen	H	**Aluminum**	Al	**Zinc**	Zn
Carbon	C	**Nitrogen**	N	**Phosphorus**	P
Boron	B	**Argon**	Ar	**Sulphur**	S
Iodine	I	**Fluoride**	F	**Lead (Plumbum)**	Pb
Lithium	Li	**Oxygen**	O	**Silver (Argentum)**	Ag
Beryllium	Be	**Barium**	Ba	**Copper (Cuprum)**	Cu
Silicon	Si	**Bromine**	Br	**Gold (Aurum)**	Au
Magnesium	Mg	**Calcium**	Ca	**Helium**	He
Manganese	Mn	**Iron (Ferrum)**	Fe	**Neon**	Ne
Chlorine	Cl	**Sulphur**	S	**Potassium (Kalium)**	K
Mercury (Hydragyrum)	Hg	**Sodium (Natrium)**	Na	**Cobalt**	Co

Chemical formula:
The symbolic representation of the composition of a chemical compound is known as its chemical formula. For example; the chemical formula of sodium chloride is NaCl.

Compounds	Formula
Carbon dioxide	CO_2
Magnesium Oxide	MgO
Sodium Chloride	$NaCl$
Copper Sulphate	$CuSO_4$
Sulphuric Acid	H_2SO_4
Nitric Acid	HNO_3
Sodium Hydroxide	$NaOH$
Sulphur dioxide	SO_2
Water	H_2O
Ammonia Gas	NH_3
Sodium Chloride	$NaCl$
Potassium Chloride	KCl
Carbon dioxide	CO_2
Magnesium Chloride	$MgCl_2$
Hydrogen Sulphide	H_2S
Methane	CH_4
Hydrochloric acid	HCl

Valency:
The combining capacity of the atom of an element with the atom of other elements is known as its valency.
Valencies of Some common elements are given below

Elements	Valency	Element	Valency	Element	Valency
Sodium	1	Magnesium	2	Chlorine	1
Potassium	2	Calcium	2	Carbon	4
Silver	1	Aluminium	3	Oxygen	2
Zinc	2	Hydrogen	1	Iodine	1

Chemical equations:
A Chemical change resulting in the formation of one or more new substances is called a chemical reaction. The representation of a chemical reaction using symbols and formulae of the elements or compounds involved in the reaction is known as chemical equation.
The chemical substances that participate in a chemical reaction are known as **reactants**.

The new substances formed due to a chemical reaction are known as **products**.
For example; Consider the reaction of magnesium with oxygen. Magnesium reacts with oxygen to form magnesium oxide.

$\text{Magnesium} + \text{oxygen} \rightarrow \text{Magnesium oxide}$Magnesium+oxygen→Magnesium oxide

$2Mg + O_2 \rightarrow 2MgO$2Mg+O2→2MgO

Types of chemical reactions:

Chemical reactions are classified in the following types:

- Combination reaction
- Decomposition reaction
- Single displacement reaction
- Double displacement reaction

Synthesis or Combination reaction:
In this type of reaction, two or more substances combine to form one new substance.
For example; hydrogen and oxygen react to form water.

$2H_2 + O_2 \rightarrow 2H_2O$2H2+O2→2H2O

Decomposition reaction:
In this type of chemical reaction, a compound breaks down into two or more substances. For example; silver chloride when exposed in sunlight breaks into silver and chlorine gas.

$2Ag + CL_2 \rightarrow 2AgCl$2Ag+CL2→2AgCl

Single displacement reaction:
In this, atoms of one element displays the atoms of another element from a compound.
For example; when iron is dipped in copper sulphate solution then iron displaced copper from copper sulphate solution and copper and iron sulphate solution is formed.

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$Fe+CuSO4→FeSO4+Cu

Double displacement reaction:
In this, Atom of two compounds switch places to form two new compounds.
For example; when hydrochloric acid and sodium hydroxide react then two new compounds sodium chloride and water are formed.

$HCl+NaOH \rightarrow NaCl+H_20$HCl+NaOH→NaCl+H20

Crystallization:
Some pure substances which are solid at room temperature from crystals. The process of formation of crystals is known as crystallization.
The process of crystallization is an example of a physical change. By obtaining crystals, we are able to purify certain substances. Pure sugar, urea, copper sulphate, alum and table salt form crystals.
The salt obtained by evaporation consists of many impurities such as sand, magnesium chloride etc. The impure salt can be purified by the crystallization process.

- For crystallization a large amount of salt is dissolved in water and allowed to boil .