# CHEMICAL REACTIONS AND EQUATIONS

1. Chemical reaction- The processes, in which a substance or substances undergo a chemical change to produce new substances or substances with entire new properties are known as chemical reactions.
2. Signs of a chemical reaction- These factors denote that a chemical reaction has taken place- change of state of a substance, change of colour of substance, change in temperature, evolution of gas and formation of precipitate.
3. Chemical Equation: The representation of chemical reaction by means of symbols of substances in the form of formulae is called chemical equation.
E.g. - $H_2 + O_2 \rightarrow H_2O$
4. Balanced Chemical Equation: A balanced chemical equation has number atoms of each element equal on both left and right sides of the reaction. According to the Law of Conservation of Mass, mass can neither be created nor destroyed in a chemical reaction. To obey this law, the total mass of elements present in reactants must be equal to the total mass of elements present in products.

# TYPES OF CHEMICAL REACTIONS

1. Combination reactions - Reactions in which two or more reactants combine to form one product is called Combination Reactions.
2. Decomposition reactions- Reactions in which one compound decomposes into two or more compounds or elements are known as Decomposition Reaction.
3. Displacement reactions- The chemical reaction in which a more reactive element displaces a less reactive element from a compound is known as a displacement reaction.
4. Double displacement reactions- Reactions in which ions are exchanged between two reactants forming new compounds are called Double Displacement Reactions.
5. Precipitation reactions- The reaction in which precipitate is formed by the mixing of the aqueous solution of two salts is called precipitation reaction.
6. Exothermic reactions- Reactions which produce energy are called exothermic reactions. Most of the decomposition reactions are exothermic.
7. Endothermic reactions- Reactions which absorb energy are called endothermic reactions. Most of the combination reactions are endothermic.
8. Oxidation: Addition of oxygen or non-metallic element or removal of hydrogen or metallic element from a compound is known as oxidation.
9. Reduction: Addition of hydrogen or metallic element or removal of oxygen or a non-metallic element from a compound is called reduction.
10. Redox reactions -A chemical reactions where oxidation and reduction both takes place simultaneously are also known as redox reactions.
$CuO + H_2 \rightarrow Cu + H_2O$

11. Neutralisation Reaction: The reaction in which an acid reacts with a base to form salt and water by an exchange of ions is called Neutralization Reaction.

Example: $NaOH + HCl \rightarrow NaCl + H_2O$

| Reaction type | Explanation | General formula |
|---|---|---|
| Combination | Two or more compounds combine to form one compound. | $A + B \rightarrow AB$ |
| Decomposition | The opposite of a combination reaction – a complex molecule breaks down to make simpler ones. | $AB \rightarrow A + B$ |
| Precipitation | Two solutions of soluble salts are mixed, resulting in an insoluble solid (precipitate) forming. | A + soluble salt B → precipitate + soluble salt C |
| Neutralisation | An acid and a base reaction with each other. Generally, the product of this reaction is a salt and water. | acid + salt → salt + water |
| Combustion | Oxygen combines with a compound to form carbon dioxide and water. These reactions are exothermic, meaning they give off heat. | $A + O_2 \rightarrow H_2O + CO_2$ |
| Displacement | One element trades places with another element in the compound. | $A + BC \rightarrow AC + B$ |

## PHYSICAL CHANGES

Physical changes are limited to changes that result in a difference in display without changing the composition. Some common changes (but not limited to) are:

- Texture
- Colour
- Temperature
- Shape
- Change of State (Boiling Point and Melting Point are significant factors in determining this change.)

In a physical change, the material involved in the change is structurally the same before and after the change. Types of some physical changes are texture, shape, temperature, and a change in the state of matter. A change in the texture of a substance is a change in the way it feels. For instance, a block of wood may feel rough when you run your finger across it but rubbing the wood with sandpaper smooths the surface so it no longer feels rough. The wood itself has not changed during sanding to become a new material, only the texture of the surface changed. A piece of metal may be heated in a fire until it glows, but the metal is the same material before heating and after cooling. Similarly, when a material changes phase, it only changes physically; the substance is still the same. Think about ice melting into water,

and then water being heated up and turning into steam. The chemical structure of water is the same whether it is a solid (ice), liquid, or gas (steam).

## CHEMICAL CHANGES

A chemical change occurs when the substance's composition is changed. When bonds are broken and new ones are formed a chemical change occurs. The following are indicators of chemical changes:

- Change in Temperature
- Change in Color
- Noticeable Odour (after reaction has begun)
- Formation of a Precipitate
- Formation of Bubbles

A chemical change occurs when the composition of a substance is changed, which requires the breaking and forming of chemical bonds during a chemical reaction. This results in the rearranging of atoms in substances to form the products of a chemical reaction, which are brand new molecules that cannot be easily reverted back to their original state.

Sometimes it is difficult to tell if a chemical reaction has taken place. To help determine whether there has been a reaction, chemists consider the basic indicators that a reaction has occurred, such as a change in temperature, a change in colour, the development of an odour, the formation of a precipitate, or the formation of a gas.

In a chemical alteration, the temperature change occurs as a result of the breaking or formation of chemical bonds. When the chemical bonds of the reactants are broken, sometimes excess energy is released, causing heat to be discharged, and leading to an increase in temperature. Alternatively, a reaction may require energy from the environment in order to take place, causing heat to be absorbed, and leading to a decrease in temperature. Burning wood is an example of a reaction that releases excess energy as heat. A chemical cold pack in a first aid kit is an example of a chemical reaction that absorbs heat energy resulting in cooling.

An example of a colour change signalling a chemical reaction can be observed when iron reacts with oxygen to produce iron oxide, such as when an iron nail is left outside, and it develops a reddish-brown rust.

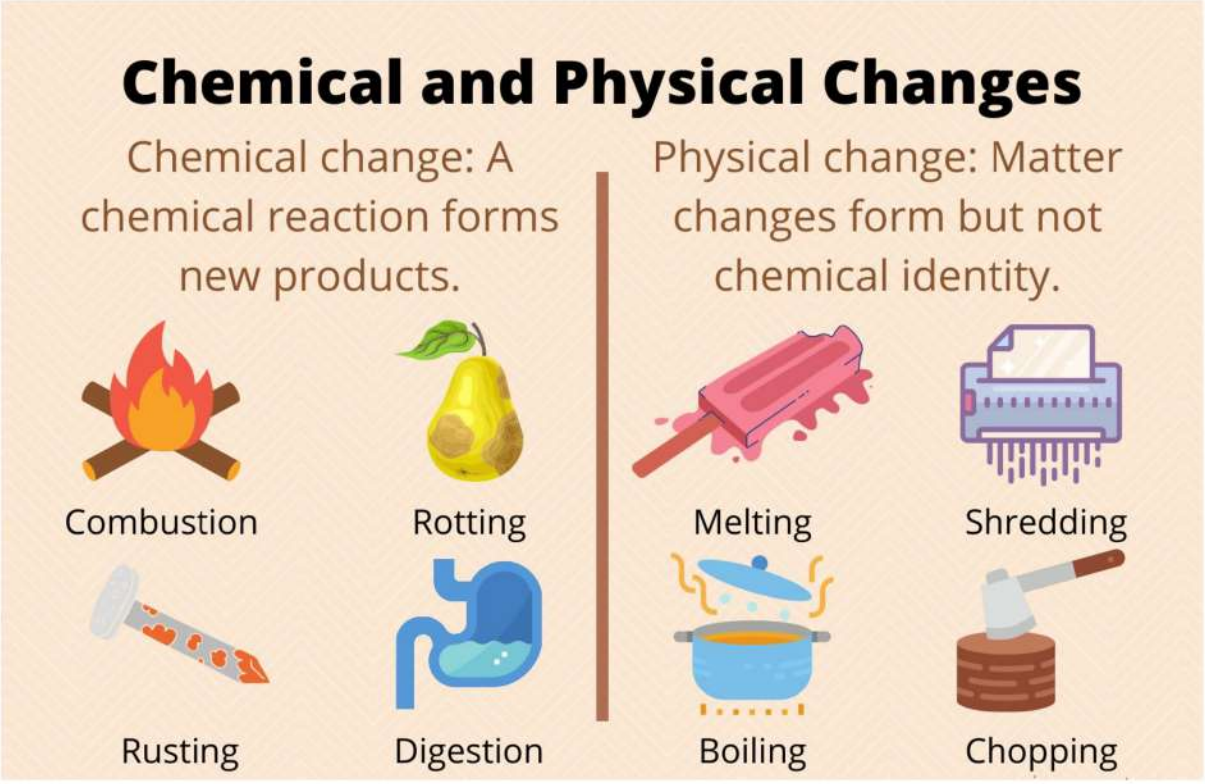
Rotting food is an example of odour development as a result of a chemical change. When food is left out for too long, or it reaches its expiration date, it eventually spoils, often producing a foul odour in its rotten state. This is because of chemical reactions that take place

as the food begins to break down and go bad, which leads to the formation of new substances that have unique smells associated with them.

Another common sign of a chemical reaction is the formation of a precipitate. This happens when chemicals dissolved in a solution are mixed together and an insoluble solid, known as a precipitate, forms in the liquid mixture. The creation of a new, solid substance from two liquid substances indicates that a reaction has taken place and altered the original substances.

A common chemical reaction is the mixing of vinegar and baking soda. When these two household chemicals are mixed together, it immediately starts bubbling and foaming. The bubbles are a release of carbon dioxide gas, a product of the chemical reaction between the baking soda and vinegar.

Remember that one way often to distinguish a physical reaction from a chemical reaction is that a chemical reaction cannot be easily reversed, if at all.



**Chemical Equation**

There are two ways of representing a chemical reaction as follows:
In terms of words (called word equation), For example, the above reaction

(i) may be represented in the form of word equation as follows:
Zinc + Sulphuric Acid $\longrightarrow$ Zinc Sulphate + Hydrogen
(Reactants) (Products)
Thus, the names of the reactants are written on the left-hand side (LHS) with a plus sign (+) between them. The names of the products are written on the right-hand side (RHS) with a plus sign between them. An arrow (→) is put between the reactants and the products, such that the direction of the arrowhead is from the reactants towards products.

(ii) In terms of symbols and formulae (called chemical equation): Even the above method of representing a chemical reaction is not too short. A still shorter and faster method is used by writing symbols and formulae of the different reactants and products in place of their names.
Thus in terms of symbols and formulae, the above reaction may be represented as follows:
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
This is called a chemical equation.
In fact, this is the most common method of representing a chemical reaction.
Hence, we define a chemical equation as follows:
The short-hand method of representing a chemical reaction in terms of symbols and formulae of the different reactants and products is called a chemical equation.

**How to balance equations?**

For balancing a chemical equation, we follow seven basic steps.

**Step 1:** To balance a chemical equation, first draw boxes around each reactant and product and do not make any changes to it.

$Fe + H_2O \rightarrow Fe_3O_4 + H_2$

**Step 2:** List the number of atoms of each element present in the unbalanced equation.

| Elements | Reactants side | Products side |
|---|---|---|
| Fe | 1 | 3 |
| H | 2 | 2 |
| O | 1 | 4 |

**Step 3:** We should always choose a compound with a maximum number of atoms in it, either on reactants side or products side.

$Fe + H_2O \rightarrow Fe_3O_4 + H_2$

Here we select $Fe_3O_4$ which contains 4 oxygen atoms on the right hand side.

As we cannot make $H_2O$ to $H_2O_4$ in order to increase oxygen atoms, so we make it to $4H_2O$.

$Fe + 4H_2O \rightarrow Fe_3O_4 + H_2$

**Step 4**: Balance other atoms now like Fe and H.

$Fe + 4H_2O \rightarrow Fe_3O_4 + H_2$

Atoms of H are 8 on L.H.S and 2 ON R.H.S, so multiply $H_2$ on R.H.S with 4, so we get

$Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

**Step 5:** $Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

Pick the last element Fe from the above partly balanced equation. Fe are 3 on R.H.S and 1 on L.H.S, so multiply 3 on L.H.S

$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

**Step 6:**

Check the equation whether it is balanced or not by counting the number of atoms on L.H.S and R.H.S

$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

This is the balanced equation.

**Step 7:** Indicate the physical state of all the reactants and products by writing symbols in brackets as subscripts on the right corner below the formula.

**Symbols:**

The symbols are denoted with some letters. For solids, we use "s", for liquids we use "l", for gases we use "g", for aqueous solutions we use "aq". These symbols help us to classify the type of equation.

**Balanced equation representation:**

Take the example of the chemical equation

$3Fe(s) + 4H2O(l) \rightarrow Fe3O4(s) + 4H2(g)$

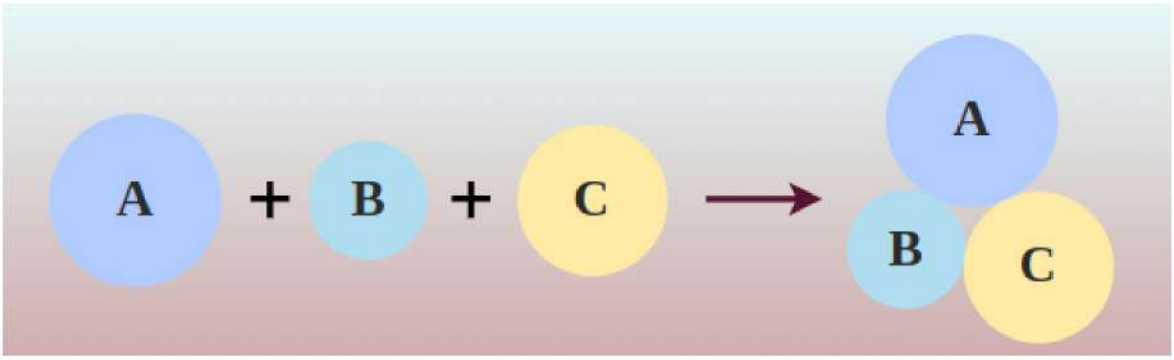
The heterogeneous chemical equation is the name given to this formula. Because the reactants and products have various physical states, the equation is known as the heterogeneous equation. Physical states are not required in balanced equations until they are required. The equation shows the catalyst and reaction conditions, such as temperature and pressure, above and below the arrow.

## TYPES OF CHEMICAL REACTIONS

A chemical reaction is a process generally characterised by a chemical change in which the starting materials (reactants) are different from the products.

Combination Reaction

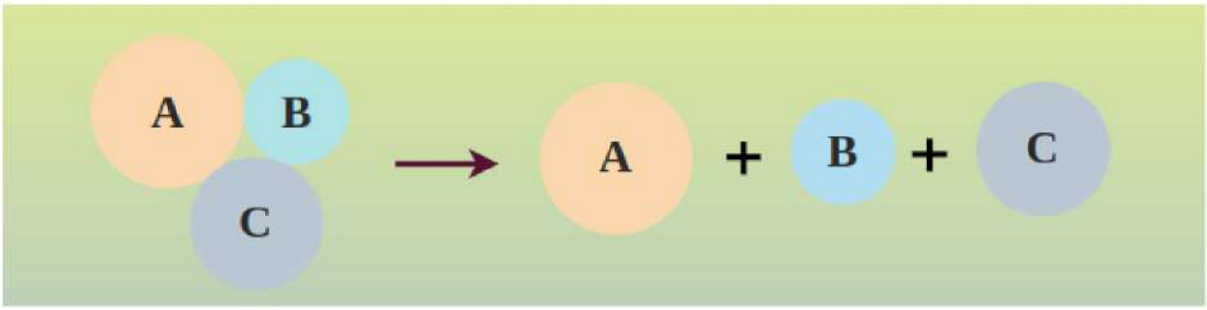
In the combination reaction, two or more reactants combine together to form a single product. As in this reaction, new compounds are formed with the help of other compounds, so it is also called a synthesis reaction.




***SO3(g)+H2O(l)→H2SO4(aq)***

Decomposition Reaction

In the decomposition reaction, a single component breaks down into two or more products, to break the bonds between different components a lot of heat is required, we can provide it in the form of heat, electricity or sunlight, etc.




$2Ni_2O_3(aq) \rightarrow 4Ni(s) + 3O_2(g)$

Redox Reaction

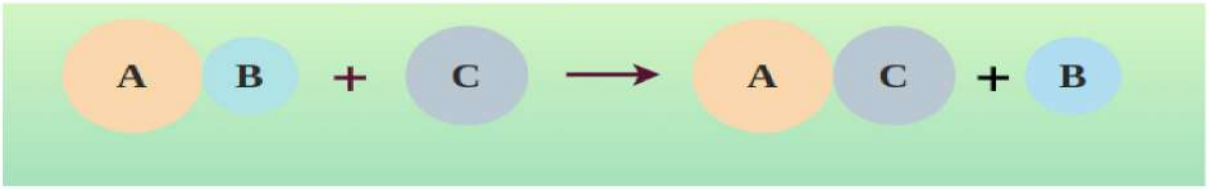
Redox reaction which is also called Reduction-oxidation reaction is the reaction in which reduction(gain of the electron) and oxidation (loss of electron) takes place simultaneously. So in other words, it is the process of transfer of electrons between different elements and compounds to form new compounds.

$CuSO_4(aq) + Fe(s) \rightarrow FeSO_4(aq) + Cu(s)$

In the above reaction, copper goes through oxidation as it gains electrons and is a reducing agent in this example, iron goes through reduction as it loses electrons and is an oxidising agent in this example.

Single Displacement Reaction

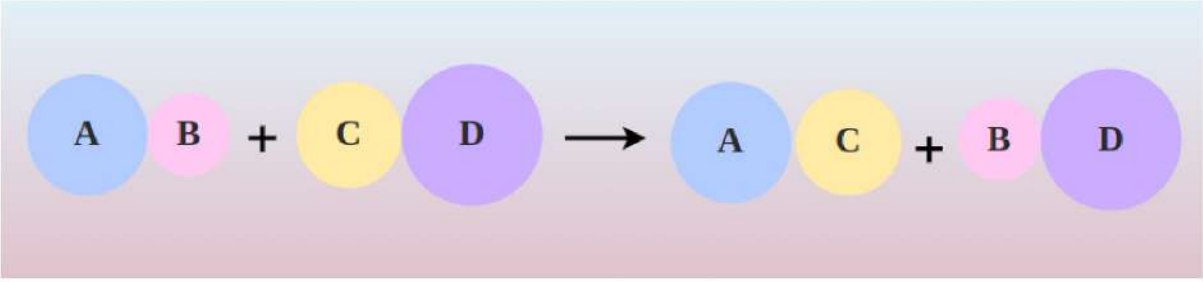
In a single displacement Reaction, more reactive metal displaces less reactive metal from its salt or other compounds. In these reactions, through reactivity series, products can be determined. Reactivity series is a series of elements in which elements are arranged in decreasing order of their reactivity. Thus, the elements present at the top of the series are more reactive than the elements present at the bottom of the series.




$Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$

Double-Displacement Reaction

It is a kind of displacement reaction in which two chemical species react and consequently, their ions i.e. cations and anions switch places forming two new products.




*AgNO3 (aq) + NaCl (s) → AgCl (aq) + NaNO3 (s)*

Look at the reaction between silver nitrate and sodium chloride. The products of the reaction will be silver chloride and sodium nitrate after the double-displacement reaction.

**Based on Heat Involved in Reaction**

Based on the heat involved in the chemical reaction, Reactions can be classified into two categories:

- Exothermic Reaction
- Endothermic Reaction

| Endothermic reaction | Exothermic reaction |
|---|---|
| 1. In endothermic reaction heat is absorbed from surroundings. | 1. In exothermic reaction heat is given out to surroundings. |
| 2. Sum of enthalpies of products is greater than sum of enthalpies of reactants i.e. $\Sigma_P H > \Sigma_R H$ | 2. Sum of enthalpies of products is less than sum of enthalpies of reactants. i.e. $\Sigma_P H < \Sigma_R H$ |
| 3. Heat of reaction, $\Delta H$ is positive. | 3. Heat of reaction, $\Delta H$ is negative. |
| 4. Products are less stable than reactants. | 4. Products are more stable than reactants. |
| 5. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H = -394$ kJ | 5. $N_{2(g)} + O_{2(g)} \rightarrow 2NO$ $\Delta H = +180$ kJ |