Types of Reaction-1

Many chemical reactions can be classified as one of five basic types. Having a thorough understanding of these types of reactions will be useful for predicting the products of an unknown reaction.

The five basic types of chemical reactions are

1. **Combination or Synthesis,**
2. **Decomposition,**
3. **Single-replacement,**
4. **Double-replacement,**
5. **Combustion**

Analyzing the reactants and products of a given reaction will allow you to place it into one of these categories.

Synthesis Reaction

A **combination reaction**, also known as a **synthesis reaction**, *is a reaction in which two or more substances combine to form a single new substance.* Combination reactions can also be called synthesis reactions .The general form of a combination reaction is:

$$A+B\rightarrow AB \ (5.3.1)(5.3.1)A+B\rightarrow AB$$

One combination reaction is two elements combining to form a compound. Solid sodium metal reacts with chlorine gas to product solid sodium chloride.

$$2Na(s) +Cl_2 \ (g) \rightarrow 2NaCl(s)(5.3.2)(5.3.2)2Na(s)+Cl2(g)\rightarrow 2NaCl(s)$$

Notice that in order to write and balance the equation correctly, it is important to remember the seven elements that exist in nature as diatomic molecules
(H_2H2, N_2N2, O_2O2, F_2F2, Cl_2Cl2, Br_2Br2, and I_2I2).

One sort of combination reaction that occurs frequently is the reaction of an element with oxygen to form an oxide. Metals and nonmetals both react readily with oxygen under most conditions. Magnesium reacts rapidly and dramatically when ignited, combining with oxygen from the air to produce a fine powder of magnesium oxide.

$$2Mg(s) +O_2 \ (g) \rightarrow 2MgO(s) \ (5.3.3)(5.3.3)2Mg(s)+O2(g)\rightarrow 2MgO(s$$

Examples of Synthesis Reactions

Another example of a synthesis reaction is the combination of sodium (Na) and chlorine (Cl) to produce sodium chloride (NaCl). This reaction is represented by the chemical equation:

$2Na + Cl_2 \rightarrow 2NaCl$

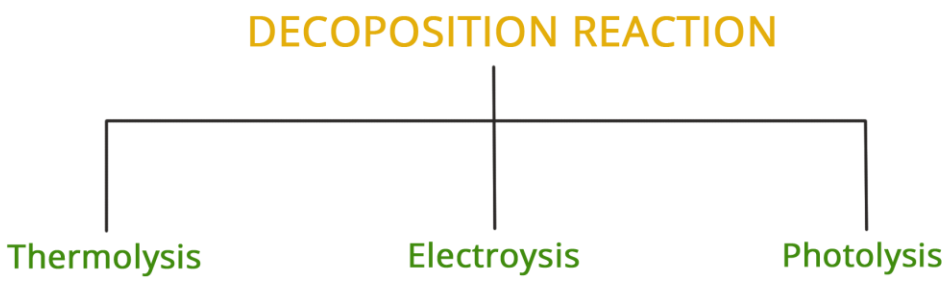
Sodium is a highly reactive metal, and chlorine is a poisonous gas.

- Water:
  $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$
- Carbon dioxide:
  $2\ CO(g) + O_2(g) \rightarrow 2CO_2(g)$
- Ammonia:
  $3\ H_2(g) + N_2(g) \rightarrow 2\ NH_3(g)$
- Aluminum oxide:
  $4\ Al(s) + 3\ O_2(g) \rightarrow 2\ Al_2O_3(s)$
- Iron sulfide:
  $8\ Fe + S_8 \rightarrow 8\ FeS$
- Potassium chloride:
  $2\ K(s) + Cl_2(g) \rightarrow 2\ KCl(s)$

Decomposition Reaction

A decomposition reaction is a chemical reaction in which one reactant breaks two from two or more products. It is the converse of a combination reaction. For example, in a displacement reaction, the atom is replaced by an atom of another element. The chemical reaction will be shown by a chemical equation. It represents the change from reactants to products. The left-hand side represents the reactant side and the right-hand side represents the product of the reaction. There are many parenthetical notes for each compound like for solid (S), liquid (l), gas(g), aqueous (aq). The form of chemical reaction be like
A (aq) + B(g) = C(s) + D(aq)
In our day-to-day chemistry lab, the decomposition reaction takes place. The food is broken down to form water, CO2, and heat. Food like protein, fats, and carbohydrates will break down into simple units. The decomposition of hydrogen peroxide into oxygen and hydrogen gas is also done by this process -
H2 O2 —> H2 + O2

Classification of Decomposition Reaction



Decomposition reactions are of three types -
Thermolysis –

- Thermolysis is decomposition due to heat.

Electrolysis –

- Electrolysis is decomposition due to electricity.

Photolysis –

- Photolysis is decomposition due to light.

1) Thermal Decomposition Reaction
Chemical reaction where one substance breaks into two or more substances during the heat. This heat is required to break the bond which is present between the substances. The reaction is endothermic.
Calcium Carbonate Decomposition Reaction
Limestone or calcium decomposes into calcium oxide or quicklime and CO2 during the heat.
$CaCO3 (s) —heat—> CaO(s) + CO2$
Potassium Chlorate Decomposition Reaction
Potassium Chlorate decomposes into potassium chloride and O2 during heating. The reaction is used for the preparation of oxygen.
The Decomposition is done In the presence of manganese dioxide as a catalyst.
$2KClO3(s) —> 2KClO(s) + 3O2 (g)$
Hydrated Oxalic Acid Decomposition Reaction The decomposition of hydrated Oxalic Acid into oxalic Acid and water takes place when heated.
$H2C2O4.2H2O —heat—> H2C2O4 + 2H2O$
2) Electrolytic Decomposition Reaction
In this reaction, an electric current is passed through the aqueous solution of a compound. E.g., electrolysis of water.
$2H2O (l) —> 2H2 (g) + O2 (g)$
Sodium Chloride Decomposition Reaction
When electricity is passed through molten sodium chloride, it gets converted into sodium and chlorine.
$2NaCl —> 2Na + Cl2$
3) Photo Decomposition Reaction
This reaction is done in the presence of sunlight.
Silver Chloride Decomposition Reaction
when a small amount of AgCl is placed into a watch glass, the crystal changes to a grey color. The decomposition of Silver chloride into silver takes place.
$2AgCl(s) —> 2Ag(s) + Cl2 (g)$
Some examples of Decomposition reactions are -
The Carbonates get decomposed into metal oxide and carbon dioxide after heating.
$CaCO3 (s) —> CaO (s) + CO2 (g) Na2CO3(s) —> Na2O (s) +CO2 (g)$

Double Decomposition Reaction

The reaction in which one part of a compound changes to form two new compounds. The positive ion is exchanged with another positive ion of the compound this is known as a double replacement reaction.

Uses of Decomposition Reaction

- It is used for metal extraction.
- It helps in the formation of cement.
- It helps to get relief from indigestion.
- It is used to decompose silver chloride in silver.
- It is also used for thermite welding.
- Reactions involving light, heat, and electricity help to break the bonds of a compound.
- The fizz in a soda bottle is due to a decomposition reaction.
- It is used in the formation of quicklime.

Single Displacement Reaction

Those reactions in which one element replaces another element from its salt or compound are called single displacement reactions. These are also called single replacement reactions. General representation can be written as well –

A + B-C □ A-C + B

It will occur if A is more reactive than B. Generally, metals and its salts give single displacement reactions. In these reactions more reactive metal displaces less reactive metal from its salt. For example, potassium is more reactive than magnesium, so potassium replaces magnesium from magnesium chloride. The reaction between potassium and magnesium chloride occurs as follows –

2K + MgCl2 □ 2KCl + Mg

When chlorine is added in its gaseous form (or as a gas dissolved in water) to the solution of sodium bromide, the chlorine acquires the place of bromine. Since chlorine is more reactive than bromine, it displaces bromine from sodium bromide, and the solutions turn blue. The brown colour is the bromine that is displaced. If you notice the equation, you can see that the Cl and Br have swapped their original places. Chlorine + sodium bromide → sodium chloride + bromine**Cl_2(aq) + 2NaBr(aq) → 2NaCl(aq) + Br_2(aq)**

Dissolve 0.5 gm of Silver nitrate in 10 ml of water in a test tube. A copper wire is then dipped in it and kept undisturbed for some time. The shining silver crystals are visible on the Copper wire. The solution becomes bluish as some amount of copper is developed. In the below reaction, the copper metal displaces silver from Silver Nitrate solution'**$s_{(s)}$ + 2$AgNo_{3\,(aq)}$ → 2$Ag_{(s)}$ + Cu$(NO_3)_{2(aq)}$**

Reactivity Series

Reactivity series is the series of metals based on their reactivity from highest to lowest. So, reactivity series of metals can be defined as a series of metals, in order of reactivity from highest to lowest. It is also known as activity series. The reactivity of metals is because of their incomplete outer orbitals or due to their electronic configuration. Metals form positively charged ions as they tend to lose electrons. Metals with high atomic numbers tend to be more reactive as their electrons are far from the positively charged nucleus. So, they can be removed easily.

Symbol of element	Name of element		
K	Potassium		Most Reactive
Na	Sodium		
Ca	Calcium		
Mg	Magnesium		
Al	Aluminum		
Zn	Zinc		
Fe	Iron		
Pb	Lead		
H	Hydrogen		↓Reactivity decreases
Cu	Copper		
Hg	Mercury		
Ag	Silver		
Au	Gold		
Pt	Platinum		Least reactive

Types of Reaction-2

Double Displacement Reaction

Double displacement reactions are those reactions where the cations and anions of reactants switch places with each other or replaces each other. Generally, it can be represented as follows –

AB + CD □ CB + AD

Example of double displacement reaction – Reaction between silver nitrate and sodium chloride is an example of double displacement reaction. The reaction given below –

AgNO3 + NaCl □ AgCl + NaNO3

Examples of Displacement Reactions

- Examples of single displacement reaction –
- Reaction between zinc and copper sulphate –

  Zn + CuSO4 □ ZnSO4 + Cu
- Reaction between copper and silver nitrate –

  Cu + 2AgNO3 □ CuNO3 + 2Ag
- Reaction between iron and copper sulphate –

  Fe + CuSO4 □ FeSO4 + Cu
- Reaction between lead and copper chloride –

  Pb + CuCl2 □ PbCl2 + Cu
- Reaction between chlorine and sodium bromide –

  Cl2 + 2NaBr □ 2NaCl + Br2
- Examples of double displacement reaction -

- Reaction between potassium nitrate and aluminum chloride –

  $KNO_3 + AlCl_3 \rightarrow Al(NO_3)_3 + KCl$

- Reaction between lead nitrate and potassium iodide –

  $Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 + PbI_2$

- Reaction between iron chloride and barium hydroxide –

  $FeCl_3 + Ba(OH)_2 \rightarrow Fe(OH)_3 + BaCl_2$

- Reaction between lead nitrate and sodium sulphate –

  $Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4 + 2NaNO_3$

- Reaction between barium chloride and copper sulphate –

  $BaCl_2 + CuSO_4 \rightarrow BaSO_4 + CUCl_2$

Combustion Reaction

A combustion reaction is a chemical reaction which a fuel undergoes oxidation by reacting with an oxidizing agent, resulting in the release of energy (usually in the form of heat). Combustion reactions are generally highly exothermic redox reactions between an oxidant and a fuel. The product formed in a combustion reaction is usually the oxidized fuel (which is mostly liberated in the gaseous state). This is often referred to as smoke. It is not uncommon for combustion reactions to be accompanied by flames. However, it is essential to note that not all combustion reactions result in fires.
Solid fuels like coal and wood are known to initially undergo endothermal pyrolysis, resulting in the creation of gaseous fuels. The combustion of these gaseous fuels is known to provide the heat required to drive more combustion. Also, it is not uncommon for combustion to also be sufficiently hot to generate incandescent light in the form of either a flame or some flickering. The transformation of hydrogen and oxygen into water vapour, a process widely used to power rocket engines, can be seen as a simple example of combustion. Here, hydrogen is used as a fuel and oxygen is used as an oxidizing agent. This combustion reaction is known to release over 242 kilojoules of heat per mole of fuel subjected to combustion.

Examples of Combustion Reactions in our Day-to-Day Lives

Common examples of combustion reactions that are very common in the day to day lives of human beings are provided below.

- The combustion of LPG fuel in gas stoves for the cooking of food involves a combustion reaction between the oxygen present in the atmosphere and the liquefied petroleum gas.

- The engines of cars, bikes, and other fossil-fuel based automobiles source their power to the combustion reaction between petrol (or diesel) with oxygen.
- The lighting of matchsticks is also based on a combustion reaction. The red phosphorus at the tip of the matchstick is heated up by striking it on a rough surface, sparking a combustion reaction between the phosphorus and the atmospheric oxygen.
- The explosion of fireworks is also a combustion reaction. In these redox reactions, certain specific ions are incorporated into the fuel to impart a colour to the flame.

Apart from these basic combustion reactions, many other such reactions are employed in a wide range of industries. For example, the space industry is known to exploit the combustion reaction between hydrogen and oxygen for the generation of clean energy in rocket ships.

Chemical Equations of Important Combustion Reactions

Some important combustion reactions and their chemical equations are listed below.

The combustion of methanol (sometimes referred to as 'wood alcohol') involves a chemical reaction between methanol and oxygen. The chemical equation for this reaction is given by:

$$2CH_3OH + 3O_2 \rightarrow 4H_2O + 2CO_2$$

The combustion reactions undergone by methane are also known to yield water and carbon dioxide as products. This reaction can be represented by the following chemical equation:

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$$

The combustion of propane, which is widely employed in cooking setups like fire grills, is represented by the following chemical equation:

$$2C_3H_8 + 7O_2 \rightarrow 8H_2O + 6CO_2$$

Another important combustion reaction involving the oxidation of a hydrocarbon is the combustion of ethane. The chemical equation for the reaction between ethane and oxygen that yields carbon dioxide and water is provided below.

$$2C_2H_6 + 7O_2 \rightarrow 6H_2O + 4CO_2$$

Naphthalene also undergoes combustion in the presence of oxygen to afford carbon dioxide gas and water. The chemical equation for this reaction is given by:

$$12O_2 + C_{10}H_8 \rightarrow 4H_2O + 10CO_2$$

Redox Reaction

A redox reaction can be defined as a chemical reaction in which electrons are transferred between two reactants participating in it. This transfer of electrons can be identified by observing the changes in the oxidation states of the reacting species.
The loss of electrons and the corresponding increase in the oxidation state of a given reactant is called oxidation. The gain of electrons and the corresponding decrease in the oxidation state of a reactant is called reduction.

Types of Redox Reactions

The different types of redox reactions are:

- Decomposition Reaction
- Combination Reaction
- Displacement Reaction
- Disproportionation Reactions

Decomposition Reaction

This kind of reaction involves the breakdown of a compound into different compounds. Examples of these types of reactions are:

- $2NaH \rightarrow 2Na + H_2$
- $2H_2O \rightarrow 2H_2 + O_2$
- $Na_2CO_3 \rightarrow Na_2O + CO_2$

All the above reactions result in the breakdown of smaller chemical compounds in the form of AB → A + B

But, there is a special case that confirms that all the decomposition reactions are not redox reactions.

For example $CaCO_3 \rightarrow CaO + CO_2$

Combination Reaction

These reactions are the opposite of decomposition reaction and hence involve the combination of two compounds to form a single compound in the form of A + B → AB. **For example:**

- $H_2 + Cl_2 \rightarrow 2HClC + O_2 \rightarrow CO_2$
- $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Displacement Reaction

In this kind of reaction, an atom or an ion in a compound is replaced by an atom or an ion of another element. It can be represented in the form of X + YZ → XZ + Y. Further displacement reaction can be categorized into

- Metal displacement Reaction
- Non-metal displacement Reaction

Metal Displacement

In this type of reaction, a metal present in the compound is displaced by another metal. These types of reactions find their application in metallurgical processes where pure metals are obtained from their ores.

For example $CuSO_4 + Zn \rightarrow Cu + ZnSO_4$

Non-Metal Displacement

In this type of reaction, we can find a hydrogen displacement and sometimes rarely occurring reactions involving oxygen displacement.

Disproportionation Reactions

The reactions in which a single reactant is oxidized and reduced is known as Disproportionation reactions.

For example: $P_4 + 3NaOH + 3H_2O \rightarrow 3NaH_2PO_2 + PH_3$

OXIDATION	REDUCTION
Losing electrons	Gaining electrons
Increase in oxidation number	Decrease in oxidation number
For a given compound losing hydrogen	For a given compound gaining hydrogen
This reaction releases energy	This reaction stores energy
oxidizing agents: Ozone, Bleach, peroxide	Common reducing agent is metal