Chapter 1: Chemical Reactions And Equations

Chemical Reactions

A **chemical reaction** is a transformation in which one or more **substances** or **reactants** react to form new substances with completely different properties. The **reactants** (substances that undergo chemical change during the reaction) are referred to as **reactants**, and the new species formed as a result of the reaction are referred to as **products** (the new substances formed during the reaction).

$$N_a(s) + H_2O(l) \rightarrow N_aOH(aq) + H_2(g)$$

The products of the above chemical reaction are sodium hydroxide and hydrogen, while the reactants are sodium and water.

Identification Of Chemical Reaction

The following observations can be used to identify a chemical reaction:

- State change
- Colour change
- Gas evolution
- Temperature change
- Precipitation formation)

Chemical Equations

The symbolic representation of a **chemical reaction** is a **chemical equation**. For this, the symbols and formulae of the **reactants** and **products** are used. The reaction of **methane gas** burning can be written as follows:

Methane + Oxygen → **Carbon dioxide + Water**

(Reactants) → (Products)

The word equation refers to this equation. By substituting symbols and formulae for the substance's name, the word equation can be converted to a chemical equation.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Writing A Chemical Equation

An arrow (→) placed between reactants and products in a chemical equation depicts the change from reactants to products. Reactants are written on the left-hand side (LHS) of the arrow with a plus sign (+) between them. Similarly, products are written on the right-hand side (RHS) with a plus sign (+) between them.

The arrowhead points to the products and indicates the reaction's direction; for example, the reaction between magnesium (Mg) and oxygen (O_2) that produces magnesium oxide can be written as:

$$Mg + O_2 \rightarrow MgO$$

The number of magnesium and oxygen atoms on both sides of the equation are not equal in the above equation. The skeletal chemical equation is a type of unbalanced equation.

Balanced Chemical Equations

- On both sides of the equation, a balanced **chemical equation** has the same total number of atoms for each element. The **law of conservation of mass** is used to balance a chemical equation.
- The **law of conservation of mass** states that "mass cannot be created or destroyed during a chemical reaction." Similarly, before and after a chemical reaction, the number of atoms in each element remains constant.
- The **hit-and-trial method** for balancing chemical equations is named after the fact that we try to balance the equation using the smallest whole number coefficient. The number of atoms in each element remains constant before and after a chemical reaction in this method.

Balancing Of A Chemical Equation

A chemical equation must be balanced in several steps.

These are the steps to take:

Step (a) **Write An Unbalanced Equation With The Formulae Enclosed In Brackets.**

$$(Na) + (H_2O) \rightarrow (NaOH) + (H_2)$$

Step (b) In an imbalanced equation, make a list of the number of atoms of different elements that are present.

Element	Number of Atoms in Reactants (LHS)	Number of Atoms in Products (RHS)
Na	1	1
H	2	3
O	1	1

C) Balancing The First Element : It is clear from the table above that only the hydrogen atoms are out of balance. As a result, we begin by trying to balance it.

Atoms of H	In Reactants	In Products
Initially	2 (in H_2O)	3 (1 in NaOH and 2 in H_2)
To balance	2×2	2×1 in NaOH, 2 in H_2 = 4H-atoms

The equation now, $(Na) + 2(H_2O) \rightarrow 2(NaOH) + (H_2)$

Step (D) Equilibration Of The Second Element: We examine the obtained equation and select another unbalanced element. Na remains unbalanced in the previous equation.

To maintain a balance in the number of Na-atoms.

Atoms of Na	In Reactants	In Products
Initially	1 (in Na)	2 (in NaOH)
To balance	2×1	2

Step (E) Balancing Other Elements: Further examination of the reaction reveals that no element is out of balance. This is referred to as the hit-and-trial method of balancing chemical equations.

Step (F) Verifying The Equation's Correctness: To guarantee that the equation is correct, we tabulate the number of atoms in each element separately.

Element	Number of Atoms in Reactants (LHS)	Number of Atoms in Products (RHS)
Na	2	2
H	4	4
O	2	2

Making A Chemical Equation More Informative

The following facts about chemistry remain unexplained. Step (d) demonstrates the equation:

- Substances' physical states
- Reaction conditions
- Energy evolution/absorption

Some of these limitations of a chemical equation can be overcome by including the following symbols or information:

1. The physical states of reactants and products are denoted by the symbols (s) for solid, (l) for liquid, (g) for gas, and (aq) for aqueous solution, respectively. If the reactant or product is dissolved in water, the term aqueous (aq) is used.

$$2N_{a(s)} + 2H_2O(l) \rightarrow 2N_aOH\,(aq) + H_{2(g)}$$

Instead of the symbol, an arrow pointing downward (↓) can be used to represent precipitation (s).

Similarly, rather than using the symbol, the gaseous state of an evolved gas can be represented (g) by an arrow pointing upward(↑)

The chemical equation for magnesium reacting with dilute sulphuric acid is,

$$M_g(s) + H_2SO_4\,(aq) \rightarrow M_gSO_4 + H_2\uparrow$$

2. The reaction's specific conditions, such as temperature, pressure, and catalyst, are specified above or below the arrow in the chemical equation.

$$CO(g) + 2H_2(g) \xrightarrow{340\,atm} CH_3OH(l)$$

3. Heat evolution or absorption can be indicated by writing [+Heat] on the right-hand side or the left-hand side of the equation, respectively.

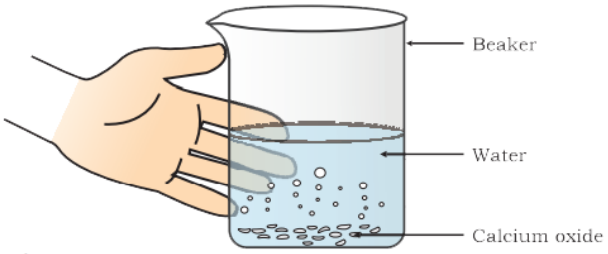
$$C(s) + O_2(g) \rightarrow CO_2(g) + Heat$$

Types Of Chemical Reactions

Chemical reactions are classified according to the type of chemical changes that occur. These are the reactions:

1. Combination Reaction

A combination reaction exists when 2 or more reactants react vigorously to form a single product.



a. Calcium oxide (quick lime) reacts vigorously with water to form calcium hydroxide (slaked lime). The reaction is highly exothermic, as it generates a great deal of heat.

$$\underset{\text{(Quick lime)}}{CaO(s)} + H_2O(l) \rightarrow \underset{\text{(Slaked lime)}}{Ca(OH)_2(aq)}$$

b. burning of coal.

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

c. reaction between hydrogen gas and oxygen gas to form water.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

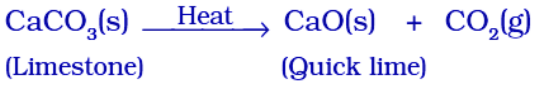
2. Decomposition Reaction

A **decomposition reaction** occurs when a single **reactant** degrades into two or more **products**. A **decomposition reaction** occurs when a single **reactant** breaks down into two or more **products**. This is the opposite reaction of the **combination reaction**.

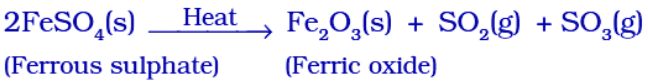
These reactions are classified into three types according to the type of energy required for the reaction:

a. **Thermal Decomposition:** These reactions utilise energy in the form of heat to cause the reactant to decompose.

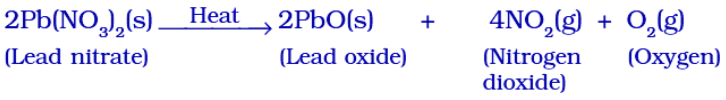
   i. Calcium carbonate decomposes upon heating to form calcium oxide and carbon dioxide. Calcium oxide is used to make cement.



   ii. Ferrous sulphate, the green crystals $F_eSO_4.7H_2O$, crystallises and dehydrates to form F_eSO_4, which decomposes to form a ferric oxide, sulphur dioxide, SO_2, and sulphur trioxide, SO_3. While ferric oxide is a solid, sulphur dioxide and sulphur trioxide are gases.

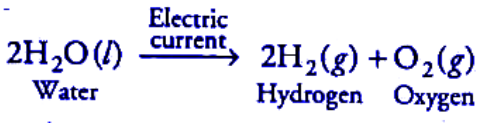


   iii. Lead nitrate decays upon heating to form yellow lead monoxide, nitrogen dioxide, and oxygen gas.

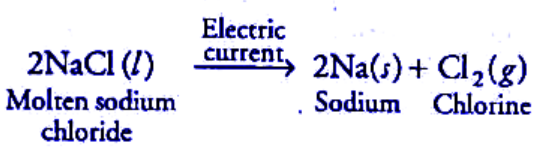


b. **Electrolysis:** Electrical energy is used to break down the reactant molecules in these reactions.

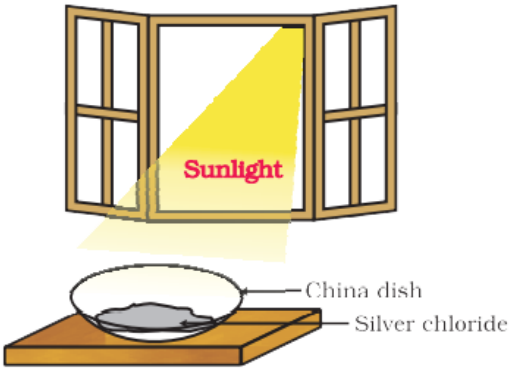
   i. Water decomposes into oxygen and hydrogen when an electric current is passed through it.



   ii. When molten sodium chloride is exposed to an electric current, it decomposes into sodium metal and chlorine gas.



c. **Photolysis Is A Term That Refers To The Photochemical Decomposition Of Matter :**

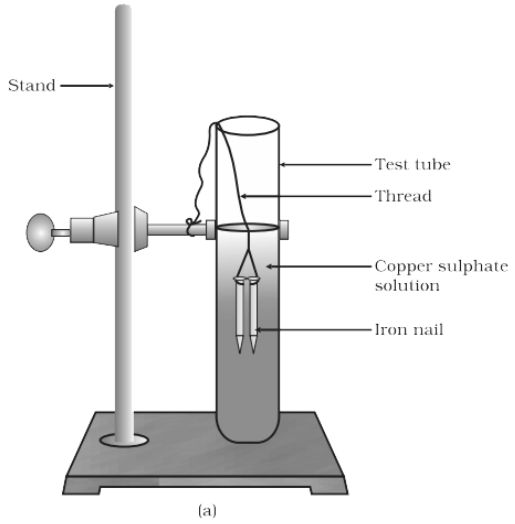


These reactions rely on light energy for decomposition.

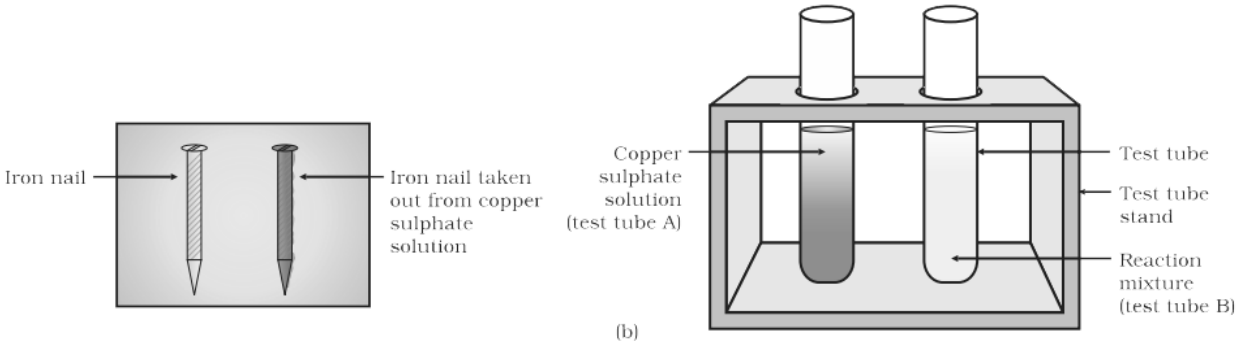
When silver chloride is exposed to sunlight, it decomposes to form silver metal and chlorine gas.

$$2AgCl(s) \xrightarrow{\text{Sunlight}} 2Ag(s) + Cl_2(g)$$

3. Displacement Reaction



(a)



(b)