

Chapter 1: Chemical Reactions and Equations

Introduction to Chemical Reactions

In our everyday lives, we observe many changes that indicate a chemical reaction has taken place. For example:

- Milk turns sour when left at room temperature during summer due to microbial activity producing lactic acid.
- Iron utensils or nails left in a humid atmosphere start forming a reddish-brown coating, known as rust. This is the result of iron reacting with oxygen and moisture.
- Grapes ferment due to yeast converting sugars into alcohol and carbon dioxide.
- Cooking food changes raw ingredients into cooked food by breaking down complex molecules and combining new ones.
- In our body, complex food molecules like carbohydrates, proteins, and fats are broken down into simpler absorbable forms during digestion.
- Respiration is a chemical reaction in which glucose reacts with oxygen to release energy needed for body functions.

These examples show **chemical changes**, where the original substances transform into new substances with different properties. Such changes are known as **chemical reactions**.

How to Identify a Chemical Reaction Has Occurred

Certain signs indicate that a chemical reaction has taken place:

1. **Change in State:** A solid forming from a solution or gas forming from a liquid.
 - Example: Zinc reacting with hydrochloric acid produces hydrogen gas (gas evolution).
2. **Change in Colour:** A substance changes its colour during the reaction.

- Example: Iron nail in copper sulfate solution causes the blue colour to fade.

3. **Evolution of Gas:** Bubbles form, showing a gas is released.

- Example: Reaction of marble chips with hydrochloric acid releases carbon dioxide.

4. **Change in Temperature:** Heat is either released or absorbed.

- Example: Calcium oxide reacts with water producing heat (exothermic reaction).

These are observable clues that help in confirming whether a chemical reaction has occurred.

Activity 1.1: Burning Magnesium Ribbon

When a magnesium ribbon is cleaned and burned in air:

- It burns with a bright white flame.
- A white powder is formed and collected in a watch-glass.
- This powder is magnesium oxide (MgO).

This activity is used to demonstrate a simple chemical reaction where magnesium (a metal) reacts with oxygen (from the air) to form a compound (magnesium oxide). This is a **combination reaction** and also an **exothermic reaction** as it releases heat and light.

Chemical Equations

A **chemical equation** represents a chemical reaction using symbols and formulas.

Word Equation

Magnesium + Oxygen → Magnesium Oxide

This represents the names of the substances involved.

Skeletal Chemical Equation

$\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$

This is the unbalanced form of a chemical equation. It is called skeletal because it only shows the basic form using symbols and formulas without considering the Law of Conservation of Mass.

1.1.1 Writing a Chemical Equation

Chemical equations are a shorthand representation of chemical reactions. They show:

- **Reactants:** Substances that react and are written on the left-hand side.
- **Products:** Substances that are formed and are written on the right-hand side.
- The arrow (\rightarrow) points from reactants to products.

Chemical equations are more informative and concise than word equations.

1.1.2 Balanced Chemical Equations

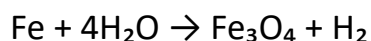
Balancing a Chemical Equation Step-by-Step:

Example: $\text{Fe} + \text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + \text{H}_2$

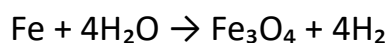
Step I: List the number of atoms on both sides:

- Fe: 1 (LHS), 3 (RHS)
- H: 2 (LHS), 2 (RHS)
- O: 1 (LHS), 4 (RHS)

Step II: Balance oxygen by adjusting H_2O molecules to 4:



Step III: Balance hydrogen: $4\text{H}_2\text{O}$ contains 8 hydrogen atoms. So we need 4H_2 on RHS.



Step IV: Balance iron: Fe_3O_4 has 3 iron atoms, so write 3Fe on LHS:



This is now a **balanced chemical equation**, meaning it respects the Law of Conservation of Mass.

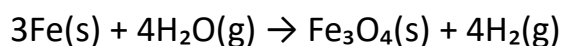


Physical States in Equations

To make chemical equations more informative, the physical states of the reactants and products are included:

- (s): Solid
- (l): Liquid
- (g): Gas
- (aq): Aqueous (dissolved in water)

Example:

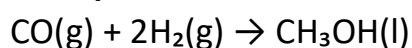


Here, water is in the form of steam (gas) and iron is solid.

Conditions of Reaction

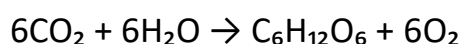
Sometimes, chemical reactions need special conditions like temperature, pressure, or the presence of a catalyst. These are indicated above or below the arrow in a chemical equation.

Example:



(With high pressure and catalyst)

Photosynthesis is another example:



(In the presence of sunlight and chlorophyll)

1.2 Types of Chemical Reactions

Chemical reactions can be classified into different types based on the nature of the transformation:

1.2.1 Combination Reaction

In a combination reaction, two or more substances combine to form a single new substance.

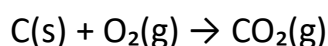
Example 1:



(Quick lime + Water \rightarrow Slaked lime)

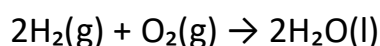
This reaction releases heat, making it exothermic. It is also used in whitewashing.

Example 2:



(Carbon burns in oxygen to form carbon dioxide)

Example 3:



(Hydrogen and oxygen combine to form water)

1.2.2 Decomposition Reaction

In this reaction, a single substance breaks down into two or more simpler substances.

Decomposition reactions require energy, and can be:

- **Thermal decomposition** (using heat)
- **Photolytic decomposition** (using light)
- **Electrolytic decomposition** (using electricity)

Example 1 (Thermal):



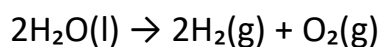
(Calcium carbonate \rightarrow Calcium oxide + Carbon dioxide)

Example 2 (Photolytic):



(Silver chloride decomposes in sunlight)

Example 3 (Electrolytic):

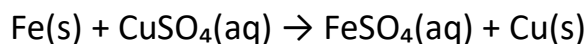


(Electrolysis of water)

1.2.3 Displacement Reaction

In displacement reactions, a more reactive element displaces a less reactive one from its compound.

Example:



(Iron displaces copper from copper sulfate solution)

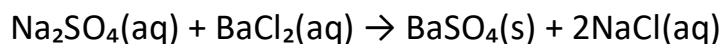
Other examples:

- $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$
 - $\text{Pb} + \text{CuCl}_2 \rightarrow \text{PbCl}_2 + \text{Cu}$
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1.2.4 Double Displacement Reaction

In this reaction, two compounds exchange ions to form new compounds. One of the products is often a precipitate.

Example:



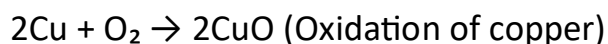
BaSO_4 is an insoluble white precipitate.

1.2.5 Oxidation and Reduction (Redox Reactions)

- **Oxidation:** Gain of oxygen or loss of hydrogen.
- **Reduction:** Loss of oxygen or gain of hydrogen.

These reactions happen together. One substance gets oxidised while the other gets reduced. Such reactions are called **Redox reactions**.

Example:



Other Examples:

- $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$ (ZnO is reduced; C is oxidised)
- $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$

1.3 Effects of Oxidation in Everyday Life

Chemical reactions involving oxidation not only occur in laboratories but also impact our daily lives. Two common examples of oxidation-related processes are **corrosion** and **rancidity**.

1.3.1 Corrosion

Corrosion is the process by which metals get deteriorated when they react with substances in their environment such as oxygen, water, acids, etc. It is essentially a slow oxidation process of metals.

Example: Rusting of Iron

When iron reacts with moisture and oxygen in the air, it forms a reddish-brown flaky substance called **rust** (chemically $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$).

Reaction: (which eventually dehydrates to form rust)

Other Examples of Corrosion:

- Silver reacts with sulfur in the air to form a black coating of silver sulfide (Ag_2S).
- Copper develops a green coating of basic copper carbonate due to prolonged exposure to moist air.

Consequences of Corrosion:

- Weakening of structures like bridges, railings, pipelines, and vehicles.
- Loss of appearance and mechanical strength.
- Huge financial losses due to maintenance and replacements.

Prevention of Corrosion:

- Painting or coating the metal surface.
- Applying oil or grease.
- Galvanization (coating with zinc).
- Electroplating.
- Using anti-rust solutions.

- Storing in dry environments.
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1.3.2 Rancidity

Rancidity refers to the condition in which fats and oils in food items get oxidised, resulting in a bad taste and unpleasant smell.

This is also a result of **oxidation** of fats and oils when exposed to oxygen in the air.

Example: Food containing oil or ghee (like chips, fried snacks) becomes inedible after being exposed to air for a few days.

Types of Rancidity:

- **Oxidative rancidity:** Caused by the oxidation of unsaturated fatty acids.
- **Hydrolytic rancidity:** Caused by the hydrolysis of fats in the presence of water.

Prevention of Rancidity:

- Adding **antioxidants** (substances that prevent oxidation), e.g., BHA and BHT.
 - Storing food in **airtight containers** to prevent exposure to oxygen.
 - Flushing packets with **nitrogen gas** (as done in chip packets) to remove oxygen.
 - **Refrigerating** or storing food in a cool and dark place to slow down oxidation.
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Summary of Key Concepts

- Chemical reactions lead to the formation of new substances with new properties.
- Word and chemical equations represent these reactions, and equations must be balanced.
- There are different types of chemical reactions: Combination, Decomposition, Displacement, Double Displacement, and Redox.



- Some reactions are **exothermic** (release heat) and others are **endothermic** (absorb heat).
- Redox reactions involve simultaneous oxidation and reduction.
- **Corrosion** and **rancidity** are oxidation reactions that affect metals and food respectively.