Ratna Sagar

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9

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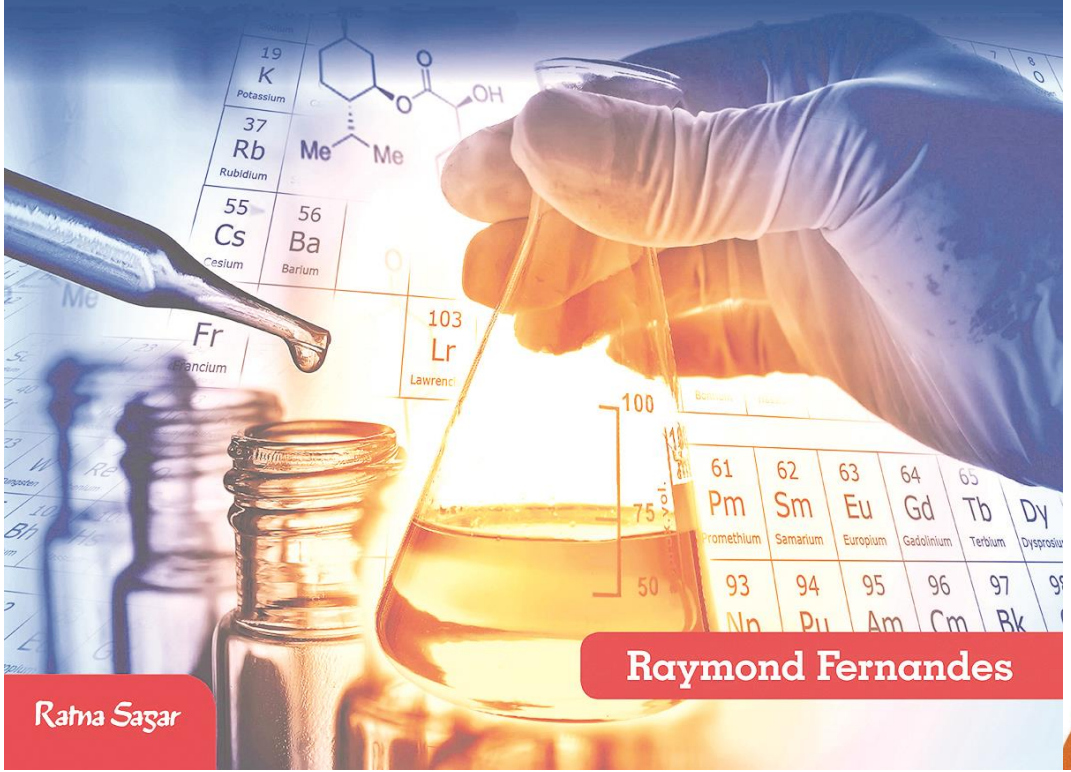
Living Science CHEMISTRY



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ICSE
Living Science
Chemistry

Class 9

Chapter 2 Chemical Changes and Reactions

LEARNING OBJECTIVES

Types of Chemical Changes

- ❖Direct combination reactions
- ❖Decomposition reactions
- ❖Displacement reactions
- ❖Double decomposition reactions

Energy Changes in a Reaction

- ❖Endothermic reactions
- ❖Exothermic reactions
- ❖Applications of energy changes in a chemical reaction

What is a Chemical Change?

A permanent change in which the original substance gives rise to one or more new substances with different properties, is called a **chemical change**.

A chemical change occurs when there is a chemical reaction between the substances. Therefore, in a chemical change (or chemical reaction), reactants combine with each other under favourable conditions to form products.

Types of Chemical Changes

Chemical changes or reactions can be classified into the following types:

1. Direct combination reactions

The reaction in which two or more substances (elements or compounds) combine together to form a single substance is called a direct combination reaction. $A + B \longrightarrow AB$

The combination reactions are of the following three types:

a. Combination of two elements to form a compound: Some examples of this type of reaction are as follows:

i Sodium combines with chlorine to form solid sodium chloride.

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$

ii. Carbon burns in oxygen to give carbon dioxide.

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

b. Combination of an element and a compound to form a new compound: The example of this type of reaction is as follows:

i. Sulphur dioxide combines with oxygen to give sulphur trioxide.

$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$

ii. Ferrous chloride combines with chlorine to give ferric chloride.

$$2FeCl_2(aq) + Cl_2(g) \longrightarrow 2FeCl_3(aq)$$

c. Combination of two compounds to form a new compound: Some examples of this type of reaction are as follows:

i. Sulphur dioxide combines with water to form sulphurous acid

$$SO_2(g) + H_2O(l) \longrightarrow H_2SO_3(aq)$$

ii. Sodium oxide reacts with water to form sodium hydroxide.

$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$$

2. Decomposition reactions

The reaction in which a compound breaks down to form two or more simpler substances (elements or compounds) is called a **decomposition reaction**.

$$AB \longrightarrow A + B$$

Decomposition reactions can be further classified into the following types:

a. Thermal decomposition reaction: The reaction in which a compound breaks down on heating to form two or more simpler substances is called thermal decomposition reaction.

Magnesium carbonate on strong heating at 1000 ° C gives magnesium oxide and carbon dioxide.

$$MgCO_3(s) \xrightarrow{1000^\circ C} MgO(s) + CO_2(g)$$

b. Electrolytic decomposition reaction: The process in which a compound in aqueous solution or in the molten state is decomposed by the passage of electricity is called **electrolytic decomposition or electrolysis**.

When electricity is passed through water containing a little sulphuric acid, water is decomposed to give hydrogen and oxygen.

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

c. Photochemical decomposition reaction: The reaction in which a compound is decomposed by light is called **photochemical decomposition or photolysis**.

Hydrogen peroxide undergoes photochemical decomposition in the presence of ultraviolet light to give hydrogen and oxygen. To protect from photochemical decomposition, H2O2 is kept in amber coloured bottle.

$$H_2O_2 \xrightarrow{\text{uv light}} H_2(g) + O_2(g)$$

3. Displacement reactions

Those reactions in which a more active element displaces a less reactive element from its compound are called **displacement reactions**.

$$A + BC \longrightarrow AC + B$$

In a displacement reaction, a more reactive metal displaces a less reactive metal from its compound. This reaction is governed by the **metal activity series**.

Zinc displaces hydrogen from sulphuric acid.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

Reactivity Series

The arrangement of the metals in decreasing order of their chemical reactivity is called metal reactivity or activity series. Metals placed above in the metal reactivity series are more reactive and will displace metals below them in the series.

K	Potassium	Most reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	Reactivity decreases
Fe	Iron	
Pb	Lead	
[H]	[Hydrogen]	
Cu	Copper	
Hg	Mercury	
Ag	Silver	
Au	Gold	Least reactive

4. Double decomposition reactions

A reaction in which two compounds in the solution react to form two other compounds by mutual exchange of atoms or groups of atoms is called **double decomposition reaction**.

$$AB + CD \longrightarrow AD + BC$$

These reactions are of two types:

a. Precipitation reaction

A chemical reaction in which two aqueous compounds reacts to form an insoluble compound (commonly called precipitate) as one of the products is called **precipitation reaction**.

In this type of reaction, the radicals of the reactants interchange places with each other such that one of the products is a precipitate.

When a solution of sodium sulphate is added to a solution of lead nitrate, a white precipitate of lead sulphate is formed.

$$Na_2SO_4(aq) + Pb(NO_3)_2(aq) \longrightarrow 2NaNO_3(aq) + PbSO_4(s)\downarrow$$

white precipitate

A **precipitate** is a compound formed which is insoluble in water. A precipitation reaction takes place only in solution. This means that both the reactants must be water soluble.

b. Neutralisation reaction

A neutralisation reaction is a special type of double decomposition reaction in which an acid reacts with a base to form salt and water as the only products. Since the products in the reaction between an acid and a base are neutral to litmus, the acid-base reaction is called neutralisation reaction.

Examples of neutralisation reaction:

1. When bee stings, formic acid enters in our body which gives pain. This can be relieved by rubbing the stung spot with a base, baking soda or slaked lime.

2. Acidity (or indigestion of food) can be relieved by the use of mild bases like milk of magnesia or sodium hydrogencarbonate.

3. The acidity of soil can be neutralised by the addition of slaked lime (that neutralises the excess acid).

Energy Changes in a Chemical Reaction

During a chemical reaction, bonds are broken between the reactants and new bonds are formed between the products. Therefore, energy is required to break the bonds and energy is liberated when bonds are formed. Hence chemical reactions are invariably accompanied by energy changes.

These energy changes appear in the form of evolution or the absorption of heat, light, etc.

Internal Energy

The internal energy of a substance is the sum total of its kinetic energy and potential energy of its molecules.

$$\mathbf{E} = \text{K.E.} + \text{P.E.}$$

The internal energy is different for different substances. Hence, the internal energy of the reactants [$\mathbf{E_r}$] is different from the internal energy of the products [$\mathbf{E_p}$].

The change in internal energy for a reaction is therefore the difference between $\mathbf{E_p}$ and $\mathbf{E_r}$, i.e. $\Delta\mathbf{E} = \mathbf{E_p} - \mathbf{E_r}$

The heat content or enthalpy of a system

When chemical reactions are performed in an open system it means that these reactions are taking place at constant pressure. Under such conditions the enthalpy of a system denoted by **H** is the sum of the internal energy of the system and the product of the pressure and volume.

The change in enthalpy of a system is the amount of heat exchanged with the surroundings and is represented by $\Delta\mathbf{H}$, i.e.

$\Delta H = H_p - H_r$ where H_r and H_p are the enthalpy of the reactants and products respectively.

These concepts therefore give rise to two major types of reactions based on energy changes— endothermic and exothermic reactions.

Endothermic reactions

In these reactions, energy is supplied to the reactants from the surroundings. An endothermic reaction is generally of the type

Reactants + energy Products

A chemical reaction which is accompanied by the absorption of heat is called **endothermic reaction**.

In an endothermic system, the enthalpy of the reactants is lesser than the enthalpy of the products and therefore the change in enthalpy is positive. It is also important to note that the heat content of the system (reaction) is raised in an endothermic change.

Reaction between nitrogen and oxygen.

$$N_2(g) + O_{2(}g) + \text{heat } 3000\ ^oC \longrightarrow 2NO(g)$$

is an endothermic reaction.

Exothermic reactions

In these reactions, energy is liberated into the surroundings by the reactants. An exothermic reaction is generally of the type

$$\text{Reactants} \longrightarrow \text{Products} + \text{energy}$$

A chemical reaction which is accompanied by the evolution of heat is called **exothermic reaction**. In an exothermic system, the enthalpy of the reactants is greater than the enthalpy of the products and therefore the change in enthalpy is negative. It is important, therefore to note that the heat content of the system (reaction) is lowered in an exothermic change.

Hydration processes, formation of anions, combustion of petrol, catalytic oxidation of ammonia, etc. are examples of exothermic changes.

Formation of ammonia

$$N_2(g) + 3H_2(g) \longrightarrow 2NH3(g) + \text{heat}$$

Addition of water to calcium oxide.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq) + \text{heat}$$

Applications of energy changes in a chemical reaction

The knowledge of energy changes accompanying a chemical change is very useful. For instance:

1. We use coal as a source of fuel because we are aware that on combustion it liberates heat and light.

2. We use a candle because on being lit it liberates energy in the form of light.

3. Methane mixed with air is used as a fuel because it liberates heat energy when ignited.

4. We keep plants in sunlight because in plants carbon dioxide and water vapour are converted into glucose by the process of photosynthesis only in the presence of sunlight.

5. We eat food because the digestion of food liberates heat energy which is important to maintain our body temperature and to furnish the body with energy to do work.

SUMMARY...

1. A permanent change in which the original substance gives rise to one or more new substances with different properties, is called a chemical change.

2. Types of chemical reactions.

i. Direct combination reactions: The reaction in which two or more substances (elements or compounds) combine together to form a single substance is called a direct combination reaction.

The combination reactions are of the following three types:

a. Combination of two elements to form a compound

b. Combination of an element and a compound to form a new compound

c. Combination of two compounds to form a new compound

ii. Decomposition reactions: The reaction in which a compound breaks down to form two or more simpler substances (elements or compounds) is called a decomposition reaction. Decomposition reactions can be further classified into the following types:

a. Thermal decomposition reaction: The reaction in which a compound breaks down on heating to form two or more simple substances is called thermal decomposition reaction.

b. Electrolytic decomposition reaction: The process in which a compound in aqueous solution or in the molten state is decomposed by the passage of electricity is called electrolytic decomposition or electrolysis.

c. Photochemical decomposition reaction: The reaction in which a compound is decomposed by light is called photochemical decomposition reaction.

ii. Displacement reactions: Those reactions in which a more active element displaces a less reactive element from its compound are called displacement reactions.

iv. Double decomposition reactions: A reaction in which two compounds in the solution react to form two other compounds by mutual exchange of atoms or groups of atoms is called double decomposition reaction.

These reactions are of two types:

a. Precipitation reactions: In this type of reaction, the radicals of the reactants interchange places with each other such that one of the products is a precipitate.

b. Neutralisation reactions: In this reaction, an acid reacts with a base to form salt and water as the only products.

3. All atoms and molecules have some energy of their own, called **internal energy**. This energy is the sum total of the kinetic and the potential energy of the molecules. It is represented by the symbol **E**.

4. The heat content of a system is called **enthalpy**. It is represented by the symbol **H**. The change in enthalpy of a system is the amount of heat exchanged with the surroundings and is represented by $\Delta\mathbf{H}$ where

$$\Delta\mathbf{H} = \mathbf{H_p} - \mathbf{H_r}.$$

5. All reactions are accompanied with the absorption or liberation of heat. Reactions that liberate heat are called **exothermic reactions**. Reactions that absorb heat are called **endothermic reactions**.

6. In an exothermic reaction, heat is liberated. In an endothermic reaction, heat is absorbed.


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