
On
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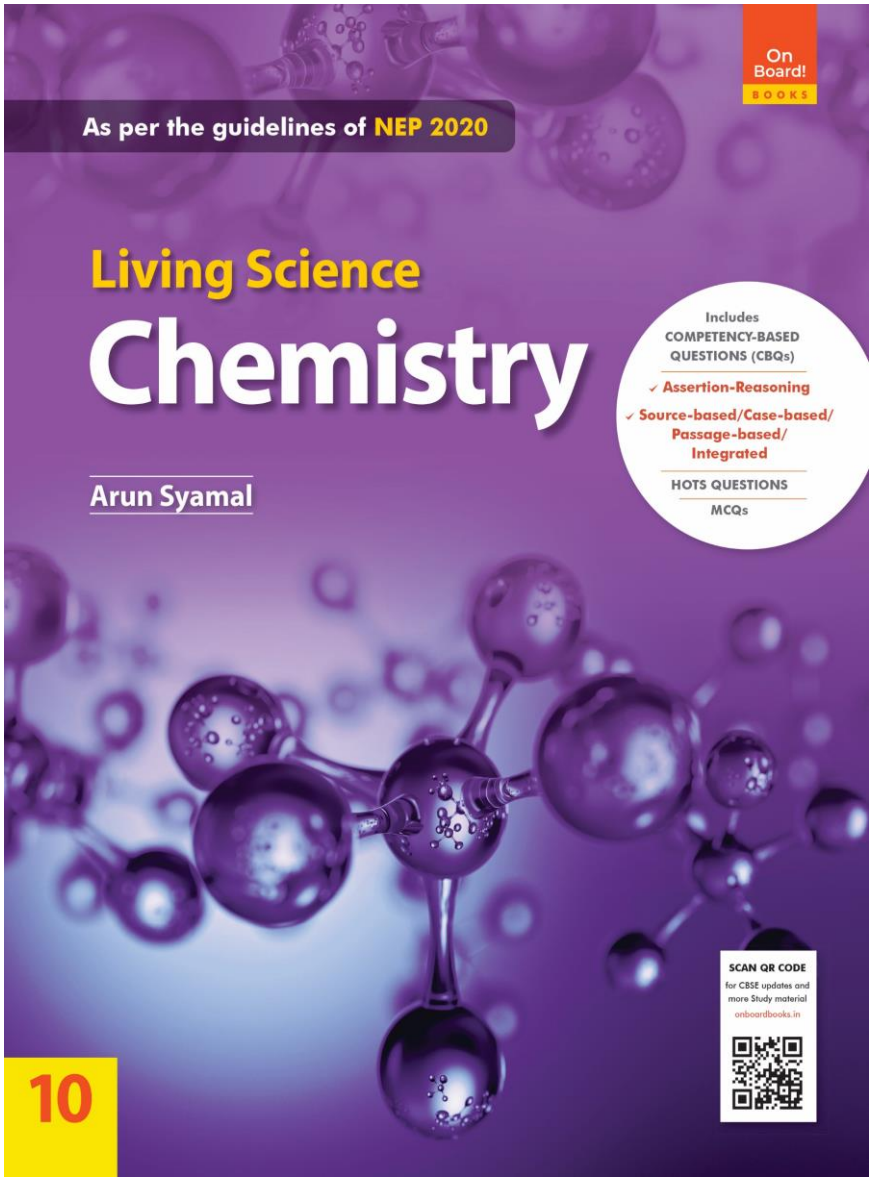
BOOKS

CBSE Living Science CHEMISTRY



CBSE LIVING SCIENCE CHEMISTRY

CLASS 10

Chapter 1

CHEMICAL REACTIONS AND EQUATIONS

Learning Objectives

- ❖Chemical Equations
- ❖Balanced Chemical Equations
- ❖Chemical Reactions
- ❖ Types of Chemical Reactions:

Combination reactions

Decomposition reactions

Displacement reactions

Double displacement reactions

Oxidation and reduction reactions

❖ Effects of Oxidation Reactions in Everyday Life

CHEMICAL REACTIONS

The process by which one or more substances react to form new substances with entirely different properties is called a chemical reaction.

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

The substances which undergo a chemical change in a chemical reaction are called reactants.

The substances which are formed during a chemical reaction are called products.

CHEMICAL REACTIONS

In our daily life, we find that there occurs a large variety of chemical reactions within our body and in our surroundings.

The changes which indicate that chemical reactions have occurred are :

- Change in colour
- Change in temperature
- Evolution of a gas
- Formation of a precipitate
- Change in state

CHEMICAL EQUATIONS

A chemical reaction is represented by a chemical equation. A chemical equation involves the formulae of reactants and products as well as the reaction conditions.

A chemical equation can be written in the form of word equation as well as equation involving the chemical formulae of reactants and products.

Rules for writing word equation

- Write the names of the reactants on the left hand side (LHS) with plus sign (+) between them.
- Write the names of the products on the right hand side (RHS) with plus sign (+) between them.
- Put an arrow between the reactants and the products in order to show the direction of the reaction. The direction of the arrowhead should point towards the products.

For example, The word equation of a chemical reaction, involving the burning of magnesium in air to form magnesium oxide reaction, can be written as follows:

Magnesium + Oxygen → Magnesium oxide

(reactants) (product)

Writing a skeletal chemical equation

A chemical equation can be written in the form of an equation which uses the chemical formulae of the reactants and the products instead of words to represent a chemical reaction.

The use of chemical formula in a chemical equation makes it more concise, simple and useful. Thus, the chemical equation for the chemical reaction involving the burning of magnesium ribbon can be written as follows:

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Oxygen}}{O_2} \rightarrow \underset{\text{Magnesium Oxide}}{MgO}$$

The above chemical equation is a skeletal chemical equation for the involved chemical reaction. It is an unbalanced equation. By unbalanced equation, we mean that the number of atoms of each element on the left and right hand side of the arrow is not equal.

Balanced chemical equations

In a chemical equation, the number of atoms of each element in the reactants must be equal to the number of atoms of each element in the products. This is known as balancing a chemical equation.
Let us try to balance the following chemical equation:

$$H_2 + O_2 \rightarrow H_2O$$

Here, the number of atoms of each element must be equal on both the sides of the equation. This can be done by putting the coefficient 2 before the formula of H_2 as well as of H_2O.

$$2H_2 + O_2 \rightarrow 2H_2O$$

4 u 32 u 36 u

This chemical equation not only balances the number of atoms of the reactants and products but balances their mass also. The masses of the reactants and the product are properly balanced. They are written in terms of their unified mass (u). Hence, this is now a balanced chemical equation. This method of balancing a chemical equation is called hit-and-trial method,since we keep on balancing the equation using the smallest whole number of coefficient only.

The chemical equation discussed above have several limitations which are as follows:

1. It does not indicate the physical states of the reactants and the products.
2. It does not indicate whether the reaction occurs with the evolution of a gas or formation of a precipitate.

Improvement in Chemical Equations

In order to make the chemical equations more informative, the following symbols and signs can be used which are discussed as follows.

1. **Physical states of reactants and products:**

The physical states of the reactants and products are represented by the notations (*g*), (*l*), (*s*) and (*aq*) to denote gaseous, liquid, solid and aqueous solution states, respectively. For example,

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

2. **Precipitation of a solid during a chemical reaction:**
The precipitation of a solid during a chemical reaction is indicated by placing a downward arrow (↓) or using the symbol (*s*). For example,

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(\downarrow) + NaNO_3(aq)$$

3. **Evolution of a gas during a chemical reaction:**
The evolution of a gas during a chemical reaction is indicated by placing an upward arrow (↑) or using the symbol (*g*). For example,

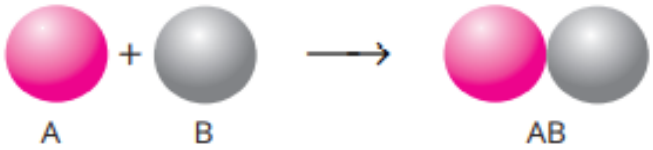
$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(\uparrow)$$

TYPES OF CHEMICAL REACTIONS

On the basis of type of chemical change, chemical reactions can be broadly classified into the following types:
1. Combination reactions
2. Decomposition reactions
3. Displacement reactions
4. Double displacement reactions
5. Oxidation and reduction reactions

Combination reactions

The reaction in which two or more elements or compounds combine together through chemical bonds to form a single compound is called a combination reaction. During a combination reaction, the chemical bonds between the atoms of the reactants are broken and new chemical bonds are formed. A combination reaction is represented as follows:



These reactions are mostly exothermic (reactions which are accompanied by the evolution of heat) in nature. Combination reactions can be further divided into the following ways:

a. Combination of two elements to form a compound:

The examples of this type of reaction are as follows:

(i) $2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$

(ii) $2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$

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

The examples of this type of reaction are as follows:

(i) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

(ii) $SO_2(g) + O_2(g) \rightarrow SO_3(g)$

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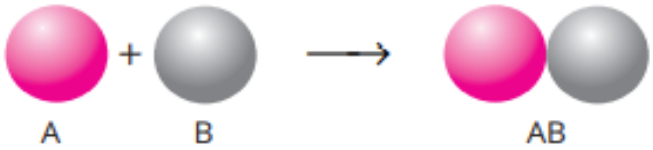

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The examples of this type of reaction are as follows:

(i) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

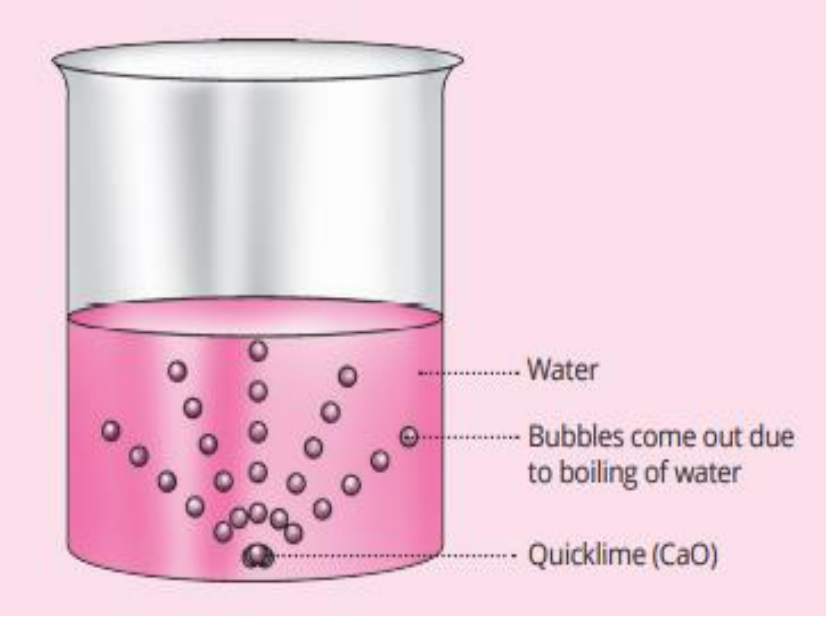
(ii) $SO_2(g) + O_2(g) \rightarrow SO_3(g)$

c. Combination of two compounds to form a new compound:

The examples of this type of reaction are as follows:

(i) $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$

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



$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + Heat$$

Combination reaction between calcium oxide and water

A chemical reaction which is accompanied by the evolution of heat is called **exothermic reaction**. For example,

- $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + Heat$
- $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + Heat$

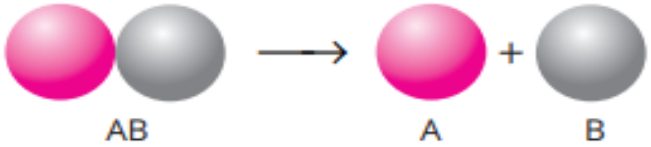
A chemical reaction which is accompanied by the absorption of heat is called **endothermic reaction**. For example,

$N_2(g) + O_2(g) + \text{Heat} \rightarrow 2NO(g) + 2H_2O(g)$

$H_2(g) + I_2(g) + \text{Heat} \rightarrow 2HI(g)$

Decomposition reactions

The reaction in which a compound breaks down to give two or more simpler substances is called a decomposition reaction. A decomposition reaction is represented as follows:



In a decomposition reaction, there is only one reactant. A decomposition reaction is the reverse of a combination reaction. Decomposition reactions are further classified into:

- Thermal decomposition reactions
- Electrolytic decomposition reactions
- Photochemical decomposition reactions

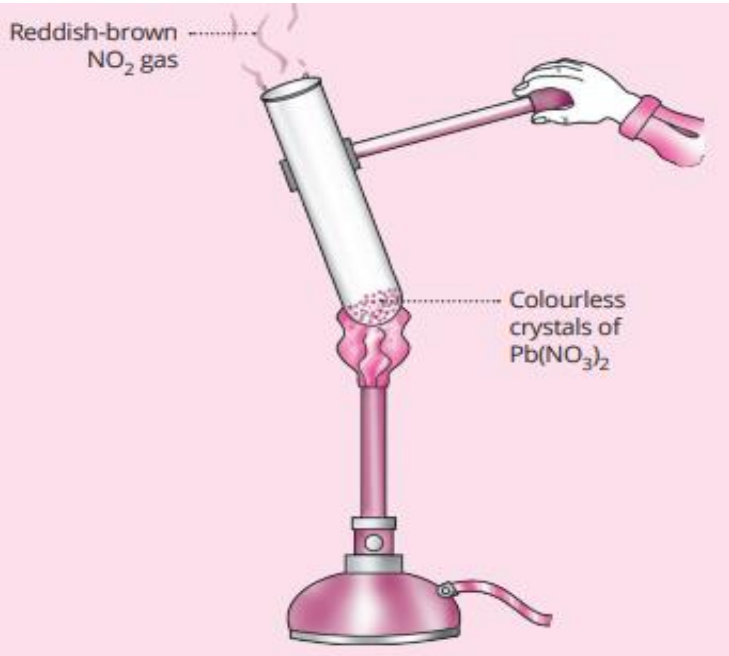
a. Thermal decomposition reactions

A reaction in which a compound is decomposed by absorbing heat is called thermal decomposition reaction. Some examples of thermal decomposition reactions are as follows:

(i) Potassium chlorate on heating decomposes to give potassium chloride and oxygen.

$$2KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2(g)$$

(ii) On heating, a colourless compound lead nitrate decomposes to form a yellow coloured compound, lead oxide and brown fumes of nitrogen dioxide gas are evolved along with oxygen.



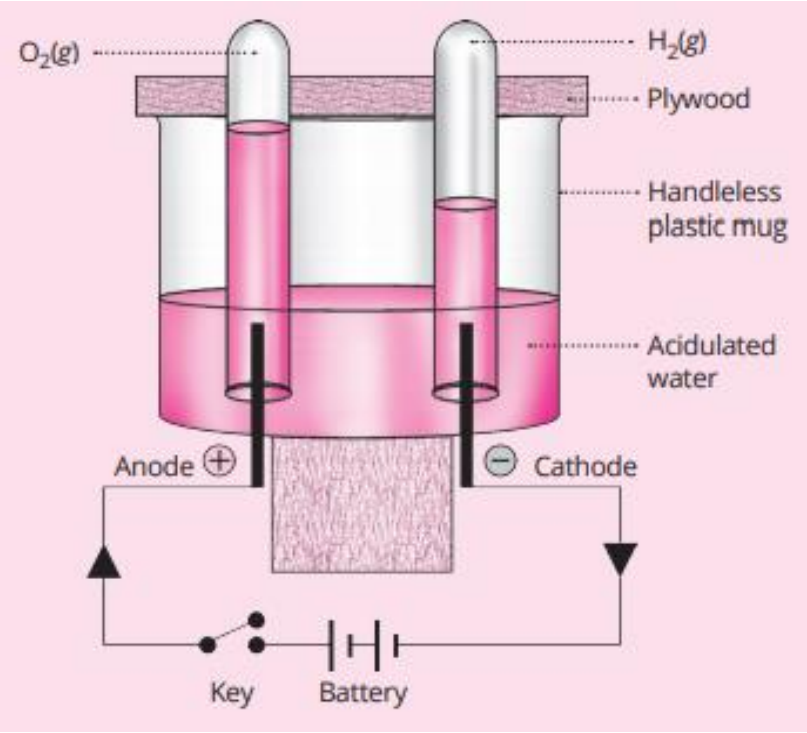
Heating of lead nitrate crystals

$$\underset{\text{Lead nitrate (colourless)}}{2Pb(NO_3)_2(s)} \xrightarrow{\text{Heat}} \underset{\text{Lead(II) oxide (light yellow)}}{2PbO(s)} + \underset{\text{Nitrogen dioxide (reddish-brown)}}{4NO_2(g)} + O_2(g)$$

b. Electrolytic decomposition reactions

The process in which a compound is decomposed by the passage of electricity is called electrolytic decomposition or electrolysis. For example, in electrolysis of water, when electricity is passed through water containing little amount of dilute sulphuric acid, it decomposes to give hydrogen and oxygen gas.

The volume of hydrogen and oxygen gases are found in the ratio 2 : 1. The volumes of gas produced at cathode (H_2) is double the volume of gas produced at anode (O_2). This is because the molar ratio of hydrogen and oxygen is 2 : 1 in water.



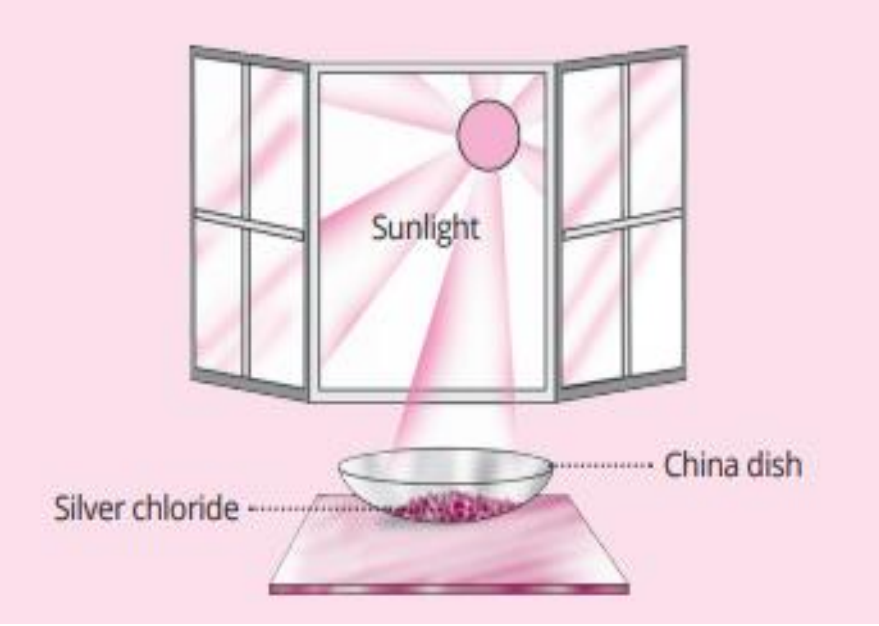
Electrical decomposition of acidulated water to produce hydrogen and oxygen

$$2H_2O(l) \xrightarrow{\text{electricity}} 2H_2(g) + O_2(g)$$

c. Photochemical decomposition reactions

The process in which a compound is decomposed by light is called photochemical decomposition or photolysis. Some examples of photochemical decomposition reactions are as follows:

(i) When silver chloride is exposed to sunlight, it is observed that the white colour of silver chloride changes to grey. This change of colour occurs due to the photochemical decomposition of silver chloride to metallic silver (grey) in the presence of sunlight.



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

Photochemical decomposition of silver chloride

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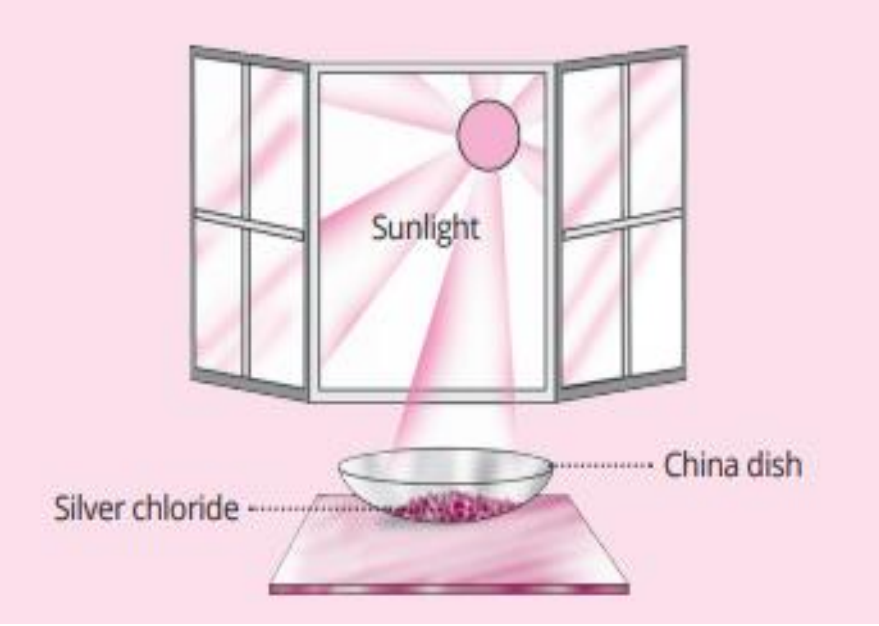


$$\underset{\text{White}}{2AgCl(s)} \xrightarrow{\text{Sunlight}} \underset{\text{Grey}}{2Ag(s) + Cl_2(g)}$$

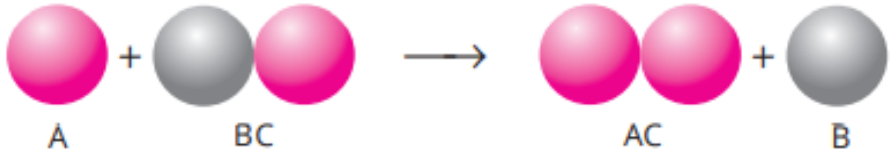
Photochemical decomposition of silver chloride

(ii) Hypochlorous acid (HOCl) undergoes decomposition in the presence of ultraviolet light to give hydrochloric acid and oxygen.

$$2HOCl(aq) \xrightarrow{\text{uv light}} 2HCl(aq) + O_2(g)$$

Displacement reactions

A reaction in which an element displaces another element present in a compound is called displacement reaction. Generally, a more reactive element displaces a less reactive element from its compound. A displacement reaction is represented as follows:



Some examples of displacement reactions are:

(i) $CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$

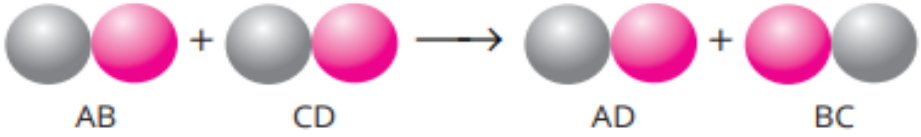
Copper sulphate (blue)	Zinc	Copper (red)	Zinc sulphate (colourless)

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

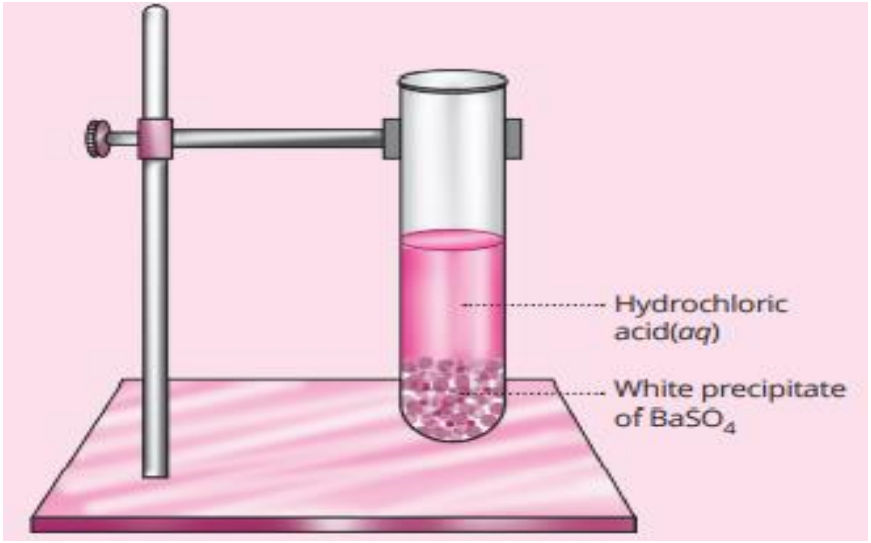
(iii) $CuSO_4(aq) + Fe(s) \rightarrow Cu(s) + FeSO_4(aq)$

Double displacement reactions

A reaction in which two ionic compounds in the solution react to form two different compounds by an exchange of atoms or groups of atom is called double displacement reaction. A double displacement reaction is represented as follows:



Generally, in double displacement reactions,the reaction of two ionic compounds leads to the formation of an insoluble product called precipitate. A reaction in which one of the products of the reaction gets precipitated is called precipitation reaction. For example, when an aqueous solution of barium chloride is treated with dilute sulphuric acid a white precipitate of barium sulphate is immediately formed.



$$BaCl_2(aq) + H_2SO_4(aq) \longrightarrow BaSO_4(s) + 2HCl(aq)$$

Barium chloride — Sulphuric acid — Barium sulphate (white precipitate) — Hydrochloric acid

Formation of white precipitate of barium sulphate on mixing barium chloride solution and dil. H_2SO_4

Similarly, a yellow precipitate of lead iodide is formed when lead nitrate reacts with potassium iodide.

$$\underset{\text{Lead(II) nitrate}}{Pb(NO_3)_2\,(aq)} + \underset{\text{Potassium iodide}}{2KI(aq)} \rightarrow \underset{\text{Lead(II) iodide (yellow ppt)}}{PbI_2(s)} + \underset{\text{Potassium nitrate}}{2KNO_3(aq)}$$

When a base and an acid are mixed, they exchange their ions and form compounds called salt, water and sometime a gas. Since the products formed in the reaction between acid and base are neutral to litmus, the acid-base reaction is called neutralisation reaction.

$$\underset{\text{Base}}{NaOH(aq)} + \underset{\text{Acid}}{HCl(aq)} \rightarrow \underset{\text{Salt}}{NaCl(aq)} + \underset{\text{Water}}{H_2O(l)}$$

$$\underset{\text{Base}}{2KOH(aq)} + \underset{\text{Acid}}{H_2SO_4(aq)} \rightarrow \underset{\text{Salt}}{K_2SO_4(aq)} + \underset{\text{Water}}{2H_2O(l)}$$

Oxidation–reduction reactions

Oxidation and reduction can be described in terms of gain or loss of oxygen or hydrogen.

Oxidation: A process which involves the addition of oxygen or removal of hydrogen is called oxidation.

1. **Addition of oxygen:** The burning of a substance occurs in the presence of oxygen. Elements burn in the presence of oxygen and combine with oxygen to form oxides of elements. For example,

- **Oxidation of copper:** When copper powder is heated in presence of air, brownish-red copper powder changes into a black substance called copper oxide. Since in this reaction oxygen is added to copper, it is an oxidation reaction.

$$\underset{\text{Copper (Brownish-red)}}{Cu(s)} + O_2(g) \rightarrow \underset{\text{Copper(II) oxide (Black)}}{CuO(s)}$$

2. **Removal of hydrogen:** Removal of hydrogen from compounds containing hydrogen leads to the oxidation of the compounds. For example,

- **Oxidation of hydrogen sulphide:** Hydrogen sulphide reacts with bromine to form hydrogen bromide and sulphur. Since in this reaction hydrogen is removed from hydrogen sulphide, it is an oxidation reaction.

$$\underset{\text{Hydrogen sulphide}}{H_2S(aq)} + \underset{\text{Bromine}}{Br_2(aq)} \xrightarrow{\text{oxidation}} \underset{\text{Hydrogen bromide}}{2HBr(aq)} + \underset{\text{Sulphur}}{S(s)}$$

Reduction: A process which involves removal of oxygen or addition of hydrogen is called reduction.

1. **Removal of oxygen:** Metals are usually prepared by the removal of oxygen from metal oxides. This process involves reduction. For example,

- **Reduction of copper(II) oxide:** When hydrogen gas is passed over heated copper(II) oxide, it gets reduced to brownish-red metallic copper. Since in this reaction oxygen is removed from copper(II) oxide, it is a reduction reaction.

$$\underset{\text{Copper(II) oxide}}{CuO(s)} + \underset{\text{Hydrogen gas}}{H_2(g)} \xrightarrow{\text{Heat}} \underset{\text{Copper}}{Cu(s)} + \underset{\text{Water vapour}}{H_2O(g)}$$

2. **Addition of Hydrogen:** The addition of hydrogen to a substance leads to reduction. For example,

- **Reduction of Bromine:** Bromine reacts with hydrogen sulphide to form hydrogen bromide and sulphur. Since in this reaction hydrogen is added to bromine, it is a reduction reaction.

$$H_2S(aq) + Br_2(aq) \rightarrow 2HBr(aq) + S(s)$$

Oxidising agent: A substance which causes addition of oxygen or removal of hydrogen from other substances is called oxidising agent. For example, oxygen, chlorine, hydrogen peroxide, potassium dichromate, manganese(IV) oxide, etc.
In the reaction, carbon is oxidised to carbon dioxide and oxygen acts as an oxidising agent.

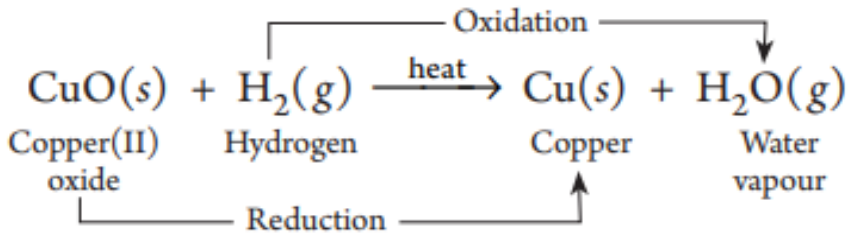
$$C(s) + O_2(g) \rightarrow CO_2(g)$$

Reducing agent: A substance which causes addition of hydrogen or removal of oxygen from other substances is called reducing agent. For example, hydrogen, carbon, hydrogen sulphide, sulphur dioxide, nitrous acid, tin(II) chloride, etc.
In the reaction, magnesium oxide is reduced to magnesium metal and carbon acts as a reducing agent since carbon is used to remove oxygen from magnesium oxide.

$$\underset{\text{Magnesium oxide}}{MgO(s)} + \underset{\text{Carbon}}{C(s)} \xrightarrow{\text{Heat}} \underset{\text{Magnesium}}{Mg(s)} + \underset{\text{Carbon monoxide}}{CO(g)}$$

Redox Reaction

A reaction in which oxidation and reduction take place simultaneously is called oxidation – reduction or redox reaction. In redox reactions, the oxidising agent is reduced and the reducing agent is oxidised.



In this reaction, CuO has given oxygen and hence CuO is the oxidising agent. Also, H_2 has gained oxygen, hence H_2 is the reducing agent.

The examples of some other oxidation – reduction or redox reactions are:

(i) Reaction between hydrogen sulphide and sulphur dioxide.

$$2H_2S(aq) + SO_2(g) \rightarrow 2H_2O(l) + 3S(s)$$

(ii) Reaction between manganese(IV) oxide and hydrochloric acid.

$$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$$

EFFECTS OF OXIDATION REACTIONS IN EVERYDAY LIFE

In our daily life, we come across many oxidation reactions. We shall consider here the oxidation reactions such as corrosion of metals and rancidity of fats, oils and fatty foods.

Corrosion

The most important oxidative process which we come across in our daily life is corrosion. The process of slow destruction of metals and manufactured materials containing metals due to their exposure to the environment is called corrosion.

Corrosion occurs when the surface of a metal is exposed to the atmosphere. Corrosion of metals leads to the weakening of the strength of metals and the metals become brittle. Enormous money is spent every year to replace the metals and metal containing materials damaged by corrosion.

Some important examples of corrosion are as follows:

1. Formation of a green coating on copper and brass.
2. Formation of a layer of oxide on aluminium leading to dullness and loss of shine.
3. Tarnishing of silver when exposed to hydrogen sulphide gas.
4. Rusting of iron.

The conditions which leads to the corrosion of substances are:

- Presence of oxygen or air
- Presence of moisture or water vapour

Rusting of Iron

Rusting is a process which involves the oxidation of iron in the presence of air and moisture to form reddish-brown hydrated iron oxide on the surface of iron. The chemical composition of rust is $Fe_2O_3 \cdot xH_2O$.

Rusting is a slow process and it weakens the strength of iron railings, bridges and automobiles, etc.

$$4Fe(s) + 3O_2(g) + xH_2O \rightarrow \underset{\text{Hydrated iron oxide (rust)}}{2Fe_2O_3 \cdot xH_2O}$$

Rancidity

The oxidation of oils and fats in the food leading to an unpleasant smell and taste is known as rancidity. Rancidity spoils the food materials prepared in fats and oils which have been kept for considerable time and makes them unfit to consume.

Rancidity can be prevented or slowed down by using following prevention methods:

- The oxidation process of home-made foods is slowed down by keeping them in a refrigerator.
- Keeping foods in air tight or sealed containers also slows down the oxidation process.
- Flushing of food packets and food containers with nitrogen gas before sealing and packaging the foods also prevents the oxidation of foods.
- The food grade antioxidants such as butyrated hydroxytoluene (BHT) and butyrated hydroxyanisole (BHA) are effective in preventing the oxidation of the fats and oils in the food materials.

SUMMARY

1. **Combination reaction**: A reaction in which two or more elements or compounds combine together through chemical bonds to form a single compound is called **combination reaction**. It is of the type:

$$A + B \longrightarrow AB$$

During a chemical combination, the chemical bonds between atoms are broken and new chemical bonds are formed.

2. **Decomposition reaction**: A reaction in which a compound breaks down to give two or more simple substances is called **decomposition reaction**. It is of the type:

$$AB \longrightarrow A + B.$$

Decomposition reactions are of three types:

   a. Thermal decomposition (pyrolysis)

   b. Electrolytic decomposition (electrolysis)

   c. Photochemical decomposition (photolysis)

3. **Displacement reaction**: A reaction in which an element and a compound react to form two other substances by mutual exchange of atoms or group of atoms is called **displacement reaction**. The displacement reaction is of the type:

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

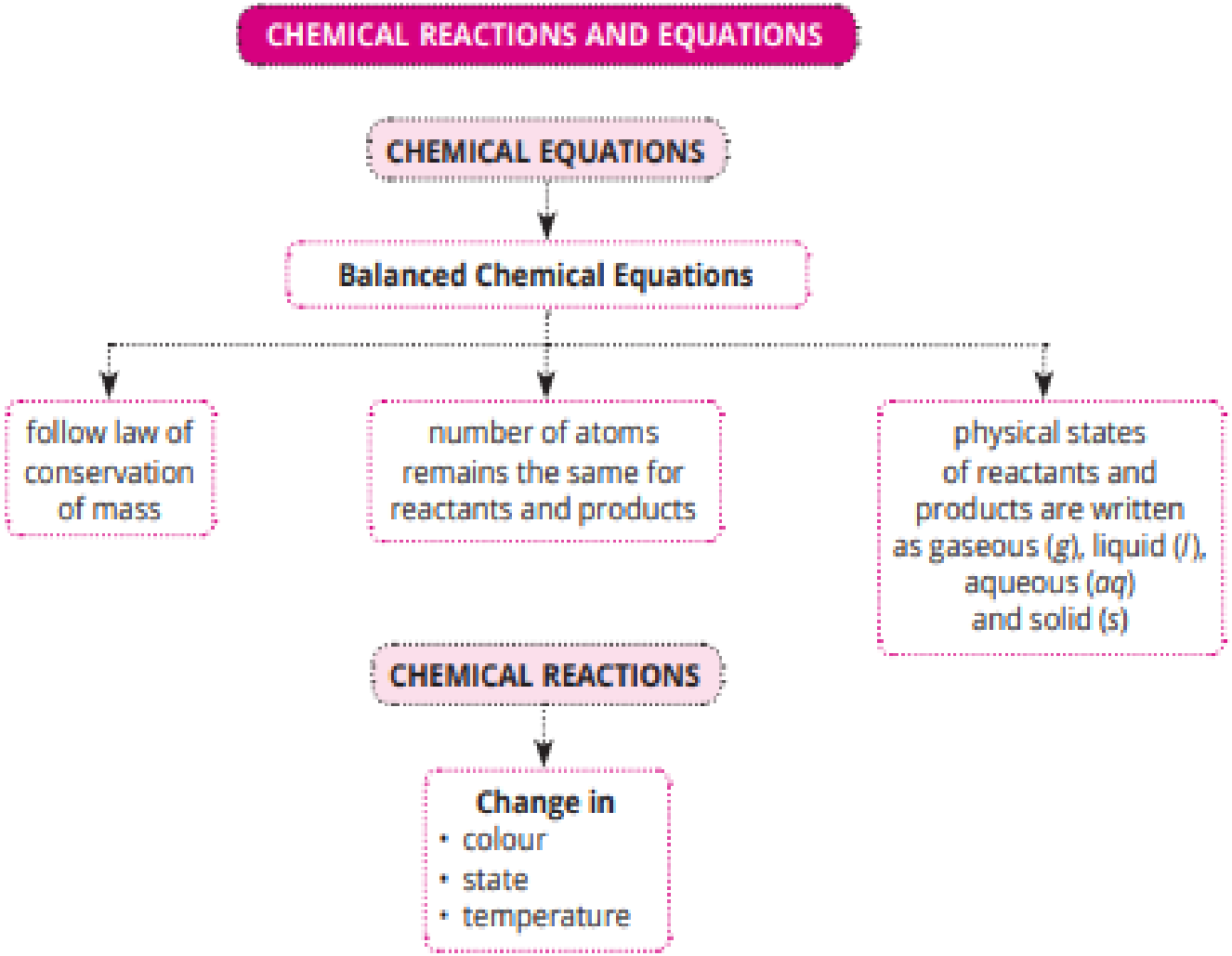
4. **Activity series**: The arrangement of elements in the decreasing order of their electropositive character is called **activity series of elements**.
The chemical reactivity of an element is related to its electropositive character. The activity of metals decreases from top to bottom in the activity series. A metal in the activity series displaces the metals coming below it in the activity series and not the ones coming above it.

5. **Double displacement reaction**: A reaction in which two compounds react to form two other compounds by mutual exchange of atoms or groups of atoms is called **double displacement reaction**. The double displacement reaction is of the type:

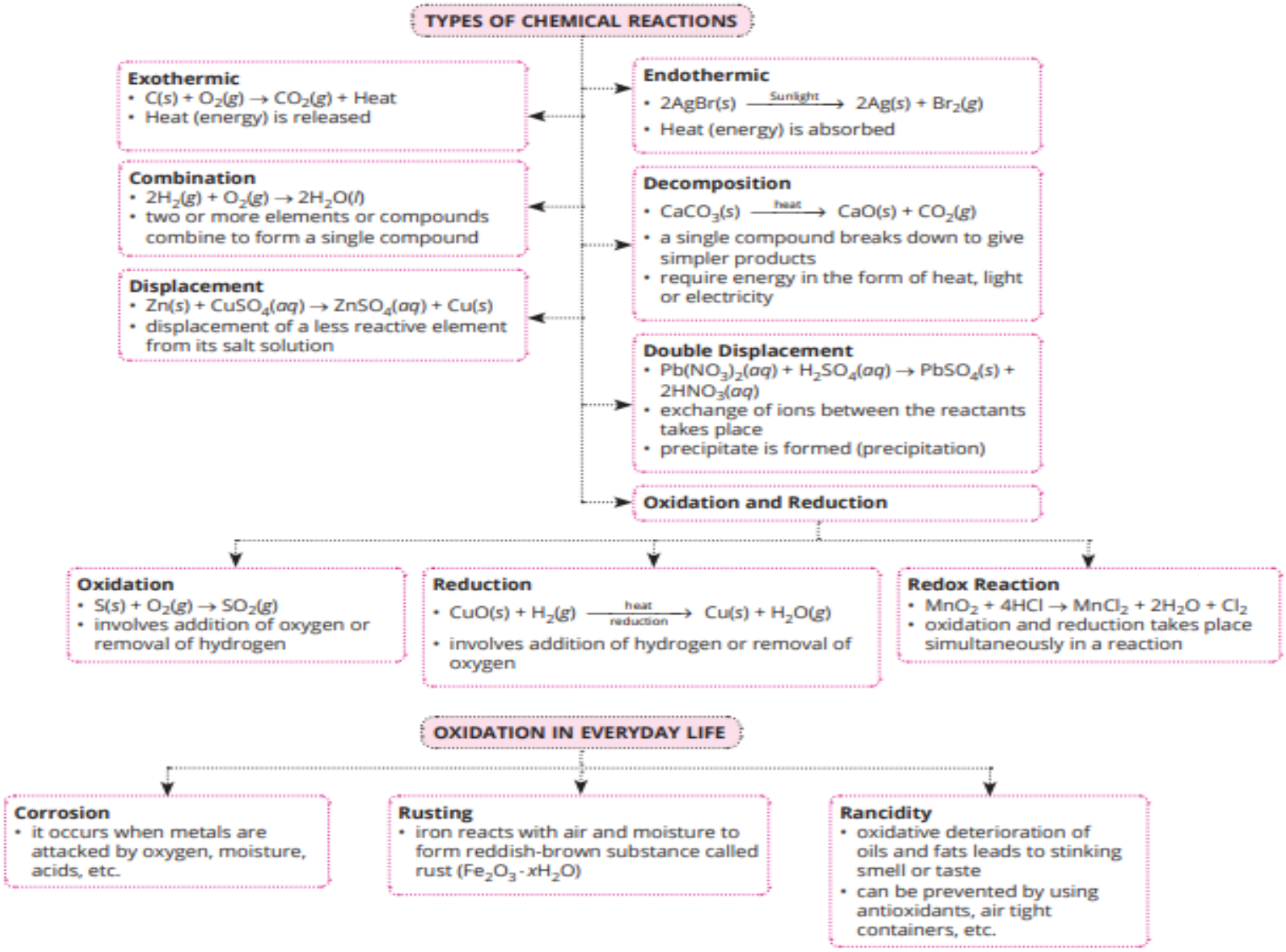
$$AB + CD \longrightarrow AD + BC$$

6. **Precipitate**: A precipitate is an insoluble product formed during the reaction of two ionic compounds in aqueous solution.
7. **Precipitation reaction**: A reaction in which one of the products of the reaction gets precipitated, is called **precipitation reaction**.
8. **Neutralisation reaction**: A reaction in which an acid reacts with a base to form a salt and water, is called **neutralisation reaction**. In a neutralisation reaction, the products formed are neutral to litmus.
9. **Oxidation**: A process which involves addition of oxygen or removal of hydrogen is called **oxidation**.
10. **Reduction**: A process which involves removal of oxygen or addition of hydrogen is called **reduction**. Reduction is the reverse of oxidation.
11. **Oxidising agent**: A substance which causes addition of oxygen to or removal of hydrogen from other substances is called **oxidising agent**.
12. **Reducing agent**: A substance which causes removal of oxygen from or addition of hydrogen to other substances is called **reducing agent**.
13. **Corrosion**: The slow destruction of metals and metal containing materials due to their exposure to the environment is called **corrosion**.
14. **Rusting**: Rusting is the slow process of oxidation of iron in the presence of air or moisture to form reddish-brown hydrated iron(III) oxide on the surface of iron. The chemical composition of rust is $Fe_2O_3 \cdot xH_2O$.
15. **Rancidity**: The oxidative deterioration of oils and fats leading to stinking smell or tasting like rank stale fat is called **rancidity**.

MIND MAP


CHEMICAL REACTIONS AND EQUATIONS
CHEMICAL EQUATIONS
Balanced Chemical Equations
follow law of conservation of mass
number of atoms remains the same for reactants and products
physical states of reactants and products are written as gaseous (g), liquid (l), aqueous (aq) and solid (s)
CHEMICAL REACTIONS
Change in
• colour
• state
• temperature

MIND MAP


TYPES OF CHEMICAL REACTIONS
Exothermic
• C(s) + O2(g) → CO2(g) + Heat
• Heat (energy) is released
Combination
• 2H2(g) + O2(g) → 2H2O(l)
• two or more elements or compounds combine to form a single compound
Displacement
• Zn(s) + CuSO4(aq) → ZnSO4(aq) + Cu(s)
• displacement of a less reactive element from its salt solution
Endothermic
• 2AgBr(s) Sunlight → 2Ag(s) + Br2(g)
• Heat (energy) is absorbed
Decomposition
• CaCO3(s) heat → CaO(s) + CO2(g)
• a single compound breaks down to give simpler products
• require energy in the form of heat, light or electricity
Double Displacement
• Pb(NO3)2(aq) + H2SO4(aq) → PbSO4(s) + 2HNO3(aq)
• exchange of ions between the reactants takes place
• precipitate is formed (precipitation)
Oxidation and Reduction
Oxidation
• S(s) + O2(g) → SO2(g)
• involves addition of oxygen or removal of hydrogen
Reduction
• CuO(s) + H2(g) heat, reduction → Cu(s) + H2O(g)
• involves addition of hydrogen or removal of oxygen
Redox Reaction
• MnO2 + 4HCl → MnCl2 + 2H2O + Cl2
• oxidation and reduction takes place simultaneously in a reaction
OXIDATION IN EVERYDAY LIFE
Corrosion
• it occurs when metals are attacked by oxygen, moisture, acids, etc.
Rusting
• iron reacts with air and moisture to form reddish-brown substance called rust (Fe2O3·xH2O)
Rancidity
• oxidative deterioration of oils and fats leads to stinking smell or taste
• can be prevented by using antioxidants, air tight containers, etc.