Introduction

- Any type of change can be classified as physical change and chemical change.
- Physical changes can be reversed easily but chemical changes are mostly irreversible because in chemical changes new substances are formed and it is very difficult to obtain the original substances back.
- We can say that whenever a chemical change occurs, a chemical reaction takes place.

Chemical Reactions

- In chemical reactions, new substances are formed, which have different properties.
- For example, Magnesium ribbon burns with a dazzling white flame to give a white powder which is magnesium oxide. It is formed because of the reaction between magnesium and atmospheric oxygen.
- Whenever a chemical reaction occurs following changes are observed:
  - Change in colour- rusting of metals produces change in colour.
  - Change in state – on heating liquid changes to its vapour state.
  - Change in temperature – chemical reactions are either endothermic or exothermic in nature, which means heat is either absorbed or liberated. This results in change in temperature.
  - Evolution of a gas – many reaction proceed with the evolution of gases such as nitrogen, hydrogen, carbon dioxide etc.

Chemical Equations

- Describing a chemical reaction in a sentence form takes more time. However, it can be written in a simpler and a shorter form by using word equation.
- For example, The word-equation for the reaction between magnesium and oxygen can be written as –

$$\text{Magnesium} + \text{Oxygen} \rightarrow \text{Magnesium oxide}$$

(Reactants) (Product)

- The substances undergoing a chemical change are called reactants and the new substances formed during the chemical reaction are called products.
- Rules to be followed while writing a chemical equation are as follows:
  - The reactants are written on the left hand side with a plus sign between them.
  - The products are written on the right-hand side.
  - The arrowhead lies between the reactants and the products and shows the direction of the reaction.
  - The conditions of the reaction and catalyst can also be mentioned.

Balanced chemical Equation

- Chemical equations can be made more concise and useful by using chemical formulae instead of words.
- The above reaction between magnesium and oxygen can be written as:

$$\mathbf{2Mg + O_2 \rightarrow 2MgO}$$

- As per the law of conservation of mass, the total mass of the elements present in the products of a chemical reaction should be equal to the total mass of the elements present in the reactants.
- This means the number of atoms of all the elements should be same before and after the reaction.
- Following steps should be followed while balancing a chemical equation:

Step I – let's take the following reaction:

$$\mathbf{Fe + H_2O \rightarrow Fe_3O_4 + H_2}$$

list the number of atoms of each element present on both sides of the equation.

	Reactant	Product
Fe	**1**	**3**
H	**2**	**2**
O	**1**	**4**

Step II – Always start balancing with the compound (reactant / product) that contains the maximum number of atoms. In that compound, select the element which has the maximum number of atoms. Using these criteria, we select Fe3O4 and the element oxygen in it. There are four oxygen atoms on the RHS and only one on the LHS. Let's, balance the oxygen atoms.

Atoms of oxygen	**reactants**	**products**
Initial	1 in H_2O	4 in Fe_3O_4
To balance	1 ×4	4

While balancing the number of atoms we should remember that we cannot alter the formula of the compound, instead we can put a coefficient.

Step III -: Fe and H atoms are yet to be balanced. Take any of these elements to proceed further. Let us balance hydrogen atoms in the partly balanced equation.

To equalise the number of H atoms, make the number of molecules of hydrogen as four on the RHS

Atoms of hydrogen	**reactants**	**products**
Initial	8 in $4H_2O$	2 in H_2
To balance	8	2 × 4

Now, equation will become:

$$\mathbf{Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2}$$

Step V – In the equation, the third element Iron is still not balanced. let us equalise the number of Iron atoms.

Atoms of Fe	**reactants**	**products**
Initial	1 in Fe	3 in Fe_3O_4
To balance	1 × 3	3

We can write the final balanced equation as follows:

$$\mathbf{3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2}$$

Types of Chemical Reactions

- Usually, chemical reactions involve the breaking and making of bonds between atoms to form new substances.
- A chemical reaction can be classified into various categories.
    1. Combination Reaction

2. Decomposition Reaction
3. Displacement Reaction
4. Double- Displacement Reaction

Combination Reaction

- Reactions in which a single product is formed by combination of two or more reactants it is known as Combination reaction.
- For example, calcium oxide reacts vigorously with water to produce calcium hydroxide with evolution of large amount of heat.

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

(Quick lime) **(Slaked lime)**

- Burning of coal is also an example of combination reaction.

$$\mathbf{C\ (s) + O_2\ (g) \rightarrow CO_2(g)}$$

- Formation of water from hydrogen and oxygen.

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

- Combination reaction are exothermic in nature because of evolution of large amount of heat.

Decomposition Reaction

- When reactants break down (decompose) into products, on application of energy either in the form of heat, light or electricity the reaction is known as decomposition reaction. Such reactions that proceed with the absorption of heat are known as endothermic reactions.
- For example, Ferrous sulphate crystals (FeSO4, 7H2O) lose water when heated and the colour of the crystals changes. It further decomposes to give ferric oxide, sulphur dioxide and sulphur trioxide. Ferric oxide is a solid, while Sulphur dioxide and trioxide are gases.

$$FeSO4.\ 7H_2O \rightarrow FeSO4 + 7H_2O$$

Heat

$$2FeSO4\ (s) \rightarrow Fe_2O_3\ (s) + SO_2\ (g) + SO_3\ (g)$$

(Ferrous sulphate) (Ferric oxide)

- Calcium carbonate Decomposes to calcium oxide and carbon dioxide on heating. It is an important decomposition reaction used in various industries. Calcium oxide also called lime or quick lime is used in the manufacture of cement. When a decomposition reaction is carried out by heating, it is known as thermal decomposition.

$$CaCO_3\ (s) \rightarrow CaO(s) + CO_2\ (g)$$

Limestone Quicklime

Displacement reaction

- In displacement reaction a more reactive metal displaces a less reactive metal from its solution but a less reactive metal cannot displace a more reactive metal.
- Example in the below given reaction iron displaces or removes another element, copper, from copper sulphate solution.

$$Fe(s) + CuSO4(aq) \rightarrow FeSO4\ (aq) + Cu(s)$$

(Copper sulphate) (Iron sulphate)

- Other examples:

$$Zn(s) + CuSO4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

(Copper sulphate) (Zinc sulphate)

$$Pb(s) + CuCl2(aq) \rightarrow PbCl2\ (aq) + Cu(s)$$

(Copper chloride) (Lead chloride)

Zinc and lead being more reactive elements than copper, displaces copper from its solution.

Double Displacement Reaction

- The reactions in which exchange of ions between the reactants takes place are called double displacement reactions.
- A general equation can be written as:

$$AB + CD \rightarrow AD + CB$$

- For example: reaction between sodium sulphate and barium chloride.

$$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$$

(Sodium sulphate) (Barium chloride) (Barium sulphate) (Sodium chloride)

- In this reaction white precipitate of $BaSO_4$ is formed by the reaction of SO_4^{2-} and Ba^{2+}. The other product formed in this reaction is sodium chloride which remains in the solution.

Oxidation and Reduction

- The reactions in which one reactant gets oxidised while the other gets reduced at the same time are called oxidation-reduction reactions or redox reactions. For example:

$$\mathbf{2Cu + O_2 \rightarrow 2CuO}$$

- The substance that gains oxygen during a reaction, is said to be oxidised. The substance that loses oxygen during a reaction, is said to be reduced. During this reaction the copper (II) oxide looses oxygen and gets reduced. The hydrogen is gaining oxygen and is being oxidised.
- Some other examples:

$$\mathbf{ZnO + C \rightarrow CuO + Zn}$$

$$\mathbf{MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2}$$

When a metal is attacked by substances around it like moisture, acids, etc., it gets corroded and this process is called corrosion. Best and the most common example is Iron coated with a reddish-brown powder when left for some time. This process is commonly known as rusting of iron. Some other metals also get tarnished in this manner. The black coating on silver and the green coating on copper are other examples of corrosion.

Corrosion causes severe damage to car bodies, iron bridges, iron railings, ships and to all objects made of metals, especially those of iron. Corrosion of iron is a very serious problem. Every year an huge amount of money is spent to replace damaged iron. tasted or smelt the

Raincidity

- Whenever fat/oil containing food materials left for a long time, their smell and taste changes. This is due to the oxidation of fats and oils to produce raincid.
- Usually, substances which (antioxidants) are added to foods containing fats and oil to prevent oxidation.
- Keeping food in air tight containers helps to slow down oxidation. This is the reason why packets of chips are flushed with gases such as nitrogen to prevent the chips from getting oxidised.