TYPES OF REDOX REACTIONS

(a) Intermolecular Redox Reaction

An intermolecular redox reaction occurs when oxidation and reduction processes take place independently in different compounds.

$$SnCl_2 + 2FeCl_3 \rightarrow SnCl_4 + 2FeCl_2$$

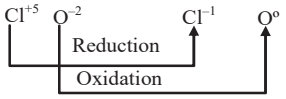
$$Sn^{+2} \rightarrow Sn^{+4} \text{ (Oxidation)}$$

$$Fe^{+3} \rightarrow Fe^{+2} \text{ (Reduction)}$$

(b) Intramolecular Redox Reaction

When a chemical reaction involves oxidation and reduction processes occurring within a single compound, it is termed an intramolecular redox reaction.

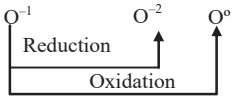
$$2KClO_3 \longrightarrow KCl + 3O_2$$



(c) Disproportionation Reaction:

A disproportionation reaction occurs when reduction and oxidation simultaneously transpire within the same element of a single compound.

$$H_2O_2 \longrightarrow H_2O + 1/2\ O_2$$



(d) Combination Reactions

A combination reaction is characterized by the amalgamation of two or more reactants, resulting in the formation of a singular product.

Example:

1. An illustrative instance of a combination reaction is the reaction between sodium (2Na) and chlorine gas (Cl_2), producing sodium chloride (2NaCl) as the sole product. The balanced chemical equation for this reaction is represented as:

   $$2Na + Cl_2 \rightarrow 2NaCl$$

   In this reaction, two moles of sodium (2Na) react with one mole of chlorine gas (Cl_2), leading to the formation of two moles of sodium chloride (2NaCl).

2. Additionally, consider the combination reaction between solid iron ($\overset{0}{Fe}$) and sulfur ($\overset{0}{S}$), resulting in the formation of iron (II) sulfide ($\overset{0}{Fe}$).

   The balanced equation for this reaction is expressed as:

   $$\overset{0}{Fe} + \overset{0}{S} \rightarrow \overset{+2-2}{Fe\,S}$$

   Here, solid iron ($\overset{+2}{Fe}$) combines with solid sulfur ($\overset{-2}{S}$), leading to the creation of iron (II) sulfide $\overset{+2-2}{Fe\,S}$. During this process, iron undergoes oxidation with a resulting +2 oxidation state, while sulfur undergoes reduction with a -2 oxidation state.

   These examples elucidate the concept of combination reactions, showcasing the synthesis of new compounds through the union of reactants.

(e) Decomposition Reaction

In order for a decomposition reaction to qualify as a redox reaction, it is imperative that at least one of the resultant components following the breakdown of the compound exists in its elemental state. Several instances of redox decomposition reactions exist,
exemplified by reactions such as:

$$\overset{+1}{2H}\,\overset{-2}{O} \xrightarrow{\Delta} \overset{0}{2H_2} + \overset{0}{O_2}$$

It is essential to recognize, however, that not all decomposition reactions exhibit redox characteristics. An illustrative example is the decomposition of calcium carbonate ($CaCO_3$) in its solid state, which does not qualify as a redox reaction due to the absence of changes in the oxidation numbers of the involved elements.

(a) Metal Displacement Reactions

$$\overset{+2}{CuSO_4} + \overset{0}{Zn} \rightarrow \overset{+2}{ZnSO_4} + \overset{0}{Cu}$$

$$\overset{+3}{Cr_2O_3} + 2Al \rightarrow 2Cr^0 + \overset{+3}{Al_2O_3}$$

(b) Non-Metal Displacement Reactions

(i) Alkali metals and certain alkaline earth metals, known for their strong reducing properties, exhibit the ability to displace hydrogen from cold water.

$$\overset{0}{2Na} + 2\overset{+1}{H}\,\overset{-2}{O} \rightarrow 2\overset{+1}{N}a\overset{-2}{O}\overset{+1}{H} + \overset{0}{H_2}$$

(ii) Metals with lower reactivity, such as magnesium (Mg) and iron (Fe), engage in a reaction with steam, resulting in the production of dihydrogen gas.

$$\overset{0}{Mg} + 2\overset{+1}{H_2}O \rightarrow \overset{+2}{Mg}(OH)_2 + \overset{0}{H_2}$$

(iii) Numerous metals, even those that exhibit little to no reactivity with cold water, demonstrate the capability to displace hydrogen (H_2) from acids.

$$\overset{0}{Zn} + 2\overset{+1}{H}Cl \rightarrow \overset{+2}{ZnCl_2} + \overset{0}{H_2}$$

This includes metals like cadmium (Cd) and tin (Sn), which, despite their non-reactivity with steam, engage with acids to release H_2 gas.

$$\overset{0}{Cd} + 2\overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Cd}\overset{-1}{Cl_2} + \overset{0}{H_2}$$

(iv) Extremely unreactive metals, such as silver (Ag) and gold (Au), which exist in their native state, remain unresponsive even when exposed to dilute hydrochloric acid (HCl).