

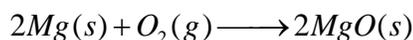
## Oxidation – Reduction Reactions

These types of reactions are very common in our nature; extraction metals and non-metals from their ores, rusting of common metals, burning of fossil fuels, action of common household bleaches, etc

**Oxidation-reduction reactions**, or simply known as **redox** (derived from reduction and oxidation) **reactions** are electron-transfer reactions. There are two definitions of oxidation and reaction, old and new (current).

According to old definition, the oxidation is the process of combining with oxygen and reduction is the process of removing the oxygen. Some times, you hear the word “oxidized”; it means combining with oxygen.

The current definitions of oxidation and reduction are based on the transfer of electrons. *Oxidation is the process of losing the electrons while the reduction is the process of gaining the electrons.* Consider the example burning of magnesium ribbon (Mg). When magnesium burns, it combines with oxygen (O<sub>2</sub>) from the air to form magnesium oxide (MgO) according to the following equation:



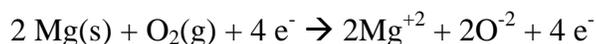
Magnesium oxide is an ionic compound containing Mg<sup>+2</sup> and O<sup>-2</sup> ions whereas Mg(s) and O<sub>2</sub>(g) are elements with no charges. Then, how the Mg(s) with zero charge becomes Mg with +2 charges (Mg<sup>+2</sup>) going from reactant side to product side? How the O<sub>2</sub> (g) with zero charge becomes -2 charge going from left side to right side? This is explained as follows. When Mg(s) becomes Mg<sup>+2</sup>, it loses 2 electrons. Since there are 2 Mg on left side, a total of 4 electrons are lost according to the following equation.



This process is known as the oxidation or oxidation process. On the other hand, O<sub>2</sub> becomes O<sup>-2</sup> by gaining 4 electrons according to



This process is known as reduction or reduction process. Note that each oxygen atom gains 2 electrons. Since there are 2 oxygen atoms, a total of 4 electrons are gained. The above each process is called **half-reaction**, i.e., **oxidation half-reaction and reduction half-reaction**. Overall reaction is the sum of both half-reactions:



When chemical reaction, especially, redox reaction takes place, we do not see the electrons as they appear and disappear during the course of the reaction. What we see is the reactants (starting material) and end products. Due to this, electrons appearing on both sides of the equation are canceled. After concealing, the equation is re-written as



Two ions, positive ( $\text{Mg}^{+2}$ ) and negative ( $\text{O}^{-2}$ ) exist on product side and they combine immediately to form a compound magnesium oxide ( $\text{MgO}$ ) due to their opposite charges (electrostatic attraction).

In any given oxidation-reduction reaction, there are two half-reactions – oxidation half-reaction and reduction half-reaction. The sum of these two half-reactions is the oxidation-reduction reaction.

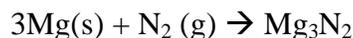
In the above example, Mg loses the electrons because of the presence of  $\text{O}_2$ , i.e.,  $\text{O}_2$  makes the Mg to lose the electrons. Therefore,  $\text{O}_2$  is the reason why Mg loses the electrons. Hence  $\text{O}_2$  is known as the **oxidizing agent**. At the same time,  $\text{O}_2$  gains electrons because Mg is willing to donate electrons to  $\text{O}_2$ . Thus Mg is the reason for  $\text{O}_2$  to accept electrons. Hence Mg is known as the **reducing agent**. The term “reducing” means reducing the charge (decrease in charge going from reactant side to product side). Here Mg reduces the  $\text{O}_2$  by supplying electrons. Then the oxidizing and reducing agents are defined as follows:

*The oxidizing agent is the substance that is being reduced or the substance that accepts electrons. The reducing agent is the substance that is being oxidized or the substance that donates electrons.*

**Important:** The definition of oxidizing and reducing agents apply only to substances present on the reactant side.

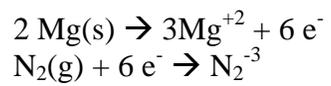
### Example

In the following redox reaction, identify oxidation half-reaction, reduction half-reaction, oxidizing agent, and reducing agent.



### Answer

First, we need to assign oxidation numbers to each element on both sides of the equation. The  $\text{Mg(s)}$  and  $\text{N}_2(\text{g})$  are elemental forms on the left side and hence carry no charges. On the product side, Mg carries +2 charges because it belongs to Group IIA. Based on this, we can assign -3 charges to N on the product side. Thus, Mg goes from zero charge to +2 charges by losing 2 electrons or a total of 6 electrons. On the other hand,  $\text{N}_2(\text{g})$  becomes  $\text{N}_2^{-3}$  by gaining 6 electrons. The half-reactions are written as



oxidation half-reaction

reduction half-reaction

The  $\text{N}_2(\text{g})$  is the oxidizing agent because it is the substance being reduced (accepts electrons) and  $\text{Mg(s)}$  is the reducing agent because it is the substance being oxidized (loses electrons).

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