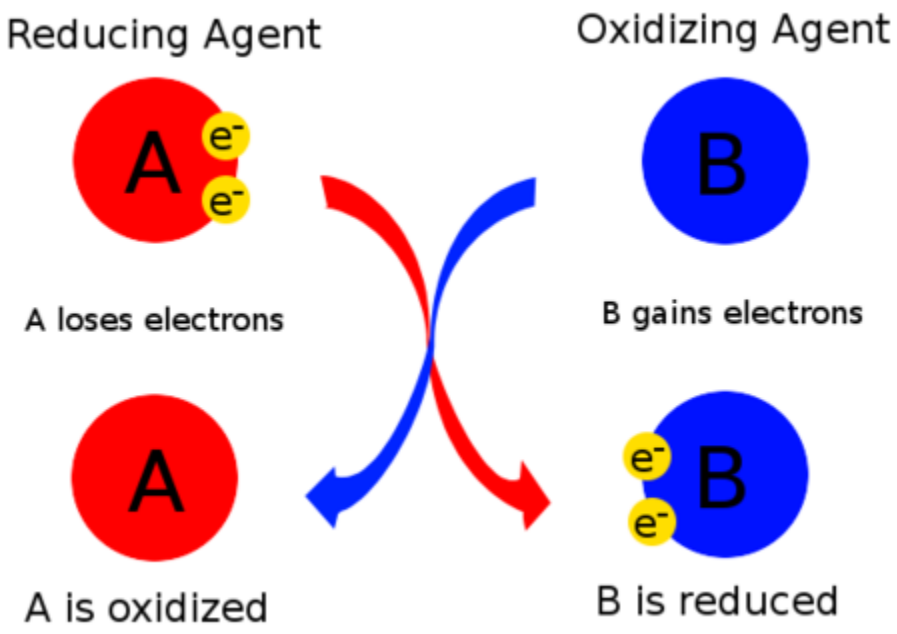
Oxidizing and Reducing Agents

Oxidizing and reducing agents are key terms used in describing the reactants in redox reactions that involve transferring electrons between reactants to form products. Here, we will look at what defines an oxidizing and reducing agent, how to determine an oxidizing and reducing agent in a chemical reaction, and the importance of this concept in real world applications.

Oxidizing and Reducing Agents

An **oxidizing agent**, or **oxidant**, *gains* electrons and is reduced in a chemical reaction. Also known as the electron acceptor, the oxidizing agent is normally in one of its higher possible oxidation states because it will gain electrons and be reduced. Examples of oxidizing agents include halogens, potassium nitrate, and nitric acid.



A **reducing agent,** or **reductant**, *loses* electrons and is oxidized in a chemical reaction. A reducing agent typically is in one of its lower possible oxidation states and is known as the electron donor. A reducing agent is oxidized because it loses electrons in the redox reaction. Examples of reducing agents include the earth metals, formic acid, and sulfite compounds.

Definitions

A reducing agent **reduces** other substances and **lose** electrons; therefore, its oxidation state will **increase**.
An oxidizing agent **oxidizes** other substances and **gains** electrons therefore, its oxidation state will **decrease**.

To help eliminate confusion, here is a mnemonic device to help you remember how to determine oxidizing and reducing agents.

OIL RIG:

Oxidation **I**s **L**oss and **R**eduction **I**s **G**ain of electrons

Identify the reducing and oxidizing agents in the balanced redox reaction:

$$Cl2\ (aq) + 2Br^{-}\ (aq) \rightarrow 2Cl^{-}\ (aq) + Br2\ (aq)$$

Oxidation half reaction

$$\mathbf{2Br^{-}\ (aq) \rightarrow Br2\ (aq)}$$

Oxidation States: -1 0

Reduction Half Reaction

$$\mathbf{Cl2\ (aq) \rightarrow 2\ Cl^{-}\ (aq)}$$

Oxidation States: 0 -1

Overview

Br^{-} loses an electron; it is being *oxidized* from Br^{-} to $Br2$, thus Br^{-} is the *reducing agent*.
$Cl2$ gains one electron; it is being *reduced* from $Cl2$ to 2 Cl^{-}, thus $Cl2$ is the *oxidizing agent.*

Common oxidizing agents	**Common reducing agents**
O_2	H_2
O_3	CO
F_2	Fe
Br_2	Zn
H_2SO_4	Li
Halogen metals (halogen metals tend to gain an electron to get to noble gas configuration)	Alkali metals (alkali metals tend to lose an electron to get to noble gas configuration)

Applications

Oxidizing and reducing agents are important in industrial applications. They are used in processes such as purifying water, bleaching fabrics and storing energy (such as in batteries and gasoline). Oxidizing and reducing agents are especially crucial in biological processes such as metabolism and photosynthesis. For example, organisms utilize electron acceptors such as NAD^+ to harvest energy from redox reactions as in the hydrolysis of glucose:

$$C_6H_{12}O_6+2ADP+2P+2NAD+\rightarrow 2CH_3COCO_2H+2ATP+2NADH$$

All combustion reactions are also examples of redox reactions. A combustion reaction occurs when a substance reacts with oxygen to create heat. One example is the combustion of octane, the principle component of gasoline:

$$\mathbf{2C_8H_{18}(l)+25O_2\ (g) \rightarrow 16CO_2(g)+18H_2O(g)}$$

Combustion reactions are a major source of energy for modern industry.

Summary

	Oxidizing Agents	**Reducing Agents**
Oxidation State	Decreases	Increases
# of Electrons	Gained	Lost
Substance is...	Reduced	Oxidized

By looking at each element's oxidation state on the reactant side of a chemical equation in comparison to the same element's oxidation state on the product side, one can determine if the element is being reduced or oxidized. Thus, one is able to conclude the oxidizing and reducing agents of a chemical reaction.

Problems Circle the element that is oxidized and underline the reduced element. Identify the oxidizing agent and the reducing agent.

1. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
2. $H_2O + C \rightarrow H_2 + CO$
3. $I_2O_5 + 5\ CO \rightarrow I_2 + 5\ CO_2$
4. $PBr_3 + 3\ H_2O \rightarrow H_3PO_3 + HBr$