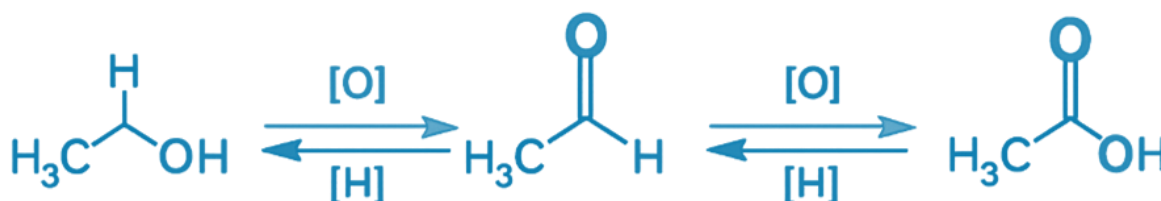


Oxidation Reduction Reaction

Oxidation-Reduction Reactions (Redox Reactions)

Overview

- Oxidation–Reduction reactions, often referred to as redox reactions, are chemical processes that involve the transfer of electrons between substances.
- One substance loses electrons (is oxidized), while another gains electrons (is reduced).
- These reactions are crucial in both biological systems (like cellular respiration) and industrial processes (like corrosion and metal extraction).
- **Example:** The conversion of the ethanol to acetaldehyde, and that of acetaldehyde to acetic acid, are oxidation reactions, and the reverse reaction are reduction reactions.



Key Features:

- **Electron transfer:** The main concept behind redox reactions is the movement of electrons from one species to another.
- **Oxidation and reduction occur simultaneously:** One can't happen without the other.
- **Involves changes in oxidation numbers:** Tracking these helps identify what is oxidized and what is reduced.

Example:

- Consider the reaction between sodium and chlorine:



- Sodium (**Na**) loses an electron:



- Chlorine (**Cl₂**) gains an electron:



- Thus, this is a redox reaction.

Definition of Oxidation

Overview

- Oxidation is the loss of electrons by a molecule, atom, or ion.

- Historically, it referred to reactions involving oxygen (like rusting), but the modern definition focuses on electron transfer and changes in oxidation states.

Ways to Identify Oxidation:

- Loss of electrons
- Increase in oxidation number
- Gain of oxygen atoms
- Loss of hydrogen atoms

Key characteristics of oxidation:

- Electron loss
- Oxidation number increases
- May involve addition of oxygen or removal of hydrogen

Example 1:



- Sodium (Na) loses one electron to become Na^+ .
- Sodium is **oxidized**.

Example 2:



- Iron (Fe^{2+}) loses one electron to become Fe^{3+} .
- This is also oxidation.

Definition of Reduction

Overview

- Reduction is the gain of electrons by an atom, ion, or molecule.
- Just as oxidation involves electron loss, reduction is its counterpart, involving electron acceptance.
- The term comes from the idea that the gain of electrons often "reduces" the positive charge of a substance.

Ways to Identify Reduction:

- Gain of electrons
- Decrease in oxidation number
- Loss of oxygen atoms

- Gain of hydrogen atoms (especially in organic/biochemical contexts)

Key characteristics of reduction:

- Electron gain
- Oxidation number decreases
- May involve removal of oxygen or addition of hydrogen

Example 1:



- Each chlorine atom gains one electron to form chloride ions (Cl^-).
- Chlorine is reduced.

Example 2:



- Copper ion gains two electrons and becomes metallic copper.
- This is a reduction process.
- Reduction always occurs alongside oxidation, because electrons lost by one substance must be gained by another.

Oxidizing and Reducing Agents

- **In a redox reaction:**
 - The oxidizing agent is the substance that causes oxidation by accepting electrons (it gets reduced).
 - The reducing agent is the substance that causes reduction by donating electrons (it gets oxidized).
- Think of them as the **facilitators** of redox change:
 - **Oxidizing agent:** gets **reduced** (gains electrons)
 - **Reducing agent:** gets **oxidized** (loses electrons)

Oxidizing Agent (Oxidant):

- The substance that causes oxidation of another.
- It accepts electrons (i.e., is reduced).
- It gets reduced itself during the reaction.

Reducing Agent (Reductant):

- The substance that causes reduction of another.

- It donates electrons (i.e., is oxidized).
- It gets oxidized itself during the reaction.

Example:



- Zinc (Zn) loses electrons $\rightarrow$ oxidized $\rightarrow$ acts as the reducing agent
- Copper ion (Cu^{2+}) gains electrons $\rightarrow$ reduced $\rightarrow$ acts as the oxidizing agent

Another Example:



- H_2 donates electrons $\rightarrow$ oxidized $\rightarrow$ reducing agent
- F_2 accepts electrons $\rightarrow$ reduced $\rightarrow$ oxidizing agent

Oxidation of Alkenes

Formation of Epoxides

Overview

- Epoxides are three-membered cyclic ethers formed by the oxidation of alkenes.
- This reaction involves the addition of an oxygen atom across the double bond to create a strained, triangular ring structure.

Reagents Used:

- Peroxy acids (most commonly *m*-chloroperoxybenzoic acid, or mCPBA)

Mechanism:

- The reaction proceeds via a concerted mechanism, meaning the π -electrons of the alkene and the oxygen from the peroxy acid simultaneously form the epoxide ring.
- It is stereospecific: the stereochemistry of the alkene (cis or trans) is preserved in the epoxide.

General Reaction:



Example:



- Propene reacts with mCPBA to form propylene oxide.

Formation of Carboxylic Acids and Ketones

- Alkenes can be oxidized under strong oxidative conditions to form carboxylic acids (from terminal or monosubstituted carbons) and ketones (from internal, disubstituted carbons).

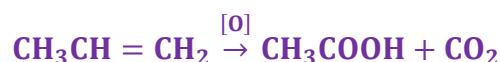
Reagents Used:

- Hot, concentrated potassium permanganate (KMnO_4)
- Ozone (O_3) followed by oxidative work-up (e.g., H_2O_2)

Reaction Overview:

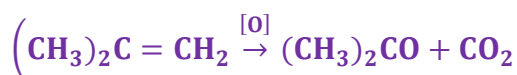
- The double bond is completely broken.
- Each carbon involved in the double bond is oxidized:
 - If it's bonded to hydrogen, it becomes a carboxylic acid.
 - If it's bonded to two carbon atoms, it becomes a ketone.
 - If it's a terminal alkene, it can produce carbon dioxide.

Example 1:



- Propene undergoes oxidation:
 - $\text{CH}_3\text{-CH=}$ yields acetic acid
 - The terminal $=\text{CH}_2$ becomes CO_2

Example 2:



- 2-methylpropene gives acetone and carbon dioxide.

Syn-Hydroxylation of Alkenes (Formation of Syn-Diols)

- Syn-hydroxylation refers to the addition of two hydroxyl ($-\text{OH}$) groups to the same side (cis addition) of the double bond, forming a cis-1,2-diol (also called a syn-diol).

Reagents Used:

- Cold, dilute KMnO_4
- Osmium tetroxide (OsO_4), often followed by a reducing agent like NaHSO_3 or H_2O_2

Mechanism:

- These reagents add hydroxyl groups across the double bond in a concerted, cis fashion.
- The double bond is preserved as a single bond, with both new $-\text{OH}$ groups on the same face of the molecule.



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