Chapter 8

Redox Reactions

REDOX REACTIONS

INTRODUCTION

Redox reactions are intricately connected to the exchange of electrons, involving the gain or loss of these fundamental particles. A redox reaction specifically refers to a chemical process where both oxidation and reduction transpire concurrently. This chapter delves into problem-solving within the realm of redox reactions, exploring topics such as oxidation numbers and the meticulous balancing of redox reactions. The methods elucidated for achieving this balance include the ion-electron method and the oxidation number method. Through an exploration of these techniques, the chapter aims to provide a comprehensive understanding of redox reactions and their associated principles.

Oxidation and Reduction

Classical Concept of Oxidation Reduction

Oxidation

In accordance with this theoretical framework, the process of oxidation is defined as either the introduction of oxygen or the elimination of hydrogen within an ion, compound, or species. Alternatively, oxidation can also be described as the inclusion of an electronegative element or the removal of an electropositive element from an ion, species, or compound.

This concept of oxidation forms the basis for understanding chemical reactions and is fundamental in the study of redox (reduction-oxidation) processes. It offers a framework to characterize the alteration of chemical species as they undergo transformations involving the transfer of electrons. By considering changes in the distribution of electrons within molecules and ions, the concept of oxidation provides a structured approach to interpreting chemical reactions and the role of oxygen and other elements in these processes.

For example:

(a) $2Mg + O_2 \rightarrow 2MgO$ $\rightarrow$ Addition of Oxygen.

(b) $C + O_2 \rightarrow CO_2$

(c) $H_2S + Cl_2 \rightarrow 2HCl + S \rightarrow$ Removal of Hydrogen

(d) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

- Oxidation Number Method
- Ion Electron Method

- Volumetric Analysis
  - Equivalent Weight
  - Normality
  - n-Factor or Valence Factor
  - Volumetric or Quantitative Analysis
- Law of Equivalence
  - Back Titration
  - Double Titration
  - Applications of Law of Equivalence
- Redox Titration
  - Oxidation-Reduction Titration
  - Dichromate Titration
  - Iodimetric Titration
  - Iodometric Titration
- Volume Strength of H_2O_2
- Galvanic Cell and Electrode Potential
  - Galvanic Cell or Voltaic Cell
  - Redox Couple

Reduction

As per this conceptual framework, the phenomenon of reduction is defined as either the incorporation of hydrogen or the elimination of an oxygen atom within an ion, compound, or species. Conversely, reduction can also be characterized as the inclusion of an electropositive element or the removal of an electronegative element from an ion, species, or compound.

This definition of reduction plays a central role in understanding chemical reactions, particularly in the context of redox (reduction-oxidation) processes. It provides a structured perspective for assessing changes in chemical species as they engage in transformations that entail the exchange of electrons. By focusing on alterations in the electron distribution within molecules and ions, the concept of reduction offers a systematic approach for interpreting chemical reactions and comprehending the role of hydrogen, oxygen, and other elements in these intricate processes.

For example:

(a) $H_2S + Cl_2 \rightarrow 2HCl + S \rightarrow$ Addition of Hydrogen

(b) $H_2 + Cl_2 \rightarrow 2HCl$

(C) $ZnO + C \rightarrow Zn + CO \rightarrow$ Removal of Oxygen

(d) $FE_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Oxidation Number Concept of Oxidation-Reduction

A. Oxidation: According to this concept, when an element undergoes an increase in its oxidation number during a reaction, it is referred to as oxidation.

B. Reduction: According to this concept, decrease in oxidation no. in an element in a reaction is called reduction.

For example:

$$\underset{+7}{KMnO_4} + \underset{+2}{FeSO_4} \rightarrow \underset{+2}{MnO} + \underset{+3}{Fe_2(SO_4)_3}$$

Modern Concept of Oxidation

Modern Or Electronic Concept of Oxidation Reduction

A. Oxidation: According to this concept, the process involving the loss of electrons by an element or species is referred to as oxidation. It is also known as de-electronation.

For example:

$$Fe \rightarrow Fe^{2+} + 2e^- \text{ (O.N. of Fe, } 0 \rightarrow 2)$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^- \text{ (O.N. of Fe, } 2 \rightarrow 3)$$

$$2Cl^- \rightarrow Cl_2 + 2e^- \text{ (O.N. of Cl, } -1 \rightarrow 0)$$

B. Reduction: Within the framework of this concept, reduction is defined as a process where an element, atom, or ion acquires electrons. This phenomenon is commonly referred to as reduction, and it can alternatively be termed "electronation."

The concept of reduction is a fundamental principle in the study of chemical reactions, particularly in the context of redox (reduction-oxidation) reactions. Reduction involves the addition of electrons to a chemical species, resulting in a decrease in its oxidation state or number. This process is characterized by the transition from a higher electron-deficient state to a lower one, which signifies a gain of electrons.

Reduction reactions play a critical role in various chemical and biological processes, as they are integral to the transfer of electrons between species. By understanding reduction, scientists can decipher the mechanisms and intricacies of chemical reactions, including how electrons move between atoms, ions, and molecules. This concept is fundamental in chemistry and serves as a cornerstone for exploring the dynamics of electron transfer in diverse chemical systems.

For example:

$$I_2 + 2e^- \rightarrow 2I^- \text{ (O.N. of I,0} \rightarrow -1)$$

$$Fe^{3+} + e^- \rightarrow Fe^{+2} \text{ (O.N. of Fe, + 3} \rightarrow + 2)$$

$$Sn^{+4} + 2e^- \rightarrow Sn^{+2} \text{ (O.N. of Sn, + 4} \rightarrow + 2)$$

Redox reactions

(a) Reactions in which both oxidation and reduction transpire concurrently are termed redox reactions.

(b) The majority of chemical reactions exhibit redox characteristics because for one element to relinquish electrons, there must be another element ready to receive them.

(c) Any redox reaction may be divided in two parts:
(i) Oxidation half reaction
(ii) Reduction half reaction
Now, we will study some reaction.

NOTE: In reaction 2 oxygens of ozone have different OS.

Structure of ozone is

$$O_3 \leftarrow O_1 = O_2$$

$$\text{OS of } O_1 = + 2$$

$$\text{OS of } O_2 = 0$$

Here O_1 is getting reduced in reaction 2

$$\text{OS of } O_3 = - 2$$

(d) Redox reactions can manifest as intramolecular, intermolecular, or disproportionation reactions, contingent on whether the transfer of electrons occurs within the atoms of the same compound or across different compounds.

(i) Intermolecular redox reaction

$$\overset{+6}{2H_2SO_4}(\text{conc.}) + \overset{0}{Cu} \rightarrow \overset{+2}{CuSO_4} + \overset{+4}{SO_2} + 2H_2O$$

(ii) Intramolecular redox reaction

$$\overset{+5}{2KClO_3} \rightarrow \overset{-1}{2KCl} + \overset{0}{3O_2}$$

(iii) Disproportions Redox Reaction: In this type of redox reactions same element acts as both oxidising & reducing agent.

$$\overset{0}{Cl_2} + H_2O \rightarrow \overset{+1}{HClO} + \overset{-1}{HCl}$$

S.No.	Reaction	Oxidant (Getting Reduced)	Reductant (Getting Oxidised)
1.	$C + O_2 \rightarrow CO_2$	O [0 → – 2]	C [0 → + 4]
2.	$PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$	O [+ 2 → 0]	S [– 2 → + 6]
3.	$PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$	O [–1 → –2]	S [– 2 → + 6]
4.	$Sn + 2F_2 \rightarrow SnF_4$	F [0 → –1]	Sn [0 →+ 4]
5.	$SO_2 + 2H_2O + Cl_2 \rightarrow 2HCl + H_2SO_4$	Cl [0 → –1]	S [+ 4 → + 6]
6.	$I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$	N [+ 5 → + 4]	I [0 → + 5]
7.	$CuO + H_2 \rightarrow Cu + H_2O$	Cu [+ 2 → 0]	H[0 → + 1]
8.	$2KMnO_4 + 3H_2SO_4 + 5H_2S \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$	Mn [+ 7 → + 2]	S [–2 → 0]
9.	$H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$ (Oxygen of H_2O_2)	Ag [+ 1 → 0]	O [–1 → 0]
10	$H_2SO_4 + 2HI \rightarrow SO_2 + I_2 + 2H_2O$	S [+6 → +4]	I [–1 → 0]