• Historically, oxidation meant reacting with oxygen.

\[ 2\text{Zn}(s) + \text{O}_2(g) \rightarrow 2\text{ZnO}(s) \]

\[ \text{Zn} \rightarrow \text{Zn}^{2+} + 2e^- \]

or

\[ 2\text{Zn} \rightarrow 2\text{Zn}^{2+} + 4e^- \]

\[ \text{O} + 2e^- \rightarrow \text{O}^{2-} \]

or

\[ \text{O}_2 + 4e^- \rightarrow 2\text{O}^{2-} \]
Many reactions that are similar to the reaction between zinc and oxygen were not considered oxidation.

For example, both the zinc-oxygen reaction and the reaction between sodium metal and chlorine gas (described on the next slide) involve the transfer of electrons.
Oxidation and Formation of Binary Ionic Compounds

**Formation of NaCl**

\[ \text{Sodium atoms} + \text{Chlorine molecule} \rightarrow \text{Sodium ions} + \text{Chloride ions} \]

**Oxidation of zinc**

\[ 2 \text{Zinc atoms} + \text{Oxygen molecule} \rightarrow 2 \text{Zinc ions} + 2 \text{Oxide ions} \]
To include the similar reactions in the same category, **oxidation** was redefined as any chemical change in which at least one element loses electrons.
Zinc Oxide Reduction

• The following equation describes one of the steps in the production of metallic zinc.

\[ \text{ZnO}(s) + \text{C}(g) \rightarrow \text{Zn}(s) + \text{CO}(g) \]

• Because zinc is reducing the number of bonds to oxygen atoms, historically, zinc was said to be *reduced*.

• When we analyze the changes taking place, we see that zinc ions are gaining two electrons to form zinc atoms.

\[ \text{Zn}^{2+} + 2e^- \rightarrow \text{Zn} \]

• The definition of reduction was broadened to coincide with the definition of oxidation. According to the modern definition, when something gains electrons, it is *reduced*. 
The loss of electrons (oxidation) by one substance is accompanied by the gain of electrons by another (reduction).

Electron transfer reactions are called oxidation-reduction reactions or redox for short.
RIG Is Gain
Reduction Oxidation Loss
Identifying Oxidizing and Reducing Agents

\[ 2\text{Zn}(s) + \text{O}_2(g) \rightarrow 2\text{ZnO}(s) \]

\[
\begin{align*}
\text{Zn} & \rightarrow \text{Zn}^{2+} + 2e^- \\
\text{O} & + 2e^- \rightarrow \text{O}^{2-}
\end{align*}
\]

- Zinc atoms lose electrons, making it possible for oxygen atoms to gain electrons and be reduced, so zinc is the **reducing agent**.
- Oxygen atoms gain electrons, making it possible for zinc atoms to lose electrons and be oxidized, so \( \text{O}_2 \) is the **oxidizing agent**.
Oxidizing and Reducing Agents

- A reducing agent is a substance that loses electrons, making it possible for another substance to gain electrons and be reduced. The oxidized substance is always the reducing agent.

- An oxidizing agent is a substance that gains electrons, making it possible for another substance to lose electrons and be oxidized. The reduced substance is always the oxidizing agent.
Partial Loss and Gain of Electrons

\[ \text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g) \]

- The N-O bond is a polar covalent bond in which the oxygen atom attracts electrons more than the nitrogen atom.
- Thus the oxygen atoms gain electrons partially and are reduced.
- The nitrogen atoms lose electrons partially and are oxidized.
- \( \text{N}_2 \) is the reducing agent.
- \( \text{O}_2 \) is the oxidizing agent.
Redox Terms (1)

The reducing agent loses electrons and thus is oxidized in the reaction.

Complete transfer of electrons

Complete transfer of electrons

Ionic bond

Polar covalent bond

The oxidizing agent gains electrons and thus is reduced in the reaction.
Redox Terms (2)

• **Oxidation-Reduction (Redox) Reaction**
  – an electron transfer reaction

• **Oxidation**
  – complete or partial loss of electrons

• **Reduction**
  – complete or partial gain of electrons

• **Oxidizing Agent**
  – the substance reduced; gains electrons, making it possible for something to lose them.

• **Reducing Agent**
  – the substance oxidized; loses electrons, making it possible for something to gain them.