

Oxidation-Reduction

An Introduction

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Oxidation-Reduction Reactions

In an oxidation-reduction (Redox) reaction, electrons are transferred from one species to another.

For example, in a single replacement reaction



The Cu atoms lose electrons to form Cu^{2+} in the $\text{Cu}(\text{NO}_3)_2$ and the Ag^+ gains electrons to form metallic Ag

Oxidation-Reduction Reactions

- This can be more easily observed by writing the net ionic equation for the reaction:



- The metallic Cu atoms are uncombined, so they are considered to have an oxidation number of zero.
- The combined Ag atoms are in a +1 oxidation state.
- Each Cu atom will lose 2 electrons to 2 Ag⁺ ions
- The resulting Ag atoms are considered to have an oxidation number of zero

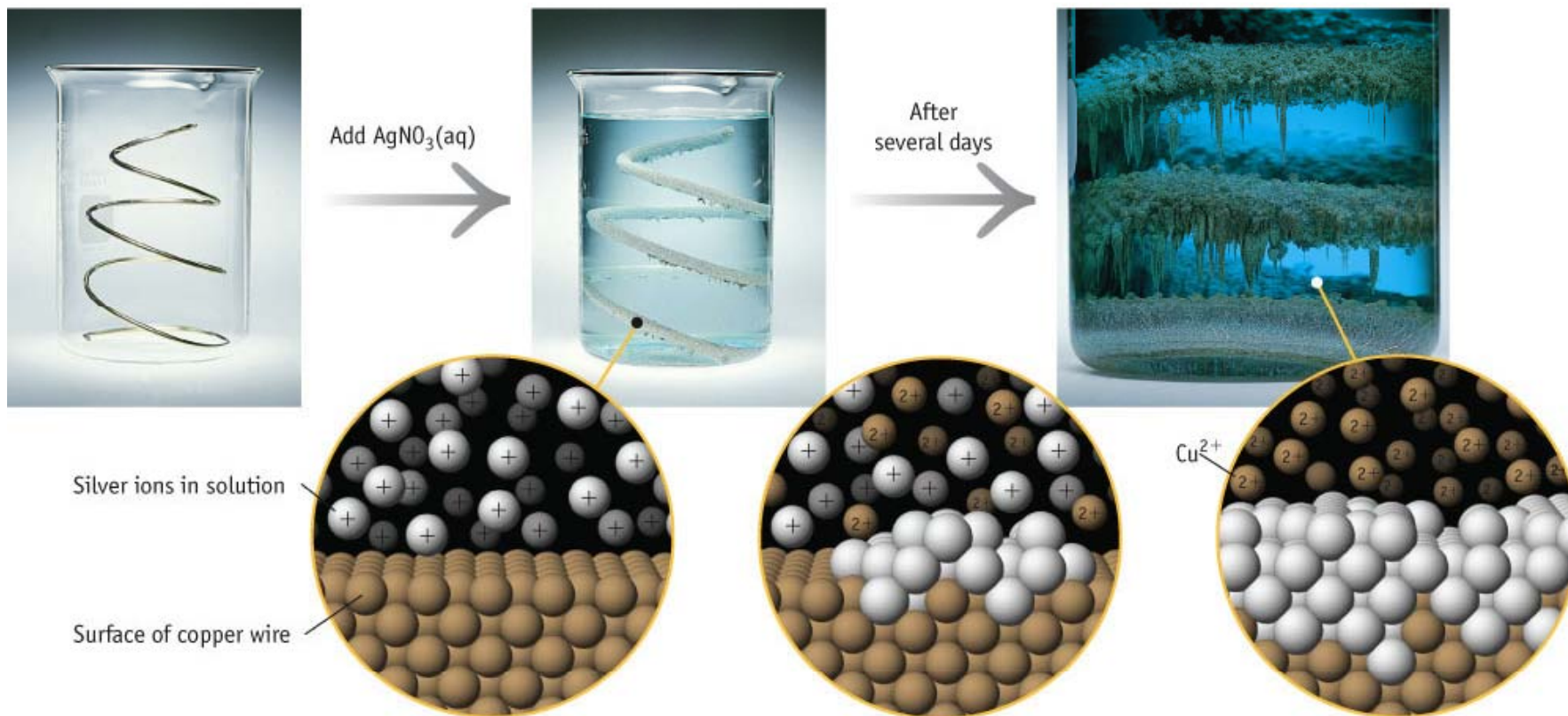
Oxidation-Reduction Reactions



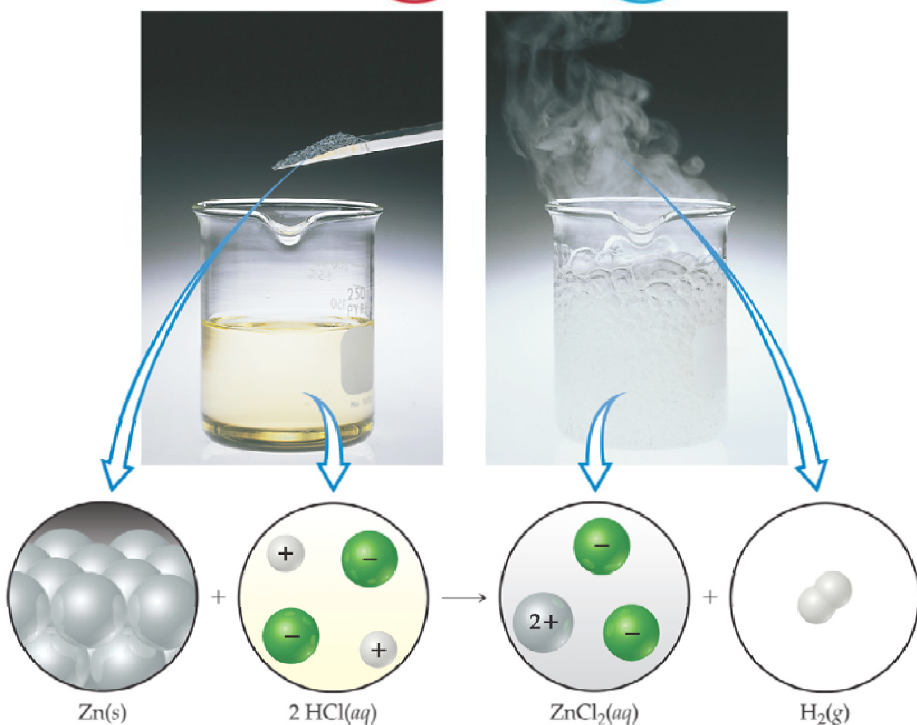
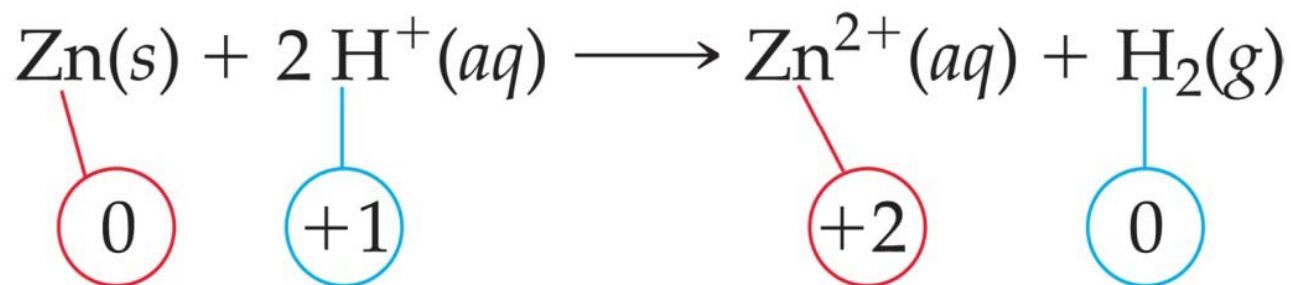
A clean piece of copper wire will be placed in a solution of silver nitrate, AgNO_3 .

With time, the copper reduces Ag^+ ions to silver metal crystals, and the copper metal is oxidized to copper ions, Cu^{2+} .

The blue color of the solution is due to the presence of aqueous copper(II) ions.

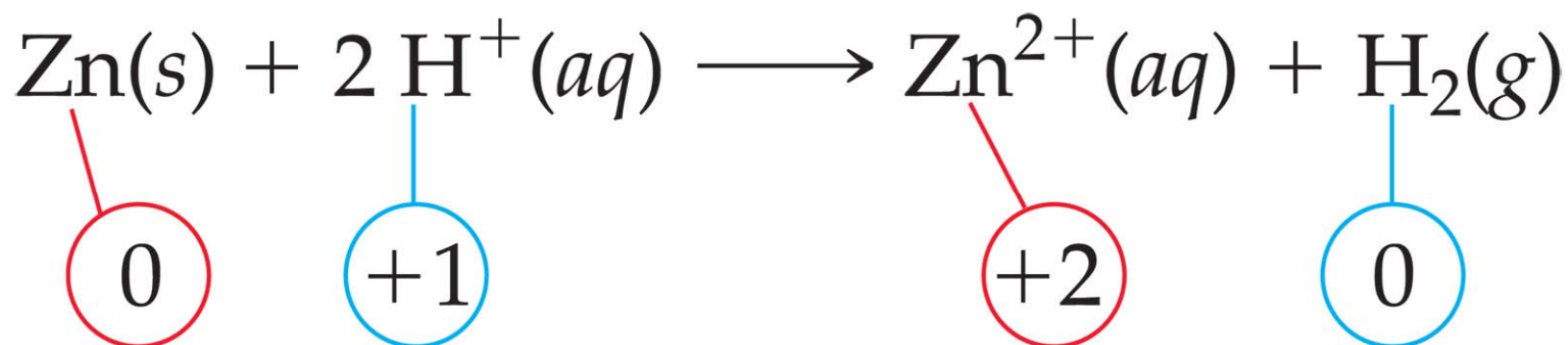


Oxidation Numbers



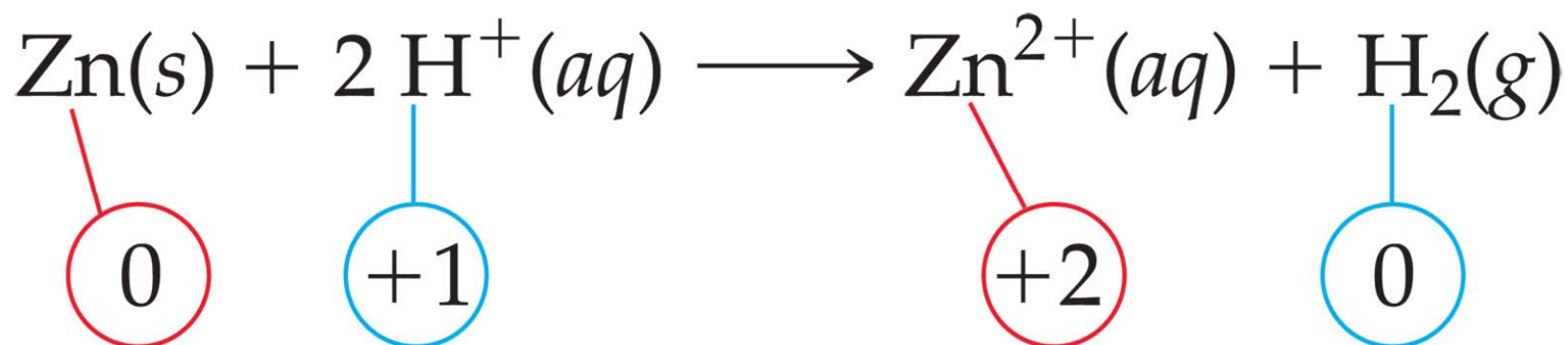
In order to keep track of what loses electrons and what gains them, we list the **oxidation numbers** of each element.

Oxidation and Reduction



- **A species is reduced when it gains electrons.**
 - Here, each of the H^+ gains an electron and they combine to form H_2 .
 - Reduction is observed as an decrease in oxidation number

Oxidation and Reduction



- The species that contains the element that is reduced is the **oxidizing agent**.
 - H^+ oxidizes Zn by taking electrons from it.
- The species that contains the element that is oxidized is the **reducing agent**.
 - Zn reduces H^+ by giving it electrons.

Assigning Oxidation Numbers

1. Elements in their elemental form have an oxidation number of 0.
2. The oxidation number of a monatomic ion is the same as its charge.

Assigning Oxidation Numbers

3. The oxidation number of metals depends on their position in the periodic table
 - Group IA elements are +1
 - Group IIA elements are +2
 - Group IIIA elements are +3
 - Group IVA metals are usually +2 or +4
 - Group VA metals are usually +3 or +5

Assigning Oxidation Numbers

- 4. Nonmetals tend to have negative oxidation numbers, although some are positive in certain compounds or ions.**
 - Oxygen always has an oxidation number of -2 , except in the peroxide ion in which it has an oxidation number of -1 .
 - Hydrogen is always -1 when bonded to a metal
 - Hydrogen is $+1$ when bonded to a nonmetal.

Assigning Oxidation Numbers

4. Nonmetals (continued).

- Fluorine always has an oxidation number of -1 .
- The halogens (Cl, Br, and I) have an oxidation number of -1 when they are negative
- The halogens (Cl, Br, and I) will have positive oxidation numbers in oxyanions (ClO^- , ClO_2^- , ClO_3^- , etc.)

Assigning Oxidation Numbers

5. The sum of the oxidation numbers in a neutral compound is 0.
6. The sum of the oxidation numbers in a polyatomic ion is the charge on the ion.