Chem edapt wk 5

Introduction

Reduction and oxidation are intertwined concepts that are important to understanding some of the most important chemical reactions in the human body. In this lesson, we will explore the relationship between these terms and the how to identify what chemicals in a reduction/oxidation reaction (redox reaction) are playing which parts.

QUESTION:

If iron reacts with oxygen gas in the reaction $2\ Fe(s) + O2(g) \rightarrow 2\ FeO(s)$, what is oxidized in this reaction?

In a redox reaction, the atom being oxidized often accepts an oxygen atom. Iron is oxidized in this reaction as the Fe is joined to an oxygen.

Reduction and Oxidation

Reduction and **oxidation** involves the transfer of electrons between two species within a chemical reaction. Not all chemical reactions involve reduction and oxidation; however, the reactions that involve reduction and oxidation are called **Redox** reactions. As usual, we need to understand a bit of terminology in order to understand these reactions further.

- Oxidation: loss of electrons
- Reduction: gain of electrons

You may find the word "reduction" a bit of an odd choice for a reaction that involves gaining of electrons. The key is to remember that electrons have a -1 charge, and thus, the more electrons an atom gains, the more negative the charge. To help remember these terms, the mnemonic below can help:

LEO the lion goes ***GER***: Loss of Electrons is Oxidation and ***G***ain of ***E***lectrons is ***R***eduction

In a chemical reaction, oxidation cannot happen without reduction and reduction cannot happen without oxidation.

Question: Oxidation involves the loss of electrons while reduction involves the gain of electrons. Consider a reaction where a Li^+ is converted into Li. Do you think that this Lithium atom gained or lost an electron?

lost electron

Ion to Neutral Atom Conversion

In this specific case, a lithium ion (Li+) has a positive charge due to the loss of one electron. When this ion is transformed into a neutral lithium atom (Li), it must gain an electron to neutralize its positive charge. Thus, the conversion from Li+ to Li represents a reduction process because the lithium ion gains an electron.

Summary

Therefore, in the reaction where Li+ is converted into Li, the lithium atom gained an electron.

Identifying Oxidation and Reduction

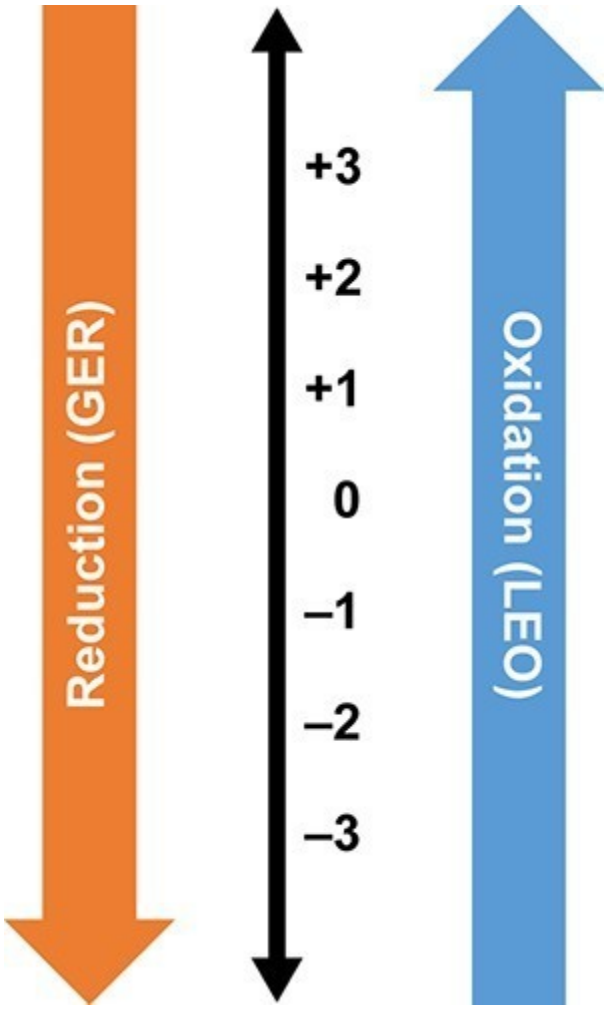
We know that electrons have a -1 charge, and we understand that +1 -1 = 0. So, if Li^+ gains an electron, this is what cancels out the positive (+1) charge and makes this atom neutral.

The rule for oxidation and reduction, based on the gain or loss of electrons is that:

- As the charge of a species increases in the positive direction, the species is oxidized.
- As the charge of a species decreases, becoming more negative, the species is reduced.

A visualization of this relationship appears in the image. Note the direction of the arrows. When the Li^+ became Li, we see that we moved from +1 to 0, or downwards, telling us that this process was reduction.

As we see, if charges are present, determining reduction and oxidation is as easy as looking at how the charges change.



In the following reactions, indicate if the species is oxidized or reduced:

Mg^{2+} becomes Mg Reduced

O becomes O^{2-} Reduced

Fe^{2+} becomes Fe^{3+} Oxidized

F becomes F^{-} Reduced

Cu becomes Cu^{+} Oxidized

H becomes H^{+} Oxidized

Conclusion

In the specified reactions, we can determine whether the species is oxidized or reduced based on the changes in their oxidation states. The oxidation state changes help to identify the electron transfer that occurs during the reactions. Below is a detailed explanation for each reaction.

1. Mg^{2+} Becomes Mg

When magnesium ion (Mg^{2+}) is converted to magnesium metal (Mg), it gains two electrons:

$Mg2^{+}+2e-\rightarrow Mg$

In this process, Mg^{2+} is **reduced**.

2. O Becomes O^{2-}

When oxygen (O) is converted to oxide ion (O^{2-}), it gains two electrons: $O+2e-\rightarrow O2-$

This indicates that oxygen is **reduced**.

3. Fe^{2+} Becomes Fe^{3+}

In this transformation, iron (Fe^{2+}) loses one electron to become iron (Fe^{3+}):

$Fe2+\rightarrow Fe3^{+}+e-$

Here, Fe^{2+} is **oxidized**.

4. F Becomes F^-

Fluorine (F) gains one electron to become fluoride ion (F^-):
$F + e^- \rightarrow F^-$
In this case, fluorine is **reduced**.

5. Cu Becomes Cu^+

When copper (Cu) is oxidized to copper(I) ion (Cu^+), it loses one electron: $Cu \rightarrow Cu^+ + e^-$
Therefore, copper is **oxidized**.

6. H Becomes H^+

In this reaction, hydrogen (H) loses one electron to become hydrogen ion (H^+):
$H \rightarrow H^+ + e^-$
Thus, hydrogen is **oxidized**.

Summary of Oxidation and Reduction

- **Mg^{2+} to Mg**: Reduced
- **O to O^{2-}**: Reduced
- **Fe^{2+} to Fe^{3+}**: Oxidized
- **F to F^-**: Reduced
- **Cu to Cu^+**: Oxidized
- **H to H^+**: Oxidized

Oxidation and Reducing Agents

Reduction cannot happen without oxidation and oxidation cannot ha ppen without reduction. For example, when a species is oxidized, los ing one or more electrons, those electrons must go to another speci es in the reaction, causing the other species to be reduced.

- **Oxidizing agents** are reduced in a chemical reaction (becaus e oxidizing agents accept electrons)
- **Reducing agents** are oxidized in a chemical reaction (becaus e reducing agents donate electrons)

As seen in the image, species A transfers electrons to species B, and thus species A is the reducing agent. You also see that since species A has lost electrons, species A is oxidized. In other words, the specie s being oxidized is the reducing agent while the species being reduc ed is the oxidizing agent (species B in this case).

In chemical reactions, a common oxidizing agent is oxygen gas, O_2. For example, rust forms when O_2 reacts with iron, Fe, causing oxidati on.

$$\mathbf{2\ Fe_{(s)} + O_{2(g)} \longrightarrow FeO_{(S)}}$$

In this reaction, we would consider the O_2 to be the oxidizing agent a nd Fe to be the reducing agent, as electrons were transferred from F e to O.

A common reducing agent is hydrogen gas, H_2. In the reaction belo w, we see how hydrogen gas can reduce the iron, forming Fe from F eO.

$$FeO_{(S)} + H_{2(g)} \longrightarrow Fe + H_2O_{(g)}$$

In this reaction, we would consider H_2 to be the reducing agent and F eO to be the oxidizing agent as electrons were transferred from the H_2 to the Fe in the FeO.

Putting together what you have learned in this lesson, you can identi fy oxidizing and reducing agents.

The key to this is to remember:

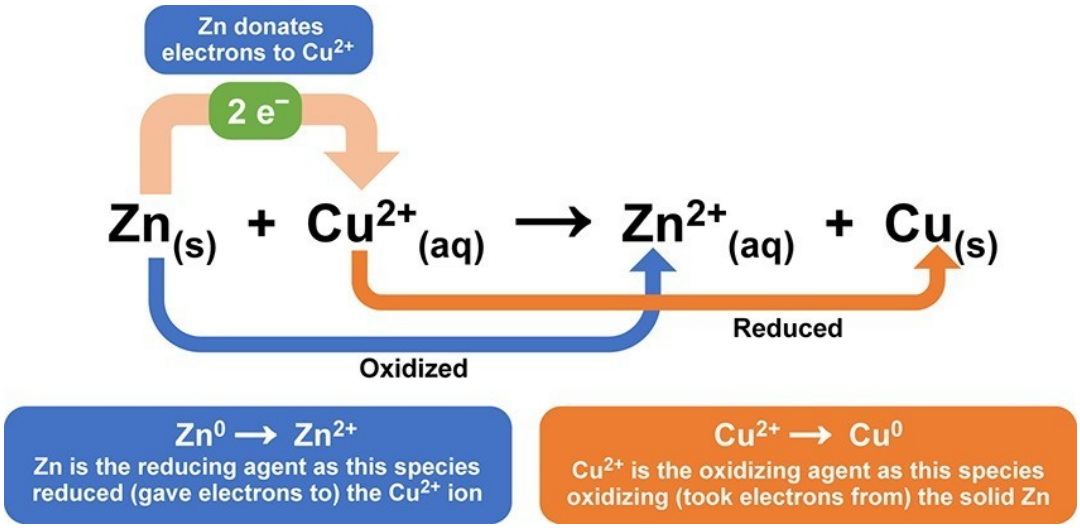
- Oxidizing agents are reduced in a chemical reaction (because o xidizing agents accept electrons)
- Reducing agents are oxidized in a chemical reaction (because r educing agents donate electrons)

In this way, if you can determine whether a species is gaining or losi ng electrons, you can determine if the species is oxidized or reduced

and thus the reducing agent or oxidizing agent. Consider the reactio n between solid zinc and a solution containing copper ions:

$$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

As you can see, the solid Zn donated two electrons to the Cu ion. We know this because you see that Zn went from having no charge (0) t o having a positive charge (+2). This tells us that the Zn has lost the se electrons. Where did these electrons go? To the Cu ion as the Cu went from a charge of +2 to a charge of 0, indicating a gain of electr ons (remember, electrons have a -1 charge, so the more electrons a n atom gets, the more negative it becomes). In the image you see t hat the solid Zn must be the reducing agent as this is the species ca using another species, the Cu^{2+}, to become reduced.



Once we know the reducing agent, we know that the oxidizing agent must be the other reactant, as reduction cannot happen without oxi dation.