Oxidation and Reduction Half-Reactions

Why?

Oxidation and reduction reactions (redox) involve the loss and gain of electrons. Half-reactions are a way for us to keep track of how many electrons are gained or lost by a particular species during a chemical reaction. These half-reactions can be useful in understanding how batteries work, and how other reactions that occur in your body and in nature work as well.

Success Criteria

- Write balanced half-reactions, given a redox reaction.
- State which species is oxidized and which species is reduced.
- Use balanced half-reactions to determine how many electrons have been lost or gained by each species in the reaction.

Prerequisites

- Oxidation numbers
- Balancing equations

New Concepts & Vocabulary

- Oxidization
- Reduction
- Conservation of charge

Definitions

- Oxidation
- Reduction
- Conservation of charge

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Model: Strategy for Balancing Redox Equations

Redox reactions can be balanced using the steps listed below:

Sample redox reaction:

$Cu(NO_3)_2 + Al \rightarrow Al(NO_3)_3 + Cu$ (Unbalanced equation)

Step 1: Assign oxidation numbers to each species in the equation

$Cu^{+2}\ N^{+5}\ O^{-2} + Al^{0} \rightarrow Al^{+3}\ N^{+5}\ O^{-2} + Cu^{0}$

Step 2: Identify the species with an increase in charge

Al^0 (on left side of equation) increases to Al^{+3} (on right side of equation)

Oxidation Half-reaction:

$Al^{0} \rightarrow Al^{+3} + 3e^{-}$

Note that the overall (net) charge on both sides of the half reaction is equal

Step 3: Identify the species with reduction in charge

Cu^{+2} (on left side of equation) reduced to Cu^0 (on right side of equation)

Reduction Half-reaction:

$Cu^{+2} + 2e^{-} \rightarrow Cu^{0}$

Note that the overall (net) charge on both sides of the half reaction is equal

***Step 4*:** Multiply each half-reaction by a factor to make the number of electrons gained in one half-reaction equal to the number of electrons lost in the other. Add the two half-reactions together.

$2\ [Al^{0} \rightarrow Al^{+3} + 3e^{-}]$ $3\ [Cu^{+2} + 2e^{-} \rightarrow Cu^{0}]$ (Total of 6 electrons gained and 6 electrons lost. Electrons disappear from the final equation.)	$2Al^{0} \rightarrow 2Al^{+3} + 6e^{-}$ $3Cu^{+2} + 6e^{-} \rightarrow 3Cu^{0}$ --- $2Al^{0} + 3Cu^{+2} \rightarrow 2Al^{+3} + 3\ Cu^{0}$

Step 5: Balance the overall equation.

$$3\ Cu(NO_3)_2 + 2\ Al \rightarrow 2\ Al(NO_3)_3 + 3\ Cu$$

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Key Questions

1. In the model, are electrons lost or gained during oxidation?

   Are electrons lost or gained during reduction?

2. In the model, what happens to oxidation number during oxidation?

   What happens to the oxidation number during reduction?

3. What is the relationship between the number of electrons gained and the number of electrons lost in the reaction?

4. What part of the equation can you change if the reaction is not balanced as written?

Exercises

1. Assign an oxidation number to each species in the redox reaction below.

   $$2\ H_2O \rightarrow 2\ H_2 + O_2$$

2. For the reaction above, identify the following:

   a. Species oxidized:

   b. Species reduced:

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3. Write the half-reaction for oxygen and the half-reaction for hydrogen in the redox reaction above.

   a. Oxygen half-reaction-

   b. Hydrogen half-reaction-

4. Number of electrons lost/gained by each species:

Problem

1. Redox reactions save lives! Airbags in automobiles are inflated with nitrogen gas produced by two redox reactions. The gas generator in some bags contains sodium azide (NaN_3) and iron (III) oxide (Fe_2O_3). The mixture is automatically ignited during a head-on collision. When this happens, the sodium azide decomposes in a redox reaction to form sodium and nitrogen. The sodium produced by this reaction then reacts with the iron (III) oxide as represented in the unbalanced equation:

   $$Na_{(s)} + Fe_2O_{3(s)} \rightarrow Na_2O_{(s)} + Fe_{(s)}$$

   Write the balanced oxidation and reduction half-reactions for the above redox reaction.

2. Balance the equation for the reaction shown in Problem 1.

Reflection on Learning

Name three insights that your team discovered about oxidation and reduction half-reactions after examining the model.

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