Writing Half Reactions

Video Workbook with Dr. B

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Half-Reactions are at the heart of balancing redox reactions. *It is also the most difficult part for most students.*

Here we will **only** write the half-reactions. We won't balance them right now.

Watch the video on Writing Half-Reactions and then work through the examples and practice problems below.

Writing Half Reactions

Full Redox Playlist

Spend time to be able to write half reactions quickly and correctly!

Simple Half-Reactions: Loss and Gain of Electrons

For these simple half reactions we don't need to consider oxidation numbers (although we could). Instead, the ionic charge has all the necessary information.

Example

Given the following equation, write the half reactions.

$$Al + Cu^{2+} \rightarrow Al^{3+} + Cu$$

Answer: Aluminum starts as neutral Al but ends up as Al^{3+}. Copper starts as Cu^{2+} and ends with neutral Cu.

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

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

We can balance the charge for each half reaction by adding electrons (e^-). But we still need to balance the **overall** charge for the entire reaction (both half reactions). We'll do that in another section.

We won't write the states (*s*, *l*, *aq*, *g*) for now.

rxn = *reaction*

e^- is an electron

Key Idea

Half-reactions don't happen separately. The are two parts of the same chemical reaction.

Watch the video for balancing the entire redox reaction.

Practice #1 (scroll so the answer is hidden!)

For the following equation, write the half rxns showing electrons lost or gained. Label each half rxn as oxidation or reduction.

$$Cu + Ag^{+} \rightarrow Cu^{2+} + Ag$$

Answer:

$Cu^{0} \rightarrow Cu^{2+} + 2e^{-}$ (Oxidation because Cu goes from 0 to 2+)

$e^{-} + Ag^{+} \rightarrow Ag^{0}$ (Reduction because Ag^{+} goes from 1+ to 0)

Note that the electrons are lost by Cu and gained by Ag^{+}.

LEO the Lion goes GER

Loses Electrons Oxidation

Gain Electrons Reduction

Watch the video for balancing the entire redox reaction.

Practice #2

For the following equation, write the half reactions with electrons lost or gained. Label each as oxidation or reduction.

$$Fe^{3+} + Cu \rightarrow Cu^{2+} + Fe^{2+}$$

Answer:

$Fe^{3+} + e^{-} \rightarrow Fe^{2+}$ (Reduction since Fe^{3+} goes from 3+ to 2+)

$Cu^{0} \rightarrow Cu^{2+} + 2e^{-}$ (Oxidation since Cu goes from 0 to 2+)

If the oxidation number in a half rxn decreases the atom has been *reduced*.

If the oxidation number increases the atom has been *oxidized*.

More Practice

Write the half rxns showing the e^{-} lost or gained, then label each half rxn as oxidation or reduction.

1. $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$
2. $Mg + 2H^{+} \rightarrow Mg^{2+} + H_2$
3. $Pb + Ag^{+} \rightarrow Pb^{2+} + Ag$
4. $Al + Ag^{+} \rightarrow Al^{3+} + Ag$
5. $Co^{2+} + 2F^{-} \rightarrow Co + F_2$

Answers Below

1. $Zn \rightarrow Zn^{2+} + 2e^-$ (oxidation)
   $2e^- + Cu^{2+} \rightarrow Cu$ (reduction)

2. $Mg \rightarrow Mg^{2+} + 2e^-$ (oxidation)
   $2e^- + 2H^+ \rightarrow H_2$ (reduction)

3. $Pb \rightarrow Pb^{2+} + 2e^-$ (oxidation)
   $e^- + Ag^+ \rightarrow Ag$ (reduction)

4. $Al \rightarrow Al^{3+} + 3e^-$ (oxidation)
   $1e^- + Ag^+ \rightarrow Ag$ (reduction)

5. $Co^{2+} + 2e^- \rightarrow Co$ (reduction)
   $2F^- \rightarrow F_2 + 2e^-$ (oxidation)

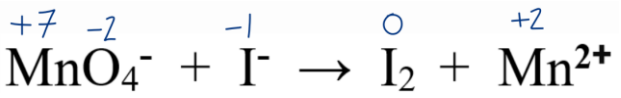
Half-Reactions Involving the H and O

We'll focus now on writing half-reactions (but not balancing). Here we'll need to use Oxidation Numbers.

Don't worry about electrons are lost or gained right now (we do that when we balance the half reactions).

Example #1

Given the following equation, write the half reactions.
Oxidation numbers are in blue above atoms.



Answer:
Manganese starts as +7 but ends up as Mn^{2+} (oxidation number = +2). The number is smaller, so it is reduced.

The Iodide ion starts as I^- but ends with I_2. It is oxidized.

$$MnO_4^- \rightarrow Mn^{2+}$$

$$I^- \rightarrow I_2$$

Note we've not balanced the atoms or electrons at this point!

Key Ideas

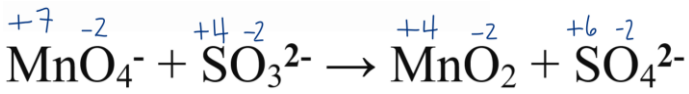
These half reactions are not balanced. We'll learn that later.

The oxidation number for Oxygen (O) did not change. We are only interested in the atoms that change.

Watch the video for balancing this entire redox reaction.

Practice #1

Given the following equation, write the half reactions.



Answer:
Manganese (Mn) starts as +7 but ends up as +4.
The number gets smaller, so it is *reduced*.

Key Ideas

Half-reactions don't happen separately. There are two parts of the same chem rxn.

Watch the video for balancing this entire redox reaction.

Sulfur (S) starts as +4 and goes to +6.
The number gets larger, so it is *oxidized*.

$$MnO_4^- \rightarrow MnO_2$$

$$SO_3^{2-} \rightarrow SO_4^{2-}$$

In general:

- losing O atoms is oxidation.
- gaining O atoms is reduction.

Practice #2

Given the following equation, write the half reactions. Indicate which is oxidized and which is reduced.

$$\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{+2}{Fe^{2+}} \rightarrow \overset{+3}{Cr^{3+}} + \overset{+3}{Fe^{3+}}$$

Answer

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduced (oxidation number decreases, loses oxygen)

$Fe^{2+} \rightarrow Fe^{3+}$ Oxidized (oxidation number increases)

Key Ideas

Watch the video for balancing the entire redox reaction.

More Practice (answers below):

Write the half-reactions and label each as oxidation or reduction.

1. $\overset{+4\ -2}{MnO_2} + \overset{0}{Al} \rightarrow \overset{0}{Mn} + \overset{+3\ -2}{Al_2O_3}$
2. $\overset{+1\ -1}{H_2O_2} + \overset{+2}{Fe^{2+}} \rightarrow \overset{+3}{Fe^{3+}} + \overset{+1\ -2}{H_2O}$
3. $\overset{+7\ -2}{MnO_4^-} + \overset{+1\ +4\ -2}{H_2SO_3} \rightarrow \overset{+2}{Mn^{2+}} + \overset{+1\ +6\ -2}{HSO_4^-}$
4. $\overset{+7\ -2}{MnO_4^-} + \overset{+4\ -2}{SO_2} \rightarrow \overset{+2}{Mn^{2+}} + \overset{+1\ +6\ -2}{HSO_4^-}$
5. $\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{+4\ -2}{SO_2} \rightarrow \overset{+3}{Cr^{3+}} + \overset{+6\ -2}{SO_4^{2-}}$
6. $\overset{+5\ -2}{BrO_3^-} + \overset{-2\ +1}{N_2H_4} \rightarrow \overset{-1}{Br^-} + \overset{0}{N_2}$
7. $\overset{+3\ -2}{Fe_2O_3} + \overset{+2\ -2}{CO} \rightarrow \overset{0}{Fe} + \overset{+4\ -2}{CO_2}$
8. $\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{+3\ -2}{C_2O_4^{2-}} \rightarrow \overset{+3}{Cr^{3+}} + \overset{+4\ -2}{CO_2}$
9. $\overset{-2\ +1\ -2\ +1}{CH_3OH} + \overset{+6\ -2}{Cr_2O_7^{-2}} \rightarrow \overset{0\ +1\ -2}{CH_2O} + \overset{+3}{Cr^{3+}}$
10. $\overset{-2\ +1\ -2\ +1}{C_2H_5OH} + \overset{+6\ -2}{Cr_2O_7^{2-}} \rightarrow \overset{+3}{Cr^{3+}} + \overset{+4\ -2}{CO_2}$
11. $\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{+4\ -2}{SO_2} \rightarrow \overset{+3}{Cr^{3+}} + \overset{+6\ -2}{SO_4^{2-}}$
12. $\overset{+7\ -2}{MnO_4^-} + \overset{-2\ +1\ -2\ +1}{C_2H_5OH} \rightarrow \overset{+2}{Mn^{2+}} + \overset{0\ +1\ -2}{C_2H_4O_2}$

Answers

1. $MnO_2 \rightarrow Mn$ Reduction $Al \rightarrow Al_2O_3$ Oxidation Video Solution	7. $Fe_2O_3 \rightarrow Fe$ Reduction $CO \rightarrow CO_2$ Oxidation Video Solution
2. $H_2O_2 \rightarrow H_2O$ Reduction $Fe^{2+} \rightarrow Fe^{3+}$ Oxidation Video Solution	8. $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduction $C_2O_4^{2-} \rightarrow CO_2$ Oxidation Video Solution
3. $MnO_4^- \rightarrow Mn^{2+}$ Reduction $H_2SO_3 \rightarrow HSO_4^-$ Oxidation Video Solution	9. $CH_3OH \rightarrow CH_2O$ Oxidation $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduction Video Solution
4. $MnO_4^- \rightarrow Mn^{2+}$ Reduction $SO_2 \rightarrow HSO4^-$ Oxidation Video Solution	10. $C_2H_5OH \rightarrow CO_2$ Oxidation $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduction Video Solution
5. $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduction $SO_2 \rightarrow SO_4^{2-}$ Oxidation Video Solution	11. $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ Reduction $SO_2 \rightarrow SO_4^{2-}$ Oxidation Video Solution
6. $BrO_3^- \rightarrow Br^-$ Reduction $N_2H_4 \rightarrow N_2$ Oxidation Video Solution	12. $MnO_4^- \rightarrow Mn^{2+}$ Reduction $C_2H_5OH \rightarrow CH_3COOH$ Oxidation Video Solution

To important things to note:

- There are two more types of redox reactions that can be challenging (but not too bad). We'll cover those at the end of the guide.
- You are past the tough part of balancing redox rxns. There rest is memorizing and following the steps. And the best way to do that is practice, practice, practice.

Report errors and suggestions to DrB@breslyn.org

Redox Guides