ChemTalk

Balancing Redox Reactions in Acidic and Basic Solutions

This worksheet will cover balancing reduction-oxidation (redox) reactions in acidic and basic solutions, as we must account for the excess of H^+ ions (acidic) or OH^- ions (basic). It will discuss the steps of doing so and how the process differs in both situations. As you progress through the worksheet, you will develop the skills necessary to balance different redox reactions in acidic and basic solutions.

<u>Redox Reactions in Acidic Solutions Practice</u>
Balance the following reactions.

1. $Cr + NO_3^- \rightarrow Cr^{+3} + NO$

2. $H_2O_2 + MnO_4^- \rightarrow O_2 + Mn^{+2}$

3. $Cr_2O_2^{-7} + HNO_2 \rightarrow Cr^{+3} + NO_3^-$

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Redox Reactions in Basic Solutions Practice

Balance the following reactions.

1. $PO_4^{-3} + MnO_2 \rightarrow PO_3^{-3} + MnO_4^-$

2. $SnO_2^{-2} + Bi^{+3} \rightarrow Bi + SnO_3^{-2}$

3. $Ag + Zn^{2+} \rightarrow Ag_2O + Zn$

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ANSWER KEY

Balancing Redox Reactions in Acidic and Basic Solutions

Redox Reactions in Acidic Solutions Practice

Balance the following reactions.

1. $Cr + NO_3^- \rightarrow Cr^{+3} + NO$

We can follow this model:

Balancing Redox Reactions in Acidic Solutions

1. Split the redox reactions into ½ reactions.
2. Balance all elements except H and O.
3. Balance O's with H_2O.
4. Balance H's with H^+.
5. Balance charge with e^-'s.
6. Do 2-5 for both ½ reactions.
7. Make sure the net number of e^-'s is the same for both reactions. Adjust if needed by multiplying both sides of a ½ reaction by a least common multiple.
8. Sum ½ reactions back into one reaction.

Step 1:

$Cr \rightarrow Cr^{+3}$	$NO_3^- \rightarrow NO$

Step 2: The elements other than H and O are already balanced.

Step 3:

$Cr \rightarrow Cr^{+3}$	$NO_3^- \rightarrow NO + 2\ H_2O$

Step 4:

$Cr \rightarrow Cr^{+3}$	$4\ H^+ + NO_3^- \rightarrow NO + 2\ H_2O$

Step 5:

$Cr \rightarrow Cr^{+3} + 3\ e^-$	$3\ e^- + 4\ H^+ + NO_3^- \rightarrow NO + 2\ H_2O$

Step 7: The number of electrons on each ½ reaction are the same.

Step 8:

$4\ H^+ + NO_3^- + Cr \rightarrow Cr^{+3} + NO + 2\ H_2O$

2. $H_2O_2 + MnO_4^- \rightarrow O_2 + Mn^{+2}$

Step 1:

$H_2O_2 \rightarrow O_2$	$MnO_4^- \rightarrow Mn^{+2}$

Step 2: The elements other than H and O are already balanced.

Step 3:

$H_2O_2 \rightarrow O_2$	$MnO_4^- \rightarrow Mn^{+2} + 4\ H_2O$

Step 4:

$H_2O_2 \rightarrow O_2 + 2\ H^+$	$8\ H^+ + MnO_4^- \rightarrow Mn^{+2} + 4\ H_2O$

Step 5:

$H_2O_2 \rightarrow O_2 + 2\ H^+ + 2\ e^-$	$5\ e^- + 8\ H^+ + MnO_4^- \rightarrow Mn^{+2} + 4\ H_2O$

Step 7:

$(H_2O_2 \rightarrow O_2 + 2\ H^+ + 2\ e^-) \times 5$ $5\ H_2O_2 \rightarrow 5\ O_2 + 10\ H^+ + 10\ e^-$	$(5\ e^- + 8\ H^+ + MnO_4^- \rightarrow Mn^{+2} + 4\ H_2O) \times 2$ $10\ e^- + 16\ H^+ + 2\ MnO_4^- \rightarrow 2\ Mn^{+2} + 8\ H_2O$

Step 8: Cancel out the H^+'s and e^-'s on each side.

$5\ H_2O_2 + 6\ H^+ + 2\ MnO_4^- \rightarrow 5\ O_2 + 2\ Mn^{+2} + 8\ H_2O$

3. $Cr_2O_7^{-2} + HNO_2 \rightarrow Cr^{+3} + NO_3^-$

Step 1:

$Cr_2O_7^{-2} \rightarrow Cr^{+3}$	$HNO_2 \rightarrow NO_3^-$

Step 2:

$Cr_2O_7^{-2} \rightarrow 2\ Cr^{+3}$	$HNO_2 \rightarrow NO_3^-$

Step 3:

$Cr_2O_7^{-2} \rightarrow 2\ Cr^{+3} + 7\ H_2O$	$HNO_2 + H_2O \rightarrow NO_3^-$

Step 4:

$14\ H^+ + Cr_2O_7^{-2} \rightarrow 2\ Cr^{+3} + 7\ H_2O$	$HNO_2 + H_2O \rightarrow 3\ H^+ + NO_3^-$

Step 5:

$6\ e^- + 14\ H^+ + Cr_2O_7^{-2} \rightarrow 2\ Cr^{+3} + 7\ H_2O$	$HNO_2 + H_2O \rightarrow 3\ H^+ + NO_3^- + 2\ e^-$

Step 7:

$6\ e^- + 14\ H^+ + Cr_2O_7^{-2} \rightarrow 2\ Cr^{+3} + 7\ H_2O$	$(HNO_2 + H_2O \rightarrow 3\ H^+ + NO_3^- + 2\ e^-) \times 3$ $3\ HNO_2 + 3\ H_2O \rightarrow 9\ H^+ + 3\ NO_3^- + 6\ e^-$

Step 8: Cancel out the H^+'s and e^-'s on each side.

$3\ HNO_2 + 5\ H^+ + Cr_2O_7^{-2} \rightarrow 3\ NO_3^- + 2\ Cr^{3+} + 4\ H_2O$

<u>Redox Reactions in Basic Solutions Practice</u>

Balance the following reactions. Make sure to follow the steps above and keep track of the number of atoms and electrons.

1. $PO_4^{-3} + MnO_2 \rightarrow PO_3^{-3} + MnO_4^-$

We can follow this model:

Balancing Redox Reactions in Basic Solutions

1. Follow steps 1-8 of "Balancing Redox Reactions in Acidic Solutions".
2. Add OH^- to neutralize all H^+'s on both sides of the reaction.
3. On one side, combine H^+'s and OH^-'s to make H_2O.
4. Eliminate as many H_2Os as possible.

Step 1:

$MnO_2 \rightarrow MnO_4^-$	$PO_4^{-3} \rightarrow PO_3^{-3}$

Step 2: The elements other than H and O are already balanced.

Step 3:

$2\ H_2O + MnO_2 \rightarrow MnO_4^-$	$PO_4^{-3} \rightarrow PO_3^{-3} + H_2O$

Step 4:

$2\ H_2O + MnO_2 \rightarrow MnO_4^- + 4\ H^+$	$2\ H^+ + PO_4^{-3} \rightarrow PO_3^{-3} + H_2O$

Step 5:

$2\ H_2O + MnO_2 \rightarrow MnO_4^- + 4\ H^+ + 3\ e^-$	$2\ e^- + 2\ H^+ + PO_4^{-3} \rightarrow PO_3^{-3} + H_2O$

Step 7:

$(2\ H_2O + MnO_2 \rightarrow MnO_4^- + 4\ H^+ + 3\ e^-)$ x2 $4\ H_2O + 2\ MnO_2 \rightarrow 2\ MnO_4^- + 8\ H^+ + 6\ e^-$	$(2\ e^- + 2\ H^+ + PO_4^{-3} \rightarrow PO_3^{-3} + H_2O)$ x3 $6\ e^- + 6\ H^+ + 3\ PO_4^{-3} \rightarrow 3\ PO_3^{-3} + 3\ H_2O$

Step 8:

$3\ PO_4^{-3} + H_2O + 2\ MnO_2 \rightarrow 2\ H^+ + 3\ PO_3^{-3} + 2\ MnO_4^-$

Step 2 (basic reaction steps):

$2\ OH^- + 3\ PO_4^{-3} + H_2O + 2\ MnO_2 \rightarrow 2\ H^+ + 2\ OH^- + 3\ PO_3^{-3} + 2\ MnO_4^-$

Step 3:

$2\ OH^- + 3\ PO_4^{-3} + H_2O + 2\ MnO_2 \rightarrow 2\ H_2O + 3\ PO_3^{-3} + 2\ MnO_4^-$

Step 4:

$2\ OH^- + 3\ PO_4^{-3} + 2\ MnO_2 \rightarrow H_2O + 3\ PO_3^{-3} + 2\ MnO_4^-$

2. $SnO_2^{-2} + Bi^{+3} \rightarrow Bi + SnO_3^{-2}$

Step 1:

$SnO_2^{-2} \rightarrow SnO_3^{-2}$	$Bi^{+3} \rightarrow Bi$

Step 2: All elements other than H and O are already balanced.

Step 3:

$SnO_2^{-2} + H_2O \rightarrow SnO_3^{-2}$	$Bi^{+3} \rightarrow Bi$

Step 4:

$SnO_2^{-2} + H_2O \rightarrow SnO_3^{-2} + 2\ H^+$	$Bi^{+3} \rightarrow Bi$

Step 5:

$SnO_2^{-2} + H_2O \rightarrow SnO_3^{-2} + 2\ H^+ + 2\ e^-$	$Bi^{+3} + 3\ e^- \rightarrow Bi$

Step 7:

$(SnO_2^{-2} + H_2O \rightarrow SnO_3^{-2} + 2\ H^+ + 2\ e^-)$ x3 $3\ SnO_2^{-2} + 3\ H_2O \rightarrow 3\ SnO_3^{-2} + 6\ H^+ + 6\ e^-$	$(Bi^{+3} + 3\ e^- \rightarrow Bi)$ x2 $2\ Bi^{+3} + 6\ e^- \rightarrow 2\ Bi$

Step 8:

$2\ Bi^{+3} + 3\ H_2O + 3\ SnO_3^{-2} \longrightarrow 3\ SnO_3^{-2} + 6\ H^+ + 2\ Bi$

Step 2 (basic reaction steps):

$6\ OH^- + 2\ Bi^{+3} + 3\ H_2O + 3\ SnO_3^{-2} \longrightarrow 3\ SnO_3^{-2} + 6\ H^+ + 6\ OH^- + 2\ Bi$

Step 3:

$6\ OH^- + 2\ Bi^{+3} + 3\ H_2O + 3\ SnO_3^{-2} \longrightarrow 3\ SnO_3^{-2} + 6\ H_2O + 2\ Bi$

Step 4:

$6\ OH^- + 2\ Bi^{+3} + 3\ SnO_3^{-2} \longrightarrow 3\ SnO_3^{-2} + 3\ H_2O + 2\ Bi$

3. $Ag + Zn^{2+} \rightarrow Ag_2O + Zn$

Step 1:

$Ag \rightarrow Ag_2O$	$Zn^{+2} \rightarrow Zn$

Step 2:

$2\ Ag \rightarrow Ag_2O$	$Zn^{+2} \rightarrow Zn$

Step 3:

$2\ Ag + H_2O \rightarrow Ag_2O$	$Zn^{+2} \rightarrow Zn$

Step 4:

$2\ Ag + H_2O \rightarrow Ag_2O + 2\ H^+$	$Zn^{+2} \rightarrow Zn$

Step 5:

$2\ Ag + H_2O \rightarrow Ag_2O + 2\ H^+ + 2\ e^-$	$Zn^{+2} + 2\ e^- \rightarrow Zn$

Step 7: The number of electrons are the same in each reaction.

Step 8:

$H_2O + 2\ Ag + Zn^{+2} \rightarrow Zn + Ag_2O + 2\ H^+$

Step 2 (basic reaction steps)::

$H_2O + 2\ Ag + Zn^{+2} + 2\ OH^- \rightarrow Zn + Ag_2O + 2\ H^+ + 2\ OH^-$

Step 3:

$H_2O + 2\ Ag + Zn^{+2} + 2\ OH^- \rightarrow Zn + Ag_2O + 2\ H_2O$

Step 4:

$2\ Ag + Zn^{+2} + 2\ OH^- \rightarrow Zn + Ag_2O + H_2O$