Chapter 18:
TWO CLASSES OF CHEMICAL REACTIONS
This lecture will help you understand:

- Acids Donate Protons, Bases Accept Them
- Relative Strengths of Acids and Bases
- Acidic, Basic, and Neutral Solutions
- Acidic Rain and Basic Oceans
- Losing and Gaining Electrons
- Harnessing the Energy of Flowing Electrons
- Electrolysis
- Corrosion and Combustion
Acids Donate Protons, Bases Accept Them
Acids Donate Protons, Bases Accept Them
Acids Donate Protons, Bases Accept Them

**Acid**
- A chemical that donates a hydrogen ion, $\text{H}^+$

**Base**
- A chemical that accepts a hydrogen ion, $\text{H}^+$
The hydrogen atom
The hydrogen atom
The hydrogen atom
The hydrogen atom

H
The hydrogen atom

H
The hydrogen atom
The hydrogen atom
The hydrogen ion

$H^+$
The hydrogen ion

$\text{H}^+$
The hydrogen ion

$H^+$
The hydrogen ion

$\text{H}^+$
The hydrogen ion

$H^+$
The hydrogen ion

$H^+$
The hydrogen ion

$\text{H}^+$
The hydrogen ion

\[ H^+ \]

proton
Base Accepts Acids Donates
HCl  +  H₂O
HCl + H₂O
\[ \text{Cl}^- + \text{H}_3\text{O}^+ \]
HCl + H₂O → Cl⁻ + H₃O⁺
HCl + H₂O → Cl⁻ + H₃O⁺

Donor → Acceptor
HCl + H₂O → Cl⁻ + H₃O⁺

(acid) (base)
H₂O + NH₃
H₂O + NH₃
OH\(^{-}\) + NH\(_{4}\)\(^{+}\)
\[ \text{H}_2\text{O} + \text{NH}_3 \]
OH\(^-\) + NH\(_4^+\)
\[ \text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{OH}^- + \text{NH}_4^+ \]
\[ \text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{OH}^- + \text{NH}_4^+ \]
H₂O + NH₃ → OH⁻ + NH₄⁺
\[
\text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{OH}^- + \text{NH}_4^+
\]

(acid) \hspace{1cm} (base)
\[ \text{H}_2\text{O} + \text{NH}_3 \quad \rightleftharpoons \quad \text{OH}^- + \text{NH}_4^+ \]
$\text{H}_2\text{O} + \text{NH}_3 \leftrightarrow \text{OH}^- + \text{NH}_4^+$
\[ \text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{OH}^- + \text{NH}_4^+ \]

(base) (acid)
\[ \text{H}_2\text{O} + \text{NH}_3 \rightleftharpoons \text{OH}^- + \text{NH}_4^+ \]
When water behaves as an acid, what does it lose?

A. A hydrogen ion.
B. A hydrogen atom.
C. An electron.
D. Water can’t behave as an acid.
When water behaves as an acid, what does it lose?

A. A hydrogen ion.
B. A hydrogen atom.
C. An electron.
D. Water can’t behave as an acid.
When water behaves as a base, what does it gain?

A. A hydrogen ion.
B. A hydrogen atom.
C. An electron.
D. Water can’t behave as an acid.
When water behaves as a base, what does it gain?

A. A hydrogen ion.
B. A hydrogen atom.
C. An electron.
D. Water can’t behave as an acid.
Which water molecule is behaving as an acid, and which is behaving as a base?

A. Molecule B as a base; Molecule A as an acid.
B. Molecule B as an acid; Molecule A as a base.
C. Both Molecules A and B are behaving as acids.
D. Both Molecules A and B are behaving as bases.
Which water molecule is behaving as an acid, and which is behaving as a base?

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Molecule A

Acids Donate Protons, Bases Accept Them

CHECK YOUR ANSWER
Which water molecule is behaving as an acid, and which is behaving as a base?

A. Molecule B as a base; Molecule A as an acid.
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C. Both Molecules A and B are behaving as acids.
D. Both Molecules A and B are behaving as bases.
Acids Donate Protons, Bases Accept Them

Salt: An ionic compound formed from the reaction of an acid and a base.
Acids Donate Protons, Bases Accept Them

Salt: An ionic compound formed from the reaction of an acid and a base.

**Table 18.1 Acid-Base Reactions and the Salts Formed**

<table>
<thead>
<tr>
<th>Acid</th>
<th>Base</th>
<th>Salt</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCN Hydrogen cyanide</td>
<td>NaOH Sodium hydroxide</td>
<td>i</td>
<td>NaCH Sodium cyanide + H₂O</td>
</tr>
<tr>
<td>HNO₃ Nitric acid</td>
<td>KOH Potassium hydroxide</td>
<td>i</td>
<td>KNO₃ Potassium nitrate + H₂O</td>
</tr>
<tr>
<td>2 HCl Hydrogen chloride</td>
<td>Ca(OH)₂ Calcium hydroxide</td>
<td>i</td>
<td>CaCl₂ Calcium chloride + 2H₂O</td>
</tr>
<tr>
<td>HF Hydrogen fluoride</td>
<td>NaOH Sodium hydroxide</td>
<td>i</td>
<td>NaF Sodium fluoride + H₂O</td>
</tr>
</tbody>
</table>
Acids Donate Protons, Bases Accept Them

Salt: An ionic compound formed from the reaction of an acid and a base.
What salt forms from the reaction of hydrogen chloride, HCl, with potassium hydroxide, KOH?

A. KCl
B. H₃OCl
C. KOH₂
D. KOH₂Cl
What salt forms from the reaction of hydrogen chloride, HCl, with potassium hydroxide, KOH?

A. KCl  
B. H₃OCl  
C. KOH₂  
D. KOH₂Cl

*Explanation:*

The K⁺ from the KOH combines with the Cl⁻ from the HCl.
Relative Strengths of Acids and Bases

• Strong acids and bases ionize completely in water.
Relative Strengths of Acids and Bases

- Strong acids and bases ionize completely in water.
Relative Strengths of Acids and Bases

• Weak acids and bases do not ionize completely in water.
Relative Strengths of Acids and Bases

• Weak acids and bases do not ionize completely in water.
Relative Strengths of Acids and Bases
Acidic, Basic, and Neutral Solutions

Water can behave as an acid or a base.

$$\text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{OH}^+ + \text{H}_3\text{O}^+$$

Water + Water ↔ Hydroxide ion + Hydronium ion
Acidic, Basic, and Neutral Solutions

Water can behave as an acid or a base.

In pure water, for every one hydronium ion, $\text{H}_3\text{O}^+$, formed, there is a hydroxide ion, $\text{OH}^-$, formed.
Acidic, Basic, and Neutral Solutions

Water can behave as an acid or a base.

In pure water, for every one hydronium ion, $\text{H}_3\text{O}^+$, formed, there is a hydroxide ion, $\text{OH}^-$, formed.

So in pure water, $[\text{H}_3\text{O}^+] = [\text{OH}^-] = 0.0000001 \text{ M} = 10^{-7} \text{ M}$.
Acidic, Basic, and Neutral Solutions

Water can behave as an acid or a base.

In pure water, for every one hydronium ion, \( H_3O^+ \), formed, there is a hydroxide ion, \( OH^- \), formed.

So, in pure water, \([H_3O^+] = [OH^-] = 0.0000001 \text{ M} = 10^{-7} \text{ M.}\)
Acidic, Basic, and Neutral Solutions

Water can behave as an acid or a base.

Add hydronium ions, $\text{H}_3\text{O}^+$, and the solution is “acidic,”
Add hydroxide ions, $\text{OH}^-$, and the solution is “basic.”
Acidic, Basic, and Neutral Solutions

In a neutral solution
\[ [\text{H}_3\text{O}^+] = [\text{OH}^-] \]
\[ \text{pH} \]
\[ \text{basic} \]
\[ \text{neutral} \]
\[ \text{acidic} \]
\[ 0 \]
\[ 7 \]
\[ 14 \]
\[ \text{H}_3\text{O}^+ \]
\[ \text{OH}^- \]

In an acidic solution
\[ [\text{H}_3\text{O}^+] > [\text{OH}^-] \]
\[ \text{pH} \]
\[ \text{basic} \]
\[ \text{neutral} \]
\[ \text{acidic} \]
\[ 0 \]
\[ 7 \]
\[ 14 \]
\[ \text{H}_3\text{O}^+ \]
\[ \text{OH}^- \]

In a basic solution
\[ [\text{H}_3\text{O}^+] < [\text{OH}^-] \]
\[ \text{pH} \]
\[ \text{basic} \]
\[ \text{neutral} \]
\[ \text{acidic} \]
\[ 0 \]
\[ 7 \]
\[ 14 \]
\[ \text{H}_3\text{O}^+ \]
\[ \text{OH}^- \]
As sodium hydroxide, NaOH, is added to water, the hydroxide ion, OH\(^-\), concentration

A. increases.
B. decreases.
C. remains the same.
As sodium hydroxide, NaOH, is added to water, the hydroxide ion, OH\(^-\), concentration

A. increases.
B. decreases.
C. remains the same.

*Explanation:*

The bond between sodium and oxygen is ionic. When dissolved in water, it separates into sodium ions and hydroxide ions, much like sodium chloride, NaCl, separates into sodium and chloride ions.
Acidic, Basic, and Neutral Solutions

pH is a measure of the concentration of hydronium ions, $\text{H}_3\text{O}^+$. 
Acidic, Basic, and Neutral Solutions

pH is a measure of the concentration of hydronium ions, H$_3$O$^+$.

$\text{pH} = -\log [\text{H}_3\text{O}^+]$
Acidic, Basic, and Neutral Solutions

pH is a measure of the concentration of hydronium ions, $\text{H}_3\text{O}^+$. 

$$\text{pH} = -\log \ [\text{H}_3\text{O}^+]$$

For pure water:

$$\text{pH} = -\log \ (10^{-7})$$
$$\text{pH} = -(– 7)$$
$$\text{pH} = 7$$
Acidic, Basic, and Neutral Solutions

pH is a measure of the concentration of hydronium ions, $H_3O^+$.

$$pH = -\log [H_3O^+]$$

For pure water:

$$\log (10^{-7})$$

$$-(-7)$$

$$pH = 7$$
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of 10³, for example, is 3.

Quiz Time

What is the log of 10²?
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

**Quiz Time**

What is the log of $10^2$?

Log $10^2 = 2$

(the power to which 10 is raised)
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$10^3 = 1000$
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$$10^3 = 1000$$

$$10^2 = 100$$
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
10^3 = 1000 \\
10^2 = 100 \\
10^1 = 10
\]
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
10^3 = 1000 \\
10^2 = 100 \\
10^1 = 10 \\
10^{-1} = 0.1
\]
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
10^3 = 1000
\]
\[
10^2 = 100
\]
\[
10^1 = 10
\]
\[
10^{-1} = 0.1
\]
\[
10^{-2} = 0.01
\]
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
10^3 = 1000 \\
10^2 = 100 \\
10^1 = 10 \\
10^{-1} = 0.1 \\
10^{-2} = 0.01 \\
10^{-3} = 0.001
\]
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$$10^3 = 1000$$
$$10^2 = 100$$
$$10^1 = 10$$
$$10^0 = ?$$
$$10^{-1} = 0.1$$
$$10^{-2} = 0.01$$
$$10^{-3} = 0.001$$
The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= ? \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

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\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= ? \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]
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\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= 1 \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]
Acidic, Basic, and Neutral Solutions

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$10^3 = 1000$
$10^2 = 100$
$10^1 = 10$
$10^0 = 1$
$10^{-1} = 0.1$
$10^{-2} = 0.01$
$10^{-3} = 0.001$

Quiz Time
Log 1000 = ?
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= 1 \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]

Quiz Time

Log 1000 = ?

Log $10^3$ =
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$10^3 = 1000$

$10^2 = 100$

$10^1 = 10$

$10^0 = 1$

$10^{-1} = 0.1$

$10^{-2} = 0.01$

$10^{-3} = 0.001$

Quiz Time

Log 1000 = ?

Log $10^3 = 3$
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$10^3 = 1000$
$10^2 = 100$
$10^1 = 10$
$10^0 = 1$
$10^{-1} = 0.1$
$10^{-2} = 0.01$
$10^{-3} = 0.001$

Quiz Time
Log 1 = ?
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

$$10^3 = 1000$$
$$10^2 = 100$$
$$10^1 = 10$$
$$10^0 = 1$$
$$10^{-1} = 0.1$$
$$10^{-2} = 0.01$$
$$10^{-3} = 0.001$$

Quiz Time

Log 1 = ?

Log $10^0 =$
The "log" of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= 1 \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]

**Quiz Time**

- Log 1 = ?
- Log $10^0 = 0$
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= 1 \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001
\end{align*}
\]

Quiz Time

Log $10^{-7}$ =
Acidic, Basic, and Neutral Solutions

The “log” of a number is simply the power to which ten is raised. The log of $10^3$, for example, is 3.

\[
\begin{align*}
10^3 &= 1000 \\
10^2 &= 100 \\
10^1 &= 10 \\
10^0 &= 1 \\
10^{-1} &= 0.1 \\
10^{-2} &= 0.01 \\
10^{-3} &= 0.001 \\
\end{align*}
\]

Quiz Time

Log $10^{-7} = -7$
Acidic, Basic, and Neutral Solutions

\[ \text{pH} = -\log [\text{H}_3\text{O}^+] \]

For acidic water pH < 7, for example:

\[ \text{pH} = -\log (10^{-5}) \]
\[ \text{pH} = -(−5) \]
\[ \text{pH} = 5 \]
Acidic, Basic, and Neutral Solutions

\[ \text{pH} = -\log [\text{H}_3\text{O}^+] \]

For basic water pH > 7, for example:

\[ \text{pH} = -\log (10^{-9}) \]
\[ \text{pH} = -(-9) \]
\[ \text{pH} = 9 \]
Acidic, Basic, and Neutral Solutions

<table>
<thead>
<tr>
<th>[H$_2$O$^+$]</th>
<th>pH</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-1}$</td>
<td>-1</td>
<td>Concentrated HCl</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>2</td>
<td>Battery acid</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>3</td>
<td>Lemon juice</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>4</td>
<td>Vinegar</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>5</td>
<td>Soft drink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beer</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>6</td>
<td>Tomato</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coffee</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>7</td>
<td>Urine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainwater</td>
</tr>
<tr>
<td>$10^{-8}$</td>
<td>8</td>
<td>Milk</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>9</td>
<td>Saliva</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pure water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seawater</td>
</tr>
<tr>
<td>$10^{-10}$</td>
<td>10</td>
<td>Baking soda</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soap</td>
</tr>
<tr>
<td>$10^{-11}$</td>
<td>11</td>
<td>Ammonia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hair remover</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oven cleaner</td>
</tr>
</tbody>
</table>
Acidic Rain and Basic Oceans

• Acid rain has a pH lower than 5.

\[2 \text{SO}_2 (g) + \text{O}_2 (g) \rightarrow \text{SO}_3 (g)\]

\[\text{SO}_3 (g) + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{SO}_4 (aq)\]
Acidic Rain and Basic Oceans

• Acid rain has a pH lower than 5.

\[ 2 \text{SO}_2 (g) + \text{O}_2 (g) \rightarrow \text{SO}_3 (g) \]

\[ \text{SO}_3 (g) + \text{H}_2\text{O} (l) \rightarrow \text{H}_2\text{SO}_4 (aq) \]

• \( \text{SO}_2 \) released from burning coal and oil.
Acidic Rain and Basic Oceans

- \( \text{CO}_2 \text{ levels in atmosphere rising} \)

\[
\text{CO}_2 (g) + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{CO}_3 (aq)
\]
Acidic Rain and Basic Oceans
Acidic Rain and Basic Oceans

1. Rain is acidified as it falls through the air.
2. Acid enters lake from rain.
3. Hydronium ions are neutralized by calcium carbonate released from limestone.

\[ 2 \text{H}_3\text{O}^+ + \text{CaCO}_3 \rightarrow 3 \text{H}_2\text{O} + \text{CO}_2 + \text{Ca}^{2+} \]

(a) Limestone

1. Rain is acidified as it falls through the air.
2. Acid enters lake from rain.
3. Hydronium ion concentration increases, with potential harm to the ecosystem.

(b) Granite rock

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Acidic Rain and Basic Oceans

Carbon dioxide is absorbed and released.

Freshwater lake pH < 7

\[ \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \]

Ocean pH ~ 8.2

Carbon dioxide is absorbed.

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]

\[ \text{H}_2\text{CO}_3 + \text{CaCO}_3 \rightarrow \text{Ca(HCO}_3)_2 \]

Deposits on ocean floor
Losing and Gaining Electrons

Acid–Base reactions: transfer of proton
Losing and Gaining Electrons

Acid–Base reactions: transfer of proton

Oxidation-Reduction reactions: transfer of ???
Losing and Gaining Electrons

Acid–Base reactions: transfer of proton

Oxidation-Reduction reactions: transfer of electron
Losing and Gaining Electrons

Oxidation: The loss of an electron
Losing and Gaining Electrons

Oxidation: The loss of an electron

\[ 2 \text{Na} \quad \rightarrow \quad 2 \text{Na}^+ \quad + \quad 2 \text{e}^- \]
Losing and Gaining Electrons

Oxidation: The loss of an electron

\[ 2 \text{Na} \rightarrow 2 \text{Na}^+ + 2 \text{e}^- \]

Reduction: The gain of an electron
Losing and Gaining Electrons

Oxidation: The loss of an electron

$$2 \text{Na} \rightarrow 2 \text{Na}^+ + 2 \text{e}^-$$

Reduction: The gain of an electron

$$\text{Cl}_2 + 2 \text{e}^- \rightarrow 2 \text{Cl}^-$$
Losing and Gaining Electrons

Oxidation: The loss of an electron

\[ 2 \text{Na} \rightarrow 2 \text{Na}^+ + 2 \text{e}^- \quad \text{“Leo”} \]

Reduction: The gain of an electron

\[ \text{Cl}_2 + 2 \text{e}^- \rightarrow 2 \text{Cl}^- \quad \text{“Ger”} \]
Losing and Gaining Electrons

Oxidation: The loss of an electron

\[ 2 \text{Na} \rightarrow 2 \text{Na}^+ + 2 \text{e}^- \]

“Leo”

Reduction: The gain of an electron

\[ \text{Cl}_2 + 2 \text{e}^- \rightarrow 2 \text{Cl}^- \]

“Ger”

(Leo the lion went “Ger”)
Losing and Gaining Electrons

\[ 2 \text{Na} + \text{Cl}_2 \rightarrow 2 \text{Na}^+ + 2 \text{Cl}^- \]
Losing and Gaining Electrons

Little tendency to lose or gain electrons

Tendency to lose electrons

Tendency to gain electrons

More likely to behave as oxidizing agent (be reduced)

More likely to behave as reducing agent (be oxidized)
Losing and Gaining Electrons

Oxidation
(Ionic state becomes more positive)

Loses electrons
Gains oxygen
Loses hydrogen

Reduction
(Ionic state becomes more negative)

Gains electrons
Loses oxygen
Gains hydrogen
What element within the reactants is oxidized in the following equation, and what element is reduced?

\[ I_2 + 2 \text{Br}^- \rightarrow 2 \text{I}^- + \text{Br}_2 \]

A. Iodine, I, is oxidized, while the bromine ion, Br\(^-\), is reduced.
B. Iodine, I, is reduced, while the bromine ion, Br\(^-\), is oxidized.
C. Both the iodine, I, and the bromine ion, Br\(^-\), are reduced.
D. Both the iodine, I, and the bromine ion, Br\(^-\), are oxidized.
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D. Both the iodine, I, and the bromine ion, Br\(^-\), are oxidized.

*Explanation:*

Note how the iodine gains a negative charge, while the bromine loses the negative charge.
Harnessing the Energy of Flowing Electrons

• Electric currents generated by oxidation-reduction reactions.
Harnessing the Energy of Flowing Electrons

• Electric currents generated by oxidation-reduction reactions.

• Useful for:
  – Batteries
  – Fuel cells
Harnessing the Energy of Flowing Electrons

• Ions must be able to flow to generate a current.
Harnessing the Energy of Flowing Electrons

• A salt bridge allows this to happen.
Harnessing the Energy of Flowing Electrons

- A battery is a self-contained voltaic cell.

Reduction: $2\text{NH}_4^+ + 2e^- \rightarrow 2\text{NH}_3 + \text{H}_2$

Oxidation: $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$
Harnessing the Energy of Flowing Electrons

• The positive electrode is the cathode, where reduction occurs.
Harnessing the Energy of Flowing Electrons

- The positive electrode is the cathode, where reduction occurs.
- The negative electrode is the anode, where the oxidation occurs.
Harnessing the Energy of Flowing Electrons

• Several types of batteries:
  – Dry cell
  – Alkaline
  – Rechargeable
    • NiMH
    • Lithium
Harnessing the Energy of Flowing Electrons

- Fuel cells convert the chemical energy of a fuel into electrical energy.
Harnessing the Energy of Flowing Electrons

Oxidation:

$$2 \text{H}_2(\text{g}) + 4 \text{OH}^-(\text{aq}) \rightarrow 4 \text{H}_2\text{O}(\text{g}) + 4 \text{e}^-$$

Reduction:

$$4 \text{e}^- + \text{O}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g}) \rightarrow 4 \text{OH}^-(\text{aq})$$
Electrolysis

• Electrolysis uses electrical energy to produce chemical change.
Electrolysis

• Electrolysis uses electrical energy to produce chemical change.

• Examples:
  – Recharging your car battery
  – Purifying metal ores
Electrolysis

Oxidation: \[ 2 \text{AlOF}_3^{2-} + 6 \text{F}^- + \text{C} \rightarrow 2 \text{AlF}_6^{3-} + \text{CO}_2 + 4 \text{e}^- \]

Reduction: \[ \text{AlF}_6^{3-} + 3 \text{e}^- \rightarrow \text{Al} + 6 \text{F}^- \]
Corrosion and Combustion
Corrosion and Combustion

Corrosion

The process whereby a metal deteriorates through oxidation-reduction reactions.
Corrosion and Combustion

Corrosion

The process whereby a metal deteriorates through oxidation-reduction reactions.

It can be prevented by coating the metal with zinc, which oxidizes first.
Corrosion and Combustion

Combustion

An oxidation-reduction reaction between a nonmetallic material, such as wood, and oxygen.
One of the products of combustion is water. Why doesn’t this water extinguish the combustion?

A. While areas of combustion are being extinguished, new areas are combusting.
B. Combustion only produces microscopic amounts of water.
C. The chemical combustion reaction is happening too fast for the water to have an effect on the fire.
D. This water is in the gaseous phase and merely floats away.
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A. While areas of combustion are being extinguished, new areas are combusting.
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C. The chemical combustion reaction is happening too fast for the water to have an effect on the fire.
D. **This water is in the gaseous phase and merely floats away.**

**Explanation:**

Carefully place your hand over a campfire, and you can feel the greater humidity as water vapor escapes.