Sec 4.6 - Strong Acids and Strong Bases

**Weak & Strong** → refers to % ionization.

**Concentration** → the moles of acid dissolved per litre.

**Strong Acid** - An acid which is 100% ionized in a water solution.

Ex: \( \text{HCl}_\text{(g)} + \text{H}_2\text{O}_\text{(l)} \rightarrow \text{H}_3\text{O}^+\text{(aq)} + \text{Cl}^-\text{(aq)} \)

If this equation was simplified without the water \( \text{HCl}_\text{(g)} \rightarrow \text{H}^+\text{(aq)} + \text{Cl}^-\text{(aq)} \)

Question: What is the \([\text{HCl}_\text{(g)}]\) in 1 M HCl?
Answer: **0 M**

What is the \([\text{Cl}^-]\) in 1 M HCl?
Answer: **1 M**

What is the \([\text{H}^+]\) in 1 M HCl?
Answer: **1 M**

Question: What is \([\text{H}_3\text{O}^+]\) in 0.20 M HCl
Answer: **0.20 M**

Important: In a **Strong Acid** \([\text{H}_3\text{O}^+] = [\text{Acid}] \)

**Weak Acid** - An Acid which is less than 100% ionized in solution.

(In Chem 12 Weak Acid’s are usually significantly less than 100% ionized. Usually < 5% ionized)

- In a solution of a **weak acid**, most of the molecules *don’t* ionize.

Ex: \( \text{HF}_\text{(g)} + \text{H}_2\text{O}_\text{(l)} \rightleftharpoons \text{H}_3\text{O}^+\text{(aq)} + \text{F}^-\text{(aq)} \)

\([\text{H}_3\text{O}^+]\) is only a small fraction of [HF]

- Any acid (weak or strong) could have a high or low **concentration**.

**Strong Base** - A substance (base) which (ionizes) or dissociates 100% in solution

**Weak Base** - A base which is less than 100% ionized in solution.

Ex: \( \text{NH}_3\text{(aq)} + \text{H}_2\text{O}_\text{(l)} \rightleftharpoons \text{NH}_4^+\text{(aq)} + \text{OH}^-\text{(aq)} \)

- Consists of mostly \( \text{H}_2\text{O} \) and \( \text{NH}_3 \) molecules with a few \( \text{NH}_4^+ \) and \( \text{OH}^- \) ions.
The Acid Table
Pg 334 in your text, also in your data booklet

**Strong Acids (top of the table on the left)**

HClO₄ → H⁺ + ClO₄⁻
HI → H⁺ + I⁻
HBr → H⁺ + Br⁻
HCl → H⁺ + Cl⁻
HNO₃ → H⁺ + NO₃⁻
H₂SO₄ → H⁺ + HSO₄⁻

*Note H₂SO₄ is a SA but diprotic

- The first ionization is 100% = H₂SO₄ + H₂O → H₃O⁺ + HSO₄⁻
- The second ionization is <100% HSO₄⁻ + H₂O ⇄ H₃O⁺ + SO₄²⁻

**Weak Acids (middle of the table on the left)**

- H₃O⁺ ⇄ H⁺ + H₂O
- HIO₃ ⇄ H⁺ + IO₃⁻
- H₂O ⇄ H⁺ + OH⁻

Most act as weak acids in water

- OH⁻ ⇄ H⁺ + O²⁻
- NH₃ ⇄ H⁺ + NH₂⁻

Bottom 2 on left NEVER act as acids in water
(too weak as acids)

Single arrows going backwards
(O²⁻ and H⁺ can form OH⁻, but OH⁻ cannot form H⁺ and O²⁻ in water solution.)

**Strong Bases (bottom of the table on the right)**

→ OH⁻
→ O²⁻
→ NH₂⁻

Strong bases (bottom 3 on right side)

- Any substance which dissociates completely to produce OH⁻, O²⁻ or NH₂⁻ is a Strong Base

**Alkali Metal Hydroxides (Group 1)**

LiOH, NaOH, KOH, RbOH, CsOH are all highly (100%) soluble and form OH⁻, so they are all strong bases.

**Alkaline Earth) Hydroxides (Group 2)**

Mg(OH)₂, Ba(OH)₂, Sr(OH)₂ are designated as Strong Bases

What is the [OH⁻] in 0.10 M NaOH?
NaOH\(_{(s)}\) \rightarrow Na^+_{(aq)} + OH^-_{(aq)}

0.10 M  0.10 M  0.10 M  \[\text{[OH}^-\] = 0.10 M\]

What is the [OH\(^-\)] in 0.10 M Ba(OH)\(_2\)?

Ba(OH)\(_2\) \rightarrow Ba^{2+}_{(aq)} + 2OH^-

0.10 M  0.10 M  0.20 M

For A Strong Base

[OH\(^-\)] = [Base] x # of OH’s in formula

Salts which produce O\(^2-\) and NH\(_2^-\) are definitely strong bases.

Example: Quicklime in water: CaO\(_{(s)}\) \rightarrow Ca^{2+}_{(aq)} + O^{2-}_{(aq)}

\[O^{2-} + H_2O \rightarrow OH^- + OH^-\]

(Oxide ion) (100%)

Or \[O^{2-} + H_2O \rightarrow 2OH^-\]

Find [OH\(^-\)] in 0.10 M CaO

\[= 0.20 M (OH^-)\]

\[O^{2-} = 0.10 M\]

\[O^{2-} + H_2O \rightarrow 2OH^-\]

(0.10M)  0.20M
Weak Bases
Found above OH\(^-\) on right side of Table.

Very Weak (non-hydrolyzing Bases) or Spectators
These are the top 5 (not 6) “bases” on the right.

\[
\begin{align*}
&\text{ClO}_4^- \\
&\text{I}^- \\
&\text{Br}^- \\
&\text{Cl}^- \\
&\text{NO}_3^-
\end{align*}
\]

They are so weak that they cannot react with H\(_2\)O to form OH\(^-\)
(They do not contribute any OH\(^-\) to a solution)

For this reason, these top 5 on the right are not usually referred to as “bases” in aqueous solution. They are called Spectators!

Conj. Bases of strong acids---- In acid-base reactions they are SPECTATORS

In a SA, the bond to H\(^+\) is weak

\[
\text{H-Cl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^{(aq)}^+ + \text{Cl}^{(aq)}^-
\]

So weak, it cannot take an H\(^+\) from H\(_2\)O or even H\(_3\)O\(^+\)

SA’s have non-hydrolyzing (spectator) ions for conj. Bases.

SO WHAT DOES ALL OF THIS MEAN???

- The higher an acid is on the left, the stronger the acid
- The lower a base is on the right, the stronger the base
- The stronger the acid, the weaker its conjugate base and vice versa

the stronger the base, the weaker it's conj. acid
Sec 4.6 - Amphiprotic Species (ions or molecules)

- are found on both sides of the table e.g.) HSO₄⁻
- can act as acids (donate H⁺'s) or as bases (accept H⁺'s)
- to look at an amphiprotic species as an acid, you must find it on the left side:

<table>
<thead>
<tr>
<th>Acid Strength Increases</th>
<th>e.g.) C₆H₅OH ⇌</th>
<th>HCO₃⁻ ⇌</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₂O₂ ⇌</td>
<td></td>
</tr>
</tbody>
</table>

HCO₃⁻ is a _______er acid than C₆H₅OH
HCO₃⁻ is a _______er acid than H₂O₂

- to look at an amphiprotic species as a base, you must find it on the right side:

for HCO₃⁻ as a base:

<table>
<thead>
<tr>
<th>Base Strength Increases</th>
<th>H⁺ + Al(H₂O)₃(OH)²⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H⁺ + HCO₃⁻ ⇐</td>
</tr>
<tr>
<td></td>
<td>H⁺ + C₆H₅O₇³⁻</td>
</tr>
</tbody>
</table>

HCO₃⁻ is a _______er base than C₆H₅O₇³⁻
HCO₃⁻ is a _______er base than Al(H₂O)₅(OH)²⁺

HSO₄⁻ in shaded region on top right will not act as a base in water (Too weak of a base)
- However, it is not a spectator! (like NO₃⁻ is) Why not?

(HSO₄⁻ is also found on the left side quite a way up, it is a relatively “strong” weak acid.)

The Leveling Effect for Acids

What is [H₃O⁺] in 1.0 M H₃O⁺ ? 1.0M
What is [H₃O⁺] in 1.0 M HNO₃? 1.0M
What is [H₃O⁺] in 1.0 M HCl ? 1.0M

Acids from HClO₄ to H₂SO₄ are 100% ionized in water

only solvent used in Chem 12 (and most Chemistry)

- so even though HClO₄ is above HCl on the chart, it is no more acidic in a water solution. Therefore the top six strong acids have been levelled.

**H₃O⁺ is the strongest acid that can exist in an undissociated form in water solution. All stronger acids 100% ionize to form H₃O⁺**
(NOTE: although $H_2SO_4$ is diprotic, the $H_3O^+$ produced from the second ionization is very little compared to that from the first)

1st ionization: $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$

\[
\begin{align*}
&\text{1M(SA)} \quad \text{1M} \\
\end{align*}
\]

2nd ionization: $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$

\[
\begin{align*}
&\approx 1\text{M (WA)} \\
\end{align*}
\]

**Leveling Affects of Bases**

*The strongest base which can exist in high concentration in water solution is $OH^-$. The two stronger bases below it will react with water completely to form $OH^-$.***

\[
\begin{align*}
\text{Eg)} \quad &O_2^- + H_2O \rightarrow OH^- + OH^- \\
&\text{SB} \\
\text{Or} \quad &O_2^- + H_2O \rightarrow 2OH^- \\
\end{align*}
\]

What is the final $[O_2^-]$ in 1.0 M Na$_2$O?  

Answer: 0 M - All the $O_2^-$ will react with water to form $OH^-$. 

\[
\begin{align*}
&1.0\text{M} \quad 2/1 \quad 2.0\text{M} \\
&O_2^- + H_2O \rightarrow 2OH^- \quad \text{so} \quad [OH^-] = 2.0 \text{M}
\end{align*}
\]

Write an equation for $NH_2^-$ reacting with $H_2O$.

Answer: ________________________________

**Write out the definition of the levelling effect from page 125**

- HW  Pg.126  # 21 -27