IV.6 - "Strong and Weak" Acids and Bases

- **Strong Acid or Base:** A STRONG acid or base is an acid or base which is 100% ionized in solution.

  Examples: $NaOH_{(s)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$

  $HCl_{(g)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

- **Weak Acid or Base**: A WEAK acid or base is an acid or base which is LESS THAN 100% ionized in solution.

  Examples: $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

  $HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}$

- **NOTE:**

  a) Weak acids and bases are involved in equilibrium reactions, strong acids and bases ***ARE NOT***.

  b) The definition of a weak acid implies that an acid which is 99.9% ionized will be "weak", while an acid which is 100% ionized is "strong".

  c) The terms **weak** and **strong** refer to the percentage of ionization. The terms **dilute** and **concentrated** refer to the molarity of a solution.

  The terms ***WEAK*** and ***STRONG*** refer to the percentage of ionization

  The terms ***DILUTE*** and ***CONCENTRATED*** refer to the molarity of a solution

  Examples:

  10.0 M $HF_{(aq)}$ is concentrated and weak

  0.001 M $HCl_{(aq)}$ is dilute and strong.

- $HClO_4$, HI, HBr, HCl, HNO_3, H_2SO_4 $\Longrightarrow$ disassociate 100% (Strong Acids)…**ALL** products, no reactants.

The Acid-Base Table ("Relative Strengths of Bronsted-Lowry Acids and Bases")

- At this point it is appropriate to introduce a table that will be very important to us in this unit. Look at the table found in your data booklet (handout) as you read the following.

  The Strong Acids:

  The strong acids are the top six acids listed on the "**Relative Strengths of Bronsted-Lowry Acids and Bases**", namely:

Name	Formula
Perchloric acid	$HClO_4$
Hydriodic acid	HI
Hydrobromic acid	HBr
Hydrochloric acid	HCl
Nitric acid	HNO_3
Sulphuric acid	H_2SO_4

  (Note: H_2SO_4 is only strong for the first dissociation: $H_2SO_4 \Longrightarrow H^+ + HSO_4^-$)

  The Strong Bases:

  Strong bases that are not metal hydroxides include O^{2-} and NH_2^- both are found on the acid-base table. The hydroxide ion, OH^-, found on the lower right side of the table, is a strong base. **All metal hydroxides** are 100% dissociated in solution, and thus are strong bases.

For example:

Name	Formula
Sodium hydroxide	$NaOH$
Potassium hydroxide	KOH
Magnesium hydroxide	$Mg(OH)_2$
Iron(III) hydroxide	$Fe(OH)_3$
Zinc hydroxide	$Zn(OH)_2$

(Note: These are just a few of the metal hydroxides that are considered to be strong bases.)

The Weak Acids:

All the acids listed on the left side of the table in the white section are "weak" acids.

The Weak Bases:

All the bases found on the right side of the table in the white section are "weak" bases

Some other relationships found on the table.

1. The higher an acid is on the left side of the table, the stronger the acid.
2. The lower a base is on the right side of the table, the stronger the base
3. The stronger an acid, the weaker its conjugate base (and vice versa.)
4. When a substance acts as an acid with water, H_3O^+ is always produced. The stronger the acid, the greater the $[H_3O^+]$
5. When a substance acts as a base with water, OH^- is always produced. The stronger the base, the greater the $[OH^-]$ produced.

Special Note: HPO_4^{2-} and HCO_3^- can be found on both the left and right sides of the table. This is because they are amphiprotic and can act as weak acids and weak bases.

The Levelling Effect:

- H_3O^+ is the strongest acid that can exist in a solution. Why?
- $HClO_4$, HI, HBr, HCl, HNO_3, H_2SO_4 don't exist in solution. Why?
- On the "chart", the top left shows the strong acids. The higher the acid, the stronger it is.
- If we take a pure strong acid such as $HClO_{4(l)}$ and dissolve it in another pure strong acid, such as $H_2SO_{4(l)}$, with no other solvent present, we will find:

$$HClO_4 + H_2SO_4 \rightleftharpoons ClO_4^- + H_3SO_4^+$$

What do you notice? Which behaves like an acid and which a base?

- Combining strong acids allows us to establish the relative order of strengths among the strong acids.
- In water, all strong acids will be 100% dissociated with water taking the H^+ forming H_3O^+.

$$HClO_4 + H_2SO_4 + 2H_2O \rightleftharpoons ClO_4^- + HSO_4^- + 2H_3O^+$$

- We say that water has **"levelled"** all the strong acids to the same strength.

Therefore, the strongest acid that can exist in aqueous solution is H_3O^+.

- So $HClO_4$, HI, HBr, HCl, HNO_3, H_2SO_4 are all levelled to the same strength as H_3O^+.
- Therefore, the central portion of the table form:

$$H_3O^+ \rightleftharpoons H^+ + H_2O$$

to

$$H_2O \rightleftharpoons H^+ + OH^-$$

shows the reactions which can occur in aqueous solution: the top six reactions are levelled to produce H_3O^+ and the bottom two reactions are levelled to produced OH^-.

Examples:

1. April 2003

Which of the following is correct if the four solutions listed are compared to one another?

		Concentration	Relative Conductivity	Ionization
A.	strong acid	0.50 M	highest	complete
B.	weak acid	0.50 M	lowest	complete
C.	strong base	1.0 M	highest	complete
D.	weak base	1.0 M	lowest	complete

2. April 2004

Which of the following best describes a weak acid?

A. Its 0.10 M solution will have pH = 1.00.
B. It may be very soluble, but only partly ionized.
C. It must be very soluble and completely ionized.
D. It must be of low solubility and completely ionized.

3. April 1998

Which of the following 0.1 M solutions will have the greatest electrical conductivity?

A. HNO_2
B. H_2SO_3
C. H_3PO_4
D. C_6H_5OH

4. August 2004

What is the main difference between a strong acid and a weak acid?

A. their degree of ionization
B. their reactivity with platinum
C. their concentration in solution
D. their effect on phenolphthalein

*****Do Hebden Questions #20 - 27, pgs 122 - 126*****