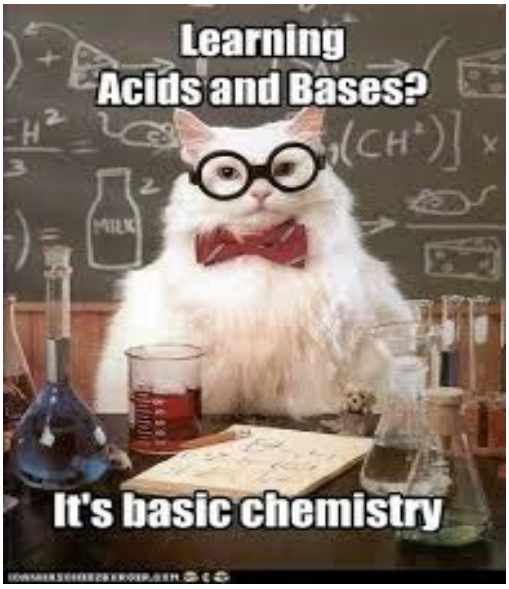
6.2 - Strength of Acids & Bases

pages 570-571 in Heath

pages 602-607 in Matter and Change



Conjugate acid-base pairs.

Conjugate acid-base pairs differ from each other by the presence or absence of a single hydrogen ion (or proton).

Every acid has a conjugate base, and every base has a conjugate acid.

Ex) Write the conjugate bases for the following acids:
HF

H_2SO_4

Ex) Write the conjugate acids for the following bases:
PO_4^{3-}

SO_4^{2-}

An acid in an aqueous solution always produces a species capable of producing a base, A base in solution always produces a substance capable of acting as an acid. Therefore, an acid-base equation contains an acid and a base for both the forward and reverse reactions.

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

Polyprotic Acids

Some acids have more than one hydrogen ion they can give up. For example, H_2SO_4 has 2 H^+ it can possibly give up.

The first hydrogen ion is released as:

$H_2SO_{4\,(aq)} \rightarrow H^+_{(aq)} + HSO_4^-{}_{(aq)}$

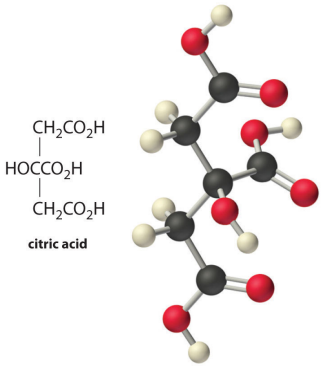
The second hydrogen is more difficult to remove, but it can happen :

$HSO_4^-{}_{(aq)} \rightarrow H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

Each hydrogen you release after the first one gets progressively more difficult to remove from these types of acids.

Acids that can donate more than one H^+ are called **polyprotic**.

Ex) Write all the equations showing the release of a H^+ ion for the acid $H_3C_6H_5O_7$.



Strong and Weak Acids and Bases

A strong acid is identified as one that can produce many H^+ (or H_3O^+) ions. Note the similarity between the definition of a strong electrolytic solution.

- Therefore, the stronger the acid, the more H^+ ions are produced. On the other hand, a weak acid produces few H^+ ions.

- Strong bases produce many OH^- ions while weak bases produce few OH ions.

Strong acids and bases produce one way reactions. That is the acid or base breaks down completely to produce ions. At equilibrium, there are very few reactants left (concentration is low).

Strong acid	Strong base
$HCl \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$	$NaOH \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

On the other hand, weak acids and bases do not ionize completely. For weak electrolytes equilibrium lies on the left hand (reactant) side - there are few ions present.

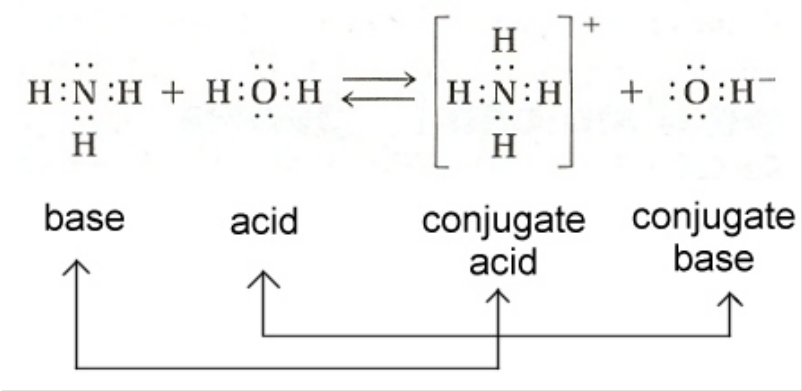
Weak Acid	Weak Base
$HCHO_2 \leftrightarrow H^+_{(aq)} + CHO_{2(aq)}^-$	$NH_{3(g)} + H_2O_{(l)} \leftrightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$

It is important to not confuse acid and base strength with dilution.

- Dilute and concentrated refers to the relative amounts of solute and solvent in a solution.
- The acid and base strength refers specifically to the concentration of ions in the solution.
- A strong acid is still a strong acid even if it gets diluted. A weak acid is still weak even when it is concentrated.

Predicting acid-base reactions in water

-acid-base reactions always yield conjugate acid-base pairs



-a strong acid has a weak conjugate base
ex: HCl

-a strong base has a weak conjugate acid
ex: NaOH

-a weak acid has a strong conjugate base
ex: CH_3COOH

-a weak base has a strong conjugate acid
ex: CH_3NH_2

Ionization Constants

Since acid/base solutions are at equilibrium, we can write equilibrium constant expressions for them.

- equilibrium constants involving **acids** are known as K_a.
- constants for **base** solutions will be denoted by K_b.

These values can be found in your resource package (*Table 14*).

Ex) Write the equilibrium constant expression for the acid or base in solution.

$HCl_{(g)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

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

- A large K_a indicates there are many H^+ ions present. Therefore, this indicates a strong acid.
- A large K_b indicates a strong base.

Polyprotic acids:
-strength of the acid decreases with each H^+ ion removed.

Acid	K_{a1}	K_{a2}	K_{a3}
sulfuric acid (H_2SO_4)	1.0×10^{3}	1.2×10^{-2}	
chromic acid (H_2CrO_4)	9.6	3.2×10^{-7}	
oxalic acid ($H_2C_2O_4$)	5.4×10^{-2}	5.4×10^{-5}	
sulfurous acid (H_2SO_3)	1.7×10^{-2}	6.4×10^{-8}	
phosphoric acid (H_3PO_4)	7.1×10^{-3}	6.3×10^{-8}	4.2×10^{-13}
glycine ($C_2H_6NO_2$)	4.5×10^{-3}	2.5×10^{-10}	
citric acid ($C_6H_8O_7$)	7.5×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
carbonic acid (H_2CO_3)	4.5×10^{-7}	4.7×10^{-11}	
hydrogen sulfide (H_2S)	1.0×10^{-7}	1.3×10^{-13}	

6.2 Strength of Acids and Bases Assignment

1) List the following acids in order from strongest to weakest.

HI	HNO_3
H_2S	H_2SO_4
$HC_2H_3O_2$	H_3PO_4

2) List all of the polyprotic acids from problem #1.

3) Write the Ka expression for the reaction in which each of the following acts as an acid with water

a) HCN

b) HPO_4^{2-}

c) HNO_2

4) Write the Kb expression for the reaction in which each of the following acts as a base with water

a) HS^-

b) CH_3NH_2

c) F^-

6.2 - Strength of Acids and Bases

5) Write the formulas for the conjugate base of each of the following acids

a. H_2SO_3 b. HCO_3^- c. NH_4^+

6) Write the formulas for the conjugate acid of each of the following bases.

a. H_2O b. CO_3^{2-} c. PH_3

7) Using your knowledge of the Bronsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair

a) $HNO_{3(aq)} + OH^-_{(aq)}$ -->

b) $CH_3NH_{2(aq)} + H_2O_{(l)}$ -->

c) $OH^-_{(aq)} + HPO4^{2-}_{(aq)}$ -->

d) $H_3O^+_{(aq)} + OH^-_{(aq)}$ -->

8) Write a balanced chemical equation for the reaction of potassium hydroxide and nitric acid.