NOTES #51 An Introduction to Acids & Bases

A. Acid Definitions:
   a) Arrhenius Acids: Any substance, when dissolved in water, increases the H^+ concentration of the water.
   b) Brønsted Acids and Bases.

* Brønsted Acid - substance that ______________ a proton. [______] Conjugate Base: what's left once the H^+ is removed.
* Brønsted Base - substance that ______________ a proton. Conjugate Acid: what's left once the H^+ is added.

EX1: CH_3COOH (aq) + H_2O(l) ⇌ CH_3COO^-(aq) + H_3O^+(aq)

H_3O^+ = the hydronium ion. H^+ is just a simplification. H_3O^+ and H^+ should be used completely interchangeably!

EX2: NH_3 (aq) + H_2O (l) ⇌

** Notice the role H_2O plays in this reaction....compare to the example above.....

EX3: Identify the following as a Bronsted acid or base and write it's respected conjugate partner:

CN^- HSO_4^- H_2S $C_6H_5NH_3^+$

B. Acid/Base properties of WATER.
   1. Water can act either as an ACID or a BASE.....as we saw above. This is referred to as _________________________.
   2. Water is a very _________ electrolyte and is, hence, a ____________ conductor of electricity. However, it does ionize to a small extent:

H_2O (l) ⇌ H^+ (aq) + OH^- (aq)

OR *what's really going on....* 2 H_2O (l) ⇌

* This ionization of water is often called AUTOIONIZATION.

3. Since water only ionizes to a SMALL extent, what do you predict K_c to be??? Why?
4. Let's talk a little more about this equilibrium with water....

   a. Write out the K_c expression for this reaction: K_c =

   b. Since only a small fraction of the water molecules will ionize, what can we say about the $[H_2O]$?

   c. $K_c \cdot [H_2O]$ equals a *new* K, which we will call K_w.

   K_w is the ION-PRODUCT constant, which is the product of the $[H^+]$ and $[OH^-]$ at a particular temperature.

   d. K_w just like any other K is CONSTANT at a particular temp and it is NOT dependent on concentration.

   The concentrations can vary as long as their product is equal to K_w. If $[H^+]$ INCREASES, $[OH^-]$ must ______________.

   e. **K_w is 1.0×10^{-14} at 25°C.**

   f. * In pure water, the $[H^+]$ and $[OH^-]$ are EQUAL and the water is said to be NEUTRAL. At 25°C, what are these concentrations?

* If $[H^+] > [OH^-]$, there is an excess of ______________ and the solution is _________________.

* If $[H^+] < [OH^-]$, there is an excess of ______________ and the solution is _________________.

EX: Calculate the concentration of OH^- ions in a HCl solution whose $[H^+]$ is 1.3 M.

A. The pH scale.
   1. Because $[H^+]$ and $[OH^-]$ are usually *so* small and inconvenient to work with, we usually use the pH scale instead.
   2. pH = the negative logarithm of the hydrogen ion concentration. **pH = - log $[H^+]$** ***{p= the – base 10 log of something}***

* Notice, as $[H^+]$ INCREASES (more acidic), pH will __________________. * pH is a unit-less quantity and is *usually* positive.

   3. The pH scale (in an aqueous soln)...

ACID____BASE

4. We can also look at a solution in terms of $[OH^-]$. This would be expressed in pOH. **pOH = - log $[OH^-]$**

5. Relationship between pH and pOH.

a. **pH + pOH = 14**

Why? Remember, the K_w expression for water: $[H^+][OH^-] = K_w = 1.0x10^{-14}$ *simplify!*

Take the log of both sides.... pH + pOH = pK_w

Name	$[H^+]$	$[OH^-]$	K_w	pH	+	pOH	=	total
Strong Acid	10^0							
Moderate Acid	10^{-2}							
Weak Acid	10^{-5}							
NEUTRAL								
Weak Base	10^{-9}							
Moderate Base	10^{-11}							
Strong Base	10^{-13}							

Example #1

Nitric acid, HNO_3, is used in the production of fertilizer, dyes, drugs and explosives. Calculate the pH of a HNO_3 solution having a $[H^+]$ of 0.76 M.

EX2: The OH^- ion concentration of a blood sample is $2.5x10^{-7}$ M. What is the pH of the blood?

B. Strength of Acids and Bases.

1. Strong acids and strong bases IONIZE 100%.

HCl (aq) + H_2O (l) → H_3O^+ (aq) + Cl

NaOH (s) → Na^+ (aq) + OH^- (aq)

What ARE the "Big Six" strong acids?

What ARE the strong bases?

** Ionization of *strong* acids and bases goes to COMPLETION. What can we say about the K value for these processes? It is for this reason, that we don't show a double arrow in these reactions. So is there such a thing as true HCl in solution?

2. Most acids and bases are actually WEAK and weak acids and bases only ionize to a limited extent.

HCOOH + H_2O ⇌ COO^- + H_3O^+

NH_3 + H_2O ⇌ NH_4^+ + OH^-

** At equilibrium, weak acid or base solutions contain a mixture of reactants and products. When compared to strong acids/bases, the K value for weak acids/ bases is ________________________. ** So, really, is there such a thing as CH_3COOH in solution???

3. What conclusions you can draw from the above? a. Acids and Bases and their conjugate partner....

The stronger the ACID, the ______________ it's conjugate base. HCl (aq) + H_2O (l) ------------> H_3O^+ (aq) + Cl^-

- From this info, you can predict the direction of an acid/base reaction by comparing the strength of the acid vs the strength of the base....

EX 3: Predict whether the equilibrium constant for the following reaction is greater than or smaller than 1: Ka vs Kb (you will need a Ka/Kb table)

a) CH_3COOH (aq) + $HCOO^-$ (aq) ⇌ CH_3COO^- (aq) + HCOOH (aq)

b) HCl (aq) + F^- (aq) ⇌ HF (aq) + Cl^- (aq)

c) NH_3 (aq) + HCN (aq) ⇌ NH_4^+ (aq) + CN^-(aq)

Really, H_3O^+ is the absolute strongest acid that can exist in an (aq) soln. Strong Acids (like all the "Big Six) ionize 100% in water to make H_3O^+. Weak acids also make H_3O^+, they just don't make as much.

EX4: Let's say you have a 1 M solution of HCl and a 1 M solution of CH_3COOH. Compare the $[H^+]$.

HCl (aq) + H_2O (l) → H_3O^+ (aq) + Cl^- $[H^+]$ = ___________

CH_3COOH + H_2O ⇌ CH_3COO^- + H_3O^+ $[H^+]$ = ___________

OH^- is the strongest base that can exist in an aq solution.