

## NOTES #51 An Introduction to Acids & Bases

### A. Acid Definitions:

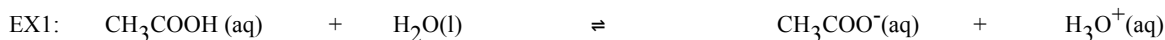
- a) Arrhenius Acids: Any substance, when dissolved in water, increases the  $H^+$  concentration of the water.
- b) Brønsted Acids and Bases.

\* 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.



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



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

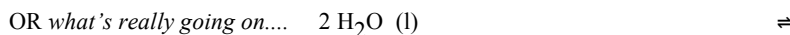
EX3: Identify the following as a Brønsted acid or base and write its respected conjugate partner:



### 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:



\* 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  $1.0 \times 10^{-14}$  at  $25^\circ C$ .

f. \* In pure water, the  $[H^+]$  and  $[OH^-]$  are EQUAL and the water is said to be NEUTRAL. At  $25^\circ C$ , 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  $[\text{OH}^-]$ . This would be expressed in pOH.  
 5. Relationship between pH and pOH.

$$\text{pOH} = -\log [\text{OH}^-]$$

a.  $\text{pH} + \text{pOH} = 14$

Why? Remember, the  $K_w$  expression for water:  $[\text{H}^+][\text{OH}^-] = K_w = 1.0 \times 10^{-14}$  *simplify!*

Take the log of both sides....  $\text{pH} + \text{pOH} = \text{p}K_w$

#### Example #1

Nitric acid,  $\text{HNO}_3$ , is used in the production of fertilizer, dyes, drugs and explosives. Calculate

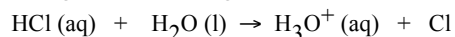
the pH of a  $\text{HNO}_3$  solution having a  $[\text{H}^+]$  of 0.76 M.

Name	$[\text{H}^+]$	$[\text{OH}^-]$	$K_w$	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	$10^{-13}$					

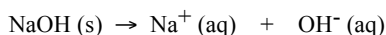
EX2: The  $\text{OH}^-$  ion concentration of a blood sample is  $2.5 \times 10^{-7}$  M. What is the pH of the blood?

#### B. Strength of Acids and Bases.

1. Strong acids and strong bases IONIZE 100%.



*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.



\*\* 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  $\text{CH}_3\text{COOH}$  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.  $\text{HCl (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{H}_3\text{O}^+ \text{ (aq)} + \text{Cl}^-$

- 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....

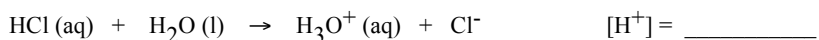
EX 3: Predict whether the equilibrium constant for the following reaction is greater than or smaller than 1:  $K_a$  vs  $K_b$  (you will need a  $K_a/K_b$  table)



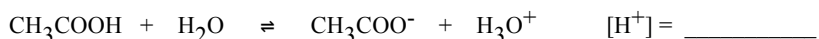
Really,  $\text{H}_3\text{O}^+$  is the absolute strongest acid that can exist in an (aq) soln. Strong Acids (like all the "Big Six") ionize

100% in water to make  $\text{H}_3\text{O}^+$ . Weak acids also make  $\text{H}_3\text{O}^+$ , 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  $\text{CH}_3\text{COOH}$ . Compare the  $[\text{H}^+]$ .



$\text{OH}^-$  is the strongest base that can exist



in an aq solution.