

NOTES #52 Ka & Kb Values & Di/Polyprotic Acids

C. Determining $[H^+]$ and $[OH^-]$ at Equilibrium for STRONG ACIDS and STRONG BASES.

** These type of problems are very easy because strong acids and strong bases dissociate 100%.

EX1: Calculate the pH of: (a) 2.3×10^{-3} M HCl solution (b) 1.8×10^{-2} M $Ba(OH)_2$ solution

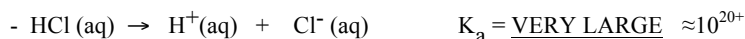
D. Determining $[H^+]$ and $[OH^-]$ at Equilibrium for WEAK ACIDS and WEAK BASES.

** These are a little more challenging just because weak acids and bases do not dissociate 100%....

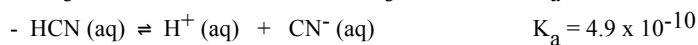
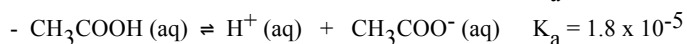
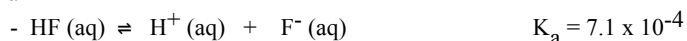
1. Weak Acids and K_a values.

a. K_a value or the **acid ionization constant** is just the Equilibrium constant for the ionization of an acid.

i. Since STRONG ACIDS dissociate 100%, the reaction goes to completion. The K_a value for a STRONG ACID is said to be VERY LARGE.



ii. K_a values for weak acids are variable.



iii. The LARGER the K_a , the _____ the acid. (The more the H^+ side of the equation is favored.)

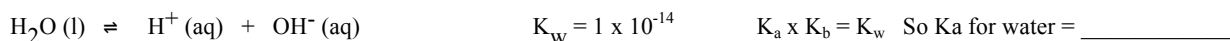
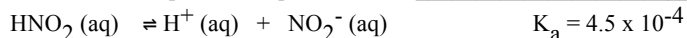
b. Using K_a to determine $[H^+]$ at Equilibrium. Use **I.C.E. TABLES**, just like we did in EQ

EX 2: (on a separate sheet of paper) Calculate the pH, $[HNO_2]$, and $[NO_2^-]$ of a 0.50 M solution of HNO_2 acid. At $25^\circ C$ the K_a is 4.5×10^{-4} .

1. Identify the major species that will provide H^+ .

a. What species will be present in this solution, in order of DECREASING [] ?? _____

b. Which of the above species will provide H^+ ?? _____



* At this point, you can single out one source of H^+ can be singled out as DOMINANT. By comparing K_a for HNO_2 acid and K_w for water, we see that although weak, HNO_2 is a much _____ acid than water. For the rest of the problem, we can ignore any H^+ contributions from the autoionization of water.

c. Construct an I.C.E. table.

d. Substitute Equilibrium concentrations into K_a expression.

e. Use the Quadratic equation and solve? NO! Since K_a is so small, you can make the assumption that x will be very small and that $0.50 - x = 0.50$.

Check to make sure that your approximation is reasonable. If your ratio of lowest initial concentration/ $K_a > 200$, then x IS small enough and your approximation is reasonable.

f. Solve for pH, $[HNO_2]$ and $[NO_2^-]$.

Different types of problems you will see:

EX 3: (on a separate sheet of paper) If you know the pH of a solution and the initial concentrations of a monoprotic acid, you can calculate K_a .

Calculate the K_a of an unknown weak monoprotic acid if the pH of a 0.60 M sample is 1.87. Identify the acid from the choices in Appendix D.

3. WEAK BASES and K_b .

a. The ionization of weak bases is treated the same way as we just saw with acids.

b. K_b , or the base ionization constant, is just a measure of how much a BASE wants to gain an H and become a + ion at equilibrium.

c. Consider the base ionization of NH_3 , ammonia. $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$ $K_b =$

d. The LARGER K_b is, the _____ the base.

Refer to Appendix D for a table of common weak Bases. What do all of these weak bases have in common???

e. Follow the same method you used for weak acids to solve for weak base problems. Just be careful in that you are dealing with $[\text{OH}^-]$ instead of $[\text{H}^+]$.

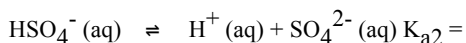
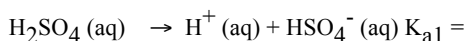
EX 4: Calculate the K_b of an unknown weak base if the pH of a 0.260 M sample is 12.03. Identify the base using the K_b value that you calculated. Determine the pH of a 0.50 M solution of this same base.

Diprotic and Polyprotic Acids

1. Diprotic Acids - Acids with 2 acidic protons (H^+ 's) to donate. EX: _____

Polyprotic Acids - Acids with more than 2 acid protons (H^+ 's) to donate. EX: _____

2. Diprotic and polyprotic acids ionize in a step-wise fashion, ONE H^+ at a time. There will be a new K_a value and equilibrium expression for each ionization. REFER TO APPENDIX D IN BOOK.



3. The first K_a is always LARGER than the second K_a . Why is this? It gets more difficult to remove the H^+ as you proceed through each ionization. In other words, it's easier to remove an H^+ from a neutral H_2CO_3 molecule than from a CHARGED HCO_3^- ion. Opposites attract! $K_{a1} > K_{a2} > K_{a3}$

4. Determining $[\text{H}^+]$ at equilibrium for a diprotic or polyprotic acid is a little tricky!

EX 1: Compare the pH of a 0.040 M HCl solution to a 0.040 M H_2SO_4 solution. Make some predictions??

1. Determine pH of the 0.040 M HCl soln. This is EASY because HCl's a STRONG acid.

2. Determine the pH of the 0.040 M H_2SO_4 . Watch out. You're going to need TWO I.C.E. tables....

5.* Final Conclusions - Fortunately, H_2SO_4 is really the only example of a diprotic acid with relatively large K_a values. ALL the other diprotic/polyprotic acids have really SMALL K_a values which makes these calculations much easier.

EX 2: Calculate the $[\text{C}_2\text{H}_2\text{O}_4]$, $[\text{C}_2\text{HO}_4^-]$, $[\text{C}_2\text{O}_4^{2-}]$, and pH of a 0.20 M oxalic acid solution. (on a separate sheet of paper)

6. Final Suggestions for handling diprotic/polyprotic acids.

a. If you're talking about a WEAK di- or polyprotic acid where $K_{a1} \gg K_{a2}$, we can make the assumption that the FIRST ionization step is the only important one. Most of the H^+ will come from this 1st step....any H^+ contributions from the second or third ionization step will be INSIGNIFICANT!



b. The concentration of the conjugate base, A^- , will be numerically equal to K_{a2} . c. If you are talking about H_2SO_4 , because it's a STRONG acid....no short cuts usually! H^+ contributions from both ionization steps will be significant....