Acids and equilibrium

Chapter 14

Acid dissociation equation prediction

- Where A is an acid
- $HA + H_2O \rightarrow H_3O^+ + A^-$
- It is also written
- $HA \rightarrow H^+ + A^-$
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Calculating the pH of strong acids

- HCl is a strong acid. Therefore, it dissociates nearly 100% as follows
- $HCl + H_2O \rightarrow H_3O^+ + Cl^-$
- We can conclude that the *solution* contains **only** H_3O^+ and Cl^- ions, and **no** HCl molecules.
- H_3O^+, Cl^-, and H_2O are the MAJOR SPECIES, those solution components present in relatively high amounts.
- The concentration of the acid is equal to the hydronium concentration for strong acids.

Calculating pH of Strong Acids

- Calculate the pH, pOH, $[H_3O^+]$, and $[OH^-]$ of 0.10 M HNO_3
- Calculate the pH, pOH, $[H_3O^+]$, and $[OH^-]$ of 3.7×10^{-5} M HCl

Calculating the pH of a weak acid

- These require ICE tables
- Again you could use simplified assumptions and test the 5% rule.
- Solver functions on the calculator are completely legal to use on my test and the AP test.

Problem

The hypochlorite ion (ClO^-) is a strong oxidizing agent found in household bleaches and disinfectants. It is also the active ingredient that forms when swimming pool water is treated with chlorine. In addition to its oxidizing abilities, the hypochlorite ion has a relatively high affinity for protons (it is a much stronger base than Cl^-, for example) and forms the weakly acidic hypochlorous acid (HOCl, $K_a = 3.5 \times 10^{-8}$). Calculate the pH of a 0.10 M aqueous solution of hypochlorous acid.

Answer

- $HOCl + H_2O \rightleftharpoons H_3O^+ + ClO^-$
- I .10 M 0 0
- C -x +x +x
- E .1-x x x
- $K_a = \frac{[H_3O^+][ClO^-]}{[HOCl]}$ $\quad 3.5 \times 10^{-8} = \frac{x^2}{.1 - x}$
- $x = 5.9 \times 10^{-5}$
- The x value is $[H_3O^+]$ so pH = 4.23

Another problem

- The conjugate acid of ammonia, NH_4^+, is a weak acid. If a 0.2 M NH_4Cl solution has a pH of 5.0, what is the K_a of NH_4^+?

Another problem

- Cyanic acid (HOCN), an extremely acrid, unstable substance, is used industrially to make cyanates. What is the $[H_3O^+]$ and pH of 0.10 M HOCN? K_a of cyanic acid is 3.5×10^{-4}.

Mixing weak acids

- Calculate the pH of a solution that contains 1.00 M HCN ($K_a = 6.2 \times 10^{-10}$) and 5.00 M HNO_2 ($K_a = 4.0 \times 10^{-4}$). Also calculate the concentration of cyanide ion (CN^-) in this solution at equilibrium.

pH

- What would the pH of a 1.0×10^{-11} M HCl solution be?
- It would be 7!!! No not 11, it is a solution of HCl!!!
- Remember it is a water solution
- $H_2O \rightleftharpoons OH^- + H^+$
- I 1×10^{-7} M $(1\times10^{-7}$ M$+1\times10^{-11}$ M)
- C -x -x
- E 1×10^{-7} -x 1.0001×10^{-7} -x
- $K_w = 1\times10^{-14} = (1\times10^{-7} - x)(1.0001\times10^{-7} - x)$
- $x = 1.0 \times 10^{-12}$

How to make it

- Another way to consider this would be how you would make a solution of 1.0×10^{-11} M HCl
- Assume you start with 1 mL of .01 M HCl
- .01 M (.01 L) = 1×10^{-11} M (V)
- V = 1×10^{7} L or 10 ML
- An Olympic size swimming pool is 2.5×10^{6} L, that means 1 mL of 0.10 M HCl is enough to to make 4 Olympic swimming pools worth.
- Each pool is 50 m x 25m x 2m or 164 ft x 82 ft x 6 ft