March 11, 2002

- ✓**Exam #2**
  - ✓7 pm, Kalkin 001
  - ✓Exam #2 info page now *up to date!*
- ✓**Monday (today!) problem session**

  3:00 - 4:00 pm, A531 Cook
- ✓**SGA evaluation test program!**
  - ✓Email your comments to me *anonymously!*
  - ✓Available for *24 hours* (**March 12th only)**
  - ✓See link on course webpage

pH of Strong Acid solutions

Simple - Strong acids dissociate *completely*:

$$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$$

So, what's the pH of a ***0.10 M HCl*** solution?

C_{HCl} **= 0.10 M**, so:

$[H^+]$ = 0.10 *M* *(complete dissociation)*

pH = -Log(0.10) = ***1.00***

(↑ solution concentration)

How about 1.0 x 10^{-10} *M* HCl?

As before:

$[H^+] = C_{HCl} = 1.0 \times 10^{-10}$ *M*

pH = ***10.00***

Yikes! It's BASIC?!

Ooops! There are *TWO sources of H^+*:

$$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$$

and

$$H_2O\ (l) \leftrightarrows H^+\ (aq) + OH^-\ (aq)$$

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$[H^+]$ from two reactions

So:

$$[H^+] = [H^+]_{HCl} + [H^+]_{H2O}$$

$$[H^+] = C_{HCl} + [OH^-]$$

$$[H^+] = C_{HCl} + K_w / [H^+]$$

It's a quadratic! Rearranging:

$$[H^+]^2 - C_{HCl}[H^+] - K_w = 0$$

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On to the solution!

$$[H^+]^2 - C_{HCl}[H^+] - K_w = 0$$

C_{HCl}: 1.0×10^{-10}

K_w: 1.0×10^{-14}

Solving for $[H^+]$, gives:

$[H^+] = \mathit{1.00050 \times 10^{-7}\ M}$

pH = 6.99978 = ***7.00***

✓Autoionization of water is the *major source* of H^+ in this solution

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Weak Acids - pH Calculation

- If we have K_a and solution concentration, this is just a straightforward equilibrium problem

Example: Calculate the pH of a 1.0×10^{-1} *M* **HF** solution ($K_a = 7.2. \mathrm{X}\ 10^{-4}$).

First, identify the major sources of H^+:

✓**HF** ← ***Major Source of*** H^+

✓$\mathbf{H_2O}$ — *Safe to ignore:*
- $K_a \gg K_w$
- C_{HF} is large

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Apply *ICE*

$$HF(aq) \leftrightarrows H^+(aq) + F^-(aq)$$

	HF (aq)	H^+ (aq)	F^- (aq)
I	1.0×10^{-1} *M*	-	-
C	-x	+x	+x
E	1.0×10^{-1} - x	x	x

Recall: $K_a = \frac{[H^+][F^-]}{[HF]} = 7.2 \times 10^{-4}$

Substituting: $\frac{x^2}{1.0 \times 10^{-1} - x} = 7.2 \times 10^{-4}$

Quadratic Formula?

Rearranging:

$$x^2 + 7.2 \times 10^{-4}x - 7.2 \times 10^{-5} = 0$$

Substituting:

$$x = \frac{-7.2 \times 10^{-4} \pm 1.6986 \times 10^{-2}}{2}$$

Finally: $x = 8.1329 \times 10^{-3} = [H^+]$

pH = 2.0897 = ***2.09***

Successive Approximations?

$$\frac{x^2}{1.0 \times 10^{-1} - \mathbf{x}} = 7.2 \times 10^{-4}$$

Assume: $x \ll 1.0 \times 10^{-1}$

$$\frac{(x')^2}{1.0 \times 10^{-1}} = 7.2 \times 10^{-4}$$

$$x' = 8.4853 \times 10^{-3}$$

First approximation

$$\frac{(x'')^2}{1.0 \times 10^{-1} - 8.4853 \times 10^{-3}} = 7.2 \times 10^{-4}$$

2nd approx

$x'' =$ ***8.11730 x 10^{-3}***

pH = ***2.09***

4.5% change - *Stop!*