

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!*

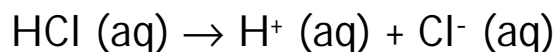
✓ Available for *24 hours* (**March 12th only**)

✓ See link on course webpage

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pH of Strong Acid solutions

Simple - Strong acids dissociate *completely*:



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

$C_{\text{HCl}} = 0.10 \text{ M}$, so:



solution
concentration

$[\text{H}^+] = 0.10 \text{ M}$ (*complete dissociation*)

$$\text{pH} = -\text{Log}(0.10) = \underline{\underline{1.00}}$$

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How about $1.0 \times 10^{-10} \text{ M HCl}$?

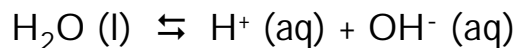
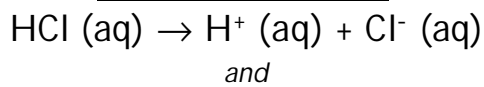
As before:

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

$$\text{pH} = \underline{\underline{10.00}}$$

Yikes! It's
BASIC?!

Ooops! There are TWO sources of H^+ :



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$[\text{H}^+]$ from two reactions

So:

$$[\text{H}^+] = [\text{H}^+]_{\text{HCl}} + [\text{H}^+]_{\text{H}_2\text{O}}$$

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

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

It's a quadratic! Rearranging:

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

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On to the solution!

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

\uparrow 1.0×10^{-10} \uparrow 1.0×10^{-14}

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

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

$$pH = 6.99978 = \underline{\underline{7.00}}$$

✓ 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 $1.0 \times 10^{-1} M$ HF solution ($K_a = 7.2 \times 10^{-4}$).

First, identify the major sources of H^+ :

✓ HF ←

Major Source of H^+

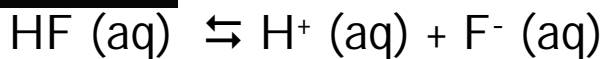
✓ H₂O

Safe to ignore:

- $K_a \gg K_w$
- C_{HF} is large

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Apply ICE



$$I \quad 1.0 \times 10^{-1} M \quad - \quad -$$

$$C \quad -x \quad +x \quad +x$$

$$E \quad 1.0 \times 10^{-1} - x \quad x \quad x$$

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

Substituting:

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

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Quadratic Formula?

Rearranging:

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

Substituting:

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

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

$$\text{pH} = 2.0897 = \underline{\underline{2.09}}$$

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Successive Approximations?

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

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

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

$$x'' = \underline{\underline{8.11730 \times 10^{-3}}}$$

$$\text{pH} = \underline{\underline{2.09}}$$

4.5% change - Stop!

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