3/27/19

Last lecture

$pH = -\log[H_3O^+]$ // $[H_3O^+] = 10^{-pH}$

Self-ionization of water: $2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

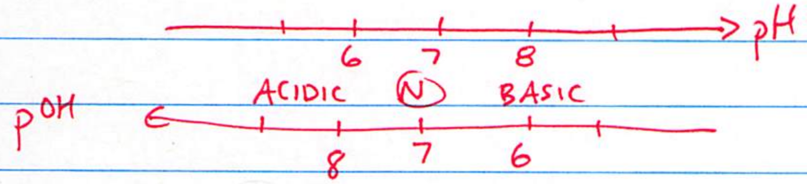
$$K_w = [H_3O^+][OH^-] = 1.0\times10^{-14} \quad (25°C)$$

pure water — SAME $\Rightarrow [H_3O^+] = [OH^-] = \sqrt{K_w} = 1.0\times10^{-7}M$

'p' = $-\log[\ ]$, so $pOH = -\log[OH^-]$

can show: $pH + pOH = 14.00$

so, if we know $[OH^-]$, can calculate pOH, then pH!



pH of strong + weak acid sol^{ns}

$pH = -\log[H_3O^+]$
  ↳ or H^+

H^+ comes from break down of acid:

strong acid: $HA \longrightarrow H^+ + A^-$

weak acid: $HA \rightleftharpoons H^+ + A^-$

(water self ionizes: $H_2O \rightleftharpoons H^+ + OH^-$

$\sim 10^{-7}M$
(v. small, often ignore)

strong acids 100% dissociation.

pH of 0.10M HCl?

lazy...
$HCl \xrightarrow{100\%} H^+ + Cl^-$
$0.10M \xrightarrow{100\%} 0.10M \quad 0.10M$

$pH = -\log[H^+] = -\log\underbrace{[0.10]}_{2sf} = \underbrace{1.00}_{2dp}$

weak acids

<100% dissoc. ~ set up + solve ICE-chart

ex: What's pH of 0.10M $HC_2H_3O_2(aq)$? $K_a = 1.8 \times 10^{-5}$ (25°C)

Write out chem. eq for K_a: $HC_2H_3O_2(aq) + H_2O(l) \overset{H^+}{\rightleftharpoons} H_3O^+(aq) + C_2H_3O_2^-(aq)$

	$HC_2H_3O_2(aq)$	$H_2O(l)$	$H_3O^+(aq)$	$C_2H_3O_2^-(aq)$
I	0.10	—	≈ 0	0
C	$-x$	—	$+x$	$+x$
E	$(0.10-x)$	—	(x)	(x)

$$K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]_{eq}} \Rightarrow 1.8 \times 10^{-5} = \frac{(x)(x)}{(0.10-x)}$$

Quadratic in x

assume: $x \ll 0.10$

$K_a = 1.8\times10^{-5} \approx \frac{x^2}{0.10} \Rightarrow x = \sqrt{0.10\times1.8\times10^{-5}}$

$= 1.34\times10^{-3}$

(0.00134)

5% rule?

let's make sure <5% has dissociated!

$\frac{[H_3O^+]_{eq}}{[HA]_0}\times100 = \frac{x}{0.10}\times100 = \frac{1.34\times10^{-3}}{0.10}\times100$

$= 1.34\%$ ✓

no need to solve Quad. eq!

pH? $pH = -\log[H_3O^+]$

$= -\log[x]$

$= -\log[1.34\times10^{-3}] = 2.87$

2sf → 2dp

0.10M $HC_2H_3O_2$

pH of 0.10M HCl was 1.00

Q: pH of 0.10 M $HClO_2(aq)$ $K_a = 1.1\times10^{-2}$

Ka chem eq: $HClO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO_2^-(aq)$ (H^+)

	$HClO_2(aq)$	$H_2O(l)$	$H_3O^+(aq)$	$ClO_2^-(aq)$
I	0.10	—	≈0	0
C	$-x$	—	$+x$	$+x$
E	$(0.10-x)$	—	(x)	(x)

$K_a = \frac{[H_3O^+][ClO_2^-]}{[HClO_2]} \Rightarrow 1.1\times10^{-2} = \frac{x^2}{0.10-x}$

assume: $x \ll 0.10$

then: $1.1\times10^{-2} \approx \frac{x^2}{0.10}$

$\Rightarrow x = \sqrt{0.10\times1.1\times10^{-2}} = 0.0332$ / $\frac{x}{0.10}\times100 = 33\%$

not <5%

$$\Rightarrow \quad 1.1 \times 10^{-2} = \frac{x^2}{0.10 - x}$$

$$1.1 \times 10^{-2}(0.10 - x) = x^2$$

$$1.1 \times 10^{-3} - 1.1 \times 10^{-2} x = x^2$$

$$\underbrace{1}_{a} x^2 + \underbrace{1.1 \times 10^{-2}}_{b} x \underbrace{- 1.1 \times 10^{-3}}_{c} = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$x = 0.0281$ or -0.039

✓ ✗ means −ve [ ]

$[H_3O^+] = x = 0.0281\,M$

$pH = -\log [H_3O^+]$
$= 1.55$

$0.10\,M$, $K_a = 1.1 \times 10^{-2}$

compare: HCl, $0.10\,M$, $pH = 1.00$