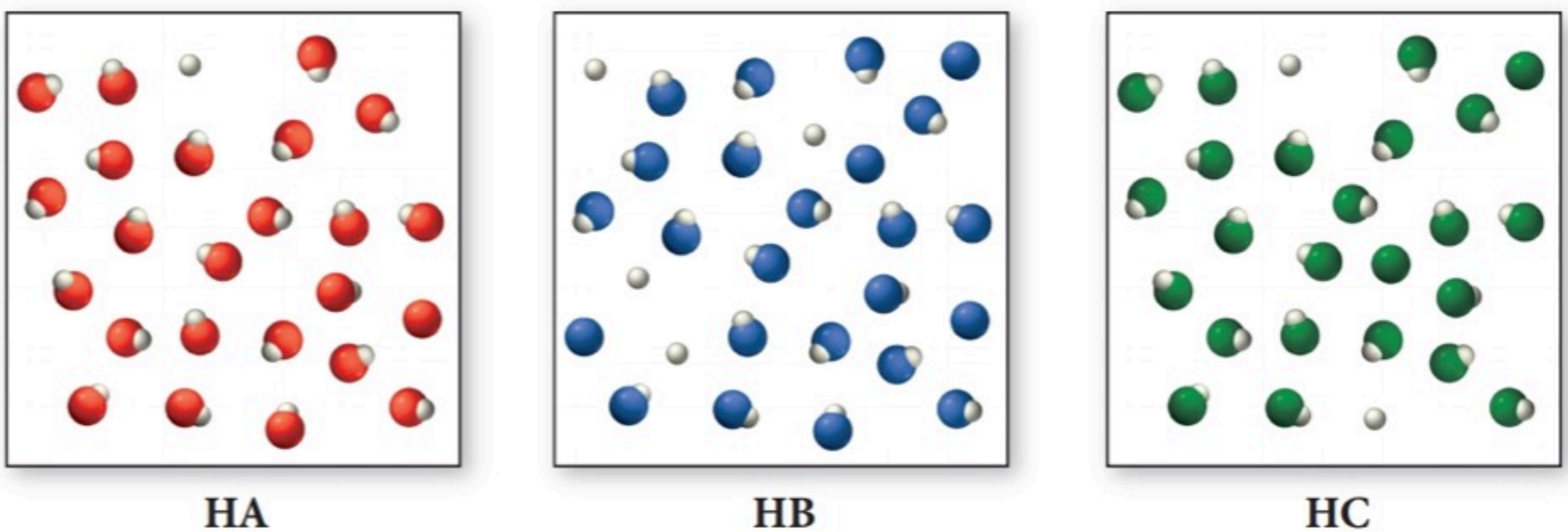
CONCEPTUAL

**CONNECTION 16.2**

**The Magnitude of the Acid Ionization Constant** Consider the three generic weak acids HA, HB, and HC. The images shown here represent the ionization of each acid at room temperature. Which acid has the largest $K_a$?




HB would have the largest K_a because there are more dissociated hydrogen ions (the white balls) in solution!

3/25/2019

## Autoionization of $H_2O$

$H_2O$ - can act as both an ACID + a BASE
- amphoteric

$H^+$

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

BASE ACID

simplified as: $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$

$$K_w = \frac{[H_3O^+][OH^-]}{[H_2O]^2} = [H^+][OH^-]$$

$K_w$ ↳ water

$[H_2O]^2$ → = 1 (pure liquid)

@ 25°C, $K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$

pure water: $[H^+]$ ($[H_3O^+]$) $= [OH^-] = \sqrt{1.0 \times 10^{-14}}$

$= 1.0 \times 10^{-7}\, M$.

Acidic solⁿ: $[H_3O^+] > [OH^-]$

ex: $[H_3O^+] = 1.0 \times 10^{-3}\, M$ Acidic?

since $K_w = 1.0 \times 10^{-14} = [H_3O^+][OH^-]$ ✓ ✓ ? $\Rightarrow [OH^-] = \frac{K_w}{[H_3O^+]}$ ~~$= 1.0 \times 10^{-11}$~~

$[OH^-] = 1.0 \times 10^{-11}\, M$

$[H_3O^+] > [OH^-] \Rightarrow$ ACIDIC!

ACIDIC $[H_3O^+] > [OH^-]$

BASIC sol^ns ... $[H_3O^+] < [OH^-]$

NEUTRAL sol^ns ... $[H_3O^+] = [OH^-]$

} always true!

## pH scale

$$pH = -\log_{10}[H^+] \quad // \quad [H^+] = 10^{-pH}$$

($H^+ \rightarrow H_3O^+$)

logarithmic scale
- when $[H^+]$ changes by a factor of 10
- pH " ——— " of 1

ex: $[H^+] = 1.0 \times 10^{-3}$ M

$$pH = -\log_{10}[1.0 \times 10^{-3}] = 3.00$$

#sf —same→ #dp

2sf. 2dp.

$$[H^+] = 10^{-pH} = 10^{-3.00} = 1.0 \times 10^{-3}\ M$$

2sf

neutral @25°C $[H^+] = 1.0 \times 10^{-7}$ M, $pH = -\log_{10}(1.0 \times 10^{-7})$

$= 7.00$

2dp

@25°C ——————→ pH

<7 7 >7

ACIDIC NEUTRAL BASIC

If pH = 8.40, Q: What's $[H_3O^+]$ ?

$[OH^-]$ ?

$[H^+] = 10^{-pH}$, $K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$

$pH = 8.40$

2dp 2sf

$[H^+] = 10^{-pH} = 10^{-8.40} = 3.98 \times 10^{-9}$

$[H^+]$ ✓

$[OH^-]$ ?

$= 4.0 \times 10^{-9} M$

✓ ✓ ?

$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$

2sf.

$[OH^-] = \frac{K_w}{[H^+]} = \frac{1.0 \times 10^{-14}}{3.98 \times 10^{-9}} = 2.5 \times 10^{-6} M$

2sf.

BASIC. (1) $[OH^-] > [H^+]$

(2) $pH > 7$

Other p-scales

$pH = -\log[H^+]$ $pOH = -\log[OH^-]$

since: $K_w = [H^+][OH^-]$

@ 25°C $1.0 \times 10^{-14} = [H^+][OH^-]$

$\log(AB) = \log A + \log B$

$-\log()$ $-\log(1.0 \times 10^{-14}) = -\log([H^+][OH^-])$

$14.00 = -\log[H^+] + -\log[OH^-]$

$\Rightarrow$ $\boxed{14.00 = pH + pOH}$

ex: if $[OH^-] = 1.0 \times 10^{-3} M$ / $pOH = -\log[OH^-] = 3.00$ ($1.0 \times 10^{-3}$)

pH ? $pH = 14.00 - pOH = 11.00$ (BASIC)