4/1/2019

Buffers:

1) Weak acid
2) Conj. base

(OR)

1) Weak base
2) Conj. acid (in eq's)

ex: $HC_2H_3O_2(aq)$ / $C_2H_3O_2^-(aq)$
acetic acid — acetate (must have counter-ion)

$NH_3(aq)$ / $NH_4^+(aq)$
ammonia — ammonium

$HC_2H_3O_2$ / $NaC_2H_3O_2$

NH_3 / NH_4Cl (in lab)

Let's calculate pH of a buffer. ($K_a = 1.8\times10^{-5}$)

ex: A sol'n that is 0.100M $HC_2H_3O_2(aq)$ and 0.100M $NaC_2H_3O_2(aq)$

Since we have a weak acid, we must write out the Ka rxn.

$NaC_2H_3O_2 \rightarrow Na^+ + C_2H_3O_2^-$

H^+ (1×10^{-7} M)

$HC_2H_3O_2(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$

	$HC_2H_3O_2$	H_2O	H_3O^+	$C_2H_3O_2^-$
I	0.100	—	≈ 0	0.100
C	$-x$	—	$+x$	$+x$
E	$(0.100-x)$	—	(x)	$(0.100+x)$

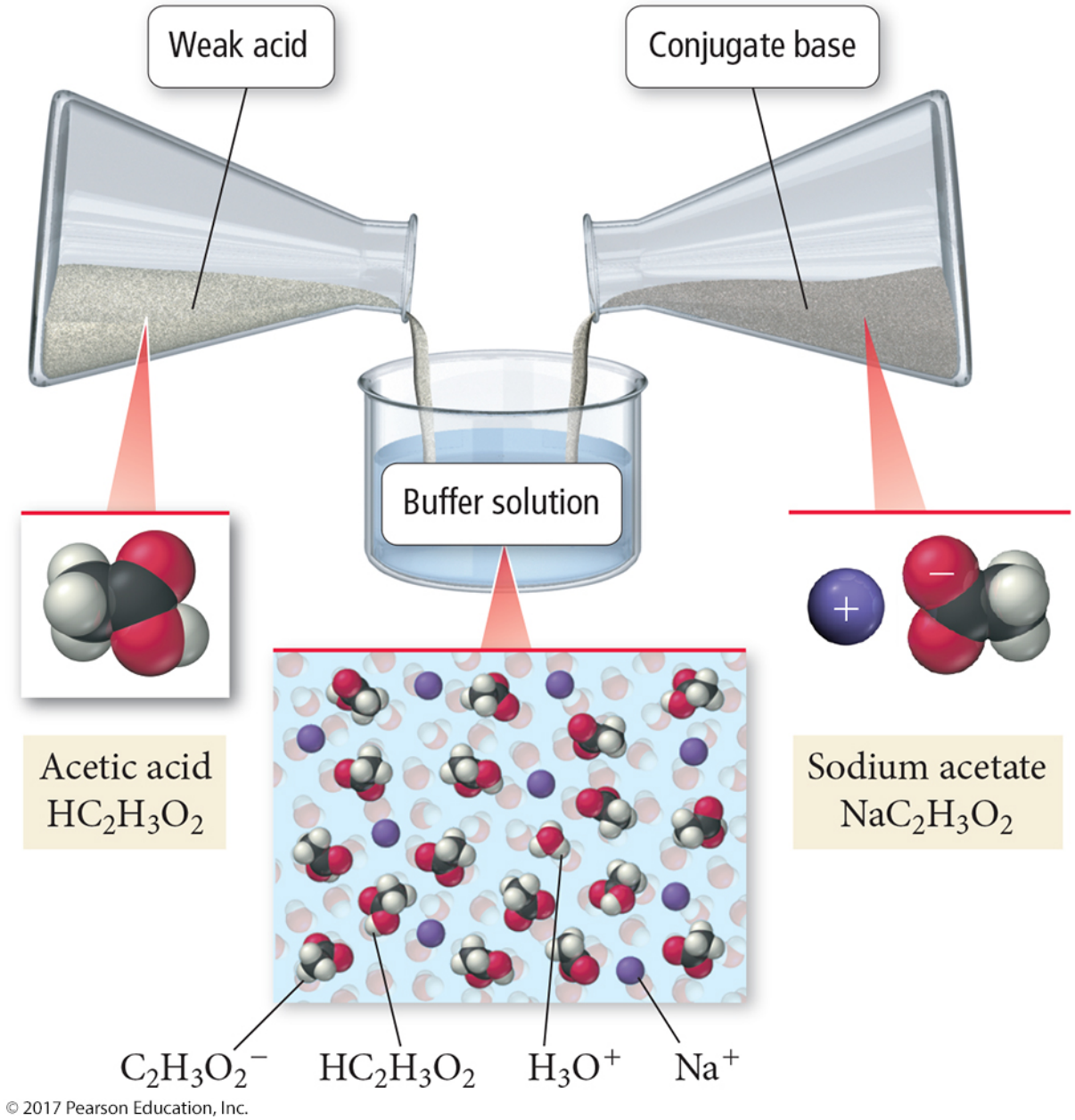
$$K_a = 1.8\times10^{-5} = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]_{eq}} = \frac{(x)(0.100+x)}{(0.100-x)}$$ (Quad in x)

let's assume $x \ll 0.100$, then: $1.8\times10^{-5} \approx \frac{x(0.100)}{(0.100)}$

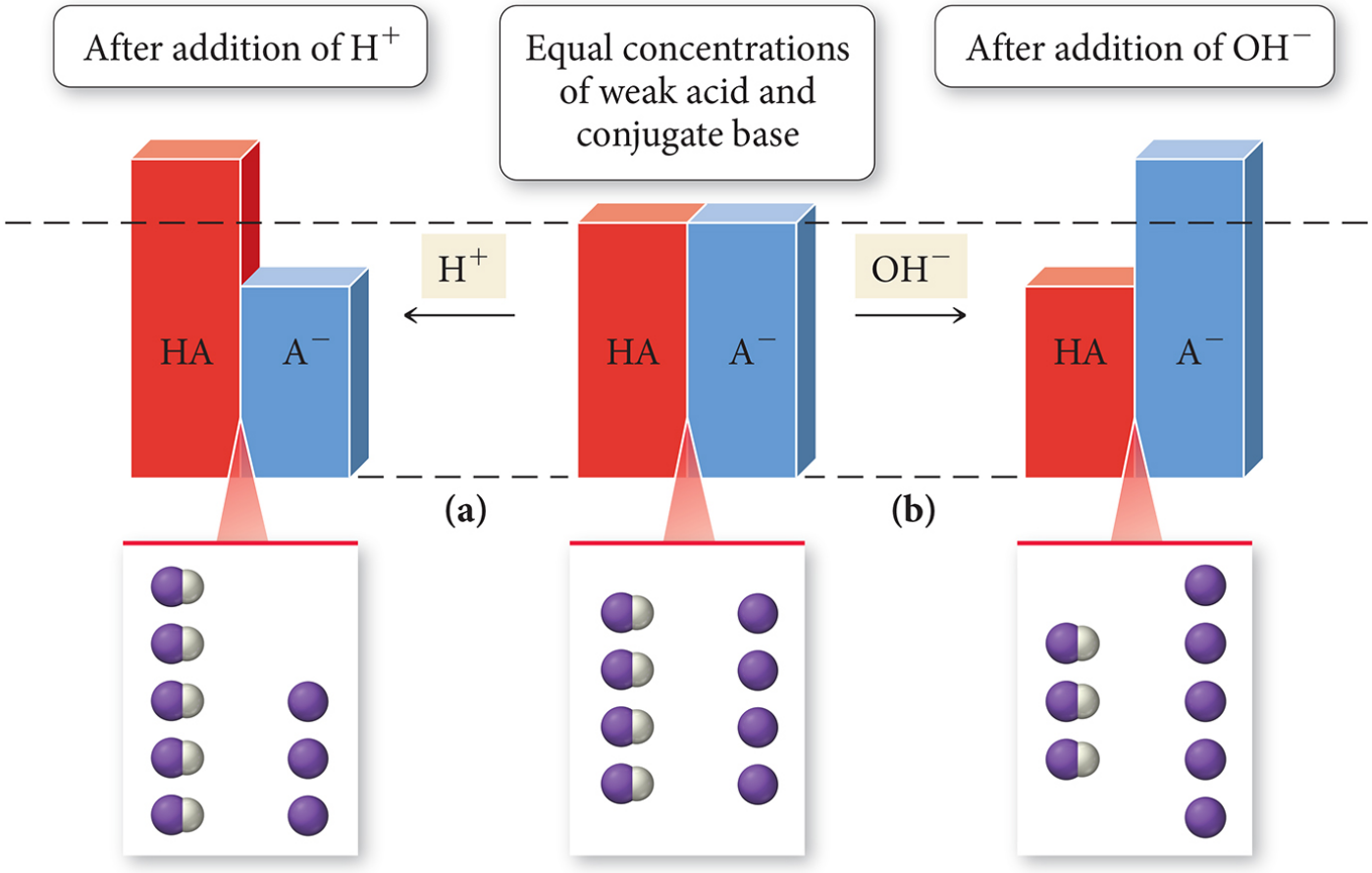
$\Rightarrow x = 1.8\times10^{-5}$

check using 5% rule (<5% dissoc) / $\frac{x}{0.100}\times100 = 0.018\%$ ✓

Formation of a Buffer



Action of a Buffer



$$pH = -\log[H_3O^+] = -\log[1.8\times10^{-5}] = 4.74$$

(x = 1.8×10^{-5})

2sf ⟶ 2dp.

Henderson – Hasselbalch (H-H) equation.

easier way to find pH of buffers

K_a eq: $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

(H+ : $HA \rightarrow A^-$; conj. acid-base pair: HA / A^- and H_3O^+ / H_2O)

$$K_a = \frac{[H_3O^+][A^-]}{[HA]_{eq}} \Rightarrow [H_3O^+] = K_a \times \frac{[HA]}{[A^-]_{eq}}$$

if we assume "x is small", then $[HA]_{eq} \approx [HA]_0 = [acid]$

$[A^-]_{eq} \approx [A^-]_0 = [base]$

$$\Rightarrow [H_3O^+] = K_a \times \frac{[acid]}{[base]}$$

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

$-\log$ "p"

$$-\log[H_3O^+] = -\log(K_a) \oplus -\log\frac{[acid]}{[base]}$$

$$\boxed{pH = pK_a \oplus \log\frac{[base]}{[acid]}}$$

H–H eq.

$\log A^n = n\cdot\log A$

$-1\times\log A = \log A^{-1}$

$-1\times\log\left(\frac{A}{B}\right) = \log\left(\frac{A}{B}\right)^{-1}$

$= \log\left(\frac{B}{A}\right)$

last buffer (pH = 4.74) ← ice-chart, etc...

[acid] = 0.100M , $K_a = 1.8 \times 10^{-5}$ (acetic acid)

[base] = 0.100M

H-H $\quad pH = pK_a + \log \frac{b}{a}$, $pK_a = -\log(K_a)$

$= -\log(1.8 \times 10^{-5})$

$= 4.74 + \log \frac{0.100M}{0.100M}$ $\quad = 4.74$

$\log(1) = 0$

$10^0 = 1$

pH = 4.74

Q: What's pH of a buffer that is (weak acid)

0.050M benzoic acid, $C_6H_5CO_2H$, $K_a = 6.5 \times 10^{-5}$

0.150M sodium benzoate, $NaC_6H_5CO_2$

$Na^+ \; C_6H_5CO_2^-$ (base (conj))

H-H: $\quad pH = pK_a + \log \frac{[base]}{[acid]}$

$pK_a = -\log(K_a)$

$= 4.187 + \log \frac{0.150M}{0.050M}$ $\quad = 4.187$

$= 4.187 + 0.477$

$= 4.66$ (2dp)

$\log(>1) = +ve$

$\log(=1) = 0$

$\log(0<\ldots<1) = -ve$