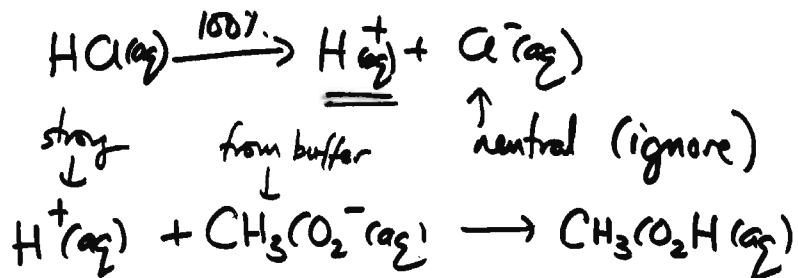


More fun w/ buffers!

120.0 mL of our buffer  $\rightarrow$  1.50 M  $\text{CH}_3\text{CO}_2\text{Na}$   
 $\rightarrow$  1.00 M  $\text{CH}_3\text{CO}_2\text{H}$  pH = 4.92  
 + add 10.0 mL of 2.00 M  $\text{HCl}$  (aq).  
 pH = ? strong acid.



Problem: Volumes change, then [ ] change  
 So... its easier to work w/ moles.

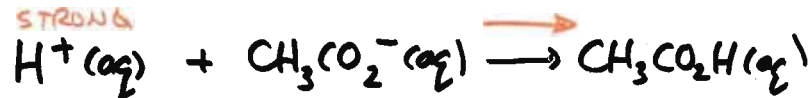
|                     |         |     |              |                    |
|---------------------|---------|-----|--------------|--------------------|
| $\times \text{H}^+$ | 10.0 mL | 1 L | 2.00 mol HCl | 1 mol $\text{H}^+$ |
|                     |         |     |              |                    |
|                     | 1000 mL | 1 L | 1 mol HCl    |                    |

= 0.0200 mol  $\text{H}^+$

|                            |          |     |  |                                  |
|----------------------------|----------|-----|--|----------------------------------|
| $\text{CH}_3\text{CO}_2^-$ | 120.0 mL | 1 L | 1.50 mol $\text{CH}_3\text{CO}_2\text{Na}$ | 1 mol $\text{CH}_3\text{CO}_2^-$ |
|                            |          |     |  |                                  |
|                            | 1000 mL  | 1 L | 1 mol $\text{CH}_3\text{CO}_2\text{Na}$    | 1 mol $\text{CH}_3\text{CO}_2^-$ |
|                            |          |     | = 0.180 mol $\text{CH}_3\text{CO}_2^-$     |                                  |

$\text{CH}_3\text{CO}_2\text{H} \dots 0.120 \text{ mol } \text{CH}_3\text{CO}_2\text{H}$

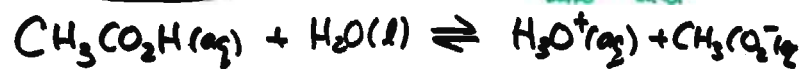
let's write out neat rxn!



|   |         |         |                           |
|---|---------|---------|---------------------------|
| I | 0.0200  | 0.180   | 0.120                     |
| C | -0.0200 | -0.0200 | +0.0200                   |
| E | 0       | 0.160   | 0.140 $\rightarrow$ 1.08M |

#mol  
 $[\text{CH}_3\text{CO}_2^-] = \frac{0.160 \text{ mol}}{0.130 \text{ L}} = 1.23 \text{ M}$

pH of sol<sup>n</sup>? ICE chart it!  
Ka rxn



|   |          |   |             |          |
|---|----------|---|-------------|----------|
| I | 1.08M    | — | $\approx 0$ | 1.23M    |
| C | -x       | — | +x          | +x       |
| E | (1.08-x) | — | (x)         | (1.23+x) |

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{CO}_2^-]}{[\text{CH}_3\text{CO}_2\text{H}]_{\text{eq}}}$$

if  $x \ll 1.08$

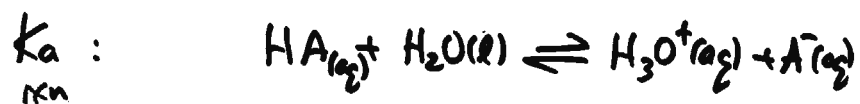
$$\Rightarrow 1.8 \times 10^{-5} = \frac{(x)(1.23+x)}{(1.08-x)} \approx \frac{(x)(1.23)}{(1.08)}$$

$$x = \frac{1.8 \times 10^{-5} \times 1.08}{1.23} = 1.6 \times 10^{-5}$$

5% rule ✓  $\Rightarrow [H^+] = 1.6 \times 10^{-5}$   
 $pH = -\log(x) = 4.80$   
 (decrease of 0.12 units of pH)

Preparing a Buffer w/ a specific pH

Buffer: Weak acid + conj. base  
 $HA \quad A^-$



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

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

$\hookrightarrow -\log_{10} [ ]$

$$-\log_{10} [H_3O^+] = -\log \left( K_a \times \frac{[HA]}{[A^-]} \right)$$

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

$$\Rightarrow pH = -\log_{10} K_a + \underbrace{-\log_{10} \frac{[HA]}{[A^-]}}_{-1 \times \log \frac{[HA]}{[A^-]}}$$

$$\log A^b = b \cdot \log A$$

ex:  $-\log A = \log A^{-1}$

ex:  $-\log \frac{a}{b} = \log \left( \frac{a}{b} \right)^{-1} = \log \left( \frac{b}{a} \right)$

$$\Rightarrow pH = pK_a + \log \frac{[A^-]}{[HA]}$$

Henderson-Hasselbalch equation  
 H-H eq.

$$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

← conj.

"best" buffer is when  $[\text{base}] \approx [\text{acid}]$

$$\Rightarrow \frac{[\text{base}]}{[\text{acid}]} = 1$$

$$\text{pH} = \text{p}K_a + \log 1$$

$$\text{pH} \approx \text{p}K_a$$

best buffer

Caveat: ① Buffers are only 'good' if pH is within 1-unit of pKa.

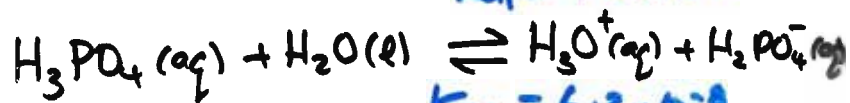
H-H

②  $[\text{base}]$  and  $[\text{acid}]$  in our H-H eqs refer to eqm concs... we will often assume that these are same as orig conc from a dilution.

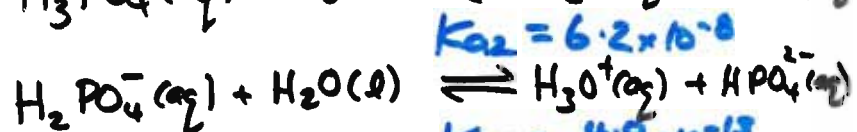
Ex: we want to make 1.0-L of a "phosphate" buffer w/ pH of 7.05

H<sub>3</sub>PO<sub>4</sub> triprotic weak acid.

$$K_{a1} = 7.5 \times 10^{-3}$$



$$K_{a2} = 6.2 \times 10^{-8}$$



$$K_{a3} = 4.8 \times 10^{-13}$$

