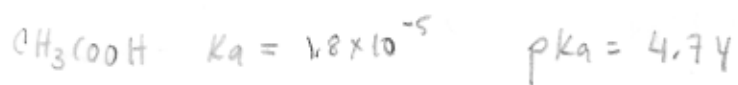
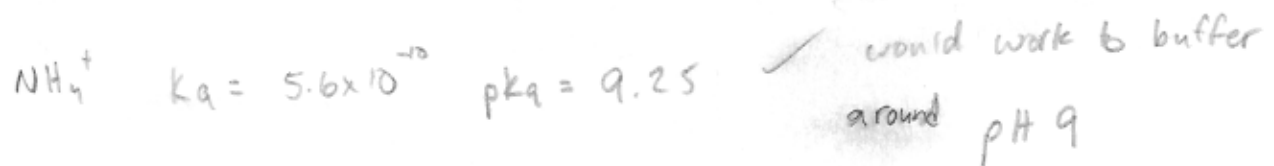


1. Buffer capacity is  $\approx \pm 1$  pH unit away from  $pK_a$  of the conj. acid



HCl is a strong acid, so we would not use it as a buffer.



$$\text{pH} = pK_a + \log \left[ \frac{[\text{conj. base}]}{[\text{conj. acid}]} \right] = pK_a + \log(1) = pK_a$$

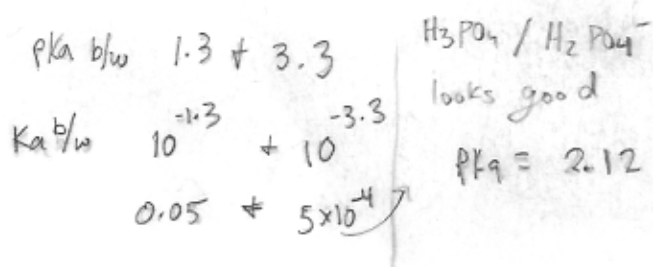
$$\text{pH} = pK_a = -\log(pK_a) = -\log(6.2 \times 10^{-8})$$

$$\text{pH} = 7.21$$

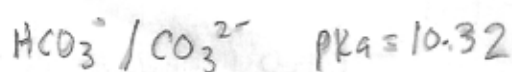
looked up  $K_a$  of  $\text{H}_2\text{PO}_4^-$  in table

3.  $\text{pH} = -\log[\text{H}^+]$

a)  $\text{pH} = -\log(4.5 \times 10^{-3}) = 2.3$



b)  $\text{pH} = -\log(9.7 \times 10^{-14}) = 10.0$



4. Acid-base pair is  $\text{NH}_4^+ / \text{NH}_3$   $pK_a = 9.25$

$$pH = pK_a + \log \left[ \frac{\text{NH}_3}{\text{NH}_4^+} \right] \quad \text{final pH is } 9.00$$

$$pH - pK_a = \log \left[ \frac{\text{NH}_3}{\text{NH}_4^+} \right]$$

$$9.00 - 9.25 = \log \left[ \frac{\text{NH}_3}{\text{NH}_4^+} \right] \rightarrow 10^{-0.25} = \frac{[\text{NH}_3]}{[\text{NH}_4^+]}$$

since the volume is the same; we can see that the molar ratio of  $\text{NH}_3$  to  $\text{NH}_4^+$  is  $10^{-0.25}$ .

$$\frac{\text{moles NH}_3}{1 \text{ L}} = \frac{0.10 \text{ moles NH}_3}{0.5 \text{ L}} \times 0.5 \text{ L} = 0.05 \text{ mol NH}_3$$

$$10^{-0.25} = \frac{0.05 \text{ mol NH}_3}{x \text{ mol NH}_4^+} \quad x = 0.0889 \text{ mol NH}_4^+$$

$$\frac{0.0889 \text{ mol NH}_4^+ \text{Cl}^-}{1} \times \frac{53.49 \text{ g}}{\text{mol}} \approx \boxed{4.8 \text{ g NH}_4^+ \text{Cl}^- \text{ needed}}$$

So Initial condition

$$pH = pK_a + \log \left[ \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} \right]$$

because  $[\text{H}_2\text{PO}_4^-] = [\text{HPO}_4^{2-}]$

$$pH = pK_a = 7.21 \quad (\text{looked up } pK_a \text{ from table})$$

if  $pH = 7.21$ , what is initial  $[\text{H}_3\text{O}^+]$ ?

$$10^{-7.21} = [\text{H}_3\text{O}^+] = 6.2 \times 10^{-8} \text{ M}$$

~~set up~~ ~~table~~ ~~table~~

$[H_3O^+] = 6.2 \times 10^{-8} \frac{\text{moles}}{L}$   $\rightarrow$  since this is a 2.00L solution we have  $1.24 \times 10^{-7} \text{ moles } H_3O^+$

- add  $\frac{0.425 \text{ g NaOH}}{1} \times \frac{\text{mole}}{40 \text{ g}} = 0.0106 \text{ mol NaOH} \rightarrow 0.0106 \text{ mol OH}$



thus remaining amount of OH = initial amount - consumed amount

$0.0106 \text{ mol OH} - 1.2 \times 10^{-7} \text{ mol OH} \approx 0.0106 \text{ mol OH}$

thus  $pOH = -\log\left(\frac{0.0106 \text{ mol OH}}{2L}\right) = 2.27$

$\therefore pH = 11.73$

6.  $pH = pKa + \log \frac{[\text{propanoate}]}{[\text{propanoic acid}]}$   $pKa = 4.85$

$pH = 4.85 + \log\left(\frac{0.3}{0.2}\right) = 5.02$

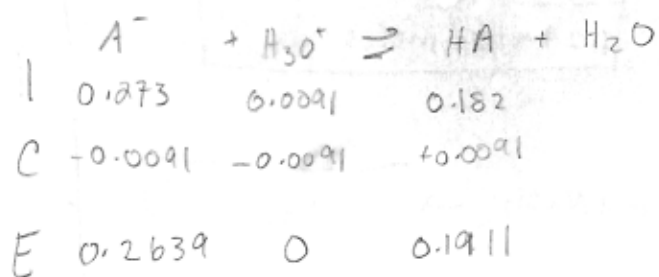
- Add HCl. what is the limiting reagent?  $\xrightarrow{\text{or}}$   $HCl + \text{propanoate} \rightleftharpoons \text{propanoic acid} + Cl^-$

moles HCl:  $\frac{0.10 \text{ moles HCl}}{1 \text{ Liter}} \times \frac{1 \times 10^{-3} L}{1} \rightarrow 1 \times 10^{-4} \text{ moles } [H^+]$

moles propanoate:  $\frac{0.30 \text{ moles}}{\text{Liter}} \times \frac{0.01 L}{1} \rightarrow 0.003 \text{ moles } [H^+]$

$\therefore [H^+]$  is the lim. reagent.  
time to set up ICE

$$[H^+]_0 = \frac{1 \times 10^{-4} \text{ moles H}}{0.011 \text{ L}} = 0.0091 \text{ M } H^+ \quad [HA]_0 = 0.182 \text{ M} \quad [A^-]_0 = 0.273 \text{ M}$$



$$K_a = 1.4 \times 10^{-5}$$

$$pH = pK_a + \log \left( \frac{0.2639}{0.1911} \right)$$

$$pH = 4.85 + 0.14 = 4.99$$

7. moles HCl:  $\frac{0.150 \text{ M}}{1} \times 0.050 \text{ L} = 0.0075 \text{ mol HCl}$

moles NaOH: (a)  $\frac{0.150 \text{ M}}{1} \times 0.025 \text{ L} = 0.00375 \text{ mol NaOH}$

\* NaOH is the limiting reagent  $\rightarrow$  0.00375 moles HCl left

$$[H^+] = \frac{0.00375 \text{ moles}}{(0.075 \text{ L})} = 0.05 \text{ M } H_3O^+$$

$$pH = 1.3$$

(b)  $0.150 \text{ M} \times 0.050 \text{ L} = 0.00752 \text{ mol NaOH}$

\* HCl is Lim. Reagent!  $2 \times 10^{-5}$  moles  $OH^-$  left

$$[OH^-] = \frac{2 \times 10^{-5} \text{ moles}}{0.100 \text{ L}} = 1.998 \times 10^{-4} \rightarrow$$

$$pOH = 3.7$$

$$pH = 10.3$$

8. 30.00 mL 0.100 M HA add 0.1 M NaOH (10, 30, 40)

$$\frac{0.1 \text{ moles HA}}{L} \times 0.030 \text{ L} = 0.003 \text{ moles HA}$$

$$\frac{0.1 \text{ moles NaOH}}{L} \times 0.010 \text{ L} = 0.001 \text{ moles NaOH} \quad \times \text{ lim reagent}$$

$$[\text{OH}]_0 = \frac{0.001 \text{ moles NaOH}}{0.04} = 0.025 \text{ M NaOH} \rightarrow 0.025 \text{ M OH}^-$$

$$[\text{HA}]_0 = \frac{0.003 \text{ moles HA}}{0.04} = 0.075 \text{ M HA}$$

|   |         |           |               |              |                      |
|---|---------|-----------|---------------|--------------|----------------------|
|   | HA      | NaOH      | $\rightarrow$ | $\text{A}^-$ | $\text{H}_2\text{O}$ |
| I | 0.075 M | + 0.025 M |               |              |                      |
| C | -0.025  | -0.025    |               | +0.025       |                      |
| E | 0.05    | 0         |               | 0.025        |                      |

Have  $[\text{HA}] \approx [\text{A}^-] \therefore$  buffer

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]} = 4.2 - 0.30 = 3.9$$

30 mL

$$\frac{0.1 \text{ moles NaOH}}{L} \times 0.03 \text{ L} = 0.003 \text{ moles OH}$$

$$[\text{OH}]_0 = \frac{0.003 \text{ moles OH}}{0.06 \text{ L}} = 0.05 \text{ M OH}$$

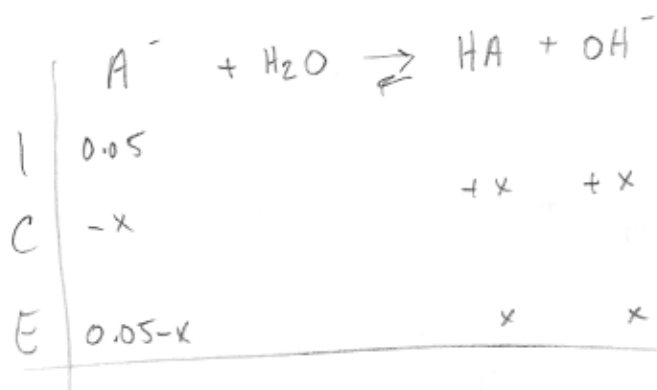
$$[\text{HA}]_0 = \frac{0.003 \text{ moles HA}}{0.06 \text{ L}} = 0.05 \text{ M HA}$$

|   |        |        |                      |              |                      |
|---|--------|--------|----------------------|--------------|----------------------|
|   | HA     | OH     | $\rightleftharpoons$ | $\text{A}^-$ | $\text{H}_2\text{O}$ |
| I | 0.05 M | 0.05 M |                      | 0            |                      |
| C | -0.05  | -0.05  |                      | +0.05        |                      |
| E | 0      | 0      |                      | 0.05 M       |                      |

Salt calculation!

0.05 M  $A^-$ , what is pH?

$$K_a = 6.3 \times 10^{-5} \quad \frac{[HA][H^+]}{[A^-]}$$



$$K_b = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{6.3 \times 10^{-5}} = 1.5 \times 10^{-10}$$

$$K_b = \frac{[HA][OH^-]}{[A^-]} = \frac{x^2}{0.05-x} = 1.5 \times 10^{-10}$$

short cut  $\rightarrow$   $(0.05)(1.5 \times 10^{-10}) = x^2$        $x = 2.82 \times 10^{-6}$

$$pOH = -\log(2.82 \times 10^{-6}) = 5.5$$

$$pH = 8.45$$