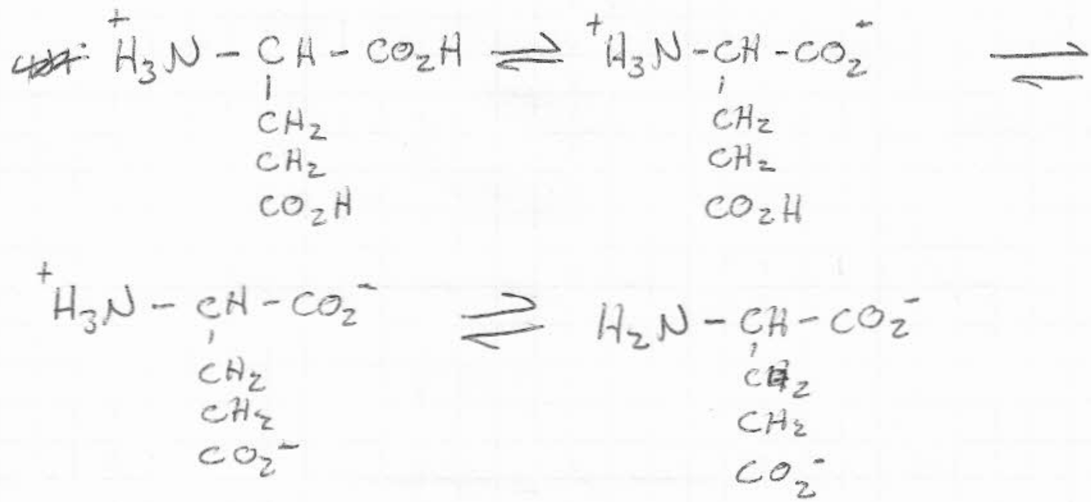
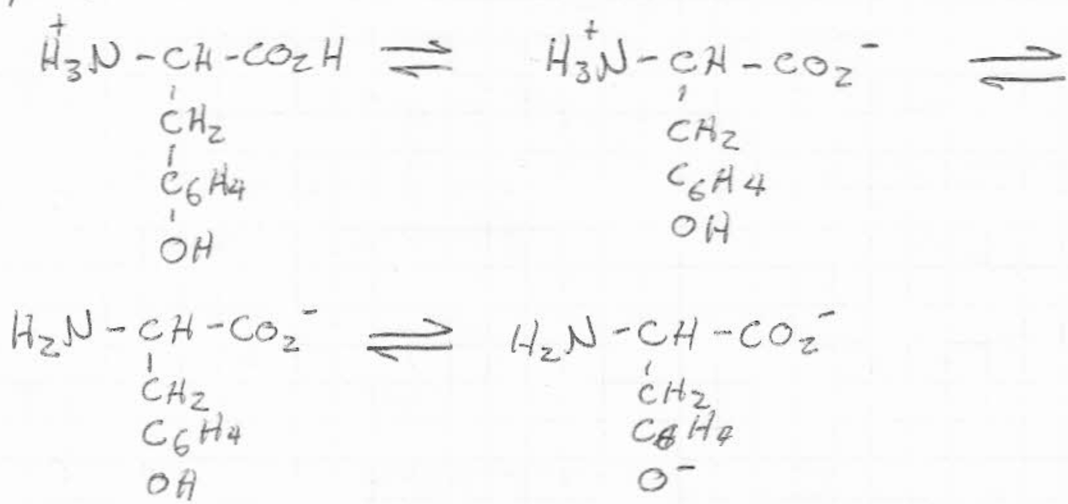
17 At a pH of 8.5 phosphate would not have as good of a buffer capacity.

glutamic acid:

18


tyrosine:



20 a. $pK_{a1} = 2.148$ ($H_3PO_4$)

$pK_{a2} = 7.198$ ($H_2PO_4^-$) ← 7.45

$pK_{a3} = 12.375$ ($HPO_4^{2-}$)

($PO_4^{3-}$)

$NaH_2PO_4$ + $Na_2HPO_4$

b. $7.45 = 7.198 + \log \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$

$\frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = 1.786$

$[HPO_4^{2-}] + [H_2PO_4^-] = 0.050M$

$[H_2PO_4^-] = 0.050M - [HPO_4^{2-}]$

$\frac{[HPO_4^{2-}]}{0.050M - [HPO_4^{2-}]} = 1.786$

$[HPO_4^{2-}] = 0.0321$

$[H_2PO_4^-] = 0.0179$

$1L \,\Big|\, \frac{0.0321 \text{ mol } HPO_4^{2-}}{1L} \,\Big|\, \frac{141.96g}{1 \text{ mol}} =$ **4.56 g $Na_2HPO_4$**

$1L \,\Big|\, \frac{0.0179 \text{ mol } H_2PO_4^-}{1L} \,\Big|\, \frac{119.98g}{1 \text{ mol}}$ = **2.15g $NaH_2PO_4$**

c. one example:

- dissolve 0.050 mol of $NaH_2PO_4$ (6.0g) in ~ 900 mL $H_2O$
- add strong base until a pH of 7.45 is reached
- dilute to 1.000L

$H_2A^+$ · first intermediate form

21 $[H^+] = \sqrt{\frac{K_1K_2F + K_1K_w}{K_1 + F}} = \sqrt{\frac{(1.7\times10^{-2})(8.51\times10^{-10})(0.010) + (1.7\times10^{-2})(10^{-14})}{1.7\times10^{-2} + 0.0100}}$

$= 2.32\times10^{-6} M = [H^+]$ **pH = 5.64**

$H_3A^{2+} \rightleftharpoons H_2A^+ + H^+$

$\frac{[H^+][H_2A^+]}{[H_3A^{2+}]} = 1.7\times10^{-2}$

$H_2A^+ = F =$ **0.010M**

$[H_3A^{2+}] = \frac{(2.32\times10^{-6})(0.010)}{1.7\times10^{-2}} =$ **$1.36\times10^{-6} M$**

$H_2A^+ \rightleftharpoons HA + H^+ \quad K_2$

$\frac{[H^+][HA]}{[H_2A^+]} = 8.51\times10^{-10}$

$[HA] = \frac{(8.51\times10^{-10})(0.010)}{2.32\times10^{-6}} =$ **$3.67\times10^{-6} M$**

$HA \rightleftharpoons H^+ + A^- \quad K_3$

$[A^-] = \frac{(1.51\times10^{-11})(3.67\times10^{-6})}{2.32\times10^{-6}} =$ **$2.39\times10^{-11} M$**

$H_2A^+$ - first intermediate form

22 $pka_1 = 1.6$

$pka_2 = 5.97$

$pka_3 = 9.28$ ← 9.30 buffer with $A^-$ + HA

$\frac{10\,g}{L} \cdot \frac{mol}{197.62\,g} = \frac{0.0522\,mol}{0.100\,L}$

$= 0.522\,M$ (total)

$$9.30 = 9.28 + \log\frac{[A^-]}{[HA]}$$

$$\frac{[A^-]}{[HA]} = 1.047$$

$$[A^-] + [HA] = 0.522\,M$$

$$[A^-] = 0.522 - [HA]$$

$$\frac{0.522 - [HA]}{[HA]} = 1.047$$

$[HA] = 0.255\,M$ → 255 mmol

$[A^-] = 0.267\,M$ → 267 mmol

mmols of KOH

52.2 to convert all $H_2A^+ \rightarrow HA$

26.7 to make $A^-$

$78.9\,mmol\,KOH \cdot \frac{mL}{1\,mmol} = $ **78.9 mL**

24 a. HA  b. $A^-$  c. pH = 7 → $[A^-]/[HA] = 1$

pH = 6 → $[A^-]/[HA] = 0.1$

25 a. 4.00  c. $H_2A$

b. 8.00  d. $HA^-$

e. $A^{2-}$

$H_2A$ $pka_1$ (4.00) $HA^-$ $pka_2$ (8.00) $A^{2-}$

26 a. 9.00  c. $BH^+$

b. 9.00  d. 1000

28 pka = 4.00  pH = 5.00

$\frac{[A^-]}{[HA]} = 10$ at pH = 5.00

$$\alpha_{HA} = \frac{10^{-5}}{10^{-5} + 10^{-4}} = 0.0909$$

$$\alpha_{A^-} = \frac{10^{-4}}{10^{-5} + 10^{-4}} = 0.909$$

$$\frac{0.909}{0.0909} = 10$$