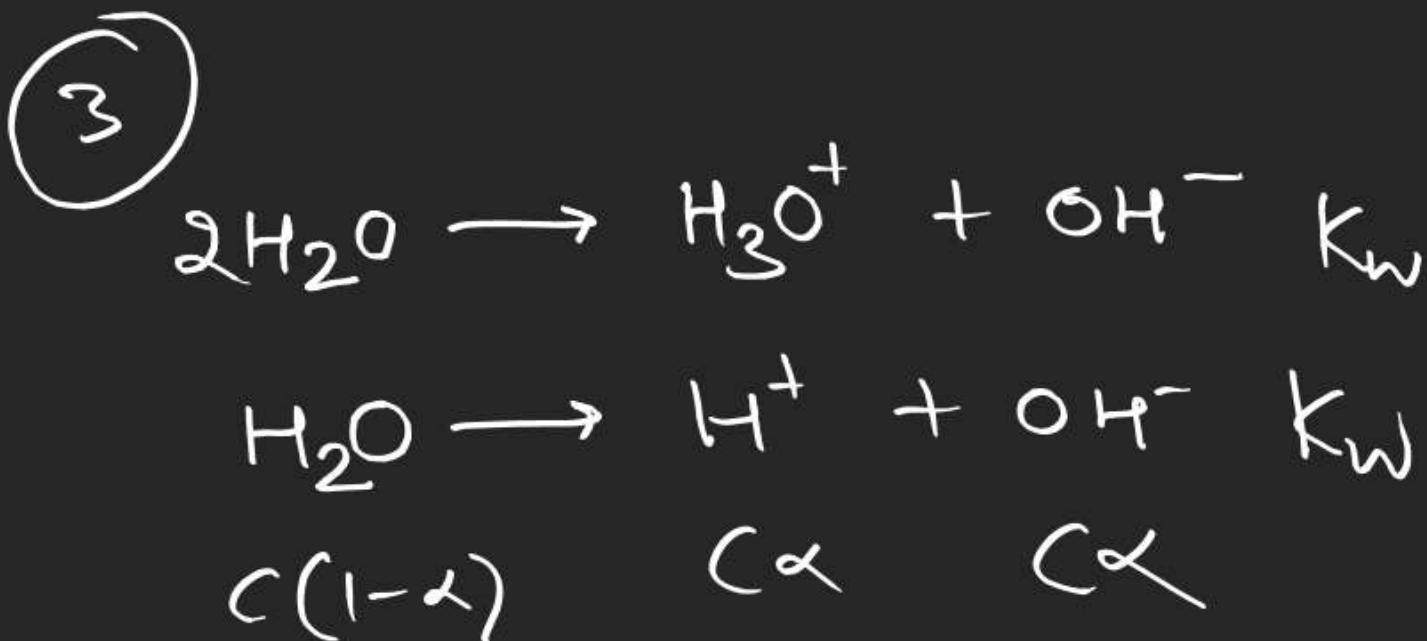
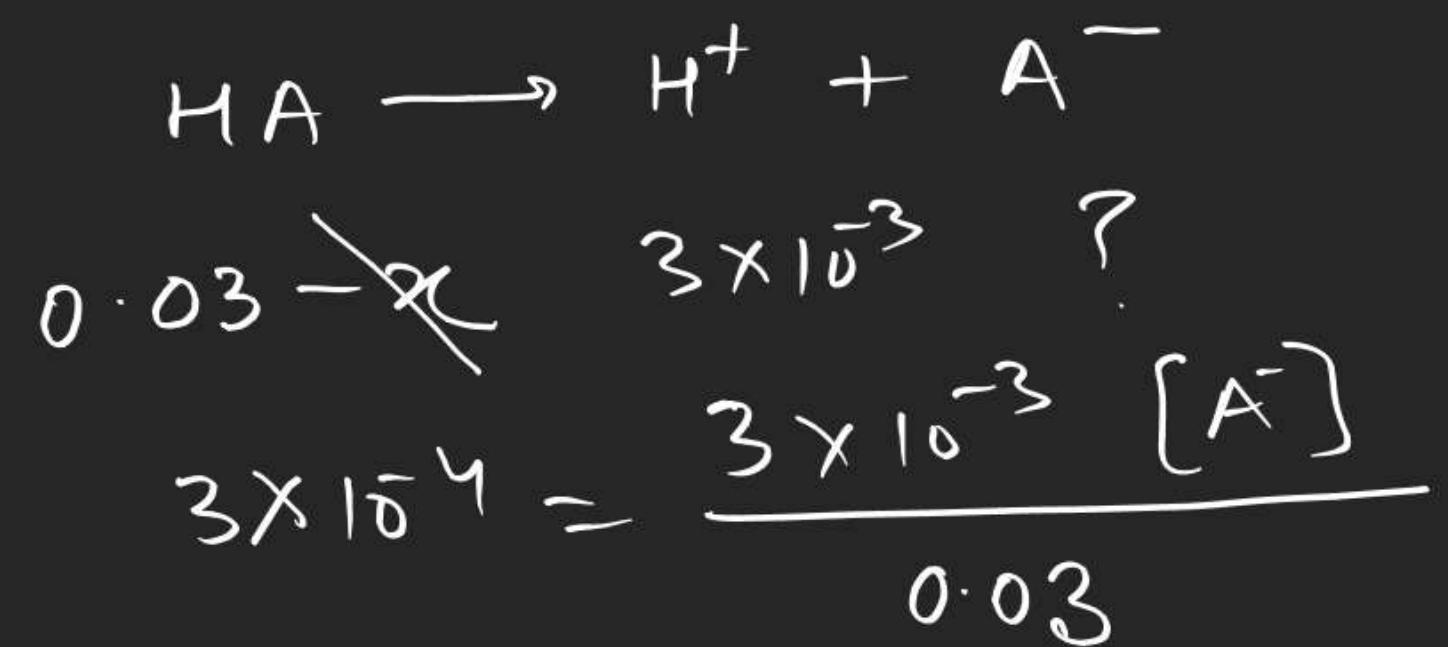


$$\textcircled{16} \quad [H^+] = \sqrt{K_{a_1}C_1 + K_{a_2}C_2} = 3 \times 10^{-3}$$



$$\begin{aligned} K_w &= (c\alpha)^2 \\ &= \left(\frac{1000}{18} \times 3.6 \times 10^{-9} \right)^2 \end{aligned}$$

(17)

0.01 mol HCl

100 ml $\frac{0.05\text{M}}{\text{HCOOH}}$ ($K_a = 1.8 \times 10^{-4}$)

$$K_a = 1.8 \times 10^{-4} = \frac{x^2}{0.05 - x}$$

~~$\sqrt{1 + 10^{-2}}$~~

$$x^2 = 9 \times 10^{-6} \quad pH_i = 2.52$$

$$\frac{1.8 \times 10^{-4}}{0.05} \times 10^3$$

$$\frac{18}{5} \times 10^{-3}$$

$$[\text{H}^+] = \frac{0.01}{0.1} = 0.1\text{M} \quad pH_f = 1$$

Q. 1 mol of HA is added to 1 lit $\text{H}_2\text{O}(l)$. [$K_a = 10^{-4} \text{ M}$] find

$$\textcircled{1} \text{ pH of soln } \textcircled{2}$$

$\textcircled{2}$ pH of soln if it is diluted 10000 times 4.21

$\textcircled{3}$ " " " 10⁷ times 6.78

$\textcircled{4}$ " " " Volume of $\text{H}_2\text{O}(l)$ required to double the pH.

$\textcircled{5}$ " " " " the $[\text{OH}^-]$.

$\textcircled{6}$ " " " removed to double the $[\text{H}^+]$.

$\textcircled{7}$ pH of soln at 80°C at 80°C $K_w = 10^{-14} \text{ M}^2$

$\textcircled{8}$ pH of soln if 3 lit of 10^{-2} M HCl is added.

$\textcircled{9}$ " " " if 3 lit of $\frac{5}{4} \text{ M HB}$ ($K_a = 4 \times 10^{-4} \text{ M}$) is added 1.7

$\textcircled{10}$ Calculate α of HA in all the above parts. \times

$$\textcircled{5} [\text{H}^+] = \frac{1}{2} \times 10^{-2} = \alpha$$

$$10^{-4} = \frac{\alpha^2}{C - \alpha} = \frac{\frac{1}{4} \times 10^{-4}}{C - \frac{1}{2} \times 10^{-2}} C = \frac{1}{4} + \frac{1}{2} \times 10^{-2}$$

$$\frac{1}{4} \times V = 1 \quad V = 4 \text{ lit}$$

$$\textcircled{1} 10^{-4} = \frac{\alpha^2}{1-\alpha} = 10^{-2}$$

$$\textcircled{2} 10^{-4} = \frac{\alpha^2}{10^{-4} - \alpha} \quad \alpha = 0.62 \times 10^{-4} \quad \text{PH} = 4.21$$

$$\textcircled{3} 10^{-14} = (10^{-7} + \alpha) \alpha$$

$$\textcircled{4} \text{ PH} = 4 \quad [\text{H}^+] = 10^{-4} = \alpha$$

$$10^{-4} = \frac{\alpha^2}{C - \alpha} = \frac{10^{-8}}{C - 10^{-4}}$$

$$C = 2 \times 10^{-4}$$

$$C \times V = 1$$

$$2 \times 10^{-4} \times V = 1$$

$$V = \frac{1000}{2} = 5000$$

⑥ $[H^+] = x = 2 \times 10^{-2}$

 $K_a = 10^{-4} = \frac{4 \times 10^{-4}}{C - 2 \times 10^{-2}}$
 $C = \cancel{2 \times 10^{-2}} + 4$
 $C = 4$
 $4 \times V = 1 \text{ mol}$
 $V = \frac{1}{4} \text{ lit}$
 $V_{\text{removed}} = 1 - \frac{1}{4}$
 $= \frac{3}{4} \text{ lit}$

⑦ $[H^+] = \sqrt{K_a C + K_w}$
 $= \sqrt{10^{-4} \times 1 + 10^{-4}}$
 $= \sqrt{2 \times 10^{-2}}$
 $pH = 2 - \log \sqrt{2} = 1.85$

⑧ $\frac{\frac{1}{4} M \text{ HA}}{4} = \frac{3 \times \frac{5}{4}}{16} M \text{ HB}$

 $[H^+] = \sqrt{10^{-4} \times \frac{1}{4} + 4 \times 10^{-4} \times \frac{15}{16}}$
 $= 2 \times 10^{-2} < 1.7$

Init 1M HA + 3lit 10^{-2} M HCl

$$C_2 = \frac{1}{4} \text{M HA}$$

$$\frac{3 \times 10^{-2}}{4} \text{M HCl} = C_1$$

$$10^{-4} = K_a = \frac{\left(\frac{3}{4} \times 10^{-2} + x\right)x}{\frac{1}{4} - x}$$

$$x^2 + \frac{3}{4} \times 10^{-2}x - \frac{1}{4} \times 10^{-4} = 0$$

$$x = \frac{-\frac{3}{4} \times 10^{-2} + \sqrt{\frac{9}{16} \times 10^{-4} + 10^{-4}}}{2}$$

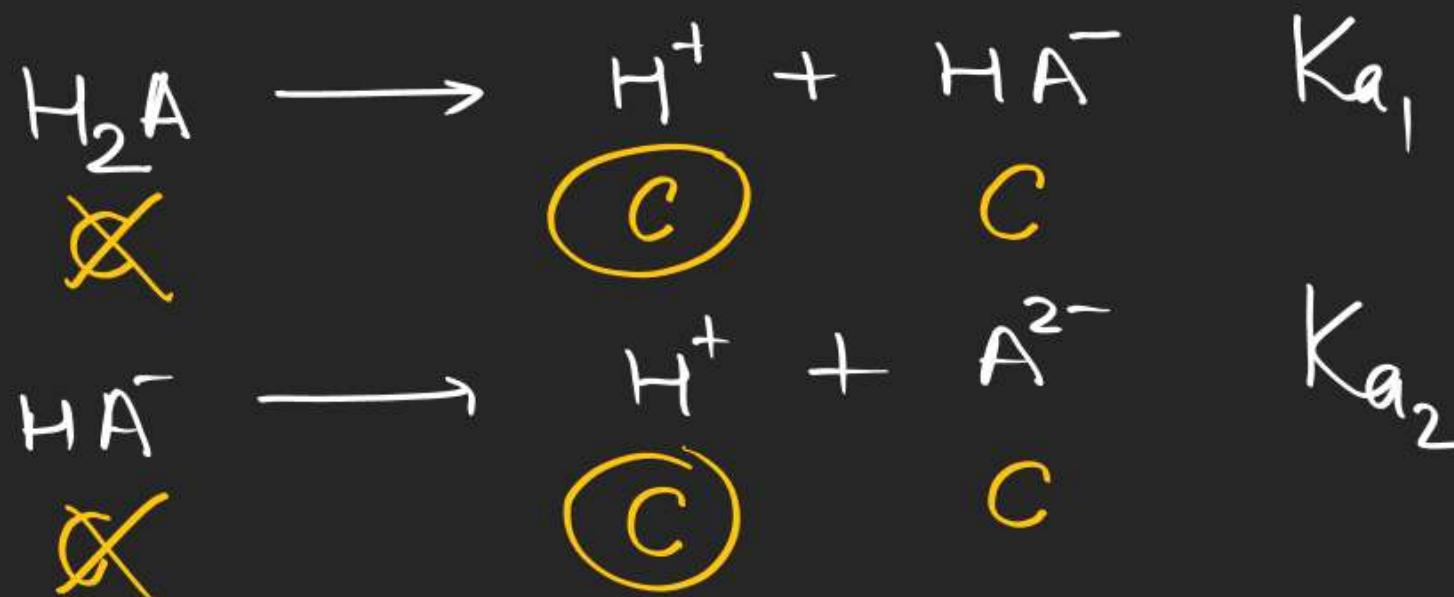
$$\begin{aligned} x &= \frac{-\frac{3}{4} \times 10^{-2} + \frac{5}{4} \times 10^{-2}}{2} \\ &= \frac{\frac{2}{4} \times 10^{-2}}{2} = \frac{1}{4} \times 10^{-2} \end{aligned}$$

$$\begin{aligned} [\text{H}^+] &= \frac{3}{4} \times 10^{-2} + \frac{1}{4} \times 10^{-2} \\ &= 10^{-2} \end{aligned}$$

$$\text{pH} = 2$$

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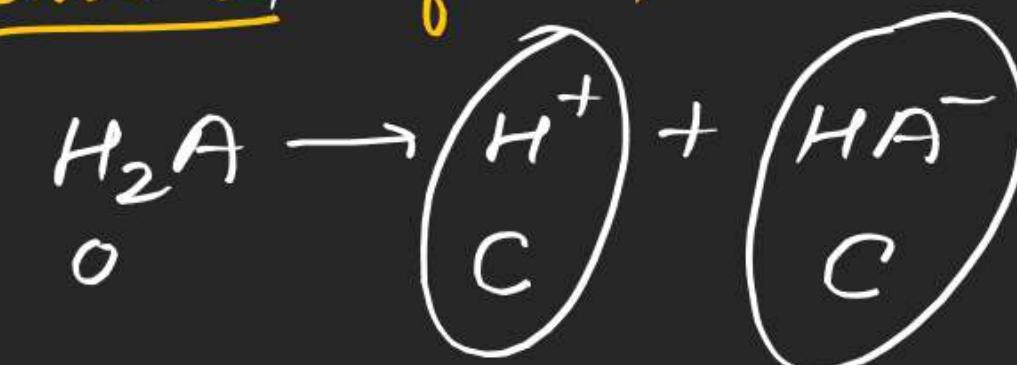
pH of a solution containing polytropic acid or base



Case-I if $\text{K}_{\text{a}_1} & \text{K}_{\text{a}_2} \gg 1$

$$[\text{H}_2\text{A}] = C \quad [\text{H}^+] = 2C$$

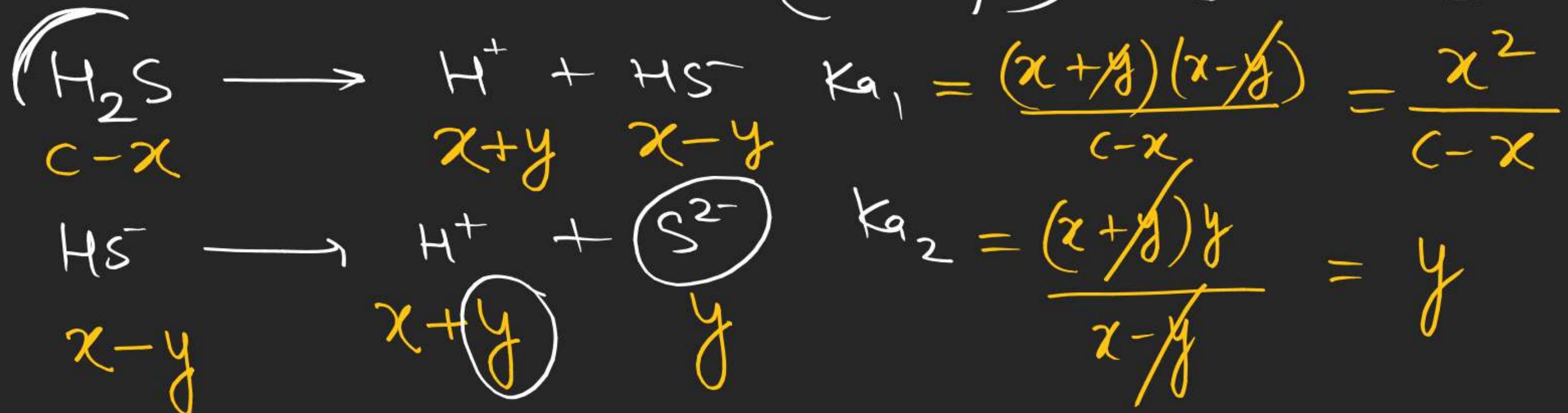
if $\text{K}_{\text{a}_1} \gg 1$ but not K_{a_2}



$$\frac{(\text{C} + \alpha)^\alpha}{\text{C} - \alpha} = \text{K}_{\text{a}_2}$$

e.g. H_2SO_4

Case-II If K_{a_1} & K_{a_2} are small



$$K_{a_1} \gg K_{a_2} \gg K_{a_3}$$

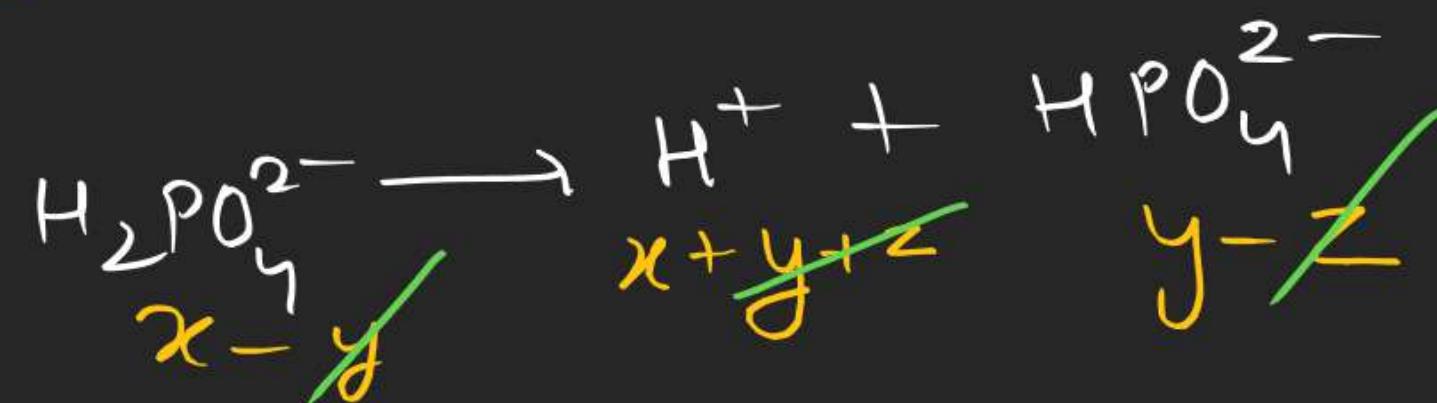
$$x \gg y \gg z$$

Q. find $[H^+]$, $[H_2PO_4^-]$, $[HPO_4^{2-}]$ & $[PO_4^{3-}]$ in

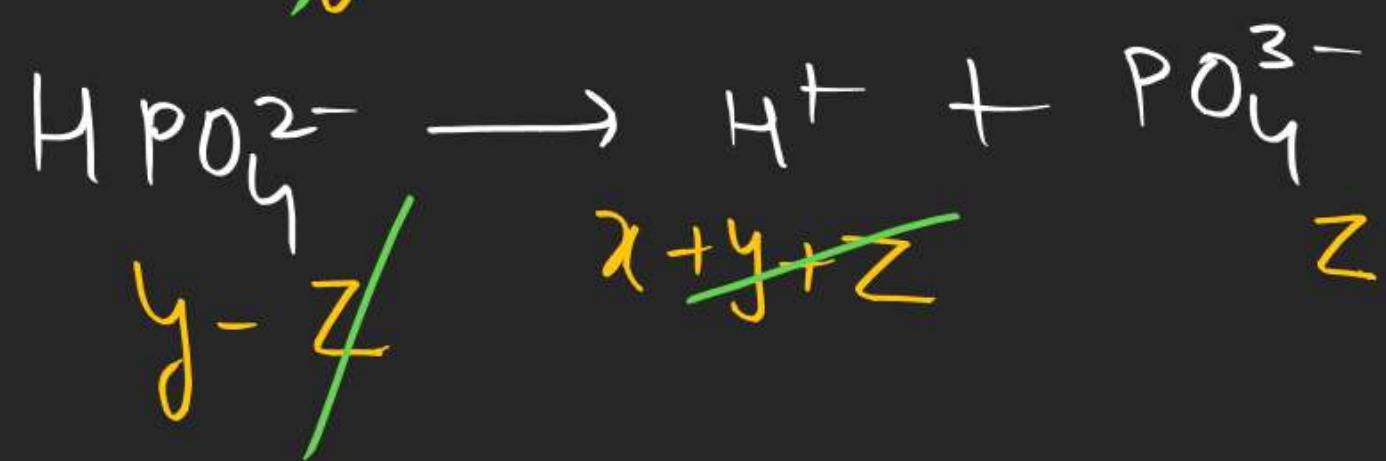
1M $H_3PO_4(aq)$ solution. Given $K_{a1} = 10^{-4}$, $K_{a2} = 10^{-7}$, $K_{a3} = 10^{-11}$



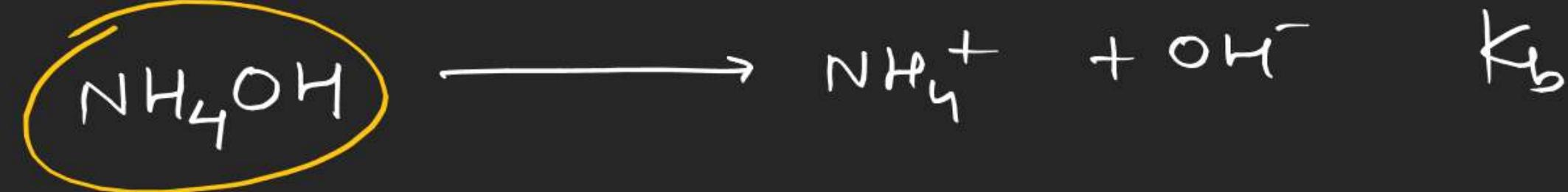
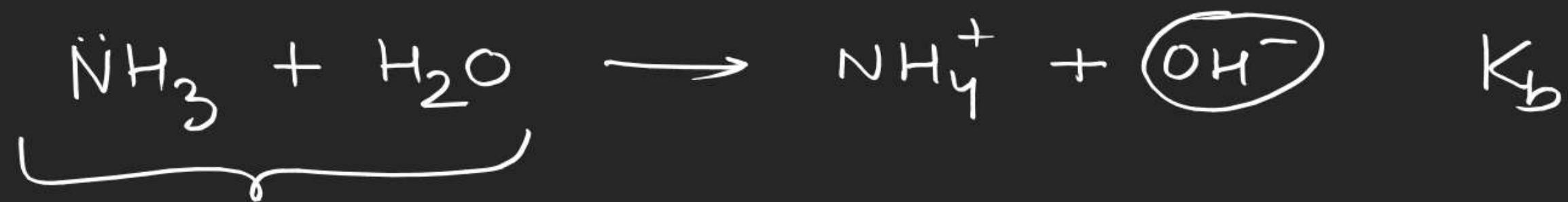
$$K_{a1} = \frac{x^2}{c-x} \Rightarrow x = 10^{-2}$$



$$K_{a2} = \frac{x \cdot y}{x} = y \quad y = 10^{-7}$$



$$K_{a3} = \frac{x \cdot z}{y} \quad z = 10^{-16}$$



$C-x$



$x-y$

