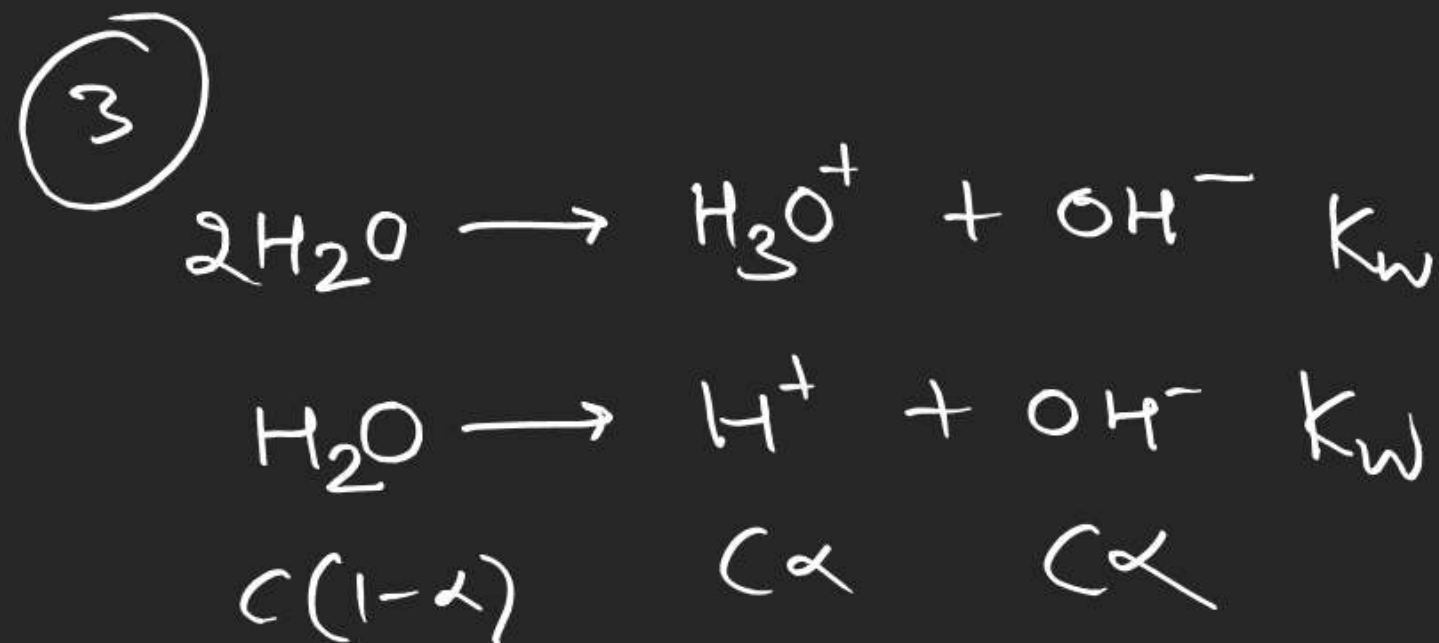
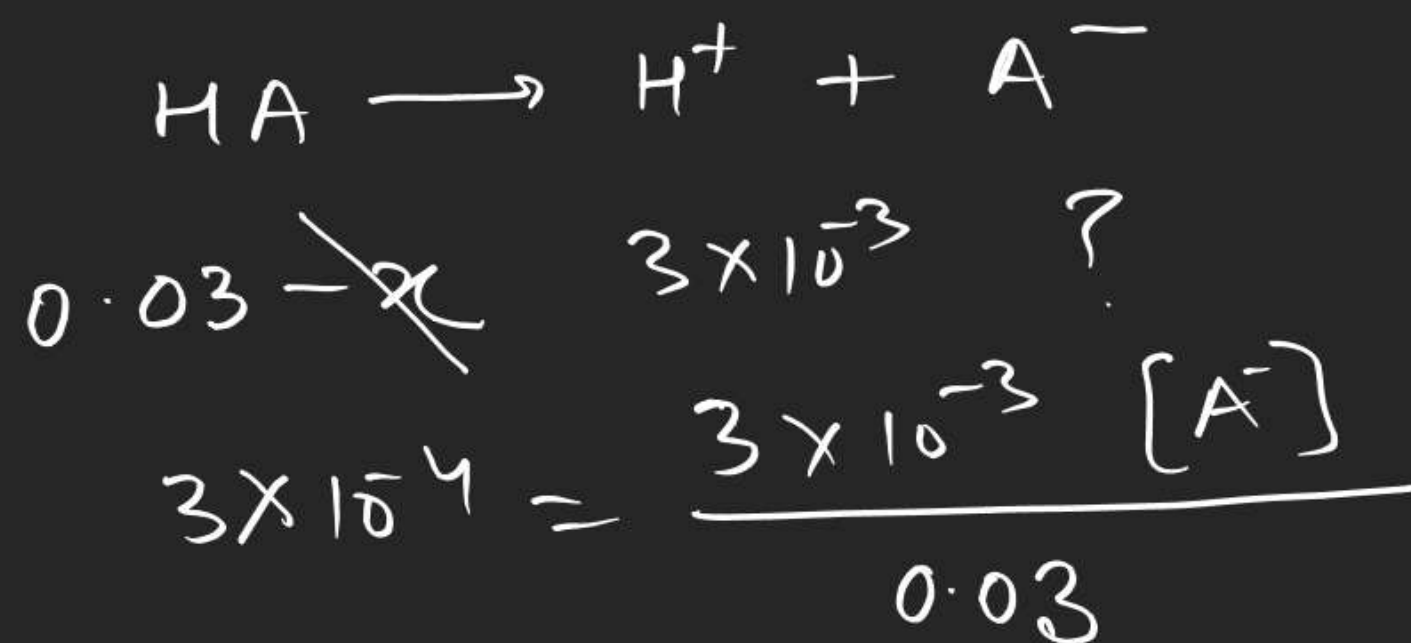


$$(16) [H^+] = \sqrt{K_{a1}C_1 + K_{a2}C_2} = 3 \times 10^{-3}$$



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

(17) 0.01 mol HCl

100 ml 0.05 M HCNH_2 ($K_a = 1.8 \times 10^{-4}$)

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

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

$$x^2 = 9 \times 10^{-6} \quad \text{pH}_i = 2.52$$

$$[\text{HCl}] = \frac{0.01}{0.1} = 0.1 \text{ M} \quad \text{pH}_f = 1$$

$$\frac{1.8 \times 10^{-4} \times 100}{0.05}$$

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

Q. 1 mol of HA is added to 1 lit $H_2O(l)$. [$K_a = 10^{-4} M$] find

- ① pH of solⁿ **2**
- ② pH of solⁿ if it is diluted 10000 times **4.21**
- ③ " " " " 10^7 times **6.78**
- ④ Volume of $H_2O(l)$ required to double the pH. **104** \times **5000** **4999**
- ⑤ " " " " the $[OH^-]$. **0.95** **3 lit**
- ⑥ " " " " to double the $[H^+]$. **0.75** **0.75**
- ⑦ pH of solⁿ at **80°C** if at 80°C $K_w = 10^{-4} M^2$ **4** \times **1.85**
- ⑧ pH of solⁿ if **3 lit of $10^{-2} M HCl$** is added. **2.083** \times **2**
- ⑨ " " " if 3 lit of $\frac{5}{4} M HB$ ($K_a = 4 \times 10^{-4} M$) is added **1.7**
- ⑩ Calculate α of HA in all the above parts. **X**

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

$$\frac{x^2}{c-x} = \frac{\frac{1}{4} \times 10^{-4}}{c - \frac{1}{2} \times 10^{-2}} \quad c = \frac{1}{4} + \frac{1}{2} \times 10^{-2}$$

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

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

② $10^{-4} = \frac{x^2}{10^{-4}-x} \quad x = 0.62 \times 10^{-4}$
 $pH = 4.21$

③ $10^{-14} = (10^{-7} + x)x$

④ $pH = 4 \quad [H^+] = 10^{-4} = x$

$$\frac{x^2}{c-x} = \frac{10^{-8}}{c-10^{-4}}$$

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

$$C \times V = 1$$

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

$$V = \frac{10000}{2} = 5000$$

⑥ $[H^+] = x = 2 \times 10^{-2}$

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

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

$$C = 4$$

$$4 \times V = 1 \text{ mol}$$

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

$$V_{\text{removed}} = 1 - \frac{1}{4}$$

$$= \frac{3}{4} \text{ lit}$$

⑦ $[H^+] = \sqrt{K_a C + K_w}$

$$= \sqrt{10^{-4} \times 1 + 10^{-14}}$$

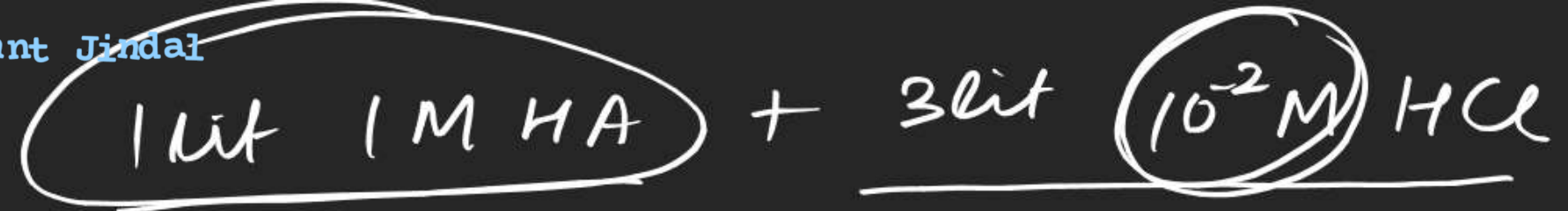
$$= \sqrt{2} \times 10^{-2}$$

$$pH = 2 - \log \sqrt{2} = 1.85$$

⑧ $\frac{1}{4} \text{ M HA} \quad \frac{3 \times \frac{5}{4}}{4} = \frac{15}{16} \text{ M HB}$

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

$$= 2 \times 10^{-2} = 1.7$$



$$C_2 = \frac{1}{4} \text{ M HA} \quad \frac{3 \times 10^{-2}}{4} \text{ M HCl} = C_1$$

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

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

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

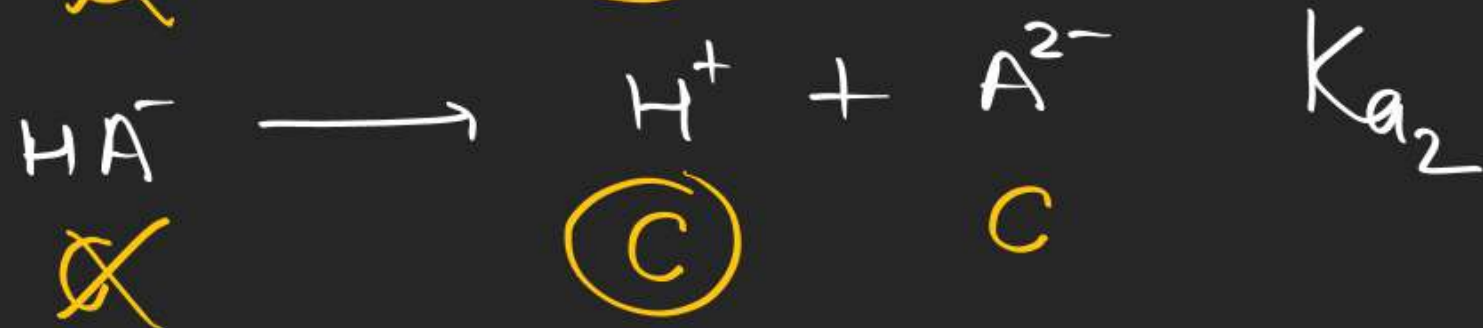
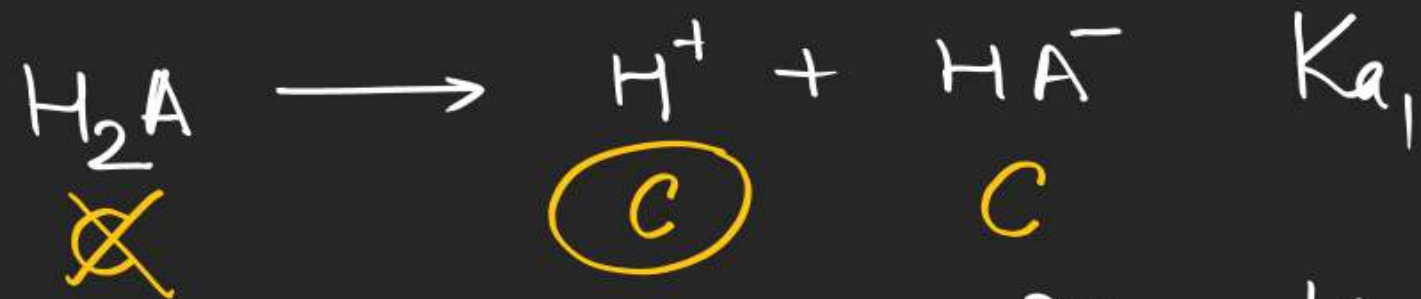
$$x = \frac{-\frac{3}{4} \times 10^{-2} + \frac{5}{4} \times 10^{-2}}{2}$$

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

$$[H^+] = \frac{3}{4} \times 10^{-2} + \frac{1}{4} \times 10^{-2} = 10^{-2}$$

$$\text{pH} = 2$$

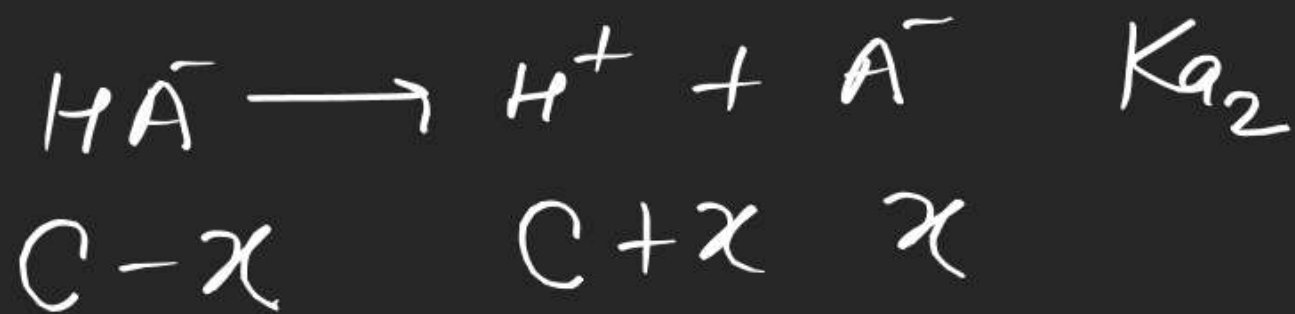
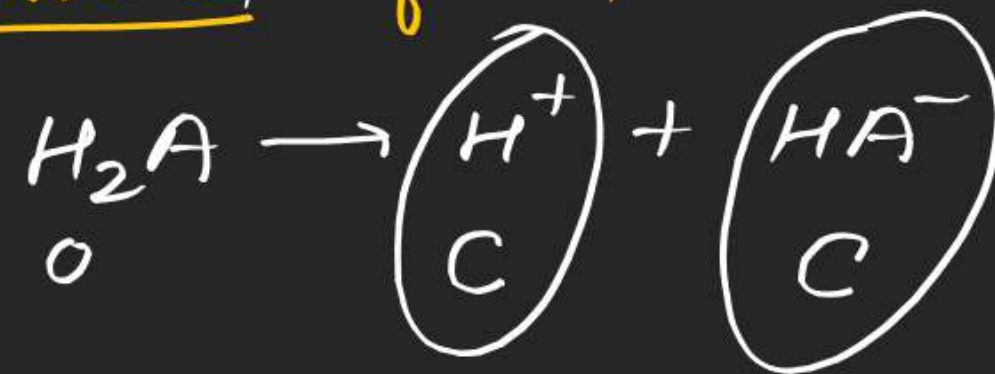
pH of a solution containing polyprotic acid or base



Case-I if $K_{a1} \& K_{a2} \gg 1$

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

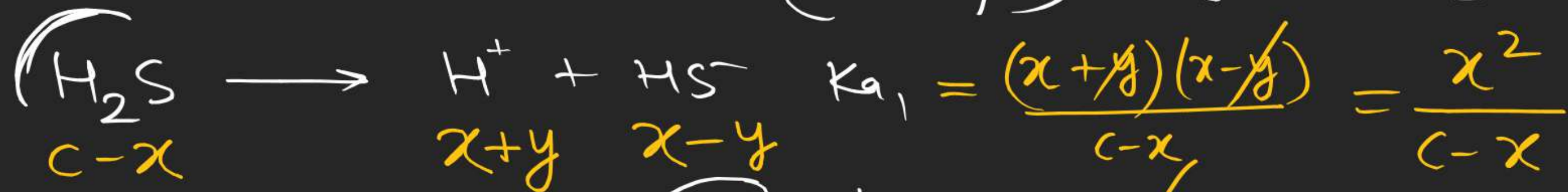
Case-I if $K_{a1} \gg 1$ but not K_{a2}



$$\frac{(C+x)x}{C-x} = K_{a2}$$

e.g. H_2SO_4

Case-III if K_{a1} & K_{a2} are small

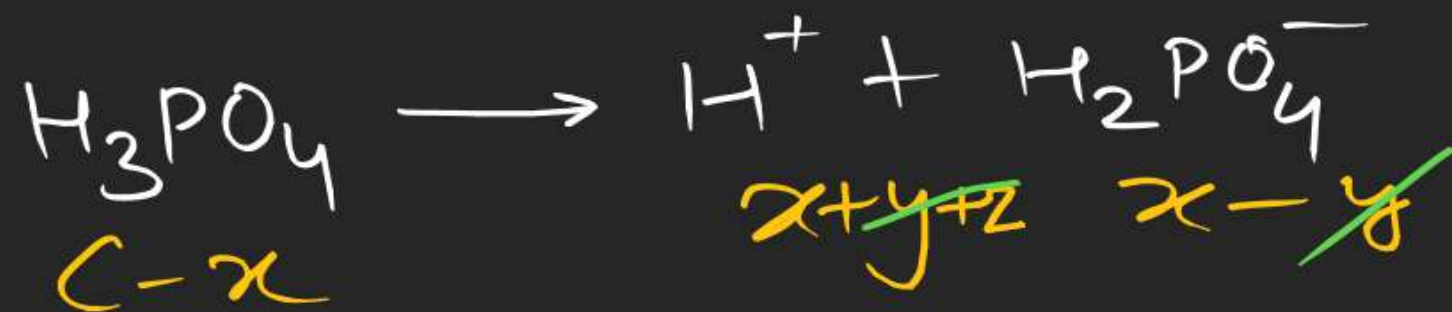


$$K_{a1} \gg K_{a2} \gg K_{a3}$$

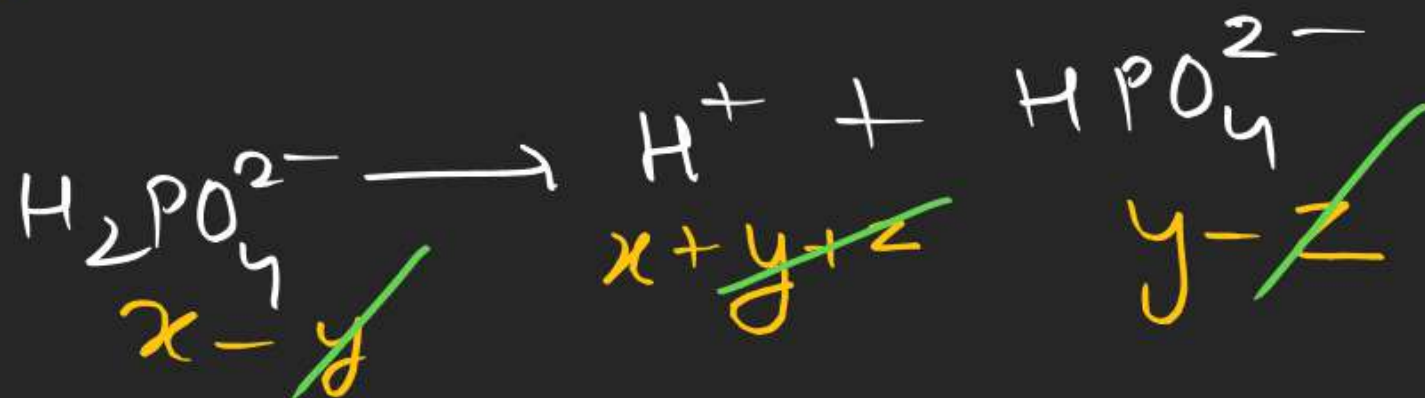
$$x \gg y \gg z$$

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

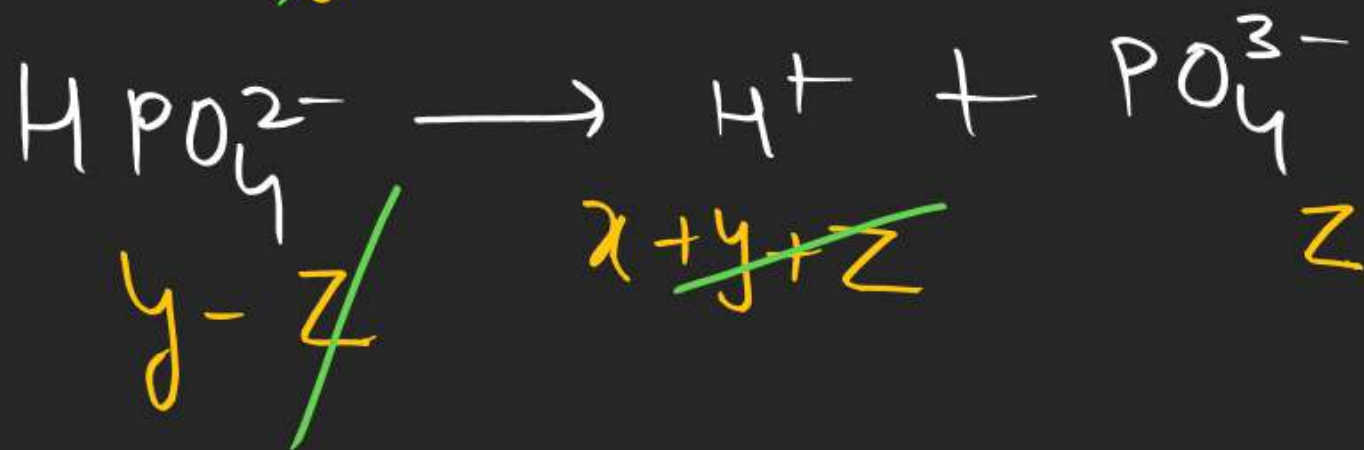
1M $H_3PO_4(aq)$ solution. Given $K_{a1}=10^{-4}$, $K_{a2}=10^{-7}$, $K_{a3}=10^{-11}$



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



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



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

