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

$$HA \longrightarrow H^+ + A^-$$

$0.03 - x$ $\quad 3 \times 10^{-3} \quad ?$

$$3 \times 10^{-4} = \frac{3 \times 10^{-3}\,[A^-]}{0.03}$$

(3)

$$2H_2O \longrightarrow H_3O^+ + OH^- \quad K_w$$

$$H_2O \longrightarrow H^+ + OH^- \quad K_w$$

$C(1-\alpha) \quad C\alpha \quad C\alpha$

$$K_w = (C\alpha)^2$$

$$= \left(\frac{1000}{18} \times 3.6 \times 10^{-9}\right)^2$$

(17) 0.01 mol HCl

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

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

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

$$[HCl] = \frac{0.01}{0.1} = 0.1M \qquad pH_f = 1$$

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

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

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

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

① pH of soln 2

② pH of soln if it is diluted 10000 times 4.21

③ pH of soln if it is diluted 10^7 times 6.78

④ Volume of $H_2O(\ell)$ required to double the pH. $10^4 \times 5000$ 4999

⑤ " " " " the $[OH^-]$. ~~0.96~~ 3 lit

⑥ " " removed to double the $[H^+]$. ~~0.752~~ 0.75

⑦ pH of soln at 80°C if at 80°C $K_W = 10^{-4}M^2$ 4 × 1.85

⑧ pH of soln if 3 lit of 10^{-2} M HCl is added. 2.083 × 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

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

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

③ $10^{-14} = (10^{-7}+x)\,x$

④ $pH = 4$ $[H^+] = 10^{-4} = x$

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

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

$C \times V = 1$

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

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

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

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

$C = \frac{1}{4}$

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

(6) $[H^+] = x = 2 \times 10^{-2}$

$K_a = 10^{-4} = \dfrac{4 \times 10^{-4}}{C - 2\times10^{-2}}$

$C = 2\times10^{-2} + 4$

$C = 4$

$4 \times V = 1\ mol$

$V = 1/4$ lit

$V_{removed} = 1 - 1/4$

$= 3/4$ 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) $\frac{1}{4}$ M HA $\qquad \dfrac{3 \times 5/4}{4} = \dfrac{15}{16}$ M HB

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

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

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

$C_2 = \frac{1}{4}$ M HA $\qquad \frac{3\times10^{-2}}{4}$ M HCl $= C_1$

$$10^{-4} = K_a = \frac{\left(\frac{3}{4}\times10^{-2} + x\right)x}{\frac{1}{4} - x}$$

$$x^2 + \frac{3}{4}\times10^{-2}x - \frac{1}{4}\times10^{-4} = 0$$

$$x = \frac{-\frac{3}{4}\times10^{-2} + \sqrt{\frac{9}{16}\times10^{-4} + 10^{-4}}}{2}$$

$$x = \frac{-\frac{3}{4}\times10^{-2} + \frac{5}{4}\times10^{-2}}{2}$$

$$= \frac{\frac{2}{4}\times10^{-2}}{2} = \frac{1}{4}\times10^{-2}$$

$$[H^+] = \frac{3}{4}\times10^{-2} + \frac{1}{4}\times10^{-2}$$

$$= 10^{-2}$$

$pH = 2$

pH of a solution containing polytropic acid or base

$H_2A \longrightarrow H^+ + HA^-$ $\quad Ka_1$

$\cancel{C}$ $\quad C$ $\quad C$

$HA^- \longrightarrow H^+ + A^{2-}$ $\quad Ka_2$

$\cancel{C}$ $\quad C$ $\quad C$

Case-I if Ka_1 & $Ka_2 \gg 1$

$[H_2A] = C \quad [H^+] = 2C$

Case-II if $Ka_1 \gg 1$ but not Ka_2

$H_2A \longrightarrow H^+ + HA^-$ $\quad Ka_1$

0 $\quad C$ $\quad C$

$HA^- \longrightarrow H^+ + A^-$ $\quad Ka_2$

$C-x \quad C+x \quad x$

$$\frac{(C+x)x}{C-x} = Ka_2$$

e.g H_2SO_4

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

H_2S, H_2CO_3, $H_2C_2O_4$, H_3PO_3 (basicity = 2), H_3PO_4 (basicity = 3)

$$H_2S \longrightarrow H^+ + HS^-$$

$$c-x \qquad x+y \qquad x-y$$

$$K_{a_1} = \frac{(x+y)(x-y)}{c-x} = \frac{x^2}{c-x}$$

$$HS^- \longrightarrow H^+ + S^{2-}$$

$$x-y \qquad x+y \qquad y$$

$$K_{a_2} = \frac{(x+y)y}{x-y} = y$$

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

$$x \gg y \gg z$$

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Q. find $[H^+]$, $[H_2PO_4^-]$, $[HPO_4^{2-}]$ & $[PO_4^{3-}]$ in 1M $H_3PO_4(aq)$ solution. Given $Ka_1 = 10^{-4}$, $Ka_2 = 10^{-7}$, $Ka_3 = 10^{-11}$

$$H_3PO_4 \longrightarrow H^+ + H_2PO_4^-$$

$C - x$; $x+y+z$; $x-y$

$$Ka_1 = \frac{x^2}{C-x} \Rightarrow x = 10^{-2}$$

$$H_2PO_4^- \longrightarrow H^+ + HPO_4^{2-}$$

$x-y$; $x+y+z$; $y-z$

$$Ka_2 = \frac{x \cdot y}{x} = y \qquad y = 10^{-7}$$

$$HPO_4^{2-} \longrightarrow H^+ + PO_4^{3-}$$

$y-z$; $x+y+z$; z

$$Ka_3 = \frac{x \cdot z}{y} \qquad z = 10^{-16}$$

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$\ddot{N}H_3 + H_2O \longrightarrow NH_4^+ + OH^-$ K_b

$NH_4OH \longrightarrow NH_4^+ + OH^-$ K_b

$\ddot{N}H_2CH_2CH_2\ddot{N}H_2$ (en)

$en + H_2O \longrightarrow enH^+ + OH^-$ K_{b_1}

$c-x$ $\quad x-y \quad x+y$

$enH^+ + H_2O \longrightarrow enH_2^{2+} + OH^-$ K_{b_2}

$x-y \quad y \quad x+y$

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