Nishant Jindal 17, 20, 26

$0.1M\ N(CH_3)_3 + \frac{4}{45} M\ NH_4OH$

$K_b = 6.4 \times 10^{-5}$ $\quad K_b = 1.8 \times 10^{-5}$

$$[OH^-] = \sqrt{\frac{0.1}{2} \times 6.4 \times 10^{-5} + \frac{2}{45} \times 1.8 \times 10^{-5}}$$

$$= \sqrt{\frac{6.4}{2} + \frac{36}{45}} \times 10^{-3}$$

$$= \sqrt{3.2 + 0.8} \times 10^{-3}$$

$$= 2 \times 10^{-3}$$

(20) $\alpha \ll 1$

$$K_{a_1} = \frac{C\alpha^2}{1-\alpha} = \frac{x^2}{C-x}$$

(21)

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

$0.1(1-\alpha)$	$0.1+0.1\alpha$	0.1α
$0.1(1+\alpha)$	0.1	0.1α

$$K_{a_1} = \frac{0.1 \times 0.1\alpha}{0.1}$$

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

0.1α	0.1	y

$$K_{a_2} = \frac{0.1 \times y}{0.1 \times \alpha} \qquad y = \alpha K_{a_2} = \underline{10 K_{a_1} K_{a_2}}$$

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(23) HSO_4^-, $H_2O \longrightarrow$, $CH_3NH_3^+ \longrightarrow$] Acid

$CH_3COO^- \rightarrow$ base

(25) & (27)

$CH_3COOH + OH^- \longrightarrow$

(31) $NaCN = 1/80$

$K_a(HCN) = 1.3 \times 10^{-9}$

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$NH_4^+ + H_2O \longrightarrow NH_4OH + H^+$

$\frac{K_w}{K_b} = \frac{[NH_4OH][H^+]}{[NH_4^+]}$

$CN^- + H_2O \longrightarrow HCN + OH^-$

$\frac{K_w}{K_a} = \frac{[HCN][OH^-]}{[CN^-]}$

$H^+ + OH^- \longrightarrow H_2O \quad \times \frac{1}{K_w}$

$NH_4^+ + CN^- + H_2O \longrightarrow NH_4OH + HCN$

$C(1-h) \quad C(1-h) \quad Ch \quad Ch$

$K_h = \frac{K_w}{K_a K_b} = \frac{Ch \times Ch}{C^2(1-h)^2} = \frac{h^2}{(1-h)^2} = h^2$

$\frac{K_w}{K_b} \times \frac{K_w}{K_a} \times \frac{1}{K_w} = \frac{K_w}{K_a K_b} = K_h$

(1) $[H^+] = \sqrt{\frac{K_w K_a}{K_b}}$

(2) $\frac{K_w}{K_a K_b} = K_h$

(3) $h = \sqrt{K_h} = \sqrt{\frac{K_w}{K_a K_b}}$

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Case-5 : solution containing multivalent Cation or anion.

H_3PO_4 | H_2S | H_2CO_3 | [en | $Fe(OH)_3$]

PO_4^{3-} | S^{2-} | CO_3^{2-} | enH_2^{2+} | Fe^{3+}

Na_3PO_4 | Na_2S | Na_2CO_3 | enH_2Cl_2 | $FeCl_3$

H_3PO_4 : K_{a_1}, K_{a_2}, K_{a_3}

PO_4^{3-} : K_{b_1}, K_{b_2}, K_{b_3}

K_{b_1} (= K_w/K_{a_3}): $PO_4^{3-} + H_2O \rightarrow HPO_4^{2-} + OH^-$ (K_{a_3}) $\quad K_{b_1} = \frac{K_w}{K_{a_3}} = \frac{x^2}{C-x}$

K_{b_2} (= K_w/K_{a_2}): $HPO_4^{2-} + H_2O \rightarrow H_2PO_4^- + OH^-$ (K_{a_2}) $\quad K_{b_2} = \frac{K_w}{K_{a_2}} = y$

K_{b_3} (= K_w/K_{a_1}): $H_2PO_4^- + H_2O \rightarrow H_3PO_4 + OH^-$ (K_{a_1}) $\quad K_{b_3} = \frac{K_w}{K_{a_1}} = \frac{xz}{y}$

Since $K_{a_1} >> K_{a_2} >> K_{a_3}$

$K_{b_1} >> K_{b_2} >> K_{b_3}$

$x >> y >> z$

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find K_{b_1} & K_{b_2} of S^{2-}. Given K_{a_1} & K_{a_2} of H_2S

$K_{a_2} = 10^{-7}$ / 10^{-11}

$$K_{b_1} = \frac{K_w}{K_{a_2}} = 10^{-3}$$

$$K_{b_2} = \frac{K_w}{K_{a_1}} = 10^{-7}$$

K_{b_1}: $S^{2-} + H_2O \rightarrow HS^- + OH^-$

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

K_{b_2}: $HS^- + H_2O \rightarrow H_2S + OH^-$

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

K_{a_1}

$$K_{b_1} = \frac{K_w}{K_{a_2}} = \frac{x^2}{10-x}$$

$$K_{b_2} = \frac{K_w}{K_{a_1}} = \frac{x \cdot y}{x}$$

find $[OH^-]$, $[HS^-]$ & $[S^{2-}]$ in 10 M $Na_2S(aq)$ soln

$K_{b_2} = y = 10^{-7}$

$$\frac{K_w}{10^{-11}} = 10^{-3} = \frac{x^2}{10-x}$$

$x^2 = 10^{-2}$

$x = 0.1$

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Case-VI pH of a solution containing amphiprotic salt

H_2CO_3	CO_3^{2-}	HCO_3^-	$NaHCO_3$
H_2S	S^{2-}	HS^-	$NaHS$
H_3PO_4	PO_4^{3-}	$H_2PO_4^-$	NaH_2PO_4
		HPO_4^{2-}	Na_2HPO_4
en	enH_2^{2+}	enH^+	enH^+Cl^-

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① $NaHCO_3$

$$HCO_3^- \longrightarrow H^+ + CO_3^{2-} \qquad K_{a_2} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

K_{b_2}

$$HCO_3^- + H_2O \longrightarrow OH^- + H_2CO_3 \qquad \frac{K_w}{K_{a_1}} = \frac{[OH^-][H_2CO_3]}{[HCO_3^-]}$$

(K_{a_1} for H_2CO_3)

$$\frac{K_{a_2}K_{a_1}}{K_w} = \frac{[H^+]}{[OH^-]} = \frac{[H^+]^2}{K_w}$$

$$[H^+] = \sqrt{K_{a_2}K_{a_1}}$$

$$pH = \frac{1}{2}(pK_{a_2} + pK_{a_1})$$

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NaH_2PO_4

Na_2HPO_4

$H_2A^{2-} \longrightarrow H^+ + HA^{3-}$ K_{a_3}

H_4A

$H_3A^- + H_2O \longrightarrow H_4A + OH^-$ K_{b_4} K_{a_1} $\frac{K_w}{K_{a_1}} = K_{b_4}$

$H_3A^- \longrightarrow H^+ + H_2A^{2-}$ K_{a_2}

$HA^{3-} + H_2O \longrightarrow H_2A^- + OH^-$ K_{b_2} K_{a_3} $\frac{K_w}{K_{a_3}}$