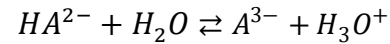
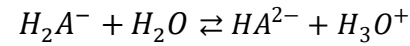
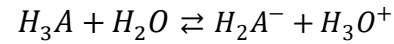


Svag treprotonig syra + svag enprotonig bas



$$K_{a_1} = \frac{[H_2A^-][H_3O^+]}{[H_3A]_2} \Leftrightarrow [H_2A^-] = \frac{K_{a_1}[H_3A]_2}{[H_3O^+]}$$

$$K_{a_2} = \frac{[HA^{2-}][H_3O^+]}{[H_2A^-]} \Leftrightarrow [HA^{2-}] = \frac{K_{a_2}[H_2A^-]}{[H_3O^+]}$$

$$K_{a_3} = \frac{[A^{3-}][H_3O^+]}{[HA^{2-}]} \Leftrightarrow [A^{3-}] = \frac{K_{a_3}[HA^{2-}]}{[H_3O^+]}$$

$$[H_3A]_1 = [H_3A]_2 + [H_2A^-] + [HA^{2-}] + [A^{3-}]$$

$$[H_3A]_1 = [H_3A]_2 + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{K_{a_2}[H_2A^-]}{[H_3O^+]} + \frac{K_{a_3}[HA^{2-}]}{[H_3O^+]}$$

$$[H_3A]_1 = [H_3A]_2 + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{K_{a_2} \frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]} + \frac{K_{a_3} \frac{K_{a_2} \frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]}}{[H_3O^+]}$$

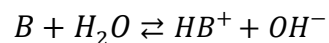
$$[H_3A]_1 = [H_3A]_2 + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{K_{a_2} \frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]} + \frac{K_{a_3} \frac{K_{a_2} \frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]}}{[H_3O^+]}$$

$$[H_3A]_1 = [H_3A]_2 \left(1 + \frac{K_{a_1}}{[H_3O^+]} + \frac{K_{a_2}K_{a_1}}{[H_3O^+]^2} + \frac{K_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]^3} \right) \Leftrightarrow$$

$$[H_3A]_2 = \frac{[H_3A]_1}{1 + \frac{K_{a_1}}{[H_3O^+]} + \frac{K_{a_2}K_{a_1}}{[H_3O^+]^2} + \frac{K_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]^3}} = \frac{[H_3A]_1}{\frac{[H_3O^+]^3 + K_{a_1}[H_3O^+]^2 + K_{a_2}K_{a_1}[H_3O^+] + K_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]^3}}$$

$$= \frac{[H_3A]_1[H_3O^+]^3}{[H_3O^+]^3 + K_{a_1}[H_3O^+]^2 + K_{a_2}K_{a_1}[H_3O^+] + K_{a_3}K_{a_2}K_{a_1}}$$

$$K_w = [OH^-][H_3O^+] \Leftrightarrow [OH^-] = \frac{K_w}{[H_3O^+]}$$



$$K_b = \frac{[HB^+][OH^-]}{[B]_2} \Leftrightarrow [HB^+] = \frac{K_b[B]_2}{[OH^-]} = \frac{K_b[B]_2}{\frac{K_w}{[H_3O^+]}} = \frac{K_b[B]_2[H_3O^+]}{K_w}$$

$$[B]_1 = [B]_2 + [HB^+] = [B]_2 + \frac{K_b[B]_2}{[OH^-]} = [B]_2 \left(1 + \frac{K_b}{[OH^-]} \right) = [B]_2 \left(\frac{[OH^-] + K_b}{[OH^-]} \right) \Leftrightarrow$$

$$[B]_2 = \frac{[B]_1}{\left(\frac{[OH^-] + K_b}{[OH^-]} \right)} = \frac{[B]_1[OH^-]}{[OH^-] + K_b}$$

$$[B]_2 = \frac{[B]_1 \frac{K_w}{[H_3O^+]}}{\frac{K_w}{[H_3O^+]} + K_b} = \frac{\frac{[B]_1 K_w}{[H_3O^+]}}{\frac{K_w + K_b[H_3O^+]}{[H_3O^+]}} = \frac{[B]_1 K_w}{K_w + K_b[H_3O^+]}$$

$$[HB^+] + [H_3O^+] = [OH^-] + [H_2A^-]_2 + 2[HA^{2-}] + 3[A^{3-}]$$

$$\frac{K_b[B]_2[H_3O^+]}{K_w} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_3A]}{[H_3O^+]} + 2\frac{K_{a_2}[H_2A^-]}{[H_3O^+]} + 3\frac{K_{a_3}[HA^{2-}]}{[H_3O^+]}$$

$$\frac{K_b[H_3O^+]\frac{[B]_1K_w}{K_w + K_b[H_3O^+]}}{K_w} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + 2\frac{K_{a_2}[H_2A^-]}{[H_3O^+]} + 3\frac{K_{a_3}[HA^{2-}]}{[H_3O^+]}$$

$$\frac{K_b[H_3O^+][B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{2K_{a_2}\frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]} + \frac{3K_{a_3}\frac{K_{a_2}[H_2A^-]}{[H_3O^+]}}{[H_3O^+]}$$

$$\frac{K_b[H_3O^+][B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{2K_{a_2}K_{a_1}[H_3A]_2}{[H_3O^+]^2} + \frac{3K_{a_3}\frac{K_{a_2}\frac{K_{a_1}[H_3A]_2}{[H_3O^+]}}{[H_3O^+]}}{[H_3O^+]}$$

$$\frac{K_b[H_3O^+][B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_3A]_2}{[H_3O^+]} + \frac{2K_{a_2}K_{a_1}[H_3A]_2}{[H_3O^+]^2} + \frac{3K_{a_3}K_{a_2}K_{a_1}[H_3A]_2}{[H_3O^+]^3}$$

$$\begin{aligned}
& \frac{K_b [H_3O^+] [B]_1}{K_w + K_b [H_3O^+]} + [H_3O^+] \\
&= \frac{K_w}{[H_3O^+]} + \frac{K_{a_1} \frac{[H_3A]_1 [H_3O^+]^3}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}}}{[H_3O^+]} \\
&+ 2 \frac{K_{a_2} \frac{[H_3A]_1 [H_3O^+]^3}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}}}{[H_3O^+]} \\
&+ 3 \frac{K_{a_3} \frac{[H_3A]_1 [H_3O^+]^3}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}}}{[H_3O^+]}
\end{aligned}$$

$$\begin{aligned}
& \frac{K_b [H_3O^+] [B]_1}{K_w + K_b [H_3O^+]} + [H_3O^+] \\
&= \frac{K_w}{[H_3O^+]} + \frac{K_{a_1} [H_3A]_1 [H_3O^+]^2}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}} + \frac{2K_{a_2} K_{a_1} [H_3A]_1 [H_3O^+]}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}} \\
&+ \frac{3K_{a_3} K_{a_2} K_{a_1} [H_3A]_1}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}} \\
& \frac{K_b [H_3O^+] [B]_1}{K_w + K_b [H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1} [H_3A]_1 [H_3O^+]^2 + 2K_{a_2} K_{a_1} [H_3A]_1 [H_3O^+] + 3K_{a_3} K_{a_2} K_{a_1} [H_3A]_1}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}} \\
& \frac{K_b [H_3O^+]^2 [B]_1}{K_w + K_b [H_3O^+]} + [H_3O^+]^2 = K_w + \frac{K_{a_1} [H_3A]_1 [H_3O^+]^3 + 2K_{a_2} K_{a_1} [H_3A]_1 [H_3O^+]^2 + 3K_{a_3} K_{a_2} K_{a_1} [H_3A]_1 [H_3O^+]}{[H_3O^+]^3 + K_{a_1} [H_3O^+]^2 + K_{a_2} K_{a_1} [H_3O^+] + K_{a_3} K_{a_2} K_{a_1}}
\end{aligned}$$

$$\begin{aligned}
& \frac{K_b[H_3O^+]^5[B]_1 + K_bK_{a_1}[H_3O^+]^4[B]_1 + K_bK_{a_2}K_{a_1}[H_3O^+]^3[B]_1 + K_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2[B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+]^5 + K_{a_1}[H_3O^+]^4 + K_{a_2}K_{a_1}[H_3O^+]^3 \\
& + K_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2 \\
& = K_w[H_3O^+]^3 + K_wK_{a_1}[H_3O^+]^2 + K_wK_{a_2}K_{a_1}[H_3O^+] + K_wK_{a_3}K_{a_2}K_{a_1} + K_{a_1}[H_3A]_1[H_3O^+]^3 + 2K_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^2 \\
& + 3K_{a_3}K_{a_2}K_{a_1}[H_3A]_1[H_3O^+] \\
K_b[H_3O^+]^5[B]_1 & + K_bK_{a_1}[H_3O^+]^4[B]_1 + K_bK_{a_2}K_{a_1}[H_3O^+]^3[B]_1 + K_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2[B]_1 + K_w[H_3O^+]^5 + K_wK_{a_1}[H_3O^+]^4 \\
& + K_wK_{a_2}K_{a_1}[H_3O^+]^3 + K_wK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2 + K_b[H_3O^+]^6 + K_bK_{a_1}[H_3O^+]^5 + K_bK_{a_2}K_{a_1}[H_3O^+]^4 + K_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^3 \\
& = K_w^2[H_3O^+]^3 + K_w^2K_{a_1}[H_3O^+]^2 + K_w^2K_{a_2}K_{a_1}[H_3O^+] + K_w^2K_{a_3}K_{a_2}K_{a_1} + K_wK_{a_1}[H_3A]_1[H_3O^+]^3 \\
& + 2K_wK_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^2 + 3K_wK_{a_3}K_{a_2}K_{a_1}[H_3A]_1[H_3O^+] + K_wK_b[H_3O^+]^4 + K_wK_{a_1}K_b[H_3O^+]^3 + K_wK_bK_{a_2}K_{a_1}[H_3O^+]^2 \\
& + K_wK_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+] + K_bK_{a_1}[H_3A]_1[H_3O^+]^4 + 2K_bK_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^3 + 3K_bK_{a_3}K_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^2 \\
K_b[H_3O^+]^5[B]_1 & + K_bK_{a_1}[H_3O^+]^4[B]_1 + K_bK_{a_2}K_{a_1}[H_3O^+]^3[B]_1 + K_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2[B]_1 + K_w[H_3O^+]^5 + K_wK_{a_1}[H_3O^+]^4 \\
& + K_wK_{a_2}K_{a_1}[H_3O^+]^3 + K_wK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^2 + K_b[H_3O^+]^6 + K_bK_{a_1}[H_3O^+]^5 + K_bK_{a_2}K_{a_1}[H_3O^+]^4 + K_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+]^3 \\
& - K_w^2[H_3O^+]^3 - K_w^2K_{a_1}[H_3O^+]^2 - K_w^2K_{a_2}K_{a_1}[H_3O^+] - K_w^2K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_1}[H_3A]_1[H_3O^+]^3 \\
& - 2K_wK_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^2 - 3K_wK_{a_3}K_{a_2}K_{a_1}[H_3A]_1[H_3O^+] - K_wK_b[H_3O^+]^4 - K_wK_{a_1}K_b[H_3O^+]^3 - K_wK_bK_{a_2}K_{a_1}[H_3O^+]^2 \\
& - K_wK_bK_{a_3}K_{a_2}K_{a_1}[H_3O^+] - K_bK_{a_1}[H_3A]_1[H_3O^+]^4 - 2K_bK_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^3 - 3K_bK_{a_3}K_{a_2}K_{a_1}[H_3A]_1[H_3O^+]^2 = 0 \\
K_b[H_3O^+]^6 & + [H_3O^+]^5(K_b[B]_1 + K_w + K_bK_{a_1}) + [H_3O^+]^4(K_bK_{a_1}[B]_1 + K_wK_{a_1} + K_bK_{a_2}K_{a_1} - K_wK_b - K_bK_{a_1}[H_3A]_1) \\
& + [H_3O^+]^3(K_bK_{a_2}K_{a_1}[B]_1 + K_wK_{a_2}K_{a_1} + K_bK_{a_3}K_{a_2}K_{a_1} - K_w^2 - K_wK_{a_1}[H_3A]_1 - K_wK_{a_1}K_b - 2K_bK_{a_2}K_{a_1}[H_3A]_1) \\
& + [H_3O^+]^2(K_bK_{a_3}K_{a_2}K_{a_1}[B]_1 + K_wK_{a_3}K_{a_2}K_{a_1} - K_w^2K_{a_1} - 2K_wK_{a_2}K_{a_1}[H_3A]_1 - K_wK_bK_{a_2}K_{a_1} - 3K_bK_{a_3}K_{a_2}K_{a_1}[H_3A]_1) \\
& - [H_3O^+](K_w^2K_{a_2}K_{a_1} + 3K_wK_{a_3}K_{a_2}K_{a_1}[H_3A]_1 + K_wK_bK_{a_3}K_{a_2}K_{a_1}) - K_w^2K_{a_3}K_{a_2}K_{a_1} = 0 \\
K_b[H_3O^+]^6 & + [H_3O^+]^5(K_b([B]_1 + K_{a_1}) + K_w) + [H_3O^+]^4(K_bK_{a_1}([B]_1 - [H_3A]_1 + K_{a_2}) + K_w(K_{a_1} - K_b)) \\
& + [H_3O^+]^3(K_{a_2}K_{a_1}(K_b[B]_1 + K_w + K_bK_{a_3} - 2K_b[H_3A]_1) - K_w(K_w + K_{a_1}[H_3A]_1 + K_{a_1}K_b)) \\
& + [H_3O^+]^2(K_{a_2}K_{a_1}(K_bK_{a_3}[B]_1 + K_wK_{a_3} - 2K_w[H_3A]_1 - K_wK_b - 3K_bK_{a_3}[H_3A]_1) - K_w^2K_{a_1}) \\
& - [H_3O^+](K_wK_{a_2}K_{a_1}(K_w + 3K_{a_3}[H_3A]_1 + K_bK_{a_3})) - K_w^2K_{a_3}K_{a_2}K_{a_1} = 0
\end{aligned}$$