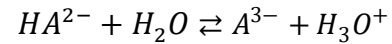
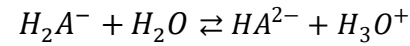
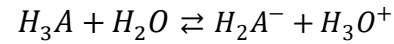


Svag treprotonig syra + stark bas



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

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

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

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

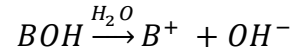
$$[H_3A]_1 = [H_3A]_2 + [H_2A^-] + [HA^{2-}] + [A^{3-}]$$

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

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

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

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



$$[BOH]_1 = [B^+]$$

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

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

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

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

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

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

$$[BOH]_1 + [H_3O^+]$$

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

$$[BOH]_1 + [H_3O^+] - \frac{K_w}{[H_3O^+]}$$

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

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

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

$$\begin{aligned}
& [BOH]_1[H_3O^+]^3 + [BOH]_1K_{a_1}[H_3O^+]^2 + [BOH]_1K_{a_2}K_{a_1}[H_3O^+] + [BOH]_1K_{a_3}K_{a_2}K_{a_1} + [H_3O^+]^4 + K_{a_1}[H_3O^+]^3 + K_{a_2}K_{a_1}[H_3O^+]^2 \\
& + K_{a_3}K_{a_2}K_{a_1}[H_3O^+] - K_w[H_3O^+]^2 - K_wK_{a_1}[H_3O^+] - K_wK_{a_2}K_{a_1} - \frac{K_wK_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]} \\
& = K_{a_1}[H_3A]_1[H_3O^+]^2 + 2K_{a_2}K_{a_1}[H_3A]_1[H_3O^+] + 3K_{a_3}K_{a_2}K_{a_1}[H_3A]_1
\end{aligned}$$

$$\begin{aligned}
& [H_3O^+]^4 + [BOH]_1[H_3O^+]^3 + K_{a_1}[H_3O^+]^3 + [BOH]_1K_{a_1}[H_3O^+]^2 + K_{a_2}K_{a_1}[H_3O^+]^2 - K_w[H_3O^+]^2 - K_{a_1}[H_3A]_1[H_3O^+]^2 \\
& + [BOH]_1K_{a_2}K_{a_1}[H_3O^+] + K_{a_3}K_{a_2}K_{a_1}[H_3O^+] - K_wK_{a_1}[H_3O^+] - 2K_{a_2}K_{a_1}[H_3A]_1[H_3O^+] + [BOH]_1K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_2}K_{a_1} \\
& - 3K_{a_3}K_{a_2}K_{a_1}[H_3A]_1 - \frac{K_wK_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]} = 0
\end{aligned}$$

$$\begin{aligned}
& [H_3O^+]^4 + [H_3O^+]^3([BOH]_1 + K_{a_1}) + [H_3O^+]^2([BOH]_1K_{a_1} + K_{a_2}K_{a_1} - K_w - K_{a_1}[H_3A]_1) + [H_3O^+]([BOH]_1K_{a_2}K_{a_1} + K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_1} \\
& - 2K_{a_2}K_{a_1}[H_3A]_1) + [BOH]_1K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_2}K_{a_1} - 3K_{a_3}K_{a_2}K_{a_1}[H_3A]_1 - \frac{K_wK_{a_3}K_{a_2}K_{a_1}}{[H_3O^+]} = 0
\end{aligned}$$

$$\begin{aligned}
& [H_3O^+]^5 + [H_3O^+]^4([BOH]_1 + K_{a_1}) + [H_3O^+]^3([BOH]_1K_{a_1} + K_{a_2}K_{a_1} - K_w - K_{a_1}[H_3A]_1) + [H_3O^+]^2([BOH]_1K_{a_2}K_{a_1} + K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_1} \\
& - 2K_{a_2}K_{a_1}[H_3A]_1) + [H_3O^+]([BOH]_1K_{a_3}K_{a_2}K_{a_1} - K_wK_{a_2}K_{a_1} - 3K_{a_3}K_{a_2}K_{a_1}[H_3A]_1) - K_wK_{a_3}K_{a_2}K_{a_1} = 0
\end{aligned}$$

$$\begin{aligned}
& [H_3O^+]^5 + [H_3O^+]^4([BOH]_1 + K_{a_1}) + [H_3O^+]^3(K_{a_1}([BOH]_1 - [H_3A]_1 + K_{a_2}) - K_w) + [H_3O^+]^2(K_{a_1}([BOH]_1K_{a_2} + K_{a_3}K_{a_2} - K_w \\
& - 2K_{a_2}[H_3A]_1)) + [H_3O^+](K_{a_2}K_{a_1}([BOH]_1K_{a_3} - K_w - 3K_{a_3}[H_3A]_1)) - K_wK_{a_3}K_{a_2}K_{a_1} = 0
\end{aligned}$$