Tvåprotonig syra + stark bas

$$H_2A + H_2O \rightleftarrows HA^- + H_3O^+$$

$$HA^- + H_2O \rightleftarrows A^{2-} + H_3O^+$$

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

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

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

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

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

$$[H_2A]_1 = [H_2A]_2\left(1 + \frac{K_{a_1}}{[H_3O^+]} + \frac{K_{a_2}K_{a_1}}{[H_3O^+]^2}\right) = [H_2A]_2\left(\frac{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}{[H_3O^+]^2}\right) \Leftrightarrow$$

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

$$BOH \xrightarrow{H_2O} B^+ + OH^-$$

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

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

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

$$[BOH] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_2A]_2}{[H_3O^+]} + \frac{2K_{a_2}\dfrac{K_{a_1}[H_2A]_2}{[H_3O^+]}}{[H_3O^+]}$$

$$[BOH] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{K_{a_1}[H_2A]_2}{[H_3O^+]} + \frac{2K_{a_2}K_{a_1}[H_2A]_2}{[H_3O^+]^2}$$

$$[BOH][H_3O^+]^2 + [H_3O^+]^3 = K_w[H_3O^+] + K_{a_1}[H_2A]_2[H_3O^+] + 2K_{a_2}K_{a_1}[H_2A]_2$$

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

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

$$\begin{aligned}[BOH][H_3O^+]^4 + [H_3O^+]^5 + K_{a_1}[BOH][H_3O^+]^3 + K_{a_1}[H_3O^+]^4 + K_{a_2}K_{a_1}[BOH][H_3O^+]^2 + K_{a_2}K_{a_1}[H_3O^+]^3 \\ = K_w[H_3O^+]^3 + K_wK_{a_1}[H_3O^+]^2 + K_wK_{a_2}K_{a_1}[H_3O^+] + K_{a_1}[H_2A]_1[H_3O^+]^3 + 2K_{a_2}K_{a_1}[H_2A]_1[H_3O^+]^2\end{aligned}$$

$$\begin{aligned}[BOH][H_3O^+]^3 + [H_3O^+]^4 + K_{a_1}[BOH][H_3O^+]^2 + K_{a_1}[H_3O^+]^3 + K_{a_2}K_{a_1}[BOH][H_3O^+] + K_{a_2}K_{a_1}[H_3O^+]^2 \\ = K_w[H_3O^+]^2 + K_wK_{a_1}[H_3O^+] + K_wK_{a_2}K_{a_1} + K_{a_1}[H_2A]_1[H_3O^+]^2 + 2K_{a_2}K_{a_1}[H_2A]_1[H_3O^+]\end{aligned}$$

$$\begin{aligned}[BOH][H_3O^+]^3 + [H_3O^+]^4 + K_{a_1}[BOH][H_3O^+]^2 + K_{a_1}[H_3O^+]^3 + K_{a_2}K_{a_1}[BOH][H_3O^+] + K_{a_2}K_{a_1}[H_3O^+]^2 - K_w[H_3O^+]^2 - K_wK_{a_1}[H_3O^+] \\ - K_wK_{a_2}K_{a_1} - K_{a_1}[H_2A]_1[H_3O^+]^2 - 2K_{a_2}K_{a_1}[H_2A]_1[H_3O^+] = 0\end{aligned}$$

$$\begin{aligned}[H_3O^+]^4 + [H_3O^+]^3\big([BOH] + K_{a_1}\big) + [H_3O^+]^2\big(K_{a_1}[BOH] + K_{a_2}K_{a_1} - K_w - K_{a_1}[H_2A]_1\big) \\ + [H_3O^+]\big(K_{a_2}K_{a_1}[BOH] - K_wK_{a_1} - 2K_{a_2}K_{a_1}[H_2A]_1\big) - K_wK_{a_2}K_{a_1} = 0\end{aligned}$$

$$[H_3O^+]^4 + [H_3O^+]^3\left([BOH] + K_{a_1}\right) + [H_3O^+]^2\left(K_{a_1}\left([BOH] + K_{a_2} - [H_2A]_1\right) - K_w\right) + [H_3O^+]\left(K_{a_2}K_{a_1}([BOH] - 2[H_2A]_1) - K_wK_{a_1}\right) - K_wK_{a_2}K_{a_1} = 0$$