Amfolyt + svag enprotonig bas

$$NaHCO_3 \xrightarrow{H_2O} Na^+ + {HCO_3}^-$$

$$[NaHCO_3] = [Na^+] = [{HCO_3}^-]_1$$

$$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$$

$$HCO_3^- + H_2O \rightleftarrows {CO_3}^{2-} + H_3O^+$$

$$K_{b_1} = \frac{[H_2CO_3][OH^-]}{[{HCO_3}^-]_2} \Leftrightarrow [H_2CO_3] = \frac{K_{b_1}[{HCO_3}^-]_2}{[OH^-]}$$

$$K_{a_2} = \frac{[{CO_3}^{2-}][H_3O^+]}{[{HCO_3}^-]_2} \Leftrightarrow [{CO_3}^{2-}] = \frac{K_{a_2}[{HCO_3}^-]_2}{[H_3O^+]}$$

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

$$K_w = K_a K_b \Leftrightarrow K_{b_1} = \frac{K_w}{K_{a_1}}$$

$$[{HCO_3}^-]_1 = [{HCO_3}^-]_2 + [H_2CO_3] + [{CO_3}^{2-}]$$

$$[{HCO_3}^-]_1 = [{HCO_3}^-]_2 + \frac{K_{b_1}[{HCO_3}^-]_2}{[OH^-]} + \frac{K_{a_2}[{HCO_3}^-]_2}{[H_3O^+]} = [{HCO_3}^-]_2\left(1 + \frac{K_{b_1}}{[OH^-]} + \frac{K_{a_2}}{[H_3O^+]}\right) = [{HCO_3}^-]_2\left(1 + \frac{\frac{K_w}{K_{a_1}}}{\frac{K_w}{[H_3O^+]}} + \frac{K_{a_2}}{[H_3O^+]}\right)$$

$$[{HCO_3}^-]_1 = [{HCO_3}^-]_2\left(1 + \frac{K_w\,[H_3O^+]}{K_{a_1}K_w} + \frac{K_{a_2}}{[H_3O^+]}\right) = [{HCO_3}^-]_2\left(1 + \frac{[H_3O^+]}{K_{a_1}} + \frac{K_{a_2}}{[H_3O^+]}\right) = [{HCO_3}^-]_2\left(\frac{K_{a_1}[H_3O^+] + [H_3O^+]^2 + K_{a_2}K_{a_1}}{K_{a_1}[H_3O^+]}\right)$$

$$\Leftrightarrow [HCO_3^-]_2 = \frac{[HCO_3^-]_1}{\left(\frac{K_{a_1}[H_3O^+] + [H_3O^+]^2 + K_{a_2}K_{a_1}}{K_{a_1}[H_3O^+]}\right)} = \frac{[HCO_3^-]_1 K_{a_1}[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}$$

$$B + H_2O \rightleftarrows HB^+ + OH^-$$

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

$$[B]_1 = [B]_2 + [HB^+] = [B]_2 + \frac{K_b[H_3O^+][B]_2}{K_w} = [B]_2\left(1 + \frac{K_b[H_3O^+]}{K_w}\right) = [B]_2\left(\frac{K_w + K_b[H_3O^+]}{K_w}\right) \Leftrightarrow$$

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

$$[Na^+] + [HB^+] + [H_3O^+] = [OH^-] + [HCO_3^-]_2 + 2\left[CO_3^{2-}\right]$$

$$[Na^+] + \frac{K_b[H_3O^+][B]_2}{K_w} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{[HCO_3^-]_1 K_{a_1}[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}} + 2\frac{K_{a_2}[HCO_3^-]_2}{[H_3O^+]}$$

$$[Na^+] + \frac{K_b[H_3O^+]\frac{[B]_1 K_w}{K_w + K_b[H_3O^+]}}{K_w} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{[HCO_3^-]_1 K_{a_1}[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}} + \frac{2K_{a_2}\frac{[HCO_3^-]_1 K_{a_1}[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}}{[H_3O^+]}$$

$$[Na^+] + \frac{K_b[H_3O^+][B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{[HCO_3^-]_1 K_{a_1}[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}} + \frac{2K_{a_2}[HCO_3^-]_1 K_{a_1}}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}$$

$$[Na^+] + \frac{K_b[H_3O^+][B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+] = \frac{K_w}{[H_3O^+]} + \frac{[HCO_3^-]_1 K_{a_1}[H_3O^+] + 2K_{a_2}[HCO_3^-]_1 K_{a_1}}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}$$

$$[Na^+][H_3O^+] + \frac{K_b[H_3O^+]^2[B]_1}{K_w + K_b[H_3O^+]} + [H_3O^+]^2 = K_w + \frac{K_{a_1}[HCO_3^-]_1[H_3O^+]^2 + 2K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+]}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}}$$

$$\begin{aligned} &K_w[Na^+][H_3O^+] + K_w[H_3O^+]^2 + K_b[Na^+][H_3O^+]^2 + K_b[H_3O^+]^3 + K_b[H_3O^+]^2[B]_1 \\ &\quad = {K_w}^2 + K_w K_b[H_3O^+] \\ &\quad + \frac{K_w K_{a_1}[HCO_3^-]_1[H_3O^+]^2 + 2K_w K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+] + K_b K_{a_1}[HCO_3^-]_1[H_3O^+]^3 + 2K_b K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+]^2}{[H_3O^+]^2 + K_{a_1}[H_3O^+] + K_{a_2}K_{a_1}} \end{aligned}$$

$$\begin{aligned} &K_w[Na^+][H_3O^+]^3 + K_w[H_3O^+]^4 + K_b[Na^+][H_3O^+]^4 + K_b[H_3O^+]^5 + K_b[H_3O^+]^4[B]_1 + K_w K_{a_1}[Na^+][H_3O^+]^2 + K_w K_{a_1}[H_3O^+]^3 \\ &\quad + K_b K_{a_1}[Na^+][H_3O^+]^3 + K_b K_{a_1}[H_3O^+]^4 + K_b K_{a_1}[H_3O^+]^3[B]_1 + K_w K_{a_2}K_{a_1}[Na^+][H_3O^+] + K_w K_{a_2}K_{a_1}[H_3O^+]^2 \\ &\quad + K_b K_{a_2}K_{a_1}[Na^+][H_3O^+]^2 + K_b K_{a_2}K_{a_1}[H_3O^+]^3 + K_b K_{a_2}K_{a_1}[H_3O^+]^2[B]_1 \\ &\quad = {K_w}^2[H_3O^+]^2 + {K_w}^2 K_{a_1}[H_3O^+] + {K_w}^2 K_{a_2}K_{a_1} + K_w K_b[H_3O^+]^3 + K_w K_b K_{a_1}[H_3O^+]^2 + K_w K_b K_{a_2}K_{a_1}[H_3O^+] \\ &\quad + K_w K_{a_1}[HCO_3^-]_1[H_3O^+]^2 + 2K_w K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+] + K_b K_{a_1}[HCO_3^-]_1[H_3O^+]^3 + 2K_b K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+]^2 \end{aligned}$$

$$\begin{aligned} &K_w[Na^+][H_3O^+]^3 + K_w[H_3O^+]^4 + K_b[Na^+][H_3O^+]^4 + K_b[H_3O^+]^5 + K_b[H_3O^+]^4[B]_1 + K_w K_{a_1}[Na^+][H_3O^+]^2 + K_w K_{a_1}[H_3O^+]^3 \\ &\quad + K_b K_{a_1}[Na^+][H_3O^+]^3 + K_b K_{a_1}[H_3O^+]^4 + K_b K_{a_1}[H_3O^+]^3[B]_1 + K_w K_{a_2}K_{a_1}[Na^+][H_3O^+] + K_w K_{a_2}K_{a_1}[H_3O^+]^2 \\ &\quad + K_b K_{a_2}K_{a_1}[Na^+][H_3O^+]^2 + K_b K_{a_2}K_{a_1}[H_3O^+]^3 + K_b K_{a_2}K_{a_1}[H_3O^+]^2[B]_1 - {K_w}^2[H_3O^+]^2 - {K_w}^2 K_{a_1}[H_3O^+] - {K_w}^2 K_{a_2}K_{a_1} \\ &\quad - K_w K_b[H_3O^+]^3 - K_w K_b K_{a_1}[H_3O^+]^2 - K_w K_b K_{a_2}K_{a_1}[H_3O^+] - K_w K_{a_1}[HCO_3^-]_1[H_3O^+]^2 - 2K_w K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+] \\ &\quad - K_b K_{a_1}[HCO_3^-]_1[H_3O^+]^3 - 2K_b K_{a_2}K_{a_1}[HCO_3^-]_1[H_3O^+]^2 = 0 \end{aligned}$$

$$K_b[H_3O^+]^5 + [H_3O^+]^4\left(K_w + K_b[NaHCO_3] + K_bK_{a_1} + K_b[B]_1\right)$$
$$+ [H_3O^+]^3\left(K_w[NaHCO_3] + K_w K_{a_1} + K_bK_{a_1}[NaHCO_3] + K_bK_{a_1}[B]_1 + K_bK_{a_2}K_{a_1} - K_w K_b - K_bK_{a_1}[NaHCO_3]\right)$$
$$+ [H_3O^+]^2\left(K_w K_{a_1}[NaHCO_3] + K_w K_{a_2}K_{a_1} + K_bK_{a_2}K_{a_1}[NaHCO_3] + K_bK_{a_2}K_{a_1}[B]_1 - {K_w}^2 - K_w K_bK_{a_1} - K_w K_{a_1}[NaHCO_3]\right.$$
$$\left. - 2K_bK_{a_2}K_{a_1}[NaHCO_3]\right) + [H_3O^+]\left(K_w K_{a_2}K_{a_1}[NaHCO_3] - {K_w}^2K_{a_1} - K_w K_bK_{a_2}K_{a_1} - 2K_w K_{a_2}K_{a_1}[NaHCO_3]\right) - {K_w}^2K_{a_2}K_{a_1}$$
$$= 0$$

$$K_b[H_3O^+]^5 + [H_3O^+]^4\left(K_b\left([NaHCO_3] + K_{a_1} + [B]_1\right) + K_w\right)$$
$$+ [H_3O^+]^3\left(K_b\left(K_{a_1}[NaHCO_3] + K_{a_1}[B]_1 + K_{a_2}K_{a_1} - K_w - K_{a_1}[NaHCO_3]\right) + K_w[NaHCO_3] + K_w K_{a_1}\right)$$
$$+ [H_3O^+]^2\left(K_w\left(K_{a_1}[NaHCO_3] + K_{a_2}K_{a_1} - K_w - K_bK_{a_1} - K_{a_1}[NaHCO_3]\right) + K_bK_{a_2}K_{a_1}[B]_1 + K_bK_{a_2}K_{a_1}[NaHCO_3]\right.$$
$$\left. - 2K_bK_{a_2}K_{a_1}[NaHCO_3]\right) + [H_3O^+]\left(K_w K_{a_1}\left(K_{a_2}[NaHCO_3] - K_w - K_bK_{a_2} - 2K_{a_2}[NaHCO_3]\right)\right) - {K_w}^2K_{a_2}K_{a_1} = 0$$

$$K_b[H_3O^+]^5 + [H_3O^+]^4\left(K_b\left([NaHCO_3] + K_{a_1} + [B]_1\right) + K_w\right) + [H_3O^+]^3\left(K_b\left(K_{a_1}[B]_1 + K_{a_2}K_{a_1} - K_w\right) + K_w[NaHCO_3] + K_w K_{a_1}\right)$$
$$+ [H_3O^+]^2\left(K_w\left(K_{a_2}K_{a_1} - K_w - K_bK_{a_1}\right) + K_bK_{a_2}K_{a_1}[B]_1 - K_bK_{a_2}K_{a_1}[NaHCO_3]\right)$$
$$+ [H_3O^+]\left(K_w K_{a_1}\left(-K_w - K_bK_{a_2} - K_{a_2}[NaHCO_3]\right)\right) - {K_w}^2K_{a_2}K_{a_1} = 0$$

$$K_b[H_3O^+]^5 + [H_3O^+]^4\left(K_b\left([NaHCO_3] + K_{a_1} + [B]_1\right) + K_w\right) + [H_3O^+]^3\left(K_b\left(K_{a_1}[B]_1 + K_{a_2}K_{a_1} - K_w\right) + K_w[NaHCO_3] + K_w K_{a_1}\right)$$
$$+ [H_3O^+]^2\left(K_w\left(K_{a_2}K_{a_1} - K_w - K_bK_{a_1}\right) + K_bK_{a_2}K_{a_1}[B]_1 - K_bK_{a_2}K_{a_1}[NaHCO_3]\right)$$
$$- [H_3O^+]\left(K_w K_{a_1}\left(K_w + K_bK_{a_2} + K_{a_2}[NaHCO_3]\right)\right) - {K_w}^2K_{a_2}K_{a_1} = 0$$