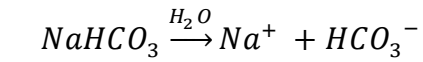
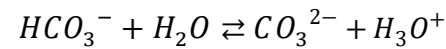
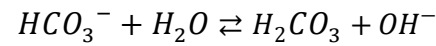


### Amfolyt + svag enprotonig syra



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



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

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

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

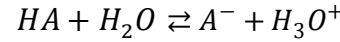
$$K_w = K_a K_b \Rightarrow K_{b_1} = \frac{K_w}{K_{a_1}}$$

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

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

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

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



$$K_a = \frac{[A^-][H_3O^+]}{[HA]_2} \Leftrightarrow [A^-] = \frac{K_a[HA]_2}{[H_3O^+]}$$

$$[HA]_1 = [HA]_2 + [A^-] = [HA]_2 + \frac{K_a[HA]_2}{[H_3O^+]} = [HA]_2 \left(1 + \frac{K_a}{[H_3O^+]}\right) = [HA]_2 \left(\frac{[H_3O^+] + K_a}{[H_3O^+]}\right) \Leftrightarrow$$

$$[HA]_2 = \frac{[HA]_1}{\left(\frac{[H_3O^+] + K_a}{[H_3O^+]}\right)} = \frac{[HA]_1[H_3O^+]}{[H_3O^+] + K_a}$$

$$[Na^+] + [H_3O^+] = [OH^-] + [A^-] + [HCO_3^-]_2 + 2[CO_3^{2-}]$$

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

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

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

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

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

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

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

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

$$\begin{aligned} & [H_3O^+]^5 + [H_3O^+]^4 ([NaHCO_3] + K_a + K_{a_1}) \\ &+ [H_3O^+]^3 (K_a [NaHCO_3] + K_{a_1} [NaHCO_3] + K_a K_{a_1} + K_{a_2} K_{a_1} - K_w - K_a [HA]_1 - K_{a_1} [NaHCO_3]) \\ &+ [H_3O^+]^2 (K_a K_{a_1} [NaHCO_3] + K_{a_2} K_{a_1} [NaHCO_3] + K_{a_2} K_{a_1} K_a - K_w K_a - K_w K_{a_1} - K_a K_{a_1} [HA]_1 - 2K_{a_2} K_{a_1} [NaHCO_3] \\ &- K_a K_{a_1} [NaHCO_3]) + [H_3O^+] (K_{a_2} K_{a_1} K_a [NaHCO_3] - K_w K_a K_{a_1} - K_w K_{a_2} K_{a_1} - K_a K_{a_2} K_{a_1} [HA]_1 - 2K_a K_{a_2} K_{a_1} [NaHCO_3]) \\ &- K_w K_a K_{a_2} K_{a_1} = 0 \end{aligned}$$

$$\begin{aligned}
& [H_3O^+]^5 + [H_3O^+]^4([NaHCO_3] + K_a + K_{a_1}) + [H_3O^+]^3(K_a[NaHCO_3] + K_aK_{a_1} + K_{a_2}K_{a_1} - K_w - K_a[HA]_1) \\
& \quad + [H_3O^+]^2(K_{a_2}K_{a_1}K_a - K_wK_a - K_wK_{a_1} - K_aK_{a_1}[HA]_1 - K_{a_2}K_{a_1}[NaHCO_3]) \\
& \quad + [H_3O^+]( -K_wK_aK_{a_1} - K_wK_{a_2}K_{a_1} - K_aK_{a_2}K_{a_1}[HA]_1 - K_aK_{a_2}K_{a_1}[NaHCO_3]) - K_wK_aK_{a_2}K_{a_1} = 0 \\
\\
& [H_3O^+]^5 + [H_3O^+]^4([NaHCO_3] + K_a + K_{a_1}) + [H_3O^+]^3(K_a[NaHCO_3] + K_aK_{a_1} + K_{a_2}K_{a_1} - K_w - K_a[HA]_1) \\
& \quad + [H_3O^+]^2(K_{a_2}K_{a_1}K_a - K_wK_a - K_wK_{a_1} - K_aK_{a_1}[HA]_1 - K_{a_2}K_{a_1}[NaHCO_3]) \\
& \quad - [H_3O^+](K_wK_aK_{a_1} + K_wK_{a_2}K_{a_1} + K_aK_{a_2}K_{a_1}[HA]_1 + K_aK_{a_2}K_{a_1}[NaHCO_3]) - K_wK_aK_{a_2}K_{a_1} = 0 \\
\\
& [H_3O^+]^5 + [H_3O^+]^4([NaHCO_3] + K_a + K_{a_1}) + [H_3O^+]^3(K_a([NaHCO_3] + K_{a_1} - [HA]_1) + K_{a_2}K_{a_1} - K_w) \\
& \quad + [H_3O^+]^2(K_{a_1}(K_{a_2}K_a - K_w - K_a[HA]_1 - K_{a_2}[NaHCO_3]) - K_wK_a) \\
& \quad - [H_3O^+](K_{a_1}(K_wK_a + K_wK_{a_2} + K_aK_{a_2}[HA]_1 + K_aK_{a_2}[NaHCO_3])) - K_wK_aK_{a_2}K_{a_1} = 0
\end{aligned}$$