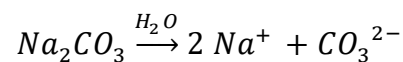
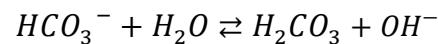
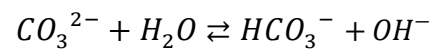


Tvåprotonig bas + stark syra



$$[Na^+] = 2[Na_2CO_3]$$

$$[CO_3^{2-}]_1 = [Na_2CO_3]$$



$$K_{b_2} = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]_2} \Leftrightarrow [HCO_3^-] = \frac{K_{b_2}[CO_3^{2-}]_2}{[OH^-]}$$

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

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

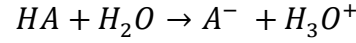
$$[CO_3^{2-}]_1 = [CO_3^{2-}]_2 + [HCO_3^-] + [H_2CO_3]$$

$$[CO_3^{2-}]_1 = [CO_3^{2-}]_2 + \frac{K_{b_2}[CO_3^{2-}]_2}{[OH^-]} + \frac{K_{b_1}[HCO_3^-]}{[OH^-]} = [CO_3^{2-}]_2 + \frac{K_{b_2}[CO_3^{2-}]_2}{[OH^-]} + \frac{K_{b_1} \frac{K_{b_2}[CO_3^{2-}]}{[OH^-]}}{[OH^-]}$$

$$[CO_3^{2-}]_1 = [CO_3^{2-}]_2 + \frac{K_{b_2}[CO_3^{2-}]_2}{[OH^-]} + \frac{K_{b_1}K_{b_2}[CO_3^{2-}]}{[OH^-]^2} = [CO_3^{2-}]_2 \left(1 + \frac{K_{b_2}}{[OH^-]} + \frac{K_{b_1}K_{b_2}}{[OH^-]^2} \right) = [CO_3^{2-}]_2 \left(\frac{[OH^-]^2 + K_{b_2}[OH^-] + K_{b_1}K_{b_2}}{[OH^-]^2} \right)$$

$$[CO_3^{2-}]_2 = \frac{[CO_3^{2-}]_1}{\left(\frac{[OH^-]^2 + K_{b_2}[OH^-] + K_{b_1}K_{b_2}}{[OH^-]^2}\right)} = \frac{[CO_3^{2-}]_1[OH^-]^2}{[OH^-]^2 + K_{b_2}[OH^-] + K_{b_1}K_{b_2}} = \frac{[CO_3^{2-}]_1 \left(\frac{K_w}{[H_3O^+]}\right)^2}{\left(\frac{K_w}{[H_3O^+]}\right)^2 + K_{b_2} \frac{K_w}{[H_3O^+]} + K_{b_1}K_{b_2}}$$

$$[CO_3^{2-}]_2 = \frac{\frac{[CO_3^{2-}]_1 K_w^2}{[H_3O^+]^2}}{\frac{K_w^2}{[H_3O^+]^2} + \frac{K_{b_2}K_w}{[H_3O^+]} + K_{b_1}K_{b_2}} = \frac{\frac{[CO_3^{2-}]_1 K_w^2}{[H_3O^+]^2}}{\frac{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}{[H_3O^+]^2}} = \frac{[CO_3^{2-}]_1 K_w^2}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$



$$[HA]_1 = [A^-]$$

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

$$2[Na_2CO_3] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + [HA]_1 + \frac{K_{b_2}[CO_3^{2-}]_2}{[OH^-]} + 2 \frac{[CO_3^{2-}]_1 K_w^2}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$

$$2[Na_2CO_3] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + [HA]_1 + \frac{K_{b_2} \frac{[CO_3^{2-}]_1 K_w^2}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}}{\frac{K_w}{[H_3O^+]}} + \frac{2[CO_3^{2-}]_1 K_w^2}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$

$$2[Na_2CO_3] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + [HA]_1 + \frac{K_w K_{b_2} [Na_2CO_3] [H_3O^+]}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2} + \frac{2K_w^2 [Na_2CO_3]}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$

$$2[Na_2CO_3] + [H_3O^+] = \frac{K_w}{[H_3O^+]} + [HA]_1 + \frac{K_w K_{b_2} [Na_2CO_3] [H_3O^+] + 2K_w^2 [Na_2CO_3]}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$

$$2[Na_2CO_3][H_3O^+] + [H_3O^+]^2 = K_w + [HA]_1[H_3O^+] + \frac{K_w K_{b_2}[Na_2CO_3][H_3O^+]^2 + 2K_w^2[Na_2CO_3][H_3O^+]}{K_w^2 + K_{b_2}K_w[H_3O^+] + K_{b_1}K_{b_2}[H_3O^+]^2}$$

$$\begin{aligned} & 2K_w^2[Na_2CO_3][H_3O^+] + 2K_{b_2}K_w[Na_2CO_3][H_3O^+]^2 + 2K_{b_1}K_{b_2}[Na_2CO_3][H_3O^+]^3 + K_w^2[H_3O^+]^2 + K_{b_2}K_w[H_3O^+]^3 + K_{b_1}K_{b_2}[H_3O^+]^4 \\ & = K_w^3 + K_{b_2}K_w^2[H_3O^+] + K_w K_{b_1}K_{b_2}[H_3O^+]^2 + K_w^2[HA]_1[H_3O^+] + K_{b_2}K_w[HA]_1[H_3O^+]^2 + K_{b_1}K_{b_2}[HA]_1[H_3O^+]^3 \\ & + K_w K_{b_2}[Na_2CO_3][H_3O^+]^2 + 2K_w^2[Na_2CO_3][H_3O^+] \end{aligned}$$

$$\begin{aligned} & 2K_w^2[Na_2CO_3][H_3O^+] + 2K_{b_2}K_w[Na_2CO_3][H_3O^+]^2 + 2K_{b_1}K_{b_2}[Na_2CO_3][H_3O^+]^3 + K_w^2[H_3O^+]^2 + K_{b_2}K_w[H_3O^+]^3 + K_{b_1}K_{b_2}[H_3O^+]^4 \\ & - K_w^3 - K_{b_2}K_w^2[H_3O^+] - K_w K_{b_1}K_{b_2}[H_3O^+]^2 - K_w^2[HA]_1[H_3O^+] - K_{b_2}K_w[HA]_1[H_3O^+]^2 - K_{b_1}K_{b_2}[HA]_1[H_3O^+]^3 \\ & - K_w K_{b_2}[Na_2CO_3][H_3O^+]^2 - 2K_w^2[Na_2CO_3][H_3O^+] = 0 \end{aligned}$$

$$\begin{aligned} & K_{b_1}K_{b_2}[H_3O^+]^4 + [H_3O^+]^3(2K_{b_1}K_{b_2}[Na_2CO_3] + K_{b_2}K_w - K_{b_1}K_{b_2}[HA]_1) \\ & + [H_3O^+]^2(2K_{b_2}K_w[Na_2CO_3] + K_w^2 - K_w K_{b_1}K_{b_2} - K_{b_2}K_w[HA]_1 - K_w K_{b_2}[Na_2CO_3]) \\ & + [H_3O^+](2K_w^2[Na_2CO_3] - K_{b_2}K_w^2 - K_w^2[HA]_1 - 2K_w^2[Na_2CO_3]) - K_w^3 = 0 \end{aligned}$$

$$\begin{aligned} & K_{b_1}K_{b_2}[H_3O^+]^4 + [H_3O^+]^3(K_{b_1}K_{b_2}(2[Na_2CO_3] - [HA]_1) + K_{b_2}K_w) + [H_3O^+]^2(K_{b_2}K_w[Na_2CO_3] + K_w^2 - K_w K_{b_1}K_{b_2} - K_{b_2}K_w[HA]_1) \\ & + [H_3O^+](K_{b_2}K_w^2 - K_w^2[HA]_1) - K_w^3 = 0 \end{aligned}$$

$$\begin{aligned} & K_{b_1}K_{b_2}[H_3O^+]^4 + [H_3O^+]^3(K_{b_1}K_{b_2}(2[Na_2CO_3] - [HA]_1) + K_{b_2}K_w) + [H_3O^+]^2(K_{b_2}K_w([Na_2CO_3] - [HA]_1) + K_w(K_w - K_{b_1}K_{b_2})) \\ & - [H_3O^+](K_w^2(K_{b_2} + [HA]_1)) - K_w^3 = 0 \end{aligned}$$