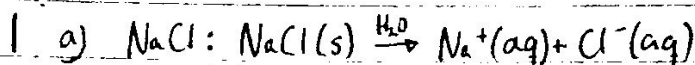
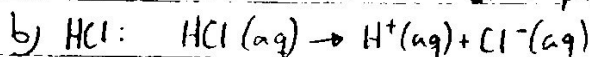


Øving 4 - Ertend Sørlie



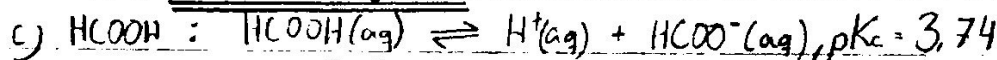
EN: $[\text{Na}^+] + [\text{H}^+] = [\text{OH}^-] + [\text{Cl}^-]$

MB: Verken Na^+ eller Cl^- vil påvirke pH, men $[\text{NaCl}]_0 = [\text{Na}^+] = [\text{Cl}^-]$



EN: $[\text{H}^+] = [\text{OH}^-] + [\text{Cl}^-]$, sterk syre $[\text{OH}^-] \approx 0 \Rightarrow [\text{H}^+] = [\text{Cl}^-]$

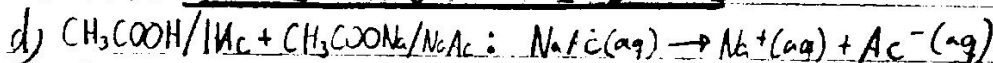
MB: $[\text{HCl}]_0 = [\text{H}^+]$



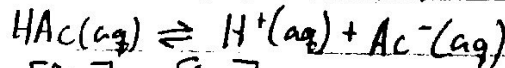
EN: $[\text{H}^+] = [\text{OH}^-] + [\text{HCOO}^-]$

EN: $\Rightarrow [\text{H}^+] = [\text{HCOO}^-] + [\text{OH}^-]$

MB: $[\text{HCOOH}]_0 = [\text{HCOOH}] + [\text{HCOO}^-]$



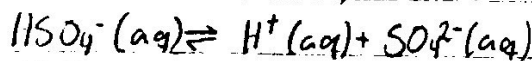
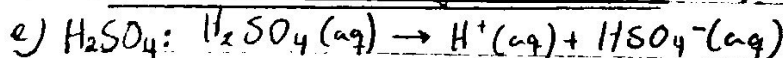
$pK_a = 4,76$



EN: $[\text{Na}^+][\text{H}^+] = [\text{OH}^-] + [\text{Ac}^-] \approx [\text{Ac}^-]$

EN: $\Rightarrow [\text{Na}^+] + [\text{H}^+] = [\text{Ac}^-] + [\text{OH}^-]$

MB: $[\text{HAc}]_0 + [\text{NaAc}]_0 = [\text{HAc}] + [\text{Ac}^-]$

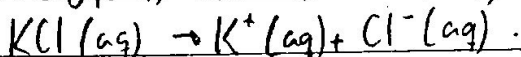
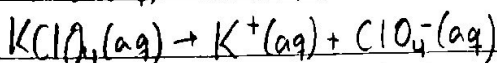
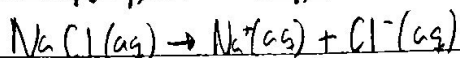


EN: $[\text{H}^+] = [\text{HSO}_4^-] + 2[\text{SO}_4^{2-}] + [\text{OH}^-] \approx [\text{HSO}_4^-] + 2[\text{SO}_4^{2-}]$

EN: $\Rightarrow [\text{H}^+] = [\text{HSO}_4^-] + 2[\text{SO}_4^{2-}] + [\text{OH}^-]$ (sterk syre)

MB: $[\text{H}_2\text{SO}_4]_0 = [\text{H}_2\text{SO}_4] + [\text{HSO}_4^-] + [\text{SO}_4^{2-}], [\text{H}_2\text{SO}_4] \approx 0$

MB: $[\text{H}_2\text{SO}_4]_0 = [\text{HSO}_4^-] + [\text{SO}_4^{2-}]$



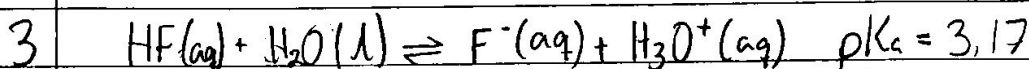
$$\text{EN: } [\text{Na}^+] + [\text{K}^+] + [\text{H}^+] = [\text{Cl}^-] + [\text{ClO}_4^-] + [\text{OH}^-], \text{ påvirker ikke pH}$$

$$[\text{Na}^+] + [\text{K}^+] = [\text{Cl}^-] + [\text{ClO}_4^-] \Rightarrow [\text{H}^+] = [\text{OH}^-]$$

$$[\text{K}^+] = [\text{Cl}^-] + [\text{ClO}_4^-] - [\text{Na}^+]$$

$$[\text{K}^+] = (0,015 + 0,01 - 0,001) \text{ mol/L} = 0,024 \text{ mol/L}$$

$$\underline{[\text{K}^+] = 0,024 \text{ mol/L}}$$



$$\frac{[\text{F}^-][\text{H}_3\text{O}^+]}{[\text{HF}]}$$

$$K_a = 6,76 \cdot 10^{-4} \text{ mol/L}$$

$$\text{MVL: } K_a = \frac{[\text{F}^-][\text{H}_3\text{O}^+]}{[\text{HF}]}$$

$$\text{MB: } [\text{HF}]_0 = [\text{HF}] + [\text{H}_3\text{O}^+] \Rightarrow [\text{HF}] = [\text{HF}]_0 - [\text{H}_3\text{O}^+]$$

$$\text{PB: } [\text{H}_3\text{O}^+] = [\text{OH}^-] + [\text{F}^-] \Rightarrow [\text{F}^-] = [\text{H}_3\text{O}^+] - [\text{OH}^-]$$

Kombiner disse og får:

$$K_a = \frac{([\text{H}^+] - [\text{OH}^-]) \cdot [\text{H}_3\text{O}^+]}{[\text{HF}]_0 - [\text{H}_3\text{O}^+]}$$

Vi gør to tilnærminger:

I): $[\text{OH}^-] \ll [\text{H}_3\text{O}^+]$ dette er en syre.

II): $[\text{H}_3\text{O}^+] \ll [\text{HF}]_0$, svag syre.

$$\Rightarrow K_a = \frac{[\text{H}_3\text{O}^+]^2}{[\text{HF}]_0} \Rightarrow [\text{H}_3\text{O}^+] = \sqrt{K_a \cdot [\text{HF}]_0} = \sqrt{6,76 \cdot 10^{-4} \cdot 0,25} \text{ mol/L}$$

$$[\text{H}_3\text{O}^+] = 0,013 \text{ mol/L} \Rightarrow \text{pH} = -\log(0,013)$$

$$\text{pH} = 1,88$$

Spekter tilnærmingerne:

$$\text{I) } [\text{H}_3\text{O}^+] = 0,013 \text{ mol/L}$$

$$[\text{OH}^-] = \frac{10^{-14}}{0,013} = 7,69 \cdot 10^{-13} \ll [\text{H}_3\text{O}^+] \Rightarrow \text{I) stemmer}$$

$$\text{II) } \frac{[\text{H}_3\text{O}^+]}{[\text{HF}]_0} \cdot 100 = \frac{0,013}{0,25} \cdot 100 = 5,2\%$$

$$\Rightarrow [\text{H}_3\text{O}^+] = 5,2\% [\text{HF}]_0, > 5\% \Rightarrow \text{tilnærmingen holder ikke}$$

$$\Rightarrow \text{pH} \approx 1,88$$

Se næste side $\Rightarrow$

3 Vi lager et nytt uttrykk, men kun med tilnærming I $[\text{OH}^-] \ll [\text{H}^+]$

$$K_a = \frac{[\text{H}_3\text{O}^+]^2}{[\text{HF}]_0 - [\text{H}_3\text{O}^+]} \Rightarrow [\text{H}_3\text{O}^+]^2 + K_a \cdot [\text{H}_3\text{O}^+] - K_a [\text{HF}]_0 = 0$$

$$[\text{H}_3\text{O}^+] = \frac{-K_a \pm \sqrt{K_a^2 + 4 \cdot 1 \cdot K_a [\text{HF}]_0}}{2 \cdot 1}$$

$$[\text{H}_3\text{O}^+] = 0,01267 \text{ V } [\text{H}_3\text{O}^+] = -0,01334$$

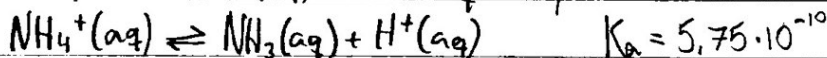
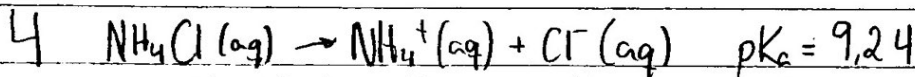
$$[\text{H}_3\text{O}^+] = 1,2 \cdot 10^{-2} \text{ mol/L} \quad \text{ikke mulig}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = 1,90$$

Spekker tilnærming I

$$[\text{OH}^-] = \frac{10^{-14}}{1,2 \cdot 10^{-2}} \ll 1,2 \cdot 10^{-2} = [\text{H}_3\text{O}^+], \text{ tilnærming I skjemmer}$$

$$\text{pH} = 1,90$$



$$\text{MB: } [\text{NH}_4^+]_0 = [\text{NH}_4^+] + [\text{NH}_3] \Rightarrow [\text{NH}_4^+] = [\text{NH}_4^+]_0 - [\text{NH}_3]$$

$$\text{PB: } [\text{H}^+] = [\text{OH}^-] + [\text{NH}_3] \Rightarrow [\text{NH}_3] = [\text{H}^+] - [\text{OH}^-]$$

$$\text{MVL: } K_a = \frac{[\text{NH}_3][\text{H}^+]}{[\text{NH}_4^+]} = (\text{setter inn MB og PB}) = \frac{[\text{H}^+][\text{H}^+] - [\text{OH}^-][\text{H}^+]}{[\text{NH}_4^+]_0 - ([\text{H}^+] - [\text{OH}^-])}$$

Tilnærminger:

I) $[\text{OH}^-] \ll [\text{H}^+]$, det er en syre

II) $[\text{H}^+] \ll [\text{NH}_4^+]_0$, det er en svak syre.

$$\text{Vi får: } K_a \approx \frac{[\text{H}^+]^2}{[\text{NH}_4^+]} \Rightarrow [\text{H}^+] \approx \sqrt{K_a \cdot [\text{NH}_4^+]} = \sqrt{10^{-9,24} \cdot 0,5} = 1,70 \cdot 10^{-5}$$

$$\text{pH} \approx 4,77$$

4 Spekker tilnærminger:

$$I) [OH^-] \ll [H^+]: [OH^-] = \frac{10^{-14}}{1,70 \cdot 10^{-5}} = 5,88 \cdot 10^{-10} \ll 1,70 \cdot 10^{-5} = [H_3O^+]$$

$\Rightarrow$ I stemmer

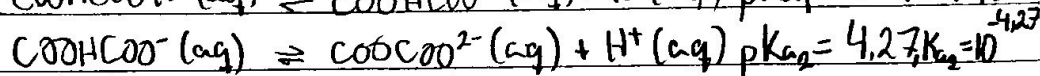
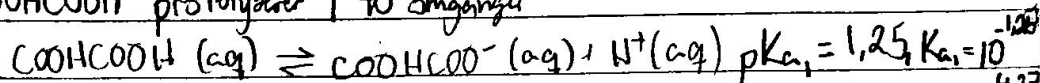
$$II) [H^+] \ll [NH_4^+]_0$$

$$[H^+] = \frac{1,70 \cdot 10^{-5}}{0,5} \cdot 100\% [NH_4^+]_0 = 3,4 \cdot 10^{-3}\% [NH_4^+] \ll 5\%$$

$\Rightarrow$ II stemmer

Tilnærmingerne stemmer $\Rightarrow$ pH = 4,77

5 COOHCOOH protolyserer i to omganger



$$PB: [H^+] = [OH^-] + [COOHCOO^-] + 2[COO^2-]$$

$$MB: [COOHCOOH]_0 = [COOHCOOH] + [COOHCOO^-] + [COO^2-]$$

$$\text{Omformer MB: } [COOHCOOH] = [COOHCOOH]_0 - [COOHCOO^-] - [COO^2-]$$

Tilnærminger:

$$I) [OH^-] \ll [H^+], [COOHCOO^-], [COO^2-]$$

$$II) K_{a1} \gg K_{a2} \Rightarrow [COOHCOO^-] \gg [COO^2-]$$

$$\text{Vi får nå: } PB: [H^+] \approx [COOHCOO^-]$$

$$MB: [COOHCOOH] \approx [COOHCOOH]_0 - [COOHCOO^-] = [COOHCOOH]_0 - [H^+]$$

MVL:

$$K_{a1} = \frac{[COOHCOO^-][H^+]}{[COOHCOOH]} \approx \frac{[H^+]^2}{[COOHCOOH]_0 - [H^+]} \Rightarrow [H^+]^2 + [H^+] \cdot K_{a1} + [COOHCOOH]_0 \cdot K_{a1} \approx 0$$

$$[H^+] \approx \frac{-K_{a1} + \sqrt{K_{a1}^2 + 4 \cdot 1 \cdot K_{a1} \cdot [COOHCOOH]_0}}{2 \cdot 1}$$

$$[H^+] \approx 0,0518 \text{ V } [H^+] \approx 0,1082$$

Ikke mulig

$$pH = -\log [H^+] \approx -\log 0,0518$$

$$pH \approx 1,29$$

5 Sjekk tilnærminger:

$$I: [OH^-] < [H^+] [Ac^-] [H_2O] [OH^-] = \frac{K_w}{[H^+]} = \frac{10^{-14}}{0,018} = 1,93 \cdot 10^{-13}$$

$$[H^+] = 0,0518$$

$$[COOHCOO^-] \approx [H^+] \text{ fra biln. 2: } \Rightarrow [COOHCOO^-] \approx 0,0518$$

$$\text{fra MVL: } K_{a2} = \frac{[H^+][COO^-]}{[COOHCOO^-]} \Rightarrow [COO^-] = \frac{K_{a2} \cdot [COOHCOO^-]}{[H^+]}$$

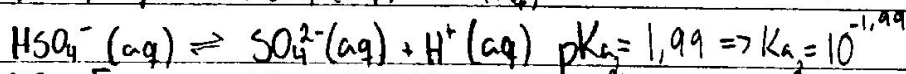
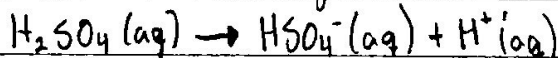
$$[COOHCOO^-] \approx [H^+] \Rightarrow [COO^-] \approx K_{a2} = 5,37 \cdot 10^{-5}$$

Dermed er: $[OH^-] \ll [H^+], [COOHCOO^-], [COO^-]$, I stemmer

$$II: K_{a1} \gg K_{a2} : \left. \begin{array}{l} K_{a1} = 10^{-1,25} = 5,62 \cdot 10^{-2} \\ K_{a2} = 10^{-1,27} = 5,37 \cdot 10^{-5} \end{array} \right\} \Rightarrow K_{a1} \gg K_{a2}, II \text{ stemmer}$$

Tilnærmingerne stemmer, pH = 1,29

6 H_2SO_4 er en sterk syre, men den er boprotisk, vi har:



$$MB: [H_2SO_4]_0 = [HSO_4^-] + [SO_4^{2-}]$$

$$I: [SO_4^{2-}] = [H_2SO_4]_0 - [HSO_4^-]$$

$$EN: [H^+] = [HSO_4^-] + 2[SO_4^{2-}] + [OH^-] \quad (\text{sterk syre } [OH^-] \approx 0)$$

$$MB \text{ innl En: } II: [H^+] = 2[H_2SO_4]_0 - [HSO_4^-] \quad \left(\text{eventuelt kan vi si } [OH^-] = \frac{K_w}{[H^+]} \right)$$

for eksakt resultat

MVL:

$$III: K_{a2} = \frac{[SO_4^{2-}][H^+]}{[HSO_4^-]}$$

Vi har 3 likninger og 3 ukjente

Vi får 3 likninger med 3 ukjente.

$$I: [SO_4^{2-}] = [H_2SO_4]_0 - [H_2SO_4]$$

$$II: [H^+] = 2[H_2SO_4]_0 - [H_2SO_4] + [OH^-]$$

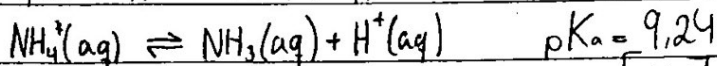
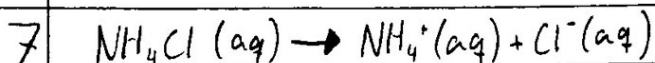
III:

$$K_{a2} = \frac{[SO_4^{2-}][H^+]}{[HSO_4^-]}$$

K_{a2} og $[H_2SO_4]_0$ er kjent

Vi har 3 likninger og 3 ukjente.

Vi kan løse dette settet



$$MB: [NH_4^+]_0 + [NH_3]_0 = [NH_4^+] + [NH_3] \quad [NH_4^+]_0 = [Cl^-]_0 = [Cl^-]$$

$$I) \Rightarrow [Cl^-] + [NH_3]_0 = [NH_4^+] + [NH_3] \Leftrightarrow [Cl^-] = [NH_4^+] + [NH_3] - [NH_3]_0$$

$$EN: [H^+] + [NH_4^+] = [OH^-] + [Cl^-] \Leftrightarrow 1,3$$

$$III) K_a = \frac{[NH_3][H^+]}{[NH_4^+]}$$

$$I: [Cl^-] = [NH_4^+] + [NH_3] - [NH_3]_0$$

$$II: [H^+] = \frac{K_w}{[OH^-]} + [Cl^-] - [NH_4^+]$$

III:

$$K_a = \frac{[NH_3][H^+]}{[NH_4^+]}$$

$[Cl^-] = [NH_4^+]_0$ og $[NH_3]_0$ er kjent

Vi har 3 lkn. og 3 ukjente.

Vi kan løse dette settet