

Bereken de molaire oplosbaarheid van MnS in water bij 25°C en pH = 5,00. Houd rekening met het feit dat het sulfide-ion in water kan hydrolyseren.

$$K_{a1}(\text{H}_2\text{S}) = 8,9 \cdot 10^{-8}$$

$$K_{a2}(\text{H}_2\text{S}) = 1,0 \cdot 10^{-14}$$

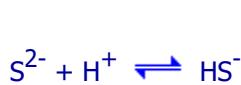
$$K_S(\text{MnS}) = 3,0 \cdot 10^{-14}$$

## Oplossing

Telkens een MnS-deeltje oplost verschijnen er in de oplossing 1  $\text{Mn}^{2+}$ -ion en 1  $\text{S}^{2-}$ -ion.

$$\text{We kunnen dus stellen dat } S_{\text{MnS}} = [\text{Mn}^{2+}]_{\text{vo}} \quad (1)$$

De  $\text{S}^{2-}$ -ionen kunnen echter reageren met  $\text{H}^+$ -ionen (pH = 5,00 : zuur milieu):



$$K = \frac{[\text{HS}^-]}{[\text{H}^+] \cdot [\text{S}^{2-}]} = \frac{1}{K_{a2\text{H}_2\text{S}}}$$



$$K = \frac{[\text{H}_2\text{S}]}{[\text{H}^+] \cdot [\text{HS}^-]} = \frac{1}{K_{a1\text{H}_2\text{S}}}$$

De oplosbaarheid van MnS is dus ook gelijk aan de totale concentratie van de sulfide-ionen en alle deeltjes die daaruit gevormd werden:

$$\begin{aligned} S_{\text{MnS}} &= [\text{S}^{2-}]_{\text{vo}} + [\text{HS}^-]_{\text{vo}} + [\text{H}_2\text{S}]_{\text{vo}} \\ &= [\text{S}^{2-}]_{\text{vo}} + \frac{[\text{H}^+]_{\text{vo}} \cdot [\text{S}^{2-}]_{\text{vo}}}{K_{a2\text{H}_2\text{S}}} + \frac{[\text{H}^+]_{\text{vo}} \cdot [\text{HS}^-]_{\text{vo}}}{K_{a1\text{H}_2\text{S}}} \\ &= [\text{S}^{2-}]_{\text{vo}} + \frac{[\text{H}^+]_{\text{vo}} \cdot [\text{S}^{2-}]_{\text{vo}}}{K_{a2\text{H}_2\text{S}}} + \frac{[\text{H}^+]_{\text{vo}}^2 \cdot [\text{S}^{2-}]_{\text{vo}}}{K_{a1\text{H}_2\text{S}} \cdot K_{a2\text{H}_2\text{S}}} \\ &= [\text{S}^{2-}]_{\text{vo}} \left( 1 + \frac{[\text{H}^+]_{\text{vo}}}{K_{a2\text{H}_2\text{S}}} + \frac{[\text{H}^+]_{\text{vo}}^2}{K_{a1\text{H}_2\text{S}} \cdot K_{a2\text{H}_2\text{S}}} \right) \\ &= \frac{K_S(\text{MnS})}{[\text{Mn}^{2+}]_{\text{vo}}} \left( 1 + \frac{[\text{H}^+]_{\text{vo}}}{K_{a2\text{H}_2\text{S}}} + \frac{[\text{H}^+]_{\text{vo}}^2}{K_{a1\text{H}_2\text{S}} \cdot K_{a2\text{H}_2\text{S}}} \right) \quad (2) \end{aligned}$$

Uit (1) en (2) volgt

$$[\text{Mn}^{2+}]_{\text{vo}}^2 = K_S(\text{MnS}) \left( 1 + \frac{[\text{H}^+]_{\text{vo}}}{K_{a2\text{H}_2\text{S}}} + \frac{[\text{H}^+]_{\text{vo}}^2}{K_{a1\text{H}_2\text{S}} \cdot K_{a2\text{H}_2\text{S}}} \right)$$

$$\begin{aligned}
S_{\text{MnS}} &= \left[ \text{Mn}^{2+} \right]_{\text{vo}} = \sqrt{K_{S_{\text{MnS}}} \left( 1 + \frac{\left[ \text{H}^+ \right]_{\text{vo}}}{K_{a_2 \text{H}_2\text{S}}} + \frac{\left[ \text{H}^+ \right]_{\text{vo}}^2}{K_{a_1 \text{H}_2\text{S}} \cdot K_{a_2 \text{H}_2\text{S}}} \right)} \\
&= \sqrt{3,0 \cdot 10^{-14} \left( 1 + \frac{10^{-5}}{1,0 \cdot 10^{-14}} + \frac{(10^{-5})^2}{8,9 \cdot 10^{-8} \cdot 1,0 \cdot 10^{-14}} \right)} \\
&= \sqrt{3,0 \cdot 10^{-14} (1 + 1,0 \cdot 10^9 + 1,1 \cdot 10^{11})} \\
&= \sqrt{3,3 \cdot 10^{-3}} = \mathbf{5,7 \cdot 10^{-2} \frac{\text{mol}}{\text{L}}}
\end{aligned}$$