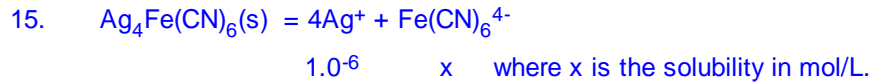


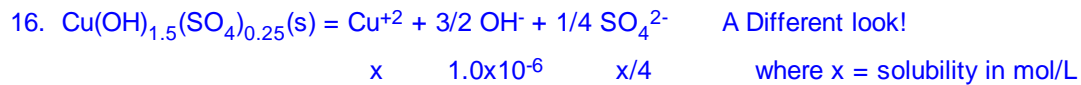
Solutions - Chapter 6



$$K_{\text{sp}} := 8.5 \cdot 10^{-45}$$

$$(10^{-6})^4 \cdot x = K_{\text{sp}} \quad x := 10^{24} \cdot (8.5 \cdot 10^{-45})$$

$$x = 8.5 \times 10^{-21} = 8.5 \text{ zM}$$

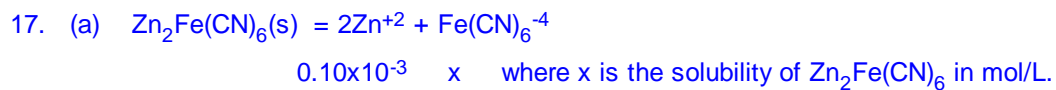


Equilibrium constant: $K = C_{\text{Cu}} \cdot C_{\text{OH}}^{\frac{3}{2}} \cdot C_{\text{SO}_4}^{\frac{1}{4}} \quad K := 6.9 \cdot 10^{-18}$

Substituting for concentrations and K in the above expression;

$$x \cdot (1.0 \cdot 10^{-6})^{\frac{3}{2}} \cdot \left(\frac{x}{4}\right)^{\frac{1}{4}} = 6.9 \cdot 10^{-18} \quad \text{simplifies to} \quad 7.071 \times 10^{-10} \cdot x^{\left(\frac{5}{4}\right)} = 6.9 \cdot 10^{-18}$$

$$x := 3.90 \cdot 10^{-7}$$

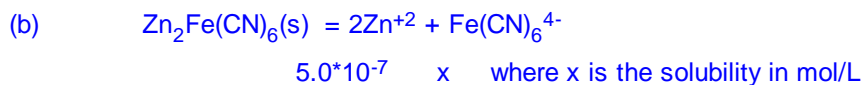


No other ions present and ionic conc. from the solubility is negligible.

$$K_{\text{sp}} := 2.1 \cdot 10^{-16}$$

For solubility eqm.; $(0.10 \cdot 10^{-3})^2 \cdot x = 2.1 \cdot 10^{-16}$

$$x := 2.10 \cdot 10^{-8}$$



The equilibrium expression is;

$$(5.0 \cdot 10^{-7})^2 \cdot x = 2.1 \cdot 10^{-16}$$

$$x := 8.40 \cdot 10^{-4}$$

19. $K_{\text{spCaSO}_4} := 2.4 \cdot 10^{-5}$ $K_{\text{spAg}_2\text{SO}_4} := 1.5 \cdot 10^{-5}$

solubility of Ca salt is lower than that of silver salt. Make sure you know why it is not always obvious. Original $C_{\text{Ca}} = 0.0500$, $C_{\text{Ag}} = 0.0300$.

Thus removing Ca ions as sulfate by 99% without precipitating silver is the task at hand. If 99% of Ca ions are precipitated (1% remain in solution) with no silver precipitating the conc. of the ions in solution are;

$$C_{\text{Ca}} := .01 \cdot 0.0500 \quad C_{\text{Ag}} := 0.0300$$

At that point the *conc of sulfate* in solution is given by the Ksp expression;

$$C_{\text{Ca}} \cdot C_{\text{sulfate}} = K_{\text{spCaSO}_4}$$

has solution(s)

$$C_{\text{sulfate}} := \frac{K_{\text{spCaSO}_4}}{C_{\text{Ca}}} \quad C_{\text{sulfate}} = 0.048$$

Now, for silver sulfate solubility; $\text{Ag}_2\text{SO}_4 = 2 \text{Ag}^+ + \text{SO}_4^{2-}$; $Q := C_{\text{Ag}}^2 \cdot C_{\text{sulfate}}$

If $Q > K_{\text{spAg}_2\text{SO}_4}$ ($= 1.5 \cdot 10^{-5}$) the the reverse reaction occurs, i.e. silver sulfate precipitates.

$Q = 4.32 \times 10^{-5}$ i.e.. silver sulfate would precipitate when 99% of calcium is pptd.

Answer; NO, silver ions would precipitate if 99% Ca is precipitated.

At the point where silver sulfate is just at the brink of precipitation, the sulfate ion conc. in solution will be given by;

$$K_{\text{spAg}_2\text{SO}_4} = C_{\text{Ag}}^2 \cdot C_{\text{sulfate}}$$

has solution(s)

$$C_{\text{sulfate}} := \frac{K_{\text{spAg}_2\text{SO}_4}}{C_{\text{Ag}}^2} \quad C_{\text{sulfate}} = 0.017$$

Just at the brink of silver precipitation the calcium ion concentration in solution is;

$$K_{spCaSO4} = C_{Ca} \cdot C_{sulfate}$$

has solution(s)

$$C_{Ca} := \frac{K_{spCaSO4}}{C_{sulfate}} \quad C_{Ca} = 1.44 \times 10^{-3}$$

The percentage of Ca ions precipitated at that point is;

$$\frac{0.050 - 1.44 \times 10^{-3}}{0.050} \cdot 100 = 97.12$$

23. Lewis acids: BF_3 , AsF_5

25. For the set of equilibria,
Given Data are;

$$K_{sp} := 3.0 \cdot 10^{-16} \quad \beta_1 := 1 \cdot 10^4 \quad \beta_2 := 2 \cdot 10^{10}$$

$$\beta_3 := 8 \cdot 10^{13} \quad \beta_4 := 3 \cdot 10^{15}$$

$$C_{OH} := 3.2 \cdot 10^{-7}$$

Initial Guesses:

$$C_{Zn} := 10^{-8} \quad C_{ZnOH} := 10^{-8} \quad C_{ZnO2H2} := 10^{-8} \quad C_{ZnO3H3} := 10^{-8} \quad C_{ZnO4H4} := 10^{-8}$$

Given

$$C_{Zn} = \frac{K_{sp}}{C_{OH}^2} \quad \text{rearranged equations.}$$

$$C_{ZnOH} = \beta_1 \cdot C_{Zn} \cdot C_{OH}$$

$$C_{ZnO2H2} = \beta_2 \cdot C_{Zn} \cdot C_{OH}^2$$

$$C_{ZnO3H3} = \beta_3 \cdot C_{Zn} \cdot C_{OH}^3$$

$$C_{ZnO4H4} = \beta_4 \cdot C_{Zn} \cdot C_{OH}^4$$

notice the four independent equations.
solution of this problem greatly simplified by the
recognition that C_{OH} is fixed.

$$\begin{pmatrix} C_{Zn} \\ C_{ZnOH} \\ C_{ZnO2H2} \\ C_{ZnO3H3} \\ C_{ZnO4H4} \end{pmatrix} := \text{Find}(C_{Zn}, C_{ZnOH}, C_{ZnO2H2}, C_{ZnO3H3}, C_{ZnO4H4})$$

Solves as;

$$\begin{pmatrix} C_{Zn} \\ C_{ZnOH} \\ C_{ZnO2H2} \\ C_{ZnO3H3} \\ C_{ZnO4H4} \end{pmatrix} = \begin{pmatrix} 2.93 \times 10^{-3} \\ 9.375 \times 10^{-6} \\ 6 \times 10^{-6} \\ 7.68 \times 10^{-9} \\ 9.216 \times 10^{-14} \end{pmatrix}$$

35. acid base

(a) H_3O^+ H_2O (extra example)

(b) $H_3N^+CH_2CH_2NH_3^+$ $H_3N^+CH_2CH_2NH_2$

(c) $C_6H_5CO_2H$ $C_6H_5CO_2^-$

(d) $C_5H_5NH^+$ C_5H_5N (extra example)

39. From tables; $K_{sp} := 2 \cdot 10^{-21}$

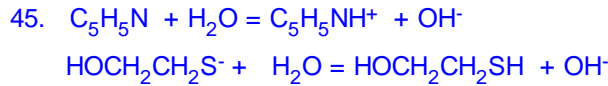
$$C_{La} := 0.010 \quad K_w := 1.0 \cdot 10^{-14}$$

By definition; $C_{La} \cdot C_{OH}^3 = K_{sp}$

Solving for C_{OH} ;

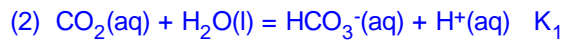
$$C_{OH} := \left(\frac{K_{sp}}{C_{La}} \right)^{\frac{1}{3}}$$

In aqueous system
$$\text{pH} := -\log\left(\frac{K_w}{C_{\text{OH}}}\right) \quad \text{pH} = 7.767$$



54 Regardless of the planet this problem considers the $\text{CaCO}_3(\text{s})$ solubility in water.

The dissolved carbonate ions establishes a series of equilibria, which involves the CO_2 in the atmosphere.



addition of the above equilibria as written yields:

$\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + \text{Ca}^{2+}(\text{aq}) = \text{CaCO}_3(\text{s}) + 2 \text{H}^+(\text{aq})$ associated with an equilibrium constant K as defined below.

$$K_{\text{CO}_2} := 6.0 \cdot 10^{-9} \quad K_{\text{CO}_2} := 3.4 \cdot 10^{-2} \quad K_1 := 4.4 \cdot 10^{-7} \quad K_2 := 4.7 \cdot 10^{-11}$$

$$P_{\text{CO}_2} := 0.10 \quad C_{\text{H}} := 1.8 \cdot 10^{-7}$$

$$K := K_{\text{CO}_2} \cdot K_1 \cdot K_2 \cdot \frac{1}{K_{\text{sp}}}$$

K expressed as
$$\frac{C_{\text{H}}^2}{P_{\text{CO}_2} \cdot C_{\text{Ca}}} = K_{\text{CO}_2} \cdot K_1 \cdot K_2 \cdot \frac{1}{K_{\text{sp}}} \quad \text{has solution(s)}$$

$$C_{\text{Ca}} := C_{\text{H}}^2 \cdot \frac{K_{\text{sp}}}{[K_{\text{CO}_2} \cdot [K_1 \cdot (K_2 \cdot P_{\text{CO}_2})]]} \quad C_{\text{Ca}} = 2.765 \times 10^{-3}$$

In 2 liters mass of $\text{Ca}(\text{II})$ in grams; $C_{\text{Ca}} \cdot 40.078 \cdot 2 = 0.222$

