Week 2 Worksheet

Chem 11300-2: Section 33

April 5, 2022

***Problem* 1:** The K_{sp} for $Pb(OH)_2$ is 1.4×10^{-20}.

a) Will this salt dissolve more easily in an acidic, neutral, or basic solution? Or would it be the same in each?

b) Calculate the solubility of lead hydroxide in pure water.

c) Calculate the solubility of lead hydroxide at pH = 12.

d) Was your prediction correct?

***Problem* 2:** So, how soluble are 'insoluble' ionic solids in water? Let's investigate.

a) What minimum volume of pure water would be needed to dissolve exactly 1.00 g of Ag_3PO_4? (Assume the volume occupied by the solid doesn't contribute to the overall solution volume.) The K_{sp} is 8.90×10^{-17}.

b) If 1.00 g of $CaCl_2$ were added to the solution prepared in part (a) above, which solid(s) would you expect to precipitate, if any? Show all work to justify your answer. (Assume no change in total solution volume upon addition or precipitation of any solids.) The K_{sp} for AgCl is 1.77×10^{-10}. The K_{sp} for $Ca_3(PO_4)_2$ is 2.07×10^{-33}.

The following problems are written by Professor Mcleod or Head TA Miah Turke. They may mimic homework problems closely, but will be highly beneficial for the midterms and final.

***Problem* 3:** Lets spend some time examining the conditions necessary for precipitation to occur.

a) Review the idea of the reaction quotient introduced in Section 16.3.1, which was first introduced in Section 14.6. If a solution is prepared by mixing a soluble salt (such as $Mg(NO_3)_2$) with another soluble salt (such as NaOH), under what conditions will precipitation of the resultant slightly-soluble salt (such as $Mg(OH)_2$) occur? Explain.

b) Will a precipitate form when 100.0 mL of 4.0×10^{-4} M $Mg(NO_3)_2$ is added to 100.0 mL of 2.0×10^{-4} M NaOH? Explain. [K_{sp} *for* $Mg(OH)_2$ *is* 8.9×10^{-12}.]

c) Determine an inequality describing concentrations for which magnesium hydroxide will precipitate when 100.0 mL of x M $Mg(NO_3)_2$ is mixed with 100.0 mL of y M NaOH (i.e., determine the relationship between x, y, and K_{sp}).

d) Draw a diagram of y versus x, labeling regions where precipitation will occur, precipitation will not occur, and equilibrium. Your diagram does not need to be exact, but it should be qualitatively accurate. (See Section 16.3.1 for an example).

***Problem* 4:** A solution is formed by mixing 25.0 mL of 20.0 M NaX with 25.0 mL of 4.0×10^{-3} M $AgNO_3$ and 50.0 mL of water where Ag^+ forms complex ions with X^-:

$$\begin{aligned} Ag^+\,(aq) + X^-\,(aq) &\rightleftharpoons AgX\,(aq), \quad K_1 = 1.0 \times 10^2 \\ AgX\,(aq) + X^-\,(aq) &\rightleftharpoons AgX_2{}^-\,(aq), \quad K_2 = 1.0 \times 10^4 \\ AgX_2{}^-\,(aq) + X^-\,(aq) &\rightleftharpoons AgX_3{}^{2-}\,(aq), \quad K_3 = 1.0 \times 10^3 \end{aligned}$$

with the overall reaction given by

$$Ag^+\,(aq) + 3\,X^-\,(aq) \rightleftharpoons AgX_3{}^{2-}(aq), \quad K_f = ?$$

a) Write equations for K_1, K_2, K_3 and K_f in terms of $[Ag^+], [X^-], [AgX], [AgX_2{}^-]$ and $[AgX_3{}^{2-}]$.

b) How is K_f related to K_1, K_2, and K_3? What is the value of K_f?

c) What are the initial concentrations of X^- and Ag^+?

d) Calculate the following concentrations at equilibrium. Note any assumptions you make

i) $AgX_3{}^{2-}$

ii) $AgX_2{}^-$

iii) Ag^+