Non Sibi High School

Andover's Chem 550/580: Advanced Chemistry

Chapter 18, Review Quiz 1 Answers

1

Calculate the molar solubility of lead(II) bromide ($K_{sp} = 4.0 \times 10^{-5}$). Include the solubility equilibrium reaction and K_{sp} expression in your answer.

R)	$PbBr_2(s)$	$\rightleftharpoons$	$Pb^{2+}(aq)$	+	$2Br^-(aq)$
I)			0		0
C)			+s		+2s
E)			s		2s

$$K_{sp} = [Pb^{2+}][Br^-]^2$$
$$4.0 \times 10^{-5} = (s)(2s)^2$$
$$s = 0.022\,M$$

2

The molar solubility of scandium(III) fluoride is 1.9×10^{-5} M. Calculate the value of K_{sp} for scandium(III) fluoride. Include the solubility equilibrium reaction and K_{sp} expression in your answer.

R)	$ScF_3(s)$	$\rightleftharpoons$	$Sc^{3+}(aq)$	+	$3F^-(aq)$
I)			0		0
C)			+s		+3s
E)			s		3s

$$K_{sp} = [Sc^{3+}][F^-]^3 = (s)(3s)^3 = 27s^4 = 27(1.9 \times 10^{-5})^4 = 3.5 \times 10^{-18}$$

3

Predict if precipitation will occur when 14 mL of 6.5×10^{-5} M $AgNO_3$ is mixed with 56 mL of 3.5×10^{-4} M K_3PO_4. ($K_{sp} = 8.9 \times 10^{-17}$ for Ag_3PO_4)

K^+ and $NO_3{}^-$ = spectator ions

$Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4{}^{3-}(aq)$

total volume after mixing = 14 mL + 56 mL = 70 mL

$$[Ag^+]_i = 6.5 \times 10^{-5}\,\mathrm{M}\left(\frac{14\,\mathrm{mL}}{70\,\mathrm{mL}}\right) = 1.3 \times 10^{-5}\,\mathrm{M}$$

$$[PO_4{}^{3-}]_i = 3.5 \times 10^{-4}\,\mathrm{M}\left(\frac{56\,\mathrm{mL}}{70\,\mathrm{mL}}\right) = 2.8 \times 10^{-4}\,\mathrm{M}$$

$Q_{sp} = (1.3 \times 10^{-5})^3(2.8 \times 10^{-4}) = 6.2 \times 10^{-19} < K_{sp}$, no precipitate

4

A metal hydroxide with the formula $M(OH)_2$ was mixed with water and stirred until a saturated solution was created. The pH of the solution was found to be 9.88. Calculate the value of K_{sp} for the metal hydroxide.

R)	$M(OH)_2(s)$	$\rightleftharpoons$	$M^{2+}(aq)$	+	$2OH^-(aq)$
I)			0		0
C)			+s		+2s
E)			s		2s

pOH = 14.00 − 9.88 = 4.12

$[OH^-] = 10^{-4.12} = 7.6 \times 10^{-5}$ M = 2s

$s = 3.8 \times 10^{-5}$ M

$K_{sp} = [M^{2+}][OH^-]^2 = (s)(2s)^2 = 4s^3 = 4(3.8 \times 10^{-5})^3 = 2.2 \times 10^{-13}$

5

Calculate the molar solubility of lead(II) bromide ($K_{sp} = 4.0 \times 10^{-5}$) in 0.25 M $Pb(NO_3)_2$. Include the solubility equilibrium reaction and K_{sp} expression in your answer.

$NO_3{}^-$ = spectator ion, $[Pb^{2+}]_i = 0.25$ M:

R)	$PbBr_2(s)$	$\rightleftharpoons$	$Pb^{2+}(aq)$	+	$2Br^-(aq)$
I)			0.25		0
C)			+s		+2s
E)			0.25+s		2s

$$K_{sp} = [Pb^{2+}][Br^-]^2$$
$$4.0 \times 10^{-5} = (0.25 + s)(2s)^2$$
$$s = 0.0062\,M$$

6

An aqueous solution of $Pb(NO_3)_2$ is added dropwise to an aqueous mixture containing 0.010 M Br^- and 0.95 M I^-.

a. Calculate the minimum molarity of Pb^{2+} that must be reached to initiate precipitation of Br^- ($K_{sp} = 4.0 \times 10^{-5}$ for $PbBr_2$) and the minimum molarity of Pb^{2+} that must be reached to initiate precipitation of I^- ($K_{sp} = 8.5 \times 10^{-9}$ for PbI_2). Which precipitates first, Br^- or I^-?

b. At the point when the second ion from the original mixture begins to precipitate, what percentage of the first ions initial molarity still remains unprecipitated in the solution? Can the Br^- and I^- mixture be effectively separated by fractional precipitation?

a. $NO_3{}^-$ = spectator ion

$PbBr_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Br^-(aq)$
$K_{sp} = [Pb^{2+}][Br^-]^2$
$4.0 \times 10^{-5} = [Pb^{2+}](0.010)^2$
$[Pb^{2+}] = 0.40\,M$ = minimum that must be reached to precipitate Br^-

$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$
$K_{sp} = [Pb^{2+}][I^-]^2$
$8.5 \times 10^{-9} = [Pb^{2+}](0.95)^2$
$[Pb^{2+}] = 9.4 \times 10^{-9}\,M$ = minimum that must be reached to precipitate I^-

Since less Pb^{2+} must be added to precipitate I^-, I^- precipitates first.

b.
$8.5 \times 10^{-9} = (0.40)[I^-]^2$
$[I^-] = 1.5 \times 10^{-4}\,M$ still remains unprecipitated in the solution at the point when Br^- begins to precipitate

$$\frac{1.5 \times 10^{-4}\,M}{0.95\,M} \times 100\% = 0.016\% \text{ of initial } \mathrm{I^-} \text{ molarity still remains}$$

unprecipitated in the solution at the point when Br^- begins to precipitate.

Only a very small percentage of the original amount of I^- remains in solution. Therefore, since nearly 100% of the original amount of I^- is incorporated into a solid precipitate before any of the Br^- can leave the solution, the Br^- and I^- mixture can be effectively separated by fractional precipitation.

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