Ch 12 **Using Solubility Products** Name ____________________

Write out the **equation** for the equilibrium and the **equilibrium expression** as well as the necessary mathematical steps used in solving the following problems. You may have to consult your Ksp chart.

1. Determine the Ksp for AgOH if its molar solubility is known to be 1.4×10^{-4}M.

$AgOH_{(s)} \rightleftharpoons Ag^+_{(aq)} + OH^-_{(aq)}$ $K_{sp} = [Ag^+][OH^-]$ 2

$K_{sp} = (1.4 \times 10^{-4})^2 = 2.0 \times 10^{-8}$ (1.96×10^{-8})

2. Find the K_{sp} for BaF_2 if its solubility is 7.5×10^{-3}M.

$BaF_{2(s)} \rightleftharpoons Ba^{+2}_{(aq)} + 2F^-_{(aq)}$ $K_{sp} = [Ba^{+2}][F^-]^2$ 2

$K_{sp} = (7.5 \times 10^{-3})(1.5 \times 10^{-2})^2 = 1.7 \times 10^{-6}$ (1.6875×10^{-6})

3. The solubility of $CaSO_4$ is 1.15g/L. Determine the K_{sp} of $CaSO_4$.

molar mass = 136.2 g/mol $CaSO_{4(s)} \rightleftharpoons Ca^{+2}_{(aq)} + SO_4^{-2}_{(aq)}$ $K_{sp} = [Ca^{+2}][SO_4^{-2}]$

mol. sol. = $\frac{1.15g}{L} \times \frac{1 mol}{136.2g} = 8.44 \times 10^{-3}$M $K_{sp} = (8.44 \times 10^{-3})^2 = 7.13 \times 10^{-5}$ 3

(7.12921×10^{-5})

4. A sample of $Cd(OH)_2$ is added to water and stirred until no more will dissolve. Subsequent analysis shows the $[Cd^{2+}]$ to be 1.7×10^{-5}M. What is the Ksp for $Cd(OH)_2$?

$Cd(OH)_{2(s)} \rightleftharpoons Cd^{+2}_{(aq)} + 2OH^-_{(aq)}$ $K_{sp} = [Cd^{+2}][OH^-]^2$

$K_{sp} = (1.7 \times 10^{-5})(3.4 \times 10^{-5})^2 = 2.0 \times 10^{-14}$ (1.9652×10^{-14}) 2

5. A saturated solution of $PbBr_2$ is found to have a $[Br^-]$ of 2.4×10^{-2}M. Determine the K_{sp} for $PbBr_2$.

$PbBr_{2(s)} \rightleftharpoons Pb^{+2}_{(aq)} + 2Br^-_{(aq)}$ $K_{sp} = [Pb^{+2}][Br^-]^2$

$K_{sp} = (1.2 \times 10^{-2})(2.4 \times 10^{-2})^2 = 6.9 \times 10^{-6}$ (6.912×10^{-6}) 2

6. What is the molar solubility of CuI if its K_{sp} is known to be 1.3×10^{-12}?

$CuI_{(s)} \rightleftharpoons Cu^+_{(aq)} + I^-_{(aq)}$ $K_{sp} = [Cu^+][I^-] = 1.3 \times 10^{-12}$

sol = $x = \sqrt{1.3 \times 10^{-12}} = 1.1 \times 10^{-6}$ M (1.14018×10^{-6}) 2

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7. What is the solubility of AgI in g/L?

$AgI_{(s)} \rightleftharpoons Ag^+_{(aq)} + I^-_{(aq)}$ $K_{sp} = 8.5\times10^{-17} = [Ag^+][I^-]$

$x = \text{sol.} = \sqrt{8.5\times10^{-17}} = 9.2\times10^{-9}\,M$ $(9.21952\times10^{-9} M)$

$\text{mass sol.} = 9.21952\times10^{-9}\frac{mol}{L} \times \frac{234.8\,g}{mol} = 2.2\times10^{-6}\,g/L$ (2.16475×10^{-6}) 3

8. What mass of FeS will 2.5L of its saturated solution contain at 25 degrees Celsius?

$FeS_{(s)} \rightleftharpoons Fe^{+2}_{(aq)} + S^{-2}_{(aq)}$ $K_{sp} = 6.0\times10^{-19} = [Fe^{+2}][S^{-2}]$

$x = \text{sol.} = \sqrt{6.0\times10^{-19}} = 7.7\times10^{-10}\,M$ (7.74597×10^{-10})

$\text{mass} = 7.74597\times10^{-10}\frac{mol}{L} \times 2.5\,L \times \frac{87.9\,g}{mol} = 1.7\times10^{-7}\,g$ (1.70218×10^{-7}) 3

9. Calculate the molar solubility of $Cu(IO_3)_2$.

$Cu(IO_3)_{2\,(s)} \rightleftharpoons Cu^{+2}_{(aq)} + 2\,IO_3^-{}_{(aq)}$ $K_{sp} = 6.9\times10^{-8} = [Cu^{+2}][IO_3^-]^2$

$K_{sp} = 6.9\times10^{-8} = (x)(2x)^2 = 4x^3$ 2

$\text{sol.} = x = \sqrt[3]{\frac{6.9\times10^{-8}}{4}} = 2.6\times10^{-3}\,M$ (2.58382×10^{-3})

10. What are the equilibrium concentrations of Ca^{2+} and F^- in a saturated solution of CaF_2? The K_{sp} for CaF_2 is 3.9×10^{-11}.

$CaF_{2\,(s)} \rightleftharpoons Ca^{+2}_{(aq)} + 2F^-_{(aq)}$ $K_{sp} = 3.9\times10^{-11} = [Ca^{+2}][F^-]^2$ (x) $(2x)^2$

$\text{sol.} = \sqrt[3]{\frac{3.9\times10^{-11}}{4}} = 2.1\times10^{-4}\,M$ (2.13633×10^{-4}) 3

$[Ca^{+2}] = 2.1\times10^{-4}\,M$ $[F^-] = 4.3\times10^{-4}\,M$

11. How many moles of calcium oxalate must dissolve to produce 750mL of a saturated solution?

$CaC_2O_{4\,(s)} \rightleftharpoons Ca^{+2}_{(aq)} + C_2O_4^{-2}{}_{(aq)}$ $K_{sp} = 2.3\times10^{-9} = [Ca^{+2}][C_2O_4^{-2}]$ (x)(x)

$\text{sol.} = \sqrt{2.3\times10^{-9}} =$ ~~1.5×10⁻² M~~ $4.8\times10^{-5}\,M$ (~~1.51658×10⁻²~~ 4.79583×10^{-5}) 3

$\text{mol} =$ ~~1.5~~ $4.8\times10^{-5}\frac{mol}{L} \times 0.750\,L =$ ~~1.1×10⁻²~~ 3.6×10^{-5} mol (~~1.13743×10⁻²~~ 3.59687×10^{-5})

12. Calculate the mass of SrF_2 that must dissolve to make 3.50L of saturated solution.

$SrF_{2\,(s)} \rightleftharpoons Sr^{+2}_{(aq)} + 2F^-_{(aq)}$ $K_{sp} = 4.3\times10^{-9} = [Sr^{+2}][F^-]^2$

$\text{sol.} = \sqrt[3]{\frac{4.3\times10^{-9}}{4}} = 1.0\times10^{-3}\,M$ (1.0244×10^{-3}) 3

$\text{mass} = 1.0244\times10^{-3}\frac{mol}{L} \times 3.50\,L \times \frac{125.6\,g}{mol} = 0.45\,g$ (0.450326)

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13. Determine the maximum $[Cu^{2+}]$ that can exist in a solution containing 0.015M S^{2-}.

$CuS_{(s)} \rightleftharpoons Cu^{+2}_{(aq)} + S^{-2}_{(aq)}$ $K_{sp} = 6.0 \times 10^{-37} = [Cu^{+2}][S^{-2}]$

$[Cu^{+2}] = \frac{6.0 \times 10^{-37}}{0.015} = 4.0 \times 10^{-35}$ M 2

14. Calculate the highest concentration of Ag^{+} ion that can be found in a solution that also contains 7.6×10^{-3}M CO_3^{2-}.

$Ag_2CO_{3(s)} \rightleftharpoons 2Ag^{+}_{(aq)} + CO_3^{-2}_{(aq)}$ $K_{sp} = 8.5 \times 10^{-12} = [Ag^{+}]^2[CO_3^{-2}]$

$[Ag^{+}] = \sqrt{\frac{8.5 \times 10^{-12}}{7.6 \times 10^{-3}}} = 3.3 \times 10^{-5}$ M (3.34428×10^{-5}) 2

15. Find the maximum $[Ca^{2+}]$ that can exist in a 0.14M Na_2SO_4 solution.

$CaSO_{4(s)} \rightleftharpoons Ca^{+2}_{(aq)} + SO_4^{-2}_{(aq)}$ $K_{sp} = 7.1 \times 10^{-5} = [Ca^{+2}][SO_4^{-2}]$

$[Ca^{+2}] = \frac{7.1 \times 10^{-5}}{0.14} = 5.1 \times 10^{-4}$ M (5.07143×10^{-4}) 2

16. What is the maximum $[Ag^{+}]$ that can be found in 2.4×10^{-3}M $BaCl_{2(aq)}$?

!! $AgCl_{(s)} \rightleftharpoons Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$ $K_{sp} = 1.8 \times 10^{-10} = [Ag^{+}][Cl^{-}]$ 2

2.4×10^{-3} M $BaCl_2$ = 4.8×10^{-3} M $[Cl^{-}]$

$[Ag^{+}] = \frac{1.8 \times 10^{-10}}{4.8 \times 10^{-3}} = 3.8 \times 10^{-8}$ M (3.75×10^{-8}) $(1 = 7.5 \times 10^{-8})$

17. Calculated the maximum mass of $CuSO_4$ that could be dissolved in 3.4L of a solution that contains 7.8×10^{-5}M Pb^{2+} ion. Assume that any increase in volume is negligible.

$PbSO_{4(s)} \rightleftharpoons Pb^{+2}_{(aq)} + SO_4^{-2}_{(aq)}$ $K_{sp} = 1.8 \times 10^{-8} = [Pb^{+2}][SO_4^{-2}]$

$[SO_4^{-2}] = \frac{1.8 \times 10^{-8}}{7.8 \times 10^{-5}} = 2.3 \times 10^{-4}$ M (2.30769×10^{-4}) 3

mass $CuSO_4$ = $2.30769 \times 10^{-4} \frac{mol}{L} \times 3.4L \times \frac{159.6g}{mol} = 0.13g$ (0.125225)

18. Calculate the maximum mass of $MgCl_2$ that could be dissolved in 1.2L of a 0.010M NaOH solution. Assume that there is no noticeable change in volume.

$Mg(OH)_{2(s)} \rightleftharpoons Mg^{+2}_{(aq)} + 2OH^{-}_{(aq)}$ $K_{sp} = 5.6 \times 10^{-12} = [Mg^{+2}][OH^{-}]^2$

$[Mg^{+2}] = \frac{5.6 \times 10^{-12}}{(0.01)^2} = 5.6 \times 10^{-8}$ M 3

mass $MgCl_2$ = $5.6 \times 10^{-8} \frac{mol}{L} \times 1.2L \times \frac{95.3g}{mol} = 6.4 \times 10^{-6}g$ (6.40416×10^{-6})

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19. Will a precipitate form if 25mL of 0.0050M $Ba(NO_3)_2$ solution are mixed with 85mL of 5.6×10^{-6}M Na_2CrO_4 solution?

$BaCrO_{4(s)} \rightleftharpoons Ba^{+2}{}_{(aq)} + CrO_4^{-2}{}_{(aq)}$ $K_{sp} = 1.2 \times 10^{-10} = [Ba^{+2}][CrO_4^{-2}]$

$[Ba^{+2}] = \frac{(0.0050\,m)(25\,mL)}{(110\,mL)} = 1.13636 \times 10^{-3}\,m$ $[CrO_4^{-2}] = \frac{(5.6 \times 10^{-6}\,m)(85\,mL)}{(110\,mL)} = 4.32727 \times 10^{-6}\,m$

Trial $K_{sp} = (1.3636 \times 10^{-3})(4.32727 \times 10^{-6})$

$= 4.9 \times 10^{-9}$ ← Since Trial Ksp > Real Ksp.... a ppt WILL form

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20. Determine whether a precipitate will form when 2.5L of 3.5×10^{-3}M $SrCl_{2(aq)}$ are mixed with 4.2L of 2.7×10^{-3}M $KF_{(aq)}$.

$SrF_{2(s)} \rightleftharpoons Sr^{+2}{}_{(aq)} + 2F^-{}_{(aq)}$ $K_{sp} = 4.3 \times 10^{-9} = [Sr^{+2}][F^-]^2$

$[Sr^{+2}] = \frac{(3.5 \times 10^{-3}\,m)(2.5L)}{(6.7L)} = 1.30597 \times 10^{-3}\,m$ $[F^-] = \frac{(2.7 \times 10^{-3}\,m)(4.2L)}{(6.7L)} = 1.69254 \times 10^{-3}\,m$

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Trial $K_{sp} = (1.30597 \times 10^{-3})(1.69254 \times 10^{-3})^2$

$= 3.7 \times 10^{-9}$ ← Since Trial Ksp < Real Ksp.... a ppt DOES NOT form

21. Determine whether a precipitate will form when 60.0mL of 4.4×10^{-5}M $MgCl_2$ solution are mixed with 30.0mL of 9.8×10^{-6}M $AgNO_3$ solution.

$AgCl_{(s)} \rightleftharpoons Ag^+{}_{(aq)} + Cl^-{}_{(aq)}$ $K_{sp} = 1.8 \times 10^{-10} = [Ag^+][Cl^-]$

$[Ag^+] = \frac{(9.8 \times 10^{-6}\,m)(30\,mL)}{(90\,mL)} = 3.2667 \times 10^{-6}\,m$ $[Cl^-] = \frac{2 \times (4.4 \times 10^{-5}\,m)(60\,mL)}{(90\,mL)} = 5.86667 \times 10^{-5}\,M$

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Trial $K_{sp} = (3.2667 \times 10^{-6})(5.86667 \times 10^{-5})$

$= 1.9 \times 10^{-10}$ ← Since Trial Ksp > Real Ksp.... a ppt WILL form

22. Will a precipitate form when equal volumes of 3.2×10^{-4}M $Cu(NO_3)_{2(aq)}$ and 2.6×10^{-4}M $NaIO_{3(aq)}$ are mixed?

$Cu(IO_3)_{2(s)} \rightleftharpoons Cu^{+2}{}_{(aq)} + 2IO_3^-{}_{(aq)}$ $K_{sp} = 6.9 \times 10^{-8} = [Cu^{+2}][IO_3^-]^2$

$[Cu^{+2}] = \frac{(3.2 \times 10^{-4}\,m)(x\,mL)}{(2x\,mL)} = 1.6 \times 10^{-4}\,m$ $[IO_3^-] = \frac{(2.6 \times 10^{-4}\,m)(x\,mL)}{(2x\,mL)} = 1.3 \times 10^{-4}\,M$

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Trial $K_{sp} = (1.6 \times 10^{-4})(1.3 \times 10^{-4})^2$

$= 2.7 \times 10^{-12}$ ← Since Trial Ksp < Real Ksp.... a ppt DOES NOT form

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