Answer Key.

Solubility #5

1. What is the minimum mass of Na_2SO_4 crystal that must be dissolved in 5.0 L of 0.0010 M $Ca(NO_3)_2$ solution in order to initiate precipitation of calcium sulphate?

2. 750 mL of a 1.0×10^{-2} M lead II chloride solution was cooled resulting in the precipitation of 1.80 g of solid $PbCl_2$. What is the molarity of the cooled solution?

3. Determine the mass of silver chloride precipitated when 50 mL of 0.60 M $AgNO_3$ solution is mixed with 100 mL of 0.10 M $CaCl_2$ solution. Assume AgCl has negligible solubility.

4. A given sample of water with temporary hardness has a $[Ca^{2+}]$ of 1.0×10^{-3} M.
(a) If the K_{sp} of CaF_2 is 1.7×10^{-10}, what is the maximum $[F^-]$ that can be attained in temporary hard water before CaF_2 would precipitate?

5. A solution is prepared by adding 1.5 mol $BaCrO_4$ to water to make 1.0 L of solution. Calculate the $[Ba^{2+}]$ and the $[CrO_4^{2-}]$ at equilibrium.

6. The $[Ag^+]$ of a solution is 4.0×10^{-3} M. Calculate the $[Cl^-]$ that must be exceeded before AgCl can precipitate.

7. Calculate the solubility of PbI_2.

8. 30 mL of 0.10 M $AgNO_3$ is added to 70 mL of 0.10 M $CaCl_2$. What is the concentration of each ion in the solution once precipitation stops and equilibrium is established?

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1. $CaSO_{4(s)} \leftrightarrow Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

$K_{sp} = [Ca^{2+}][SO_4^{2-}] = 7.1 \times 10^{-5}$

$7.1 \times 10^{-5} = (0.0010M)[SO_4^{2-}]$

$[SO_4^{2-}] = 7.1 \times 10^{-2}$ M

mols $SO_4^{2-} = 7.1 \times 10^{-2}$ mol/L $\times$ 5.0L = 0.355 mol

FW Na_2SO_4 = 2(23.0u) + 32.1u + 4(16.0u) = 142.1 g/mol

mass Na_2SO_4 = 0.355 mol $\times$ 142.1 g/mol = 50 g

2. $PbCl_{2(s)} \leftrightarrow Pb^{2+}_{(aq)} + 2Cl^-_{(aq)}$

mols $PbCl_2$ in solution = .750L $\times$ 1.0×10^{-2} M
$= 7.5 \times 10^{-3}$ mol

FW $PbCl_2$ = 207.2u + 2(35.5u) = 278.2 g/mol

mols $PbCl_2$ ppt = 1.80g ÷ 278.2 g/mol = 6.47×10^{-3} mol

mols left in sol^n = $7.5 \times 10^{-3} - 6.47 \times 10^{-3} = 1.03 \times 10^{-3}$ mol

$[PbCl_2] = \frac{1.03 \times 10^{-3} \text{ mol}}{.750 \text{ L}} = 1.4 \times 10^{-3}$ M

3. $AgCl_{(s)} \leftrightarrow Ag^+_{(aq)} + Cl^-_{(aq)}$

mols Ag^+ = 0.050L $\times$ 0.60M = 0.030 mol

mols Cl^- = 0.100L $\times$ 0.10M $\times$ 2 = 0.020 mol

1:1 ratio ∴ Cl^- is the limiting factor

0.020 mol of precipitate will form

FW AgCl = 107.9u + 35.5u = 143.4 g/mol

mass of AgCl = 0.020 mol $\times$ 143.4 g/mol
= 2.9 g

Solubility #5 - Answer key

4(a) $CaF_{2(s)} \longleftrightarrow Ca^{2+}_{(aq)} + 2F^-_{(aq)}$

$K_{sp} = [Ca^{2+}][F^-]^2 = 1.7 \times 10^{-10}$

$1.7 \times 10^{-10} = (1.0 \times 10^{-3})[F^-]^2$

$[F^-] = 4.1 \times 10^{-4}\,M$

5.

R	$BaCrO_{4(s)}$ $\longleftrightarrow$	$Ba^{2+}_{(aq)}$ +	$CrO_4^{2-}{}_{(aq)}$
i		0.00	0.00
c		+ x	+ x
E		x	x

$K_{sp} = [Ba^{2+}][CrO_4^{2-}] = 1.2 \times 10^{-10}$

$1.2 \times 10^{-10} = x^2$

$x = 1.1 \times 10^{-5}\,M$

The $[Ba^{2+}]$ and $[CrO_4^{2-}]$ are $1.1 \times 10^{-5}\,M$ at equilibrium

6. $AgCl_{(s)} \longleftrightarrow Ag^+_{(aq)} + Cl^-_{(aq)}$

$K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$

$1.8 \times 10^{-10} = (4.0 \times 10^{-3})[Cl^-]$

$[Cl^-] = 4.5 \times 10^{-8}\,M$

7.

R	$PbI_{2(s)}$ $\longleftrightarrow$	$Pb^{2+}_{(aq)}$ +	$2I^-_{(aq)}$
i		0.00	0.00
c		+ x	+ 2x
E		x	2x

$K_{sp} = [Pb^{2+}][I^-]^2 = 8.5 \times 10^{-9}$

$8.5 \times 10^{-9} = x\,(2x)^2$

$= 4x^3$

$x = 1.3 \times 10^{-3}\,M$ = solubility of PbI_2

8. $AgCl_{(s)} \longleftrightarrow Ag^+ + Cl^-$

$K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$

$[Ag^+] = \dfrac{30\,mL \times 0.10\,M}{100\,mL} = 0.030\,M$

$[Cl^-] = \dfrac{70\,mL \times 0.10\,M \times 2}{100\,mL} = 0.140\,M$

If all the Ag^+ precipitates $[Cl^-] = 0.140\,M - 0.030\,M = 0.11\,M$

then at eqm:

$[Ag^+] = x$

$[Cl^-] = 0.11\,M + x \approx 0.11\,M$ if x is small

$1.8 \times 10^{-10} = x\,(0.11\,M)$

$x = 1.64 \times 10^{-9}\,M$

at eqm:

$[Ag^+] = 1.6 \times 10^{-9}\,M$

$[Cl^-] = 0.11\,M$