

5.4 - Special K's - Solubility Equilibrium Teacher.notebook

5.4 - Special K's - Equilibrium Solubility - Assignment

1. Write the balanced equation and the solubility product constant expression, K_{sp} , for each of the following dissociation reactions. All compounds are solids. One has been given as an example.

- Reminders
- ion charges MUST BE included.
 - solids (and liquids) are NOT included in the equilibrium expression
 - don't forget to include exponents when needed
 - polyatomic ions (e.g. CO_3) do not break apart

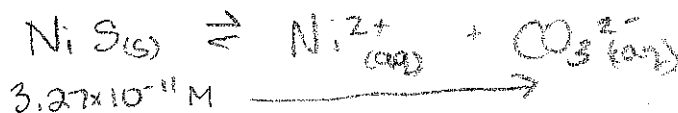
Compound	Equation	K_{sp}
$(\text{NH}_4)_2\text{S}$	$(\text{NH}_4)_2\text{S} (s) \rightleftharpoons 2 \text{NH}_4^+ (aq) + \text{S}^{2-} (aq)$	$K_{sp} = [\text{NH}_4^+]^2 [\text{S}^{2-}]$
CaS	$\text{CaS} (s) \rightleftharpoons \text{Ca}^{2+} (aq) + \text{S}^{2-} (aq)$	$K_{sp} = [\text{Ca}^{2+}] [\text{S}^{2-}]$
K_2SO_4	$\text{K}_2\text{SO}_4 (s) \rightleftharpoons 2 \text{K}^+ (aq) + \text{SO}_4^{2-} (aq)$	$K_{sp} = [\text{K}^+]^2 [\text{SO}_4^{2-}]$
$\text{Mg}(\text{OH})_2$	$\text{Mg}(\text{OH})_2 (s) \rightleftharpoons \text{Mg}^{2+} (aq) + 2 \text{OH}^- (aq)$	$K_{sp} = [\text{Mg}^{2+}] [\text{OH}^-]^2$

2. Organize the following salts in order of solubility (highest to lowest):

AgCl ; $K_{sp} = 1.8 \times 10^{-10}$ AgI ; $K_{sp} = 8.5 \times 10^{-17}$ AgBr ; $K_{sp} = 5.4 \times 10^{-13}$

$\text{AgCl}, \text{AgBr}, \text{AgI}$

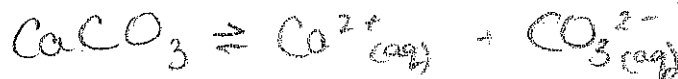
3. Calculate K_{sp} for a saturated nickel(II) sulfide, NiS , solution with a solubility of 3.27×10^{-11} . Calculate the K_{sp} .



$$K_{sp} = [\text{Ni}^{2+}] [\text{S}^{2-}] = (3.27 \times 10^{-11} \text{ M}) (3.27 \times 10^{-11} \text{ M})$$

$$K_{sp} = 1.07 \times 10^{-21}$$

4. Calculate the concentration of ions in a saturated solution of CaCO_3 in water at 25°C . K_{sp} for CaCO_3 is 4.8×10^{-9} .



$$[\text{Ca}^{2+}] = [\text{CO}_3^{2-}] = x$$

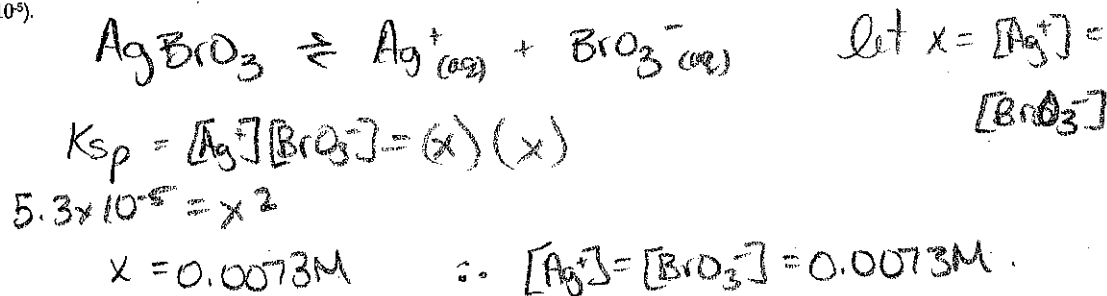
$$K_{sp} = 4.8 \times 10^{-9} = [\text{Ca}^{2+}] [\text{CO}_3^{2-}]$$

$$\sqrt{4.8 \times 10^{-9}} = \sqrt{x^2}$$

$$x = 6.93 \times 10^{-5} \text{ M}$$

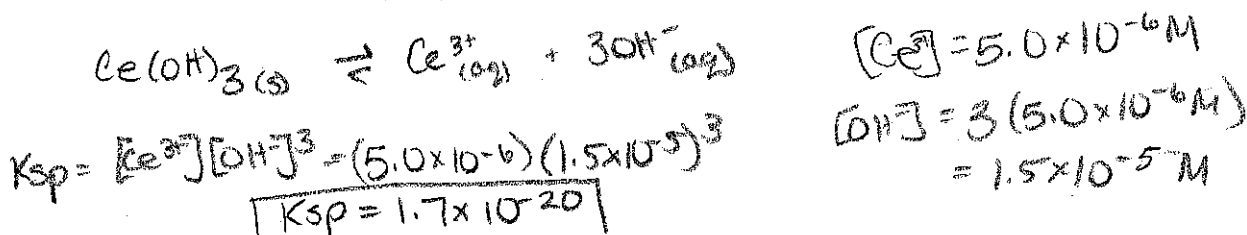
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5. Calculate the concentrations of ions at 25°C for a saturated solution of silver bromate ($K_{sp} = 5.3 \times 10^{-5}$).

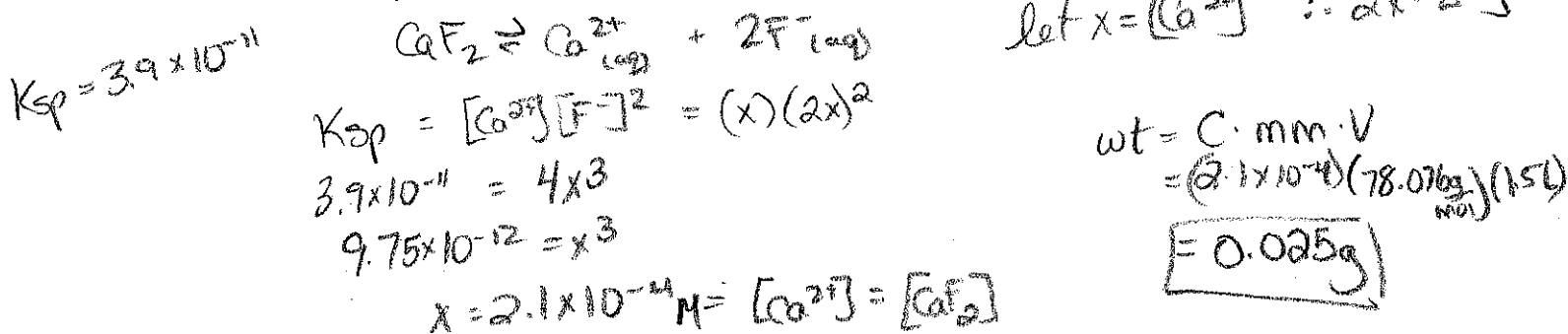


6. At 25°C, 0.0024 g of $\text{Ce}(\text{OH})_3$ is contained in a 2.5 L solution. Calculate K_{sp} .

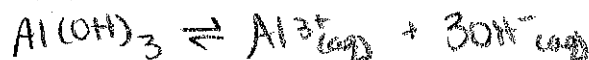
$$C = \frac{\text{wt}}{\text{mm} \cdot V} = \frac{0.0024 \text{ g}}{(191.15 \frac{\text{g}}{\text{mol}})(2.5 \text{ L})} = 5.0 \times 10^{-6} \text{ M}$$



7. What is the mass of calcium fluoride present in a saturated 1.5 L solution?



8. 400.0 mL of $4.00 \times 10^{-10} \text{ M}$ $\text{Al}(\text{NO}_3)_3$ is mixed with 500.0 mL of $3.00 \times 10^{-7} \text{ M}$ NaOH . If K_{sp} for $\text{Al}(\text{OH})_3$ is 5.00×10^{-33} at this temperature, will there be a precipitate?



$$\text{Al}(\text{NO}_3)_3 \rightarrow M_1 V_1 = M_2 V_2$$

$$(4.0 \times 10^{-10})(0.4) = M_2(0.9)$$

$$M_2 = 1.78 \times 10^{-10} \text{ M} = [\text{Al}^{3+}]$$

$$\text{NaOH} \rightarrow M_1 V_1 = M_2 V_2$$

$$(3.0 \times 10^{-7})(0.5) = M_2(0.9)$$

$$M_2 = 1.67 \times 10^{-7} \text{ M} = [\text{OH}^-]$$

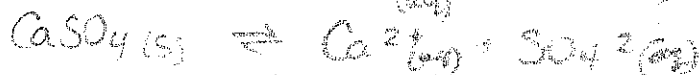
$$Q = [\text{Al}^{3+}][\text{OH}^-]^3 = (1.78 \times 10^{-10})(1.67 \times 10^{-7})^3 = 8.29 \times 10^{-31}$$

$$Q > K_{sp} \quad \therefore \text{yes}$$

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$$K_{sp} = 2.0 \times 10^{-4}$$

9. Will a precipitate form if 20.0 mL of 0.0100 M CaCl_2 are mixed with 20.0 mL of 0.00800 M Na_2SO_4 at 25.0 °C?



$$\text{CaCl}_2: M_1V_1 = M_2V_2$$

$$(0.01M)(0.02L) = M_2(0.04L)$$

$$M_2 = 0.005M = [\text{Ca}^{2+}]$$

$$\text{Na}_2\text{SO}_4: (0.008M)(0.02L) = M_2(0.04L)$$

$$M_2 = 0.004M = [\text{SO}_4^{2-}]$$

$$Q = [\text{Ca}^{2+}][\text{SO}_4^{2-}] = (0.005M)(0.004M)$$

$$[Q < K_{sp} \therefore \text{NO}] \quad Q = 2.00 \times 10^{-5}$$

10. Will a precipitate form if 40.0 mL of 8.0×10^{-3} M $\text{Mg}(\text{NO}_3)_2$ are mixed with 60.0 mL of 1.00×10^{-2} M K_2CO_3 ? (K_{sp} for $\text{MgCO}_3 = 2.60 \times 10^{-5}$)

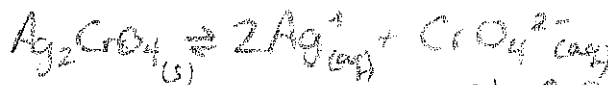
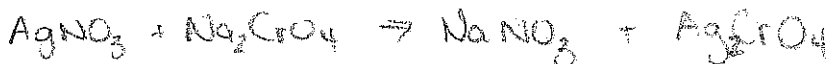
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$$\text{removed} \quad Q < K_{sp} \therefore \text{NO}$$

$$Q = 2.00 \times 10^{-5}$$

11. Will a precipitate form if 25 mL of 4.0×10^{-3} M AgNO_3 are mixed with 75 mL of 2.0×10^{-4} M Na_2CrO_4 at 25.0 °C?

$$K_{sp} = 1.1 \times 10^{-12}$$



$$M_1V_1 = M_2V_2$$

$$\text{AgNO}_3: (4.0 \times 10^{-3})(0.025L) = M_2(0.1L)$$

$$M_2 = 0.001M = [\text{Ag}^+]$$

$$\text{Na}_2\text{CrO}_4: (2.0 \times 10^{-4})(0.075L) = M_2(0.1L)$$

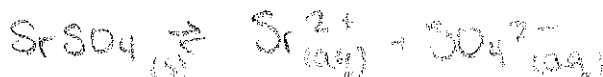
$$M_2 = 1.5 \times 10^{-5}M = [\text{CrO}_4^{2-}]$$

$$Q = [\text{Ag}^+]^2[\text{CrO}_4^{2-}] = (0.001)^2(1.5 \times 10^{-5}M)$$

$$= 1.5 \times 10^{-10}$$

$$[Q > K_{sp} \therefore \text{Yes}]$$

12. What is the maximum $[\text{Sr}^{2+}]$ that can be dissolved in a 0.020 M solution of K_2SO_4 without precipitating SrSO_4 ? (K_{sp} of $\text{SrSO}_4 = 7.6 \times 10^{-7}$)



$$K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}]$$

$$7.6 \times 10^{-7} = x(0.020M)$$

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