





7. A sample of a saturated solution of  $\text{MgF}_2$  was evaporated and the following data table was constructed:

Mass of empty evaporating dish .....	78.5418 g
Mass of evaporating dish and $\text{MgF}_2$ residue after evaporation .....	78.5434 g
Volume of saturated $\text{MgF}_2$ .....	100.00 mL
Temperature .....	25.0 °C

Use this data to calculate the value of  $K_{sp}$  for  $\text{MgF}_2$  at 25 °C. Show all of your steps clearly.

8. Calculate the  $[\text{Ag}^+]$  required to just start precipitation of  $\text{Ag}_2\text{CO}_3$  in a 0.0030 M solution of  $(\text{NH}_4)_2\text{CO}_3$ .
9. A solution is prepared by mixing 20.0 mL of 0.60 M  $\text{Na}_2\text{SO}_4$  with 60.0 mL of 1.1 M  $\text{NaOH}$ . Calculate the  $[\text{Na}^+]$  in the final mixture.

10. The molar solubility of nickel (II) sulphide is  $3.317 \times 10^{-11}$  M. Calculate the value of the solubility product for nickel (II) sulphide. Show all of your work clearly.

11. A solution of potassium chloride is titrated with 0.200 M silver nitrate solution. The following data table was obtained:

	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>
Initial AgNO <sub>3</sub> burette reading (mL)	0.00	5.26	14.63
Final AgNO <sub>3</sub> burette reading (mL)	5.26	12.19	19.87
Volume of KCl titrated	25.0	25.0	25.0

Use the information in the data table to calculate the  $[Cl^-]$  in the KCl solution. Show all of your work clearly.

## Chemistry 12

## Extra Solubility Problems (ESP)

Name \_\_\_\_\_

**KEY**

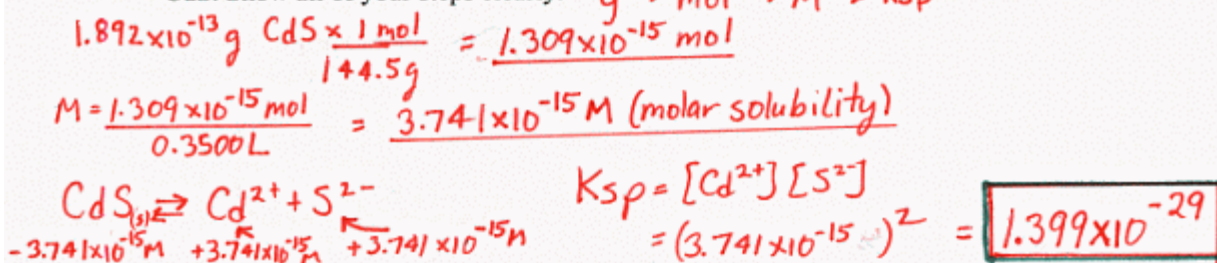
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## Chemistry 12

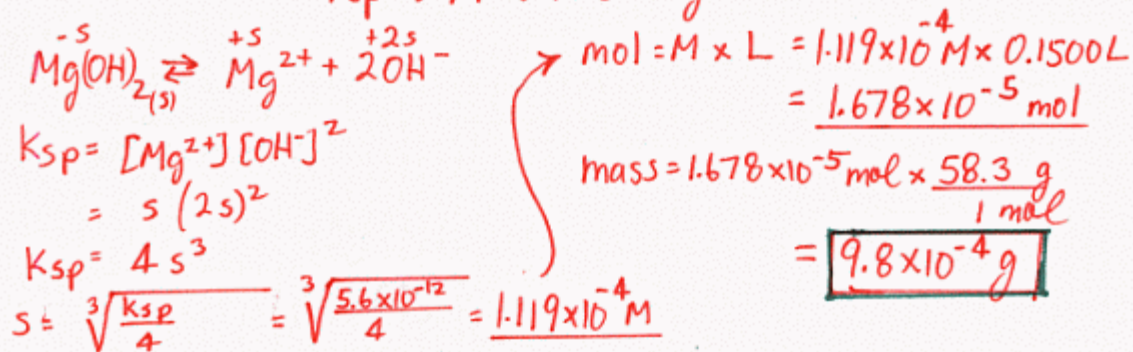
## Extra Solubility Problems (ESP)

Do as many of these problems as you can and check your answers with the key. Get help on any you don't understand. This sheet contains most of the major types of problems found in Unit 3—Solubility.

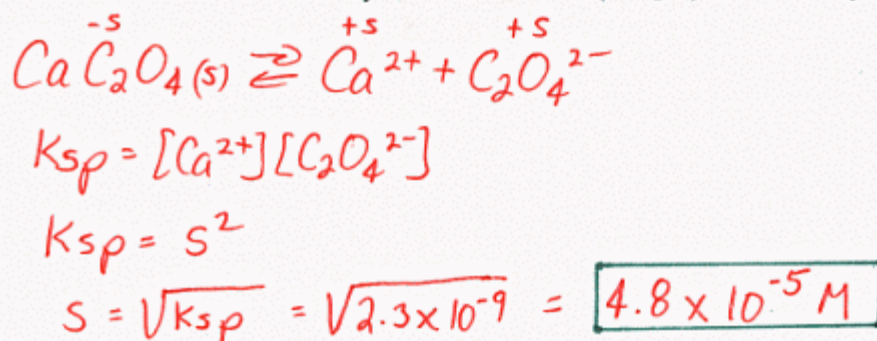
1. It is found that  $1.892 \times 10^{-13}$  grams of the compound cadmium (II) sulphide (CdS) will dissolve in 350.0 mL of water to form a saturated solution. Using this data, calculate the value for the  $K_{sp}$  of CdS. Show all of your steps clearly.  $g \rightarrow mol \rightarrow M \rightarrow K_{sp}$



2. Calculate the maximum mass of  $\text{Mg}(\text{OH})_2$  which will dissolve in 150.0 mL of water. Show all of your steps clearly.  $K_{sp} \rightarrow M \rightarrow mol \rightarrow g$



3. Calculate the molar solubility of calcium oxalate ( $\text{CaC}_2\text{O}_4$ ). Show all of your steps clearly.



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## Extra Solubility Problems (ESP)

**KEY**

4. If 250.0 mL of 0.000340M  $\text{Cu}(\text{NO}_3)_2$  is mixed with 350.0 mL of  $3.12 \times 10^{-4}\text{M}$   $\text{KIO}_3$ , will a precipitate form? Show all of your steps clearly.

Possible ppt is  $\text{Cu}(\text{IO}_3)_2$  ( $\text{Cu}(\text{IO}_3)_2(s) \rightleftharpoons \text{Cu}^{2+} + 2\text{IO}_3^-$ )

$$[\text{Cu}^{2+}] = 3.40 \times 10^{-4}\text{M} \times \frac{250.0\text{mL}}{600.0\text{mL}} = 1.417 \times 10^{-4}\text{M}$$

$$[\text{IO}_3^-] = 3.12 \times 10^{-4}\text{M} \times \frac{350.0\text{mL}}{600.0\text{mL}} = 1.82 \times 10^{-4}\text{M}$$

$$\text{Trial } K_{sp} = [\text{Cu}^{2+}][\text{IO}_3^-]^2$$

$$= (1.417 \times 10^{-4})(1.82 \times 10^{-4})^2 = 4.69 \times 10^{-12} < 6.9 \times 10^{-8} \quad \text{SO NO PRECIPITATE}$$

5. Calculate the maximum  $[\text{F}^-]$  that can exist in a solution in which  $[\text{Sr}^{2+}] = 0.00050\text{M}$ . Show all of your steps clearly.



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

$$[\text{F}^-]^2 = \frac{K_{sp}}{[\text{Sr}^{2+}]} \quad \text{or} \quad [\text{F}^-] = \sqrt{\frac{K_{sp}}{[\text{Sr}^{2+}]}} = \sqrt{\frac{4.3 \times 10^{-9}}{5.0 \times 10^{-4}}} = 2.9 \times 10^{-3}\text{M}$$

6. Calculate the mass of  $\text{Na}_2\text{CO}_3$  that must be added to 2.50 L of 0.00085 M  $\text{MgCl}_2$  in order to just start precipitation. Show all of your steps clearly.

ppt is  $\text{MgCO}_3$



$$K_{sp} = [\text{Mg}^{2+}][\text{CO}_3^{2-}]$$

$$[\text{CO}_3^{2-}] = \frac{K_{sp}}{[\text{Mg}^{2+}]} = \frac{6.8 \times 10^{-6}}{8.5 \times 10^{-4}} = 8.0 \times 10^{-3}\text{M}$$

$$[\text{Na}_2\text{CO}_3] = [\text{CO}_3^{2-}] = 8.0 \times 10^{-3}\text{M}$$

$$\text{moles} = 8.0 \times 10^{-3}\text{M} \times 2.50\text{L} = 2.0 \times 10^{-2}\text{mol}$$

$$\text{mass } \text{Na}_2\text{CO}_3 = 2.0 \times 10^{-2}\text{mol} \times \frac{106.0\text{g}}{1\text{mol}} = 2.1\text{g}$$

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Extra Solubility Problems (ESP)

**KEY**

7. A sample of a saturated solution of  $\text{MgF}_2$  was evaporated and the following data table was constructed:

Mass of empty evaporating dish .....	78.5418 g
Mass of evaporating dish and $\text{MgF}_2$ residue after evaporation .....	78.5434 g
Volume of saturated $\text{MgF}_2$ .....	100.00 mL
Temperature .....	25.0 °C

Use this data to calculate the value of  $K_{sp}$  for  $\text{MgF}_2$  at 25 °C. Show all of your steps clearly.

$$\begin{aligned} \text{mass of } \text{MgF}_2 &= 78.5434 - 78.5418 = 0.0016 \text{ g} \quad \begin{matrix} (4 \text{ dp's}) \\ (2 \text{ SD's}) \end{matrix} \\ \text{moles of } \text{MgF}_2 &= 0.0016 \text{ g} \times \frac{1 \text{ mol}}{62.3 \text{ g}} = 2.568 \times 10^{-5} \text{ mol} \\ M &= \frac{\text{mol}}{L} = \frac{2.568 \times 10^{-5} \text{ mol}}{0.10000 \text{ L}} = 2.568 \times 10^{-4} \text{ M} \\ -2.568 \times 10^{-4} \text{ M} & \quad +2.568 \times 10^{-4} \text{ M} \quad 5.136 \times 10^{-4} \text{ M} \\ \text{MgF}_2(\text{s}) &\rightleftharpoons \text{Mg}^{2+} + 2 \text{F}^- \\ K_{sp} &= [\text{Mg}^{2+}][\text{F}^-]^2 = (2.568 \times 10^{-4})(5.136 \times 10^{-4})^2 \\ &= 6.8 \times 10^{-11} \end{aligned}$$

8. Calculate the  $[\text{Ag}^+]$  required to just start precipitation of  $\text{Ag}_2\text{CO}_3$  in a 0.0030 M solution of  $(\text{NH}_4)_2\text{CO}_3$ .

$$\begin{aligned} \text{Ag}_2\text{CO}_3(\text{s}) &\rightleftharpoons 2\text{Ag}^+ + \text{CO}_3^{2-} \\ K_{sp} &= [\text{Ag}^+]^2 [\text{CO}_3^{2-}] \\ [\text{Ag}^+] &= \sqrt{\frac{K_{sp}}{[\text{CO}_3^{2-}]}} = \sqrt{\frac{8.5 \times 10^{-12}}{3.0 \times 10^{-3}}} = 5.3 \times 10^{-5} \text{ M} \end{aligned}$$

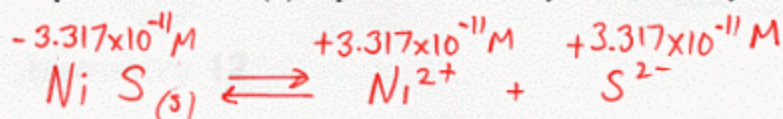
9. A solution is prepared by mixing 20.0 mL of 0.60 M  $\text{Na}_2\text{SO}_4$  with 60.0 mL of 1.1 M  $\text{NaOH}$ . Calculate the  $[\text{Na}^+]$  in the final mixture.

$$\begin{aligned} [\text{Na}_2\text{SO}_4] &= 0.60 \text{ M} \times \frac{20.0 \text{ mL}}{80.0 \text{ mL}} = 0.15 \text{ M} \\ & \quad \begin{matrix} 0.15 \text{ M} \\ \text{Na}_2\text{SO}_4(\text{s}) \rightarrow 2\text{Na}^+ + \text{SO}_4^{2-} \end{matrix} \\ & \quad \begin{matrix} 0.30 \text{ M} & 0.15 \text{ M} \\ \text{Na}^+ & \text{SO}_4^{2-} \end{matrix} \\ [\text{NaOH}] &= 1.1 \text{ M} \times \frac{60.0 \text{ mL}}{80.0 \text{ mL}} = 0.825 \text{ M} \\ & \quad \begin{matrix} 0.825 \text{ M} & 0.825 \text{ M} & 0.825 \text{ M} \\ \text{NaOH}(\text{s}) \rightarrow \text{Na}^+ + \text{OH}^- \end{matrix} \\ \text{Final } [\text{Na}^+] &= 0.30 + 0.825 = 1.125 \text{ M} \\ &= 1.1 \text{ M} \quad (2 \text{ SD's}) \end{aligned}$$

## Chemistry 12

## Extra Solubility Problems (ESP)

10. The molar solubility of nickel (II) sulphide is  $3.317 \times 10^{-11}$  M. Calculate the value of the solubility product for nickel (II) sulphide. Show all of your work clearly.



$$K_{sp} = [\text{Ni}^{2+}][\text{S}^{2-}]$$

$$K_{sp} = (3.317 \times 10^{-11})^2 = \boxed{1.100 \times 10^{-21}}$$

11. A solution of potassium chloride is titrated with 0.200 M silver nitrate solution. The following data table was obtained:

	Trial 1	Trial 2	Trial 3
Initial AgNO <sub>3</sub> burette reading (mL)	0.00	5.26	14.63
Final AgNO <sub>3</sub> burette reading (mL)	5.26	12.19	19.87
Volume of KCl titrated	25.0	25.0	25.0

Use the information in the data table to calculate the [Cl<sup>-</sup>] in the KCl solution. Show all of your work clearly.

	Trial 1	Trial 2	Trial 3
Vol. AgNO <sub>3</sub> used (mL)	5.26	6.93 ↳ DISCARD	5.24

$$\text{Best average volume} = \frac{5.26 + 5.24}{2} = 5.25 \text{ mL}$$

$$= \underline{0.00525 \text{ L AgNO}_3}$$

$$\text{moles of AgNO}_3 = 0.200 \text{ M} \times 0.00525 \text{ L} = \underline{0.00105 \text{ mol AgNO}_3 (\text{Ag}^+)}$$



$$\text{moles KCl} = 0.00105 \text{ mol AgNO}_3 \times \frac{1 \text{ mol KCl}}{1 \text{ mol AgNO}_3}$$

$$= 0.00105 \text{ mol KCl}$$

$$[\text{Cl}^-] = [\text{KCl}] = \frac{0.00105 \text{ mol}}{0.0250 \text{ L}} = \boxed{0.0420 \text{ M}}$$