Ksp Problems

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Solubility

- By definition it is the number of grams of solute that can be dissolved in 100 mL of the solvent at the given temperature.
- That statement also implies solubility changes with temperature
- It can also be expressed as mol L^{-1}

Sparingly soluble salts – in water

- Until now we classified salts as soluble or insoluble salts which is not totally true
- Salts with low solubility are called sparingly soluble salts and they are considered an equilibrium system between the unionized salt and the aqueous ions, this is expressed using the equilibrium constant expression called Ksp
- $PbI_2 \Leftrightarrow Pb^{2+} + 2I^-$
  - $Ksp = [Pb^{2+}][2I^-]^2$

Saturated solutions at const. T

- By definition a saturated solution cannot dissolve more of the solute at the given temperature.
- That also means that if we add more solute into a saturated solution we will get a precipitate.
- This is true of all saturated solutions even of sparingly soluble salts in water.
- Which also implies that a small quantity of solute is sufficient to make a saturated solution using a sparingly soluble salt.

Ksp Expression

- AgCl and PbI_2 are sparingly soluble salts the equilibrium expression and Ksp can be written as follows
- $AgCl \Leftrightarrow Ag^{+} + Cl^{-}$
  - $Ksp = [Ag^{+}] [Cl^{-}]$
- $PbI_2 \Leftrightarrow Pb^{2+} + 2I^{-}$
  - $Ksp = [Pb^{2+}][2I^{-}]^2$

Calculation of solubility from Ksp

- $PbI_2 \Leftrightarrow Pb^{2+} + 2I^-$
- -x   +x   +   +2x
  - $Ksp = [Pb^{2+}][2I^-]^2$
- If Ksp is known the concentration x can be determined
  - $Ksp = [x][2x]^2$
  - $Ksp = 4x^3$
  - $x = \sqrt[3]{\frac{Ksp}{4}}$
  - .
  - x = solubility of the solution

Problem on prediction of precipitation

- Can we expect a precipitate of lead(II)iodide, PbI_2 to form when 20.00 mL of 0.0050 mol L^{-1} aqueous calcium iodide, CaI_2, solution is added to 80.00 mL of 0.0010 mol L^{-1} aqueous solution of lead(II) nitrate $Pb(NO_3)_2$? Ksp for lead (II) iodide is 1.4×10^{-8}

CaI_2 and $Pb(NO_3)_2$ are completely dissociated.

- $CaI_2 \rightarrow Ca^{2+} + 2I^{-1}$
- $Pb(NO_3)_2 \rightarrow Pb^{2+} + 2NO_3^{-1}$
- All ions are aqueous dissolved in water

Determining concentration of ions to predict precititation.

- Concentration of I^{-1} $_{aq}$
- Conc of I^{-1} is twice the concentration of CaI_2 which is observed from the ionization equation
- $[I^{-1}] = 0.005 \text{ mol L}^{-1} \times \frac{2 \text{mol} I^{-1}}{1 \text{ mol } CaI_2}$
- $= 1.0 \times 10^{-2} \text{ mol L}^{-1}\ I^{-1}$

Conc of lead ions…

- Concentration of Pb^{2+}
- Concentration of Pb^{+} = $Pb(NO_3)_2$
- $[Pb^{+}] = 0.0010 \text{ mol } L^{-1}\ Pb(NO_3)_2 \times \frac{1 \text{mol } Pb^{2+}}{1 \text{mol } Pb(NO_3)_2}$.
- = $1.0 \times 10^{-3} \text{ mol } L^{-1}\ Pb^{2+}$

Concentration after mixing 20+80 =100 ml new volume

- Concentration of $[I^{-1}]$
  - = $\frac{20.00 mL}{100.0 mL} \times 1.0 \times 10^{-2}$ mol L^{-1}.
  - = 0.2000 x 1.0 x 1.0^{-2} mol L^{-1}
  - = 2.0 x 10^{-3} mol L^{-1}
- Concentration of $[Pb^{2+}]$
  - = $\frac{80.00 mL}{100.0 mL} \times 1.0 \times 10^{-3}$ mol L^{-1}.
  - = 0.2000 x 1.0 x 1.0^{-3} mol L^{-1}
  - = 8.0 x 10^{-4} mol L^{-1}

After mixing the trial ion product

- $Q_p = [Pb^{2+}][2I^-]^2$
  - $= [8.0 \times 10^{-4}][2.0 \times 10^{-3}]^2$
  - $= 3.2 \times 10^{-9}$
  - The trial ion product ($Q_p = 3.2 \times 10^{-9}$) is less than solubility product (K_{sp} 1.4×10^{-8}) hence there will be no precipitation of lead iodide.