IX) Type B Problems: Calculating Solubility

In Type B problems, you must calculate the solubility of a salt using the K_{sp} constant from p.5 of the data booklet.
Remember that **solubility** is the molarity at saturation. (ie: calc a concentration of the salt @ saturation @ equilibrium)

Example:

1. Calculate the solubility of $CaCO_3$ in water at 25°C.

$[CaCO_3] = ?$

$CaCO_{3(s)} \rightleftharpoons Ca^{2+}_{(aq)} + CO_3^{2-}_{(aq)}$

ratio 1 : 1 : 1

$K_{sp} = [Ca^{2+}][CO_3^{-2}]$

look up value in table

$K_{sp} = 5.0 \times 10^{-9}$

let $x = [Ca^{2+}]$

$\therefore x = [CO_3^{2-}]$

$\sqrt{5.0\times10^{-9}} = (x)(x) = \sqrt{x^2}$

$x = 7.071 \times 10^{-5} M = [Ca^{2+}] = [CO_3^{2-}]$

$\therefore [CaCO_3] = 7.071\times10^{-5} M$

* The solubility of $CaCO_3$ is $7.1\times10^{-5} M$

2. Calculate the solubility of PbI_2 in g/L.

$M = \frac{mol}{L} \Rightarrow \frac{g}{L}$

solve for $[PbI_2]$ @ saturation

$PbI_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2I^-_{(aq)}$

ratio: 1 : equal 1 : 2

$K_{sp} = [Pb^{2+}][I^-]^2$

$K_{sp} = 8.5\times10^{-9}$ (from table)

let $x = [Pb^{2+}]$

$\therefore 2x = [I^-]$

$K_{sp} = (x)(2x)^2 = 4x^3$

$\sqrt[3]{\frac{8.5\times10^{-9}}{4}} = \sqrt[3]{\frac{4x^3}{4}}$

$x = 1.28564\times10^{-3} M$

$[PbI_2] = x = 1.28564\times10^{-3} M = \frac{mol}{L}$

$\frac{1.28564\times10^{-3}\ mol}{L} \Big| \frac{461.0\ g}{1\ mol}$

$= 0.59268\ g/L$

$\therefore$ 0.59 g of PbI_2 can be added to 1L of water to reach a point of saturation. (before a ppt will form)

3. How many grams of $PbBr_2$ can be dissolved in 250.0mL of water at 25°C?

($\frac{1}{4}$ of 1L. $\div 4$)

$PbBr_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Br^-_{(aq)}$

1 : 1 : 2

$K_{sp} = [Pb^{2+}][Br^-]^2$

$K_{sp} = 1.1\times10^{-6}$ (from table)

$1.18167\times10^{-2} M = \frac{mol}{L} \Rightarrow \frac{g}{250mL}$?

$\frac{1.18167\times10^{-2}\ mol}{} \Big| \frac{367.0\ g}{}$

$K_{sp} = [Pb^{2+}][Br^-]^2$

$K_{sp} = 6.6 \times 10^{-6}$ (from table)

let $x = [Pb^{2+}]$

$\therefore \; 2x = [Br^-]$

$6.6 \times 10^{-6} = (x)(2x)^2$

$\sqrt[3]{\frac{6.6 \times 10^{-6}}{4}} = \sqrt[3]{\frac{4x^3}{4}}$

$x = 1.18167 \times 10^{-2} M = [Pb^{2+}]$

$\therefore [PbBr_2] = 1.18167 \times 10^{-2} M$

$\frac{1.18167 \times 10^{-2} \text{ mol}}{1 \text{ L}} \mid \frac{367.0 \text{ g}}{1 \text{ mol}}$

$= 4.34 \text{ g/L}$

$\frac{4.34 \text{ g}}{1000 \text{ mL}} \times \frac{?}{250 \text{ mL}}$

$= 1.1 \text{ g of } PbBr_2$

∴ in 250.0mL, you can add 1.1g of $PbBr_2$ before a precipitate forms. (@saturation)

Assignment 7: Type B Exercises

1. The K_{sp} at a certain temperature for $Ni(OH)_2$ is 1.6×10^{-16}. Calculate the solubility of $Ni(OH)_2$.
2. Find the solubility of $CaSO_4$ in g/L.
3. Which saturated solutions at 25°C will have a greater $[Ag^+]$, AgCl or Ag_2CO_3?
4. Calculate the mass of $MgCO_3$ which could be dissolved in 3.0L of water at 25°C.