

### Example 3

Will precipitation occur when 50.0 cm<sup>3</sup> of a 3.00 × 10<sup>-2</sup> M Pb(NO<sub>3</sub>)<sub>2</sub> solution is added to 50.0 cm<sup>3</sup> of 2.00 × 10<sup>-3</sup> M KCl? The K<sub>sp</sub> of PbCl<sub>2</sub> is 1.62 × 10<sup>-5</sup>.

#### Solving Process:

Assume that no change in volume occurs when the two solutions are mixed and that the final volume will be 100.0 cm<sup>3</sup>. First calculate the concentration of ions in the mixture as if they do not react. The Pb<sup>2+</sup> concentration, because of a twofold dilution, is 1.50 × 10<sup>-2</sup> M. The Cl<sup>-</sup> concentration, because of a twofold dilution, is 1.00 × 10<sup>-3</sup> M. Use these new concentrations of Pb<sup>2+</sup> and Cl<sup>-</sup> to calculate the ion product and determine if it exceeds the K<sub>sp</sub>.

The equation for equilibrium of a saturated solution is



Therefore, on substitution the ion product becomes

$$[\text{Pb}^{2+}][\text{Cl}^-]^2 = [1.50 \times 10^{-2}][1.00 \times 10^{-3}]^2 = 1.50 \times 10^{-8}$$

Since 1.50 × 10<sup>-8</sup> is smaller than the K<sub>sp</sub> of PbCl<sub>2</sub> (1.62 × 10<sup>-5</sup>), precipitation does not occur. The solution is unsaturated.

### PROBLEMS

From the solubilities, determine the experimental value of the K<sub>sp</sub> for each of the following compounds.

1. AgI 2.88 × 10<sup>-6</sup> g/1.00 dm<sup>3</sup>
2. BaCO<sub>3</sub> 7.00 × 10<sup>-5</sup> mol/dm<sup>3</sup>
3. CaF<sub>2</sub> 0.0170 g/1.00 dm<sup>3</sup>
4. Pb(OH)<sub>2</sub> 4.20 × 10<sup>-6</sup> mol/dm<sup>3</sup>
5. SrF<sub>2</sub> 1.22 × 10<sup>-2</sup> g/100 cm<sup>3</sup>
6. Pb(IO<sub>3</sub>)<sub>2</sub> 2.30 mg/100 cm<sup>3</sup>

Calculate the molar solubility of the following compounds from their K<sub>sp</sub> values.

7. CuS 6.31 × 10<sup>-36</sup>
8. SrC<sub>2</sub>O<sub>4</sub> 1.58 × 10<sup>-7</sup>
9. Al(OH)<sub>3</sub> 1.26 × 10<sup>-33</sup>
10. PbI<sub>2</sub> 7.08 × 10<sup>-9</sup>
11. Determine the solubility in g/dm<sup>3</sup> of the compounds listed in Problems 8 and 10.

Determine if precipitation would occur in the following cases. (Use Table A-15 for  $K_{sp}$  values.)

- 25.0 cm<sup>3</sup> of  $6.00 \times 10^{-6} M$  Sr(NO<sub>3</sub>)<sub>2</sub> is mixed with 25.0 cm<sup>3</sup> of  $4.00 \times 10^{-7} M$  H<sub>3</sub>PO<sub>4</sub>.  $K_{sp}$  of Sr<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> is  $4.07 \times 10^{-28}$ .
- 100.0 cm<sup>3</sup> of a  $5.00 \times 10^{-3} M$  Ba(NO<sub>3</sub>)<sub>2</sub> is mixed with 100.0 cm<sup>3</sup> of  $2.00 \times 10^{-2} M$  NaF.
- 50.0 cm<sup>3</sup> of  $6.0 \times 10^{-4} M$  AgNO<sub>3</sub> is mixed with 50.0 cm<sup>3</sup> of  $5.0 \times 10^{-2} M$  K<sub>2</sub>CrO<sub>4</sub>.

### PROBLEMS

- $1.50 \times 10^{-16}$
- $4.90 \times 10^{-9}$
- $4.14 \times 10^{-11}$
- $2.96 \times 10^{-16}$
- $3.63 \times 10^{-9}$
- $2.82 \times 10^{-13}$
- $2.51 \times 10^{-18} M$
- $3.97 \times 10^{-4} M$
- $2.61 \times 10^{-9} M$
- $1.21 \times 10^{-3} M$
- 0.0699 g SrC<sub>2</sub>O<sub>4</sub>/dm<sup>3</sup>, 0.558 g PbI<sub>2</sub>/dm<sup>3</sup>
- no,  $1.08 \times 10^{-30} < 4.07 \times 10^{-28}$
- no,  $2.50 \times 10^{-7} < 1.05 \times 10^{-6}$
- yes,  $2.3 \times 10^{-11} > 1.12 \times 10^{-12}$
- pH 4.0, pOH 10
  - pH 12.3, pOH 1.74
  - pH 9.21, pOH 4.79
  - pH 1.39, pOH 12.6
- $1.91 \times 10^{-4} M$
  - $2.24 \times 10^{-7} M$
  - $1.00 \times 10^{-2} M$
  - $6.3 \times 10^{-9} M$
- $1.00 \times 10^{-11} M$
  - $1.78 \times 10^{-10} M$
  - $3.2 \times 10^{-9} M$
  - $7.9 \times 10^{-12} M$

### Solubility Product Constants (at 25°C)

Substance	$K_{sp}$	Substance	$K_{sp}$
AgBr	$5.01 \times 10^{-13}$	CuS	$6.31 \times 10^{-36}$
AgBrO <sub>3</sub>	$5.25 \times 10^{-5}$	FeC <sub>2</sub> O <sub>4</sub>	$3.16 \times 10^{-7}$
Ag <sub>2</sub> CO <sub>3</sub>	$8.13 \times 10^{-12}$	Fe(OH) <sub>3</sub>	$3.98 \times 10^{-38}$
AgCl	$1.78 \times 10^{-10}$	FeS	$6.31 \times 10^{-18}$
Ag <sub>2</sub> CrO <sub>4</sub>	$1.12 \times 10^{-12}$	Hg <sub>2</sub> SO <sub>4</sub>	$7.41 \times 10^{-7}$
Ag <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	$2.00 \times 10^{-7}$	Li <sub>2</sub> CO <sub>3</sub>	$2.51 \times 10^{-2}$
AgI	$8.32 \times 10^{-17}$	MgCO <sub>3</sub>	$3.47 \times 10^{-8}$
AgSCN	$1.00 \times 10^{-12}$	MgC <sub>2</sub> O <sub>4</sub>	$6.57 \times 10^{-5}$
Al(OH) <sub>3</sub>	$1.26 \times 10^{-33}$	MgF <sub>2</sub>	$6.46 \times 10^{-9}$
Al <sub>2</sub> S <sub>3</sub>	$2.00 \times 10^{-7}$	MnCO <sub>3</sub>	$1.82 \times 10^{-11}$
BaCO <sub>3</sub>	$5.13 \times 10^{-9}$	NiCO <sub>3</sub>	$6.61 \times 10^{-9}$
BaCrO <sub>4</sub>	$1.17 \times 10^{-10}$	NiS	$3.16 \times 10^{-19}$
BaF <sub>2</sub>	$1.05 \times 10^{-8}$	PbCl <sub>2</sub>	$1.62 \times 10^{-5}$
BaSO <sub>4</sub>	$1.10 \times 10^{-10}$	PbI <sub>2</sub>	$7.08 \times 10^{-9}$
CaCO <sub>3</sub>	$2.88 \times 10^{-9}$	Pb(IO <sub>3</sub> ) <sub>2</sub>	$3.24 \times 10^{-13}$
CaSO <sub>4</sub>	$9.12 \times 10^{-6}$	SrCO <sub>3</sub>	$1.10 \times 10^{-10}$
CdS	$7.94 \times 10^{-27}$	TlBr	$3.39 \times 10^{-6}$
Cu(IO <sub>3</sub> ) <sub>2</sub>	$7.41 \times 10^{-8}$	ZnCO <sub>3</sub>	$1.45 \times 10^{-11}$
CuC <sub>2</sub> O <sub>4</sub>	$2.29 \times 10^{-8}$	Zn(OH) <sub>2</sub>	$1.20 \times 10^{-15}$
Cu(OH) <sub>2</sub>	$2.19 \times 10^{-20}$	ZnS	$1.58 \times 10^{-24}$