

Chemistry

Killer and Not-so-Difficult Ksp Problems From Various Tests

1. a) Calculate the solubility product constant(Ksp) for manganese(II) hydroxide, Mn(OH)₂, if 100.0 mL of a saturated solution of manganese(II) hydroxide was found to contain 3.28 X 10⁻⁴ grams of manganese(II) hydroxide dissolved in it.

Manganese has a charge of +2

		Mn(OH)₂(s) =	Mn⁺²_(aq)	+ 2 OH⁻_(aq)
Mole /L	I		0	0
	C	3.28 X 10⁻⁴ grams/(88.95g/mole)/0.100 L= 3.687464868 X 10⁻⁵	3.687464868 X 10⁻⁵	3.687464868 X 10⁻⁵ *2 = 7.374929736X10⁻⁴
	E		3.687464868 X 10⁻⁵	7.374929736X10⁻⁴

$$\begin{aligned}K_{sp} &= [\text{Mn}^{+2}] [\text{OH}^{-}]^2 \\&= [3.687464868 \times 10^{-5}] [7.374929736 \times 10^{-4}]^2 \\&= 2.01 \times 10^{-13}\end{aligned}$$

- b) You are concerned about disposing a saturated solution of Mn(OH)₂, because of Mn⁺²'s effects on wildlife and humans. What could be done to lower the concentration of Mn⁺²?

Raise the pH (raise concentration of OH⁻)

2. The watery portion of a 100.0 ml saturated solution of what was supposed to be cadmium arsenate, $\text{Cd}_3(\text{AsO}_4)_2$ is evaporated. 0.050 grams of $\text{Cd}_3(\text{AsO}_4)_2$ (s) were left behind after evaporation. Prove that it was not really $\text{Cd}_3(\text{AsO}_4)_2$. The solubility product constant (Ksp) for cadmium arsenate is 2.20×10^{-33} .

		$\text{Cd}_3(\text{AsO}_4)_2$ (s) =	3 Cd^{+2} (aq)	$+ 2 \text{ AsO}_4^{-3}$ (aq)
Mole /L	I		0	0
	C	x	3x	2x
	E		3x	2x

$$K_{sp} = [\text{Cd}^{+2}]^3 [\text{AsO}_4^{-3}]^2$$

$$2.20 \times 10^{-33} = [3x]^3 [2x]^2$$

$$108 x^5 = 2.20 \times 10^{-33}$$

$$x = (2.20 \times 10^{-33} / 108)^{0.2}$$

$$= 1.1529 \times 10^{-7} \text{ moles/L } \text{Cd}_3(\text{AsO}_4)_2$$

$$= 1.1529 \times 10^{-7} \text{ moles/L } \text{Cd}_3(\text{AsO}_4)_2 (615.07 \text{g/mole})(0.100 \text{ L}) = 7.0 \times 10^{-6} \text{ g}$$

So there should have been only 7.0×10^{-6} g, not 0.050 grams

3. a) Calculate the solubility product constant (K_{sp}) for $PbCl_{2(s)}$, if 50.0 mL of a saturated solution of lead(II) chloride was found to contain 0.2207 g of lead(II) chloride dissolved in it.

		$PbCl_{2(s)} =$	$Pb^{+2} (aq)$	$+ 2 Cl^{-} (aq)$
Mole /L	I		0	0
	C	$\frac{0.2207}{278.11 \text{ g/mole} / 0.050 \text{ L}} = 0.01587141778$	0.01587141778	$2 * 0.01587141778 = 0.03174283556$
	E		0.01587141778	0.03174283556

$$\begin{aligned}
 K_{sp} &= [Pb^{+2}] [Cl^{-}]^2 \\
 &= [0.01587141778] [0.03174283556]^2 \\
 &= \mathbf{1.60 \times 10^{-5}}
 \end{aligned}$$

- b) You are concerned about disposing a saturated solution of $PbCl_2$ because of Pb^{+2} effects on wildlife and humans. What could be done to lower the concentration of Pb^{+2} ?

Add chloride

- c) What could happen in the environment that would increase the concentration of Pb^{+2} ?

precipitation of chloride by another ion; more $PbCl_2$ dissolving

4. If 55 mg of lead (II) sulfate, PbSO_4 , is placed in 250.0 mL of pure water, how much PbSO_4 will remain undissolved?
The solubility product constant (K_{sp}) for PbSO_4 is 2.53×10^{-8} .

		$\text{PbSO}_{4(s)} =$	$\text{Pb}^{+2} \text{ (aq)}$	$+ \text{SO}_4^{-2} \text{ (aq)}$
Mole /L	I		0	0
	C	x	x	x
	E		x	x

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

$$2.53 \times 10^{-8} = x^2$$

$$x = 1.590597372 \times 10^{-3} \text{ mole/L}$$

$$x = 1.590597372 \times 10^{-3} \text{ mole/L} (303.26 \text{ g/mole})(0.250 \text{ L}) = 0.01205911398 \text{ g}$$

$$= 12.1 \text{ mg}$$

$$\text{Undissolved} = 55 - 12.1 \text{ mg} = 43 \text{ mg}$$

5. Estimate the solubility of barium sulfate (BaSO_4) in a solution that already has 0.020 moles/L of sulfate (SO_4^{2-}) initially.
The solubility product constant (K_{sp}) for barium sulfate is 1.1×10^{-10} .

		$\text{BaSO}_{4(s)} =$	$\text{Ba}^{+2} \text{ (aq)}$	$+ \text{SO}_4^{-2} \text{ (aq)}$
Mole /L	I		0	0.020
	C	x	x	x
	E		x	x + 0.020

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

$$1.1 \times 10^{-10} = x (x + 0.020)$$

$$x^2 + 0.020x - 1.1 \times 10^{-10} = 0.$$

$$x = 5.5 \times 10^{-9} \text{ moles } \text{BaSO}_4 \text{ /L}$$