

Ionic Equilibria Problems

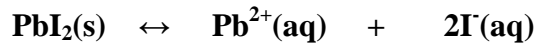
- 1) The solubility of lead(II) chloride is 0.064 g/100. mL at 25° C. What is its solubility product?
- 2) The K_{sp} for barium sulfate is 1.1×10^{-10} . Calculate the molar solubility of barium sulfate.
- 3) What is the fluoride concentration in a saturated barium fluoride solution?
The $K_{sp} = 1.7 \times 10^{-6}$.
- 4) Will a precipitate form when 0.15 L of a 3.0×10^{-2} M lead(II) nitrate solution is added to 300. mL of a 8.0×10^{-2} M sodium chloride solution?
The $K_{sp} = 2.4 \times 10^{-4}$.
- 5) What is the solubility of silver phosphate in a 0.20 M silver nitrate solution?
The $K_{sp} = 1.1 \times 10^{-16}$.
- 6) What is the solubility of Fe^{2+} in a solution with a pH of 9.00?
The $K_{sp} = 7.9 \times 10^{-15}$.

Solutions

1) $s = 0.064 \text{ g}/100. \text{ mL}$

$$[\text{PbCl}_2] = 0.064 \text{ g-PbI}_2/100. \text{ mL} \times 1000 \text{ mL/L} \times 1 \text{ mol PbI}_2/461.00 \text{ g-PbI}_2$$

$$[\text{PbCl}_2] = 1.4 \times 10^{-3} \text{ M}$$



$$[\]_i \qquad \qquad \qquad 0 \qquad \qquad 0$$

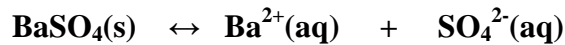
$$[\]_c \qquad \qquad \qquad +1.4 \times 10^{-3} \qquad +2.8 \times 10^{-3}$$

$$[\]_e \qquad \qquad \qquad 1.4 \times 10^{-3} \qquad 2.8 \times 10^{-3}$$

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

$$K_{\text{sp}} = 1.4 \times 10^{-3} \times (2.8 \times 10^{-3})^2 = 1.1 \times 10^{-8}$$

2) $K_{\text{sp}} = 1.1 \times 10^{-10}$



$$[\]_i \qquad \qquad \qquad 0 \qquad \qquad 0$$

$$[\]_c \qquad \qquad \qquad +x \qquad \qquad +x$$

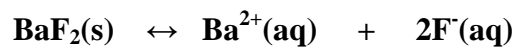
$$[\]_e \qquad \qquad \qquad x \qquad \qquad x$$

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

$$1.1 \times 10^{-10} = x \cdot x = x^2$$

$$s = x = 1.0 \times 10^{-5} \text{ M}$$

3) $K_{sp} = 1.7 \times 10^{-6}$



| | | |
|------------------|----|-----|
| [] _i | 0 | 0 |
| [] _c | +x | +2x |
| [] _e | x | 2x |

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

$$1.7 \times 10^{-6} = x \cdot (2x)^2 = 4x^3$$

$$s = x = 7.5 \times 10^{-3} \text{ M}$$

$$[\text{F}^{-}] = 2 \times 7.5 \times 10^{-3} \text{ M} = 1.5 \times 10^{-2} \text{ M}$$

$$4) \quad [\text{Pb}(\text{NO}_3)_2]_1 = 3.0 \times 10^{-2} \text{ M} \qquad [\text{NaCl}]_2 = 8.0 \times 10^{-2} \text{ M}$$

$$V_1 = 0.15 \text{ L}$$

$$V_2 = 300. \text{ mL}$$

$$K_{\text{sp}} = 2.4 \times 10^{-4}$$

$$[\] = n/V$$

$$n = [\] \times V$$

$$n_1 = 3.0 \times 10^{-2} \text{ mol Pb}(\text{NO}_3)_2/\text{L} \times 0.15 \text{ L} = 4.5 \times 10^{-3} \text{ mol Pb}(\text{NO}_3)_2$$

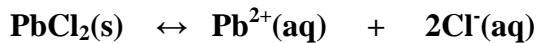
$$n_2 = 8.0 \times 10^{-2} \text{ mol NaCl}/\text{L} \times 300. \text{ mL} \times 1 \text{ L}/10^3 \text{ mL} = 2.4 \times 10^{-2} \text{ mol NaCl}$$

$$[\text{Pb}^{2+}] = n/V$$

$$[\text{Pb}^{2+}] = 4.5 \times 10^{-3} \text{ mol Pb}(\text{NO}_3)_2/0.45 \text{ L} \times 1 \text{ mol Pb}^{2+}/1 \text{ mol Pb}(\text{NO}_3)_2 = 0.010 \text{ M}$$

$$[\text{Cl}^-] = n/V$$

$$[\text{Cl}^-] = 2.4 \times 10^{-2} \text{ mol NaCl}/0.45 \text{ L} \times 1 \text{ mol Cl}^-/1 \text{ mol NaCl} = 0.053 \text{ M}$$



$$[\]_i \qquad \qquad \qquad 0 \qquad \qquad \qquad 0$$

$$[\]_c \qquad \qquad \qquad +0.010 \qquad \qquad \qquad +0.053$$

$$[\]_e \qquad \qquad \qquad 0.010 \qquad \qquad \qquad 0.053$$

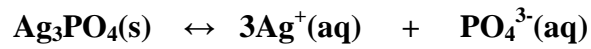
$$P = [\text{Pb}^{2+}] \times [\text{Cl}^-]^2$$

$$P = 0.010 \times 0.053^2 = 2.8 \times 10^{-5}$$

No precipitate forms because $P < K_{\text{sp}}$.

5) $[\text{AgNO}_3] = [\text{Ag}^+] = 0.20 \text{ M}$

$$K_{\text{sp}} = 1.1 \times 10^{-16}$$



$$[\]_{\text{i}} \qquad \qquad \qquad 0.20 \qquad \qquad 0$$

$$[\]_{\text{c}} \qquad \qquad \qquad +3x \qquad \qquad +x$$

$$[\]_{\text{e}} \qquad \qquad \qquad 0.20 + 3x \qquad \qquad x$$

$$K_{\text{sp}} = [\text{Ag}^+]^3 \times [\text{PO}_4^{3-}]$$

$$1.1 \times 10^{-16} = (0.20 + 3x)^3 \cdot x$$

$$(0.20 + 3x) \approx (0.20)$$

$$1.1 \times 10^{-16} = (0.20)^3 \cdot x$$

$$s = x = 1.4 \times 10^{-14} \text{ M}$$

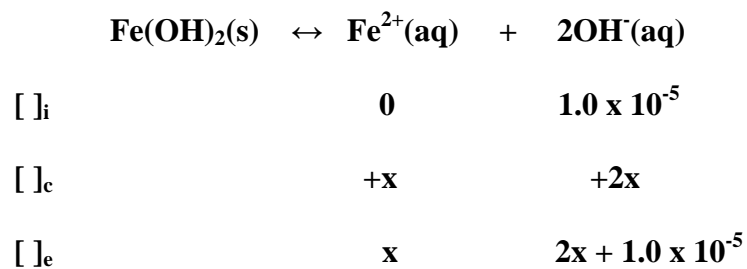
6) $\text{pH} = 9.00$

$$K_{\text{sp}} = 7.9 \times 10^{-15}$$

$$\text{pH} + \text{pOH} = 14.00$$

$$\text{pOH} = 14.00 - 9.00 = 5.00$$

$$[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-5.00} = 1.0 \times 10^{-5} \text{ M}$$



$$K_{\text{sp}} = [\text{Fe}^{2+}] \times [\text{OH}^-]^2$$

$$7.9 \times 10^{-15} = x \cdot (2x + 1.0 \times 10^{-5})^2$$

$$(2x + 1.0 \times 10^{-5}) \approx (1.0 \times 10^{-5})$$

$$7.9 \times 10^{-15} = x \cdot (1.0 \times 10^{-5})^2$$

$$s = x = 7.9 \times 10^{-5} \text{ mol Fe}^{2+}/\text{L}$$