

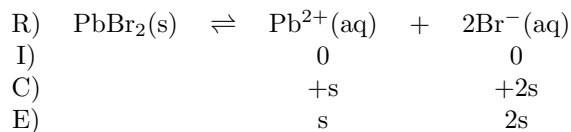
# Non Sibi High School

Andover's Chem 550/580: Advanced Chemistry

Chapter 18, Review Quiz 1 Answers

## 1

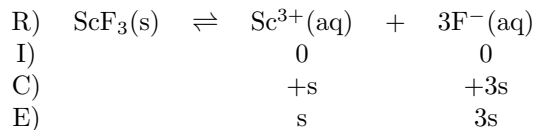
Calculate the molar solubility of lead(II) bromide ( $K_{sp} = 4.0 \times 10^{-5}$ ). Include the solubility equilibrium reaction and  $K_{sp}$  expression in your answer.



$$K_{sp} = [\text{Pb}^{2+}][\text{Br}^{-}]^2$$
$$4.0 \times 10^{-5} = (s)(2s)^2$$
$$s = 0.022 \text{ M}$$

## 2

The molar solubility of scandium(III) fluoride is  $1.9 \times 10^{-5} \text{ M}$ . Calculate the value of  $K_{sp}$  for scandium(III) fluoride. Include the solubility equilibrium reaction and  $K_{sp}$  expression in your answer.

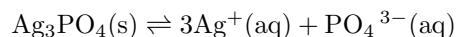


$$K_{sp} = [\text{Sc}^{3+}][\text{F}^{-}]^3 = (s)(3s)^3 = 27s^4 = 27(1.9 \times 10^{-5})^4 = 3.5 \times 10^{-18}$$

### 3

Predict if precipitation will occur when 14 mL of  $6.5 \times 10^{-5}$  M  $\text{AgNO}_3$  is mixed with 56 mL of  $3.5 \times 10^{-4}$  M  $\text{K}_3\text{PO}_4$ . ( $K_{\text{sp}} = 8.9 \times 10^{-17}$  for  $\text{Ag}_3\text{PO}_4$ )

$\text{K}^+$  and  $\text{NO}_3^-$  = spectator ions



total volume after mixing = 14 mL + 56 mL = 70 mL

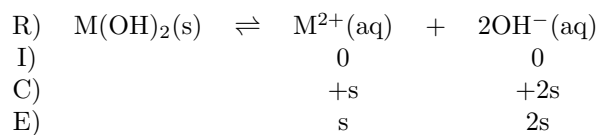
$$[\text{Ag}^+]_i = 6.5 \times 10^{-5} \text{ M} \left( \frac{14 \text{ mL}}{70 \text{ mL}} \right) = 1.3 \times 10^{-5} \text{ M}$$

$$[\text{PO}_4^{3-}]_i = 3.5 \times 10^{-4} \text{ M} \left( \frac{56 \text{ mL}}{70 \text{ mL}} \right) = 2.8 \times 10^{-4} \text{ M}$$

$$Q_{\text{sp}} = (1.3 \times 10^{-5})^3 (2.8 \times 10^{-4}) = 6.2 \times 10^{-19} < K_{\text{sp}}, \text{ no precipitate}$$

### 4

A metal hydroxide with the formula  $\text{M}(\text{OH})_2$  was mixed with water and stirred until a saturated solution was created. The pH of the solution was found to be 9.88. Calculate the value of  $K_{\text{sp}}$  for the metal hydroxide.



$$\text{pOH} = 14.00 - 9.88 = 4.12$$

$$[\text{OH}^-] = 10^{-4.12} = 7.6 \times 10^{-5} \text{ M} = 2s$$

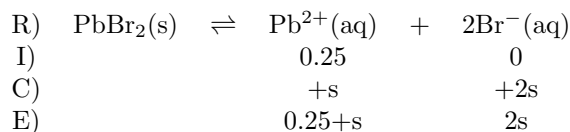
$$s = 3.8 \times 10^{-5} \text{ M}$$

$$K_{\text{sp}} = [\text{M}^{2+}][\text{OH}^-]^2 = (s)(2s)^2 = 4s^3 = 4(3.8 \times 10^{-5})^3 = 2.2 \times 10^{-13}$$

### 5

Calculate the molar solubility of lead(II) bromide ( $K_{\text{sp}} = 4.0 \times 10^{-5}$ ) in 0.25 M  $\text{Pb}(\text{NO}_3)_2$ . Include the solubility equilibrium reaction and  $K_{\text{sp}}$  expression in your answer.

$\text{NO}_3^-$  = spectator ion,  $[\text{Pb}^{2+}]_i = 0.25 \text{ M}$ :



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

$$4.0 \times 10^{-5} = (0.25 + s)(2s)^2$$

$$s = 0.0062 \text{ M}$$

## 6

An aqueous solution of  $\text{Pb}(\text{NO}_3)_2$  is added dropwise to an aqueous mixture containing 0.010 M  $\text{Br}^{-}$  and 0.95 M  $\text{I}^{-}$ .

a. Calculate the minimum molarity of  $\text{Pb}^{2+}$  that must be reached to initiate precipitation of  $\text{Br}^{-}$  ( $K_{\text{sp}} = 4.0 \times 10^{-5}$  for  $\text{PbBr}_2$ ) and the minimum molarity of  $\text{Pb}^{2+}$  that must be reached to initiate precipitation of  $\text{I}^{-}$  ( $K_{\text{sp}} = 8.5 \times 10^{-9}$  for  $\text{PbI}_2$ ). Which precipitates first,  $\text{Br}^{-}$  or  $\text{I}^{-}$ ?

b. At the point when the second ion from the original mixture begins to precipitate, what percentage of the first ions initial molarity still remains unprecipitated in the solution? Can the  $\text{Br}^{-}$  and  $\text{I}^{-}$  mixture be effectively separated by fractional precipitation?

a.  $\text{NO}_3^{-}$  = spectator ion

$$\text{PbBr}_2(\text{s}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{Br}^{-}(\text{aq})$$

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

$$4.0 \times 10^{-5} = [\text{Pb}^{2+}](0.010)^2$$

$$[\text{Pb}^{2+}] = 0.40 \text{ M} = \text{minimum that must be reached to precipitate } \text{Br}^{-}$$

$$\text{PbI}_2(\text{s}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq})$$

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

$$8.5 \times 10^{-9} = [\text{Pb}^{2+}](0.95)^2$$

$$[\text{Pb}^{2+}] = 9.4 \times 10^{-9} \text{ M} = \text{minimum that must be reached to precipitate } \text{I}^{-}$$

Since less  $\text{Pb}^{2+}$  must be added to precipitate  $\text{I}^{-}$ ,  $\text{I}^{-}$  precipitates first.

b.

$$8.5 \times 10^{-9} = (0.40)[\text{I}^{-}]^2$$

$$[\text{I}^{-}] = 1.5 \times 10^{-4} \text{ M}$$

still remains unprecipitated in the solution at the point when  $\text{Br}^{-}$  begins to precipitate

$$\frac{1.5 \times 10^{-4} M}{0.95 M} \times 100\% = 0.016\% \text{ of initial } \text{I}^- \text{ molarity still remains}$$

unprecipitated in the solution at the point when  $\text{Br}^-$  begins to precipitate.

Only a very small percentage of the original amount of  $\text{I}^-$  remains in solution. Therefore, since nearly 100% of the original amount of  $\text{I}^-$  is incorporated into a solid precipitate before any of the  $\text{Br}^-$  can leave the solution, the  $\text{Br}^-$  and  $\text{I}^-$  mixture can be effectively separated by fractional precipitation.



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