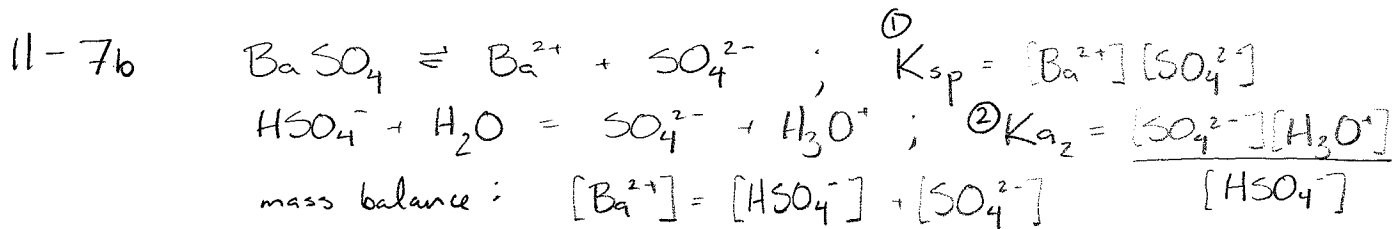


# Chem 321 Homework

Chap 11 7b, 9a, 12, 14, 16ac



substitute ②  
into m.b. eq

$$[\text{Ba}^{2+}] = \frac{[\text{SO}_4^{2-}][\text{H}_3\text{O}^+]}{K_{a2}} + [\text{SO}_4^{2-}]$$

$$[\text{Ba}^{2+}] = [\text{SO}_4^{2-}] \left( \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right)$$

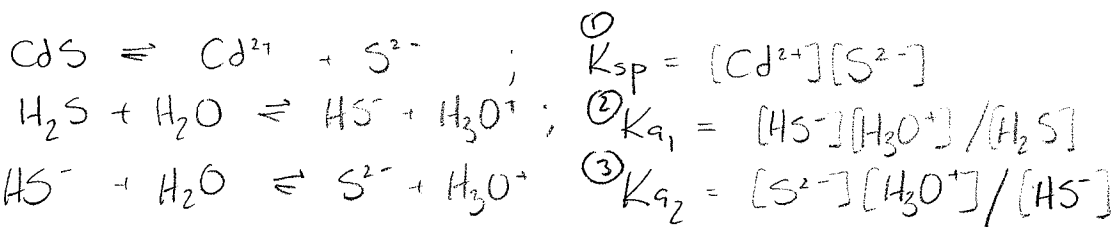
substitute ①

$$[\text{Ba}^{2+}] = \frac{K_{sp}}{[\text{Ba}^{2+}]} \left( \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right)$$

$$[\text{Ba}^{2+}]^2 = K_{sp} \left( \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right) = 1.1 \times 10^{-10} \left( \frac{1.5}{0.0102} + 1 \right)$$

$$[\text{Ba}^{2+}] = \Rightarrow = 1.3 \times 10^{-4} \text{ M}$$

11-9a



mult. ② × ③

$$K_{a1} K_{a2} = \frac{[\text{H}_3\text{O}^+]^2 [\text{S}^{2-}]}{[\text{H}_2\text{S}]} ; [\text{Cd}^{2+}] = s$$

mass balance:  $[\text{Cd}^{2+}] = [\text{H}_2\text{S}] + [\text{HS}^-] + [\text{S}^{2-}]$

substitute ④ & ③  
into m.b. eq

$$[\text{Cd}^{2+}] = \frac{[\text{H}_3\text{O}^+]^2 [\text{S}^{2-}]}{K_{a1} K_{a2}} + \frac{[\text{H}_3\text{O}^+] [\text{S}^{2-}]}{K_{a2}} + [\text{S}^{2-}]$$

$$[\text{Cd}^{2+}] = [\text{S}^{2-}] \left( \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right)$$

substitute ①

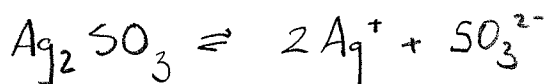
$$[\text{Cd}^{2+}] = \frac{K_{sp}}{[\text{Cd}^{2+}]} \left( \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right)$$

$$[\text{Cd}^{2+}]^2 = K_{sp} \left( \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + 1 \right)$$

$$[\text{Cd}^{2+}] = \left[ 1 \times 10^{-27} \left( \frac{(0.2)^2}{(9.6 \times 10^{-8})(1.3 \times 10^{-14})} + \frac{0.2}{1.3 \times 10^{-14}} + 1 \right) \right]^{1/2} = 2 \times 10^{-4} \text{ M}$$

①

11-12



$$K_{sp} = [\text{Ag}^+]^2 [\text{SO}_3^{2-}]$$



$$K_{a1} = \frac{[\text{H}_3\text{O}^+][\text{HSO}_3^-]}{[\text{H}_2\text{SO}_3]}$$



$$K_{a2} = \frac{[\text{H}_3\text{O}^+][\text{SO}_3^{2-}]}{[\text{HSO}_3^-]}$$

$$[\text{Ag}^+] = 2 \cdot ([\text{SO}_3^{2-}] + [\text{HSO}_3^-] + [\text{H}_2\text{SO}_3])$$

$$[\text{H}_3\text{O}^+] = 1.00 \times 10^{-8} \quad [\text{Ag}^+] = 2s$$

$$K_{a1}, K_{a2} = \frac{[\text{H}_3\text{O}^+]^2 [\text{SO}_3^{2-}]}{[\text{H}_2\text{SO}_3]}$$

$$[\text{Ag}^+] = 2 \cdot \left( \text{SO}_3^{2-} + \frac{[\text{H}_3\text{O}^+][\text{SO}_3^{2-}]}{K_{a2}} + \frac{[\text{H}_3\text{O}^+]^2 [\text{SO}_3^{2-}]}{K_{a1} K_{a2}} \right)$$

$$[\text{Ag}^+] = 2 [\text{SO}_3^{2-}] \left( 1 + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} \right)$$

$$[\text{Ag}^+] = 2 \frac{K_{sp}}{[\text{Ag}^+]^2} \left( 1 + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} \right)$$

$$[\text{Ag}^+] = \left( 2 K_{sp} \left( 1 + \frac{[\text{H}_3\text{O}^+]}{K_{a2}} + \frac{[\text{H}_3\text{O}^+]^2}{K_{a1} K_{a2}} \right) \right)^{1/3}$$

$$[\text{Ag}^+] = \left( 2 \cdot (1.5 \times 10^{-14}) \left( 1 + \frac{10^{-8}}{6.6 \times 10^{-8}} + \frac{(10^{-8})^2}{(1.23 \times 10^{-2})(6.6 \times 10^{-9})} \right) \right)^{1/3}$$

$$[\text{Ag}^+] = 3.3 \times 10^{-5} \text{ M}$$

$$s = \frac{1}{2} [\text{Ag}^+] = 1.6 \times 10^{-5} \text{ M}$$

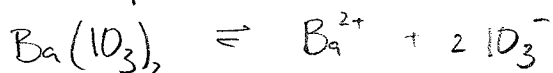
11-14

$$C_{\text{Na}_2\text{SO}_4} = 0.040 \text{ M}$$

$$C_{\text{Na}_2\text{CO}_3} = 0.050 \text{ M}$$



$$K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.1 \times 10^{-10}$$



$$K_{sp} = [\text{Ba}^{2+}][\text{IO}_3^-]^2 = 1.57 \times 10^{-9}$$

$[\text{HSO}_4^-]$  is negligible

$$\text{BaSO}_4 \text{ ppt} : [\text{Ba}^{2+}] = \frac{K_{sp}}{[\text{SO}_4^{2-}]} = \frac{1.1 \times 10^{-10}}{0.040} = 2.75 \times 10^{-9} \text{ M}$$

$$\text{Ba}(\text{IO}_3)_2 \text{ ppt} : [\text{Ba}^{2+}] = \frac{K_{sp}}{[\text{IO}_3^-]^2} = \frac{1.57 \times 10^{-9}}{(0.050)^2} = 6.28 \times 10^{-7} \text{ M}$$

(a, b)  $\text{BaSO}_4$  is less soluble  $\therefore$  ppt's when  $[\text{Ba}^{2+}] = 2.8 \times 10^{-7} \text{ M}$

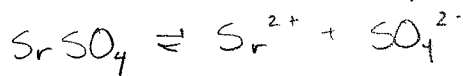
$$c \quad [\text{SO}_4^{2-}] = \frac{K_{sp}}{[\text{Ba}^{2+}]} = \frac{1.1 \times 10^{-10}}{6.28 \times 10^{-7}} = 1.8 \times 10^{-4} \text{ M } \text{SO}_4^{2-}$$

when  $\text{Ba}(\text{IO}_3)_2$  starts precipitating

11-16 a



$$K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.1 \times 10^{-10}$$



$$K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}] = 3.2 \times 10^{-7}$$

$[\text{HSO}_4^-]$  is negligible

$$\text{BaSO}_4 \text{ ppt when } [\text{SO}_4^{2-}] = \frac{K_{sp}}{[\text{Ba}^{2+}]} = \frac{1.1 \times 10^{-10}}{0.30} = 3.7 \times 10^{-10} \text{ M}$$

$$\text{SrSO}_4 \text{ ppt when } [\text{SO}_4^{2-}] = \frac{K_{sp}}{[\text{Sr}^{2+}]} = \frac{3.2 \times 10^{-7}}{0.05} = 6.4 \times 10^{-6} \text{ M}$$

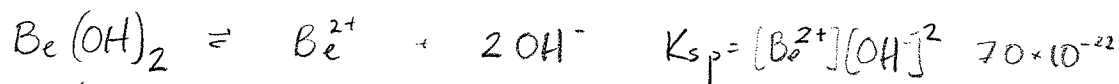
$\text{BaSO}_4$  ppt's first - what is  $[\text{SO}_4^{2-}]$  when  $[\text{Ba}^{2+}] = 10^{-6} \text{ M}$

$$[\text{SO}_4^{2-}] = \frac{1.1 \times 10^{-10}}{10^{-6}} = 1.1 \times 10^{-4} \text{ M}, \text{ SrSO}_4$$

precipitates when  $[\text{SO}_4^{2-}] = 6.4 \times 10^{-6} \text{ M} \therefore$  not feasible

(3)

11-16 c



$$\text{Be}(\text{OH})_2 \text{ ppt's when } [\text{OH}^-] = \left( \frac{K_{sp}}{[\text{Be}^{2+}]} \right)^{1/2} = \left( \frac{7.0 \times 10^{-22}}{0.02} \right)^{1/2} = 1.87 \times 10^{-10} \text{ M}$$

$$\text{Hf}(\text{OH})_4 \text{ ppt when } [\text{OH}^-] = \left( \frac{K_{sp}}{[\text{Hf}^{4+}]} \right)^{1/4} = \left( \frac{4.0 \times 10^{-26}}{0.01} \right)^{1/4} = 1.41 \times 10^{-6} \text{ M}$$

$\text{Be}(\text{OH})_2$  ppt's first - what is  $[\text{OH}^-]$  when  $[\text{Be}^{2+}] = 10^{-6} \text{ M}$

$$[\text{OH}^-] = \left( \frac{7.0 \times 10^{-22}}{10^{-6}} \right)^{1/2} = 2.6 \times 10^{-8} \text{ M}, \quad \text{Hf}(\text{OH})_4$$

has not started ppt, so feasible