Solubility Product

$$AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$$

$$K_{sp} = [Ag^{+}][Cl^{-}]$$

$$= 1.6 \times 10^{-10} \quad \text{AT } 25^{\circ}C$$

I	—	0	0
C	$-x$	x	x
E	—	x	x

$$x^{2} = 1.6 \times 10^{-10}$$

$$x = 1.3 \times 10^{-5}$$

$$[Ag^{+}] = 1.3 \times 10^{-5}\ M$$

CONSIDER THE FOLLOWING SULFIDES:

$ZnS(s) \rightleftharpoons Zn^{2+}(aq) + S^{2-}(aq) \quad K_{sp1} = 1.6 \times 10^{-24}$

$FeS(s) \rightleftharpoons Fe^{2+}(aq) + S^{2-}(aq) \quad K_{sp2} = 6.3 \times 10^{-18}$

$S^{2-}(aq)$ IS A CONJUGATE BASE OF HYDROGEN SULFIDE $HS^-(aq)$

$HS^-(aq)$ IS A CONJUGATE BASE OF HYDROSULFURIC ACID $H_2S(aq)$

$H_2S(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HS^-(aq)$

$K_{a1} = 9.1 \times 10^{-8}$

$HS^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + S^{2-}(aq)$

$K_{a2} = 1.3 \times 10^{-13}$

$H_2S(aq) + 2H_2O(l) \rightleftharpoons 2H_3O^+(aq) + S^{2-}(aq)$

$$K_{a3} = K_{a1} K_{a2} = 1.1 \times 10^{-20}$$

$$K_{a3} = \frac{[H_3O^+]^2 [S^{2-}]}{[H_2S]}$$

$$[S^{2-}] = K_{a3} \frac{[H_2S]}{[H_3O^+]}$$

We can saturate the solution with $H_2S(aq)$ hydrosulfuric acid.

For a saturated solution $[H_2S] = 0.10\ M$ at 25 °C

We can also control the pH, and for $pH = 2.00 \Rightarrow [H_3O^+] = 1.0 \times 10^{-2}\ M$

$$\Rightarrow [S^{2-}] = 1.1 \times 10^{-17}\ M$$

$K_{sp1} = [Zn^{2+}][S^{2-}] = 1.6 \times 10^{-24}$

$K_{sp2} = [Fe^{2+}][S^{2-}] = 6.3 \times 10^{-18}$

BUT FOR A SATURATED SOLUTION WITH $H_2S(aq)$ AT pH = 2.00, WE HAVE $[S^{2-}] = 1.1 \times 10^{-17} M$.

THEREFORE

$[Zn^{2+}] = 1.5 \times 10^{-7} M$ INSOLUBLE

$[Fe^{2+}] = 0.57 M$ SOLUBLE