General Chemistry II

RR # 12
Summer 2022

1. **What mass of ZnS ($K_{sp} = 2.5 \times 10^{-22}$) will dissolve in 300.0 mL of 0.050 M $Zn(NO_3)_2$? Ignore the basic properties of S^{2-}. "X" is negligible.**

$$ZnS\ (s) \leftrightarrow Zn^{2+}(aq) + S^{2-}(aq)$$

	[Zn^{2+}]	**[S^{2-}]**
I	**0.050**	**0**
C	**+x**	**+x**
E	**0.050+x**	**x**

$$K_{sp} = 2.5 * 10^{-22} = [Zn^{2+}][S^{2-}] = x(0.050)$$

$$x = 5.0 * 10^{-21} M = [S^{-2}]$$

$$\frac{5.0 * 10^{-21}\ mol\ S^{-2}}{L} * 0.300\ L = 15\ X\ 10^{-21}\ mol\ S^{-2} * \frac{1\ mol\ ZnS}{1\ mol\ S^{-2}} * \frac{97.45g}{1\ mol\ Zns} = \mathbf{1.46 * 10^{-19}}$$

2. **Predict whether the equivalence point of each of the following titration is below, above, or at pH 7.**
   a. **$NaHCO_3$ titrated with NaOH** basic
   b. **NH_3 titrated with HCl** acidic
   c. **KOH titrated with HBr** neutral

3. **Consider a beaker containing a saturated solution of CaF_2 in equilibrium with undissolved CaF_2. The molar solubility of CaF_2 at 35 degrees Celsius is 1.24×10^{-3} M.**

   a. **What are the expression and the value for K_{sp}?**

   $$K_{sp} = [Ca^{2+}][F^{2-}]^2 = [1.24 * 10^{-3}][2.48 * 10^{-3}]^2 = 7.63 * 10^{-9}$$

   b. **Solid $CaCl_2$ is then added to the solution. Will the amount of CaF_2 (s) increase, decrease, or remain the same? Explain**

It increases. Because Ca^{2+}, one of the products of the dissociation of CaF_2, is already present in solution, owing to $CaCl_2$, less CaF_2 will dissolve, leading to more solid CaF_2 in the mixture.

4. **The molar solubility of PbBr2 is 2.17 x 10^{-3} M at a certain temperature. Calculate K_{sp} for $PbBr_2$.**

$$PbBr_2(s) \leftrightarrow Pb^{2+}(aq) + 2Br^-(aq)$$

Recall that the molar solubility refers to the solubility of the solid compound. Set up an ICE chart.

	Pb^{2+}	$2Br^-$
I	0	0
C	+x	+2x
E	x	2x

Because the stoichiometry of the equation indicates that PbBr2 (s) and Pb2+ (aq) are in 1:1 ratio, the given molar solubility will be equal to x. Thus,

$$[Pb^{2+}]_{eq} = 2.17 * 10^{-3}\ M$$

$$[Br^-]_{eq} = 4.34 * 10^{-3}\ M$$

$$K_{sp} = [Pb^{2+}][Br^-]^2 = (\ 2.17 * 10^{-3}\ M)(\ 4.34 * 10^{-3}\ M)^2 = 4.09 * 10^{-8}$$

5. **What is the pH at which $Cr(OH)_3$, K_{sp} =6.3x 10^{-31}, just starts to precipitate from a 1.0 x 10^{-12} M Cr^{+3} solution?**

$$Cr(OH)_3(s) \leftrightarrow Cr^{3+}(aq) + 3OH^-(aq)$$

Precipitation will occur when the reaction quotient, Q, just begins to exceed K_{sp}. You are given the concentration of Cr^{3+}, so you can solve for the equilibrium OH^- concentration.

$$K_{sp} = [Cr^{3+}][OH^-]^3$$

$$6.3 * 10^{-31} = (\ 1.0 * 10^{-12} M)[OH^-]^3$$

$$[OH^-]_{eq} = 8.57 * 10^{-7} M$$

$$pOH = -\log([OH^-]_{eq}) = -\log\ (8.57 * 10^{-7} M) = 6.07$$

$$pH = 14 - pOH = 14 - 6.07 = \mathbf{7.93}$$

6. **Solution A is 1.0 L of pure water. Solution B is 1.0 L of 3.4x 10^{-2} M NaCl. How many more moles of AgCl (K_{sp}= 1.77x10^{-10}) dissolve in solution A than solution B? (Hint: for solution B, you can consider the change to be negligible compared to the initial concentration of Cl^-)**

Solution A:

$$AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$$

	Ag^+	Cl^-
I	0	0
C	+x	+x
E	x	x

$$K_{sp} = [Ag^+][Cl^-] = 1.77 * 10^{-10} = x^2$$

$$x = 1.33 * 10^{-5}\ M\ \ = molar\ solubility\ of\ AgCl$$

$$\frac{1.33 * 10^{-5}\ mol\ AgCl}{1\ L} * 1.0\ L = 1.33 * 10^{-5}\ mol\ AgCl\ dissolved$$

Now, consider solution B. The Na+ plays no role chemically in this case (spectator).

$$AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$$

	Ag^+	Cl^-
I	0	0.034
C	+x	+x
E	x	0.034+x

← we get this number from that fact that sol'n B is 1 L of 3.4 *10^{-2} M NaCl which means we have 3.4 *10^{-2} mol of Cl^-

$$K_{sp} = [Ag^+][Cl^-] = 1.77 * 10^{-10} = (x)(0.034 + x)$$

You can assume that "x" is negligible compared to the 0.034 so:

$$1.77 * 10^{-10} = 0.034x$$

$$x = 5.21 * 10^{-9}M = molar\ solubility\ of\ AgCl$$

$$\frac{5.21 * 10^{-9}M\ mol\ AgCl}{1\ L} * 1.0\ L = 5.21 * 10^{-9}\ mol\ AgCl\ dissolved$$

LAST PART OF SOLUTION ON NEXT PAGE!!!!!

Lastly, find the difference in moles.

$$1.33 * 10^{-5}\ mol\ AgCl\ dissolved\ in\ A - 5.21 * 10^{-9} mols\ AgCl\ dissolved\ in\ B$$
$$= \mathbf{1.33 * 10^{-5}\ more\ mol\ AgCl\ dissolved\ in\ A}$$