Name:________________________
Blk:______Date:__________________

Chemistry 12
Solubility Lesson # 8
Chloride Titrations

Recall from Unit V + Chem 11:
A Titration is a process where a measured amount of a substance is reacted with an unknown quantity of another substance until the desired "equivalence point" is reached (coincides with a colour Δ)
The purpose of carrying out a TITRATION is to determine either [ ] or L of an unknown substance.

For SILVER-CHLORIDE TITRATIONS the chromate ion is used as an indicator.
WHY?

$AgCl\,(s) \leftrightarrow Ag^{+}\,(aq) + Cl^{-}\,(aq)$ $\boxed{\textbf{Ksp} = [Ag^{+}][Cl^{-}] = \mathbf{1.8 \times 10^{-10}}}$
(white) (colourless) (colourless)

$Ag_2CrO_4\,(s) \leftrightarrow 2\,Ag^{+}\,(aq) + CrO_4^{2-}\,(aq)$ $\boxed{\textbf{Ksp} = [Ag^{+}]^2 [CrO_4^{2-}] = \mathbf{1.1 \times 10^{-12}}}$
(red) (colourless) (yellow)

When unknown $[Ag^{+}]$(aq) is slowly added into a beaker containing both 0.10 M Cl^{-} (aq) and 0.10 M CrO_4^{-2} (aq). What will the first ppt to form be? ($Q = Ksp$)

Re-arrange the above Ksp expressions and Solve for $[Ag^{+}]$:

$Ksp = [Ag^{+}][Cl^{-}] = 1.8 \cdot 10^{-10}$

$\frac{[x][0.10]}{0.10} = \frac{1.8 \cdot 10^{-10}}{0.10}$

$[Ag^{+}] = x = 1.8 \cdot 10^{-9}\ M$

$Ksp = [Ag^{+}]^2[CrO_4^{2-}] = 1.1 \cdot 10^{-12}$

$\frac{[x]^2[0.10]}{0.10} = \frac{1.1 \cdot 10^{-12}}{0.10}$

$\sqrt{x^2} = \sqrt{1.1 \times 10^{-11}}$

$Ag^{+} = x = 3.3 \cdot 10^{-6}\ M\ Ag^{+}$

The first ppt to form will be AgCl(s) as is requires a SMALLER $[Ag^{+}]$.
As more and more Ag^{+} is added to the beaker the Cl^{-} is eventually all used up, and at that point the CrO_4^{2-} will begin to combine with the Ag^{+} and there will be a distinctive orange colour produced as Ag_2CrO_4 is formed. At this point the titration is **STOPPED**.

AT THIS POINT THE MOLES OF Ag^{+} ADDED = MOLES OF Cl^{-} PRESENT

→ you have reached the "EQUIVALENCE POINT" of the rxn

IN SUMMARY: when the colour ORANGE appears the titration is STOPPED as the equivalence point is reached.

$NaCl + AgNO_3 \rightarrow AgCl(s) + NaNO_3(aq)$

Example 1. In order to find the [Cl⁻] in a sample of sea water, a 25.0 mL sample was titrated with 0.500 M $AgNO_3$ solution, using sodium chromate as an indicator. At the EQUIVALENCE POINT 26.8 mL of $AgNO_3$ had been added. What was the [Cl⁻] in the sea water?

Step 1. Balanced equation

$1\,AgCl(s) \rightleftharpoons 1\,Ag^+(aq) + 1\,Cl^-(aq)$

Step 2. Solve for moles of KNOWN

$0.0268\,\cancel{L}\left(\frac{0.500\,\text{mol}\,\cancel{AgNO_3}}{1\,\cancel{L}}\right)\left(\frac{1\,\cancel{\text{mol}\,Ag^+}}{1\,\text{mol}\,\cancel{AgNO_3}}\right)\left(\frac{1\,\text{mol}\,Cl^-}{1\,\cancel{\text{mol}\,Ag^+}}\right)\left(\frac{1}{0.0250\,L}\right)$

Step 3 .Convert to moles of UNKNOWN

$= \boxed{0.536\,M\,Cl^-}$

Step 4 .Solve for [ ] of UNKNOWN

$M = \text{mol} \div L$

Example 2. What volume of 0.125 M $AgNO_3$ will be required to titrate 50.0 mL of 0.0500 M Cl⁻ solution, using the chromate indicator?

Step 1. Balanced equation

$AgCl(s) \rightleftharpoons 1\,Ag^+(aq) + 1\,Cl^-(aq)$

Step 2. Solve for moles of KNOWN

$0.0500\,\cancel{L}\left(\frac{0.0500\,\cancel{\text{mol}\,Cl^-}}{1\,\cancel{L}}\right)\left(\frac{1\,\cancel{\text{mol}\,Ag^+}}{1\,\text{mol}\,\cancel{Cl^-}}\right)\left(\frac{1\,\cancel{\text{mol}}\,AgNO_3}{1\,\cancel{\text{mol}\,Ag^+}}\right)\left(\frac{1\,L}{0.125\,\cancel{\text{mol}\,AgNO_3}}\right)$

Step 3. Convert to moles of UNKNOWN

$= 0.0200\,L\,AgNO_3$

$\frac{0.125\,\text{mol}\,AgNO_3}{1\,L}$

Step 4. Solve for volume of UNKNOWN

$L = \text{mol} \div M \leftarrow 0.125\,M$

or $20.0\,mL\,AgNO_3$

Sample Problem. A 5.29 g sample of impure NaCl was dissolved and diluted to at total volume of 250.0 mL. If 25.0 mL of the NaCl solution required 28.5 mL of 0.300 M $AgNO_3$ solution to reach the equivalence point, using the chromate indicator, what was the percentage purity of the original NaCl solution?

Recall Percent Purity = actual /expected x 100 = %

Seatwork/Homework: Exercises 70-75 pgs 101-102

PLO's: I7

Sample Problem:

$$P.P = \frac{actual}{expected} \cdot 100$$

$$AgNO_3 (aq) + NaCl (aq) \rightarrow AgCl (s) + NaNO_3$$

$$\therefore 1 AgCl (s) \rightleftharpoons 1 Ag^+ + 1 Cl^-$$

actual → (titration)

$$0.0285 \cancel{L} \cdot \left(\frac{0.300 \text{ mol } \cancel{Ag^+}}{1 \cancel{L}}\right)\left(\frac{1 \text{ mol } Cl^-}{1 \cancel{\text{mol } Ag^+}}\right)$$

$$= 8.55 \cdot 10^{-3} \text{ mol } Cl^- \Rightarrow 8.55 \cdot 10^{-3} \text{ mol NaCl}$$

$$[NaCl] = \frac{8.55 \cdot 10^{-3} \text{ mol NaCl}}{0.0250 \text{ L}} = \boxed{0.342 \text{ M NaCl}}$$

actual

expected → (impure)

$$5.29 \text{ g NaCl} \left(\frac{1 \text{ mol}}{58.5 \text{ g}}\right)\left(\frac{1}{0.2500 \text{ L}}\right)$$

$$= \boxed{0.362 \text{ M NaCl}}$$ ← expected

$$\text{Percent Purity} = \frac{0.342 \text{ M}}{0.362 \text{ M}} \cdot 100 = \boxed{94.6\%}$$