## Selective Precipitation

*Qualitative Analysis:*
*Separating & Identifying Metal Ions II*

## *Precipitation and Separation of Ions*

$CuS(s) \quad Cu^{2+}(aq) + S^{2-}(aq)$

- At any instant in time, $Q = [Cu^{2+}][S^{2-}]$.
  - ❖ If $Q > K_{sp}$, precipitation occurs until $Q = K_{sp}$.
  - ❖ If $Q = K_{sp}$, equilibrium exists.
  - ❖ If $Q < K_{sp}$, solid dissolves until $Q = K_{sp}$.
- Based on solubilities, ions can be selectively removed from solutions.
- Consider a mixture of $Zn^{2+}(aq)$ and $Cu^{2+}(aq)$. CuS ($K_{sp} = 6 \times 10^{-37}$) is less soluble than ZnS ($K_{sp} = 2 \times 10^{-25}$), CuS will be removed from solution before ZnS.

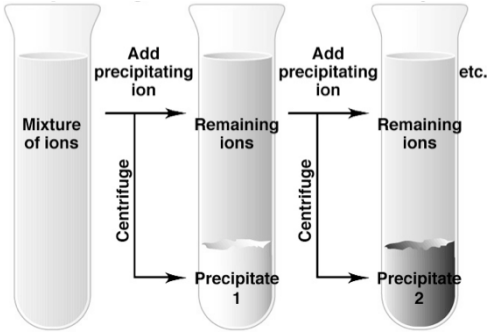
## *Precipitation and Separation of Ions*

- As $H_2S$ is added to the green solution, black CuS forms in a colorless solution of $Zn^{2+}(aq)$.
- When more $H_2S$ is added, a second precipitate of white ZnS forms.

Selective Precipitation of Ions

- Ions can be separated from each other based on their salt solubilities.
- Example: if HCl is added to a solution containing $Ag^+$ and $Cu^{2+}$, the silver precipitates ($K_{sp}$ for AgCl is $1.8 \times 10^{-10}$) while the $Cu^{2+}$ remains in solution.
- Removal of one metal ion from a solution is called *selective precipitation*.

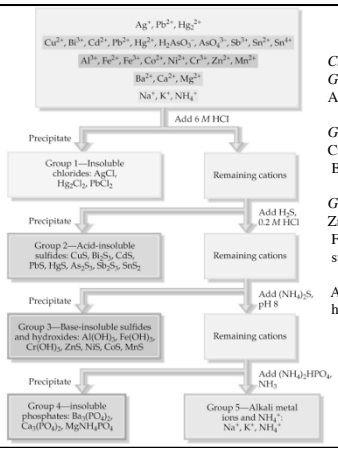
## The General Procedure for Separating Ions in Qualitative Analysis



# QUESTION #K.7

To separate a solution containing 0.000 10 M silver and 0.10 M lead ions, as done in some qualitative analysis separation schemes, a source of $I^-$ may be slowly added to the mixture of ions. Which will precipitate first: AgI ($K_{sp} = 1.5 \times 10^{-16}$ ) or $PbI_2$ ($K_{sp} = 1.4 \times 10^{-8}$)? Also, what would be the concentration of $I^-$ necessary to see that first precipitation?

A. AgI; $[I^-]$ would be $1.5 \times 10^{-12}$ M
B. AgI; $[I^{-1}$ would be $1.4 \times 10^{-4}$ M
C. $PbI_2$; $[I^-]$ would be $1.4 \times 10^{-7}$ M
D. $PbI_2$; $[I^-]$ would be $1.4 \times 10^{-6}$ M




*Chem 121 Ions:*
*Group I:*
$Ag^+$, $Pb^{2+}$

*Group II:*
$Cu^{2+}$, $Cd^{2+}$, $Sb^{3+}$, $Bi^{3+}$, $Pb^{2+}$

*Group III:*
$Zn^{2+}$, $Mn^{2+}$, $Ni^{2+}$, $Fe^{2+}$, $Co^{2+}$ as sulfides,

$Al^{3+}$, $Cr^{3+}$ as hydroxides

## Separation into Ion Groups

**Ion Group 1:** Insoluble chlorides
$Ag^+$, $Pb^{2+}$ // $Hg_2^{2+}$

**Ion Group 2:** Acid-insoluble sulfides
$Cu^{2+}$, $Cd^{2+}$, $Sb^{3+}$, $Bi^{3+}$, $Pb^{2+}$ // $Hg^{2+}$, $As^{3+}$, $Sn^{2+}$, $Sn^{4+}$

**Ion Group 3:** Base-insoluble *sulfides* and hydroxides
$Zn^{2+}$, $Mn^{2+}$, $Ni^{2+}$, $Fe^{2+}$, $Co^{2+}$ as sulfides, and $Al^{3+}$, $Cr^{3+}$ as hydroxides

**Ion Group 4:** Insoluble phosphates
$Mg^{2+}$, $Ca^{2+}$, $Ba^{2+}$

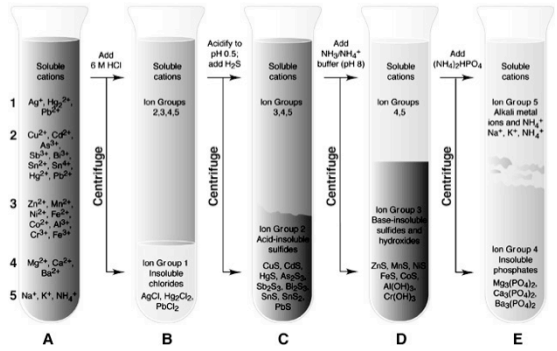
**Ion Group 5:** Alkali metal and ammonium ions
$Na^+$, $K^+$, $NH_4^+$

# QUESTION Q.1.

In the qualitative analysis scheme for metal ions, how are the Analytical Group II cations separated from the cations of Analytical Groups III?

A) by addition of HCl, forming insoluble metal chlorides
B) by addition of $H_2SO_4$, forming insoluble metal sulfates
C) by addition of $H_2S$ in acidic solution, forming insoluble metal sulfides
D) by addition of $H_2S$ in basic solution, forming insoluble metal sulfides or hydroxides
E) by addition of $(NH_4)_2CO_3$ or $(NH_4)_3PO_4$, forming insoluble metal carbonates or phosphates

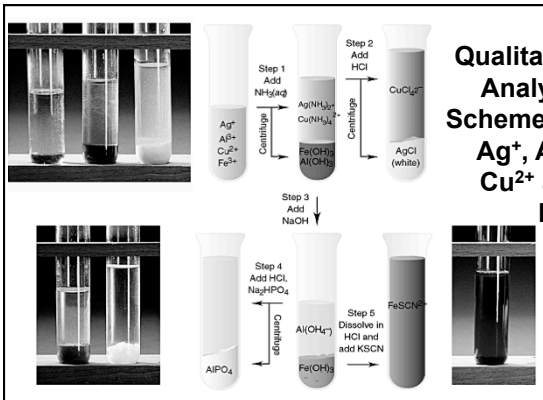
## Qualitative Analysis for Separating Cations




# QUESTION Q.2.

When a mixture containing cations of Analytical Groups I–III is treated with $H_2S$ in acidic solution, which cations are expected to precipitate?

A)Analytical Group I only
B)Analytical Group II only
C) Analytical Group III only
D) Analytical Groups I and II
E) Analytical Groups II and III




## A Qualitative Analysis Scheme for $Ag^+$, $Al^{3+}$, $Cu^{2+}$ and $Fe^{3+}$

# QUESTION Q.3.

The cation $M^{2+}$ reacts with $NH_3$ to form a series of complex ions as follows:

$M^{2+} + NH_3 \rightleftharpoons M(NH_3)^{2+}$ $\quad K_1 = 10^2$

$M(NH_3)^{2+} + NH_3 \rightleftharpoons M(NH_3)_2^{2+}$ $\quad K_2 = 10^3$

$M(NH_3)_2^{2+} + NH_3 \rightleftharpoons M(NH_3)_3^{2+}$ $\quad K_3 = 10^2$

A 1.0 x $10^{-3}$ mol sample of $M(NO_3)_2$ is added to 1.0 L of 15.0 *M* $NH_3$ ($K_b = 1.8 \times 10^{-5}$). Choose the dominant species in this solution:

A) $M^{2+}$ B) $M(NH_3)^{2+}$ C) $M(NH_3)_2^{2+}$

D) $M(NH_3)_3^{2+}$ E) $M(NO_3)_2$