Group Separation:
- Qual II cations are separated as base insoluble sulfides and hydroxides. Pay close attention to the color of the ppt.
- Both zinc and aluminum cations are amphoteric, which makes them soluble at extreme pH.

Experiment
All waste in the waste jar.

Part A1. Precipitation of Group 2 cations
- Ni$^{2+}$, Mn$^{2+}$, Fe$^{3+}$, Al$^{3+}$, Zn$^{2+}$ are reacted with H$_2$S in basic medium to precipitate the cations as sulfides, NiS, MnS, FeS, Al(OH)$_3$ and ZnS.
- NiS and FeS are black, ZnS is white, MnS is light pink (almost white), Al(OH)$_3$ is gelatinous white (almost clear and very hard to see).
- Fe$^{3+}$ is initially reduced to Fe$^{2+}$ by the H$_2$S before it is converted to FeS.
- The sulfides and hydroxides are then dissolved in concentrated acid for further separation.
- Since your samples contain only Group II cations skip Part A

Procedure
Part A  Skip all.

Part B. Separation of Mn$^{2+}$, Ni$^{2+}$ and Fe$^{3+}$ from Zn$^{2+}$ and Al$^{3+}$
- The addition of NaOH uses the amphoteric characteristic of to the hydroxides of Zn$^{2+}$ and Al$^{3+}$ and are separated in the supernatant.

\[
\begin{align*}
\text{Al}^{3+} + 4 \text{OH}^- & \rightarrow [\text{Al(OH)}_4]^- \\
\text{Zn}^{2+} + 4\text{OH}^- & \rightarrow [\text{Zn(OH)}_4]^{2-}
\end{align*}
\]
- Hydroxides of Mn$^{2+}$, Ni$^{2+}$ and Fe$^{3+}$ are dissolved in HNO$_3$.

Procedure
1. The pH of the solution must be over 9 to keep the Zn(OH)$_2$ and Al(OH)$_3$ in solution.
2. Dissolve the hydroxide precipitates with acid in the hood or under the portable hood.
Part C Confirmation of Mn$^{+2}$

\[ 2\text{Mn}^{+2} + 5\text{BiO}_3^- + 14\text{H}^+ \rightarrow 2\text{MnO}_4^- + 5\text{Bi}^{+3} + 7\text{H}_2\text{O} \]

light pink  \[\rightarrow\]  purple

Procedure
Part C #1.
- Centrifuge after addition of sodium bismuthate to see purple permangante ion.
- If you see purple after you've added the sodium bismuthate and the color disappears after centrifuging, it is still positive.

Part D Separation and Confirmation of Iron
- Iron is precipitated in excess NH$_3$.

\[ \text{Fe}^{+3} + 3\text{NH}_3 + 3\text{H}_2\text{O} \rightarrow \text{Fe(OH)}_3(\text{s}) + 3\text{NH}_3 \]

\[ \text{Ni}^{+2} + 6\text{NH}_3 \rightleftharpoons [\text{Ni(NH}_3)_6]^{+2}_{(\text{aq})} \]

- Fe(OH)$_3$ dissolves in 6 M HCl.
- The Fe$^{+3}$ is confirmed with KSCN.

\[ \text{Fe}^{+3} + \text{SCN}^- \rightarrow [\text{FeNCS}]^{+2} \]

Blood red

Procedure
Part D #1. The color must be blood red, any other variation of red or brown is negative.

Part E Confirmation of Nickel
- [Ni(NH$_3$)$_6$]$^{2+}$ is tested with dimethylglyoxime (DMG).

\[ [\text{Ni(NH}_3)_6]^{2+} + 2\text{H}_2\text{DMG} \rightarrow \text{Ni(HDMG)}_{2(\text{s})} + 2\text{NH}_4^+ + 4\text{NH}_3 \]

strawberry red

Part E #1. Add 10 drops of NH$_4$Cl and NH$_3$ until basic. Add 3 or more drops of dimethylglyoxime.

Part F Confirmation of Aluminum
- [Al(OH)$_4$]$^- \text{ and [Zn(OH)}_4]^{-2}$ is converted to Al$^{+3}$ and Zn$^{+2}$ with the addition of HNO$_3$.

\[ [\text{Al(OH)}_4]^- + 4\text{H}^+ \rightarrow \text{Al}^{+3} + 4\text{H}_2\text{O} \]

- Aluminum is separated from zinc by reprecipitating the Al$^{+3}$ with NH$_3$. Confirmation is with aluminon reagent to give a "red lake" precipitate.
\[
\text{Al}^{3+} + 3\text{NH}_3(aq) \rightarrow \text{Al(OH)}_3 + 3\text{NH}_3 + \text{H}_2\text{O} + \text{aluminon} \rightarrow \\
\text{Al(OH)}_3 \cdot \text{aluminon} + 3\text{NH}_4^+
\]

*Pink to red*

**Procedure**

**Part F** #1. Adjust pH to 8 using HNO\(_3\) or NH\(_3\).

#2. Make sure the pH is basic before concluding that Al\(^{3+}\) is absent.

**Part G  Confirmation of Zinc**

* The solution containing the zinc cation is acidified.

\[
\text{[Zn(OH)₄]}^{2-} + 4\text{H}^+ \rightarrow \text{Zn}^{2+} + 4\text{NH}_4^+
\]

* Zn\(^{2+}\) is confirmed with K\(_4\)[Fe(CN)₆] to give a precipitate.

\[
3\text{Zn}^{2+} + 2\text{K}_4[\text{Fe(CN)}_6] \rightarrow \text{K}_2\text{Zn}_3[\text{Fe(CN)}_6]_{(s)} + 6\text{K}^+
\]

*light green*

**Procedure**

**Part G #1.** pH must be around 4 to 5.