Exp. 4: Group III

1. You will be using high concentrations (6 M) of HCl and HNO₃.
   a. What should you do if you get some on your hand?
   b. What safety precaution(s) can you use to avoid getting acid on your hand?
   c. If you drip some acid on the table, how should it be cleaned up?

2. Consider the following reaction at equilibrium.
   a. How will the addition of base affect the position of equilibrium?
      \[ \text{H}_2\text{S} (aq) + 2\text{H}_2\text{O} (l) \rightleftharpoons 2\text{H}_3\text{O}^+ (aq) + \text{S}^{2-} (aq) \]
   b. How is thioacetamide involved in this process?
   c. Explain why base is added.

3. Thioacetamide provides two necessary components for today’s experiment. List the two components and the function of each.

4. When sodium hydroxide is added to the aqueous group III ions, they are precipitated as hydroxides, except for aluminum and zinc ions.
   What is the chemical form of each (Al and Zn) which allow these two group III ions to remain in solution?
5. Thioacetamide is added to a mixture of group III ions to get the basic sulfide precipitation of the group III ions. Write the chemical equation that shows how these group III ions are subsequently solubilized (brought back into solution).

6. Complete and balance the following chemical reactions, and include the phase of the products.

\[
\begin{align*}
\text{Al(OH)}_3 (s) + \_\text{H}^+ (aq) & \rightarrow \\
\text{Zn}^{2+} (aq) + \_\text{OH}^- (aq) & \rightarrow \\
\text{ZnS} (s) + \_\text{H}^+ (aq) & \rightarrow 
\end{align*}
\]

7. For a solution containing Al\(^{3+}\), Zn\(^{2+}\), and Fe\(^{3+}\), describe how to separate these ions.

8. Describe how to use a centrifuge.

9. Write the chemical equation for the confirmation of silver cation.

10. Complete and balance the following chemical equations:

a. \(\text{AgCl(s) + Cl}^- (aq) \rightarrow\)

b. \(\text{Hg}^{2+}(aq) + \text{NH}_3(aq) + \text{Cl}^-(aq) \rightarrow\)

11. In the test for Fe\(^{3+}\), why does a brown precipitate not conclusively show that Fe\(^{3+}\) is present?

12. When sodium hydroxide is added to the aqueous group III ions, they are precipitated as hydroxides, except for aluminum and zinc ions. What is the chemical form of each (Al and Zn) which allows these two group III ions to remain in solution?

13. Hg(I) in NH\(_3\) solution will exist as:

a. Hg\(^{+2}\)

b. Hg\(^{+}\)

c. Hg

d. both b and c

e. both a and b

f. both a and c

14. When you add sodium bicarbonate to an acid spill, how do you know when the acid has been completely neutralized?

15. Fe\(^{3+}\) and Ni\(^{2+}\) can be separated by the addition of NH\(_4\)Cl and NH\(_3\). One of these ions will be in the precipitate I and the other is in the supernatant I.

a. Precipitate I is solubilized with HCl and NH\(_4\)SCN is added, giving a blood-red precipitate II. Which ion does this confirm, Fe\(^{3+}\) or Ni\(^{2+}\)?

b. H\(_2\)DMG is added to supernatant I, giving a bright-red precipitate III. Which ion does this confirm, Fe\(^{3+}\) or Ni\(^{2+}\)?

16. When you add NaOH to the group 3 ions, some of them precipitate and some of them stay in solution.

a. Name the ions that precipitate at this step.

b. Name the ions that stay in solution at this step.

17. In the first step of the group 3 analysis, you add NaOH. Why does this separate Zn and Al from the other group 3 ions? (hint: what is the chemical formula of the resulting zinc and aluminum compounds and what phase are they in?)

18. In the first step of the group 3 analysis, you end up with Zn and Al ions together, separated from the rest of the group 3 ions. To separate these two ions from each other, HNO\(_3\) and NH\(_3\) are added, resulting in precipitate II and supernatant II.

a. Precipitate II is dissolved again in HNO\(_3\), a reagent is added that makes the solution turn red, and NH\(_3\) is added, which causes a red precipitate III to form. Which ion is indicated by this red precipitate III?

b. Supernatant II is treated with HCl and K\(_4\)Fe(CN)\(_6\), which generates a green precipitate IV. Which ion is indicated by this green precipitate IV?

19. There are three group 3 ions that give some form of red precipitate (red, blood red, bright red) in their diagnostic tests. One ion gives a purple solution. The fifth ion gives a light green precipitate.

Identify the ions with the colors in their diagnostic tests:
a. purple solution

b. blood-red precipitate after HCl and NH₄SCN are added

c. bright-red precipitate after H₂DMG is added

d. red precipitate after HNO₃ and NH₃ are added

e. light green precipitate after HCl and K₄Fe(CN)₆ are added