**I. INTRODUCTION**

Chemists are often times given mixtures in which they have no idea which substances are present. Thus they rely on qualitative analysis to determine which elements make up the mixture. By adding various chemicals and observing the reactions that take place, they are able to compare the products to those of reactions they do know.

In this experiment, four mixtures containing the cations Cu2+, Co2+, Fe3+, and Al3+ were assessed qualitatively. Various tests were performed on these solutions, one of them being the addition of aqueous NH3. This was done to examine whether a precipitate containing hydroxide would form. Should, for example, NH3 be added to mixture containing a zinc cation, the following reaction would occur and a precipitate would be formed.

However, when performing this test of adding the weak acid NH3, a certain amount must be added, for should a large quantity of NH3 be added, the precipitate will dissolve. There are cases though where the addition of too much NH3 does not cause the hydroxide precipitate to dissolve.

Besides NH3, NaOH and HCl are used to determine the compounds of a mixture. The addition of NaOH will cause the precipitate to dissolve. (Should no precipitate form with the addition of NaOH, then the mixture contains cations from Groups 1A and 2A.) Then through the addition of an acid, in this case being HCl, will reform the precipitate.

Once the reactions between these given mixtures containing the cations Cu2+, Co2+, Fe3+, and Al3+ and the addition of NH3, NaOH, and HCl were observed and recorded, the same was done with an unknown solution. Thus just like chemists, the products of known reactions (such as the physical appearance of precipitates formed, if a precipitate formed, any color changes) were used to determine the compounds of an unknown solution.

**II. EXPERIMENTAL**

Before starting the experiment, it was made sure that the clean test tube selected could fit into the provided centrifuge. It was also important to be able to note the chemical properties of the cations one is looking for. First, 0.5 mL of each of the solutions containing the cations one is testing were obtained and placed in separate test tubes. Then 1.5 mL of 15 M NH3 was added to the test tubes. The color of each solution, and any solid or complex ions formed were noted. Next, more NH3 were added to the beakers since the precipitate can form a soluble complex ion and dissolve. The solution that became soluble was left undisturbed. The experiment was continued on test tubes containing the precipitate as NaOH were added to these test tubes. It was then noted if a solid did or did not form. If there was a precipitate, then the tube(s) was centrifuged, and the supernatant was poured out. The test tubes could be centrifuged by placing another test tube filled with an equal volume of water on the opposite end. After discarding the supernatant in the beaker once the centrifuge was finished, a few drops of HCl were added in test tubes to make the precipitate reform again. Color changes and color formations were once again noted.

To begin the analysis of an unknown solution, a clean test tube was filled with a few milliliters of the unknown. The color of the original solution that one started with and the color changes as the experiment progressed were noted. 15M NH3 were then added and the solution was mixed thoroughly. Next, the beaker was centrifuged for three minutes. After the three minutes, the beaker containing the unknown solution was taken out. The color of the supernatant and the precipitate were noted. One is able to determine the ions present in the supernatant from the previous testing of the known solutions. The supernatant was later decanted into a waste beaker and the color of the precipitate was noted. If not all of the supernatant comes out, the inside of the beaker was washed with deionized water, centrifuged, and decanted again. If the precipitate was just white, then the cations present were predicted. However if the precipitate was brown, it can contain a mixture of aluminum and iron ions. To test this, NaOH was added to the brown precipitate. Since there was no visible reaction, HCl was added. The addition of HCl would lead to the formation of a white precipitate if aluminum ions were present. Thus, both ions would be present. However, if there was no reaction, then just the iron cation is in the solution.

**III. RESULTS & DISCUSSION**

Table 1 represents the results from the analysis of the known solutions and Table 2 represents the results of the unknown solution analysis. Unknown solution 4 yielded a blue/yellow aqueous solution after adding NH3 which is very similar to the result obtained from adding NH3 to the Co2+ solution. Thus, unknown 4 has some colbalt (II) cations. Moroever, the precipitate formed was a brown color however, this could either be Al3+ or Fe3+, adding the NaOH and HCl will determine which cation is present in the unknown solution. As indicated by Table 1, if a white precipitate forms after adding HCl the solution contains Al3+. However, Table 2 shows that after HCl was added the brown precipitate had remained in the unknown solution. Based on these results it is evident that only Fe3+ was present. Thus, unknown solution 4 contains the cations Co2+ and Fe3+.

**Table 1. Analysis of Known Solutions**. This table shows the colors of the known solutions after adding NH3. By comparing Table 2 with this table the cations in the unknown solution were determined.

|  |  |  |
| --- | --- | --- |
| Cation | Color of Aqueous Solution | Color of Precipitate (if any) |
| Cu2+ | Blue | None |
| Co2+ | Yellow/Green | None |
| Fe3+ | -- | Brown |
| Al3+ | -- | White |

**Table 2. Analysis of Unknown Solution.** This table shows the processes and results of identifying the cations of the unknown solution.

|  |  |
| --- | --- |
| Process | Result |
| Adding NH3 | Blue aqueous solution formed |
| Adding NaOH | No reaction |
| Adding HCl | Brown precipitate remained |

**Figure 1. Cation Flowchart**. This flowchart summarizes the results of Table 1 and Table 2 and helps visually depict how to determine which ions are present in an unknown solution.

(Cu+2), (Co2+), (Fe3+), (Al3+)

Add NH3

Color of supernatant is

Color of precipitate is

Blue

Green

Yellow/Green

Brown

White

Add NaOH

Dissolve any Aluminum

Al3+is present

Both, Cu2+ and Co2+ is present

Co2+ is present

Cu2+ is present

Add HCl

No reaction

White precipitate

Fe2+is present

Both, Al3+and Fe+2 is present