6 Qualitative Analysis I: C

ations I

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**DISCUSSION**

In Experiment 5, you learned how to separate mixtures of ions in solution, and you saw how reagents can be used to produce colored solutions or precipitates when certain ions are present. Using such techniques to determine what components are present in a sample is called qualitative analysis. This experiment and four of the five remaining experiments are devoted to qualitative analysis.

Historically, most qualitative analysis was done at a lab bench, with beakers, test tubes, centrifuges, etc. In recent years, however, sophisticated instruments have been developed which are more sensitive, more accurate, and more efficient than most of the old “wet chemistry” techniques. Many of you will become familiar with these instrumental techniques as you continue your education. There is still much value in doing the outdated “wet chemistry,” however, because as you do these experiments you will see many examples of acid-base, solubility, oxidation-reduction, and complex ion equilibria, and you will learn some descriptive chemistry of the elements as you determine the composition of solutions given to you for analysis.

This experiment and Experiment 7 focus on the analysis of some common cations. Experiments 9 and 10 will teach you how to detect the presence of several common anions in solution. Then, in Experiment 11, you will be given an ionic solid and will be asked to determine the cations and anions present in the solid. As you do these experiments, look for examples of the equilibrium principles you are studying in the lecture portion of the course.

The cations to be studied include some common alkali metals (Na+ and K+) and some alkaline earth metals (Mg2+, Ca2+, and Ba2+), along with Zn2+, Al3+, and NH4+. These ions are not colored in solution, and most of their compounds are white. It is impossible therefore to use colors of solutions or precipitates (as you did in the last experiment) to indicate which of these cations is present in solution. Instead, in this experiment, you will use differences in solubilities to separate the cations from each other. Na+, K+, and NH4+ ions form very few insoluble compounds. Experiment 7 will illustrate other techniques for identifying these cations.

If you will take a moment to review the solubility rules you have learned, you will realize that the sulfates of the cations listed above are all soluble, with the exception of barium sulfate. Calcium sulfate is slightly soluble and will not precipitate under the conditions of this experiment. Thus adding sulfate to a mixture of these cations will allow you to detect barium and remove it from solution.

Four of the other cations form insoluble hydroxides. (Calcium hydroxide is slightly soluble, but will precipitate in a strongly basic solution.) Two of these, however, are amphoteric and will dissolve in a strongly basic solution to form complex ions (see Experiment 5). By making the solution strongly basic, then, two of the remaining cations will precipitate, while two more will be converted to complex ions. The two which precipitate can be separated due to differences in the solubilities of their oxalates. One of them will precipitate when ammonium oxalate is added. The other will then be precipitated by adding NaH2PO4*(aq).*

The solution containing the complex ions will then be acidified, then neutralized with NH3*(aq)*. In this weakly basic solution one of the amphoteric hydroxides will precipitate, while the other forms a complex ion with NH3*(aq)*. Finally, this last cation is precipitated with sulfide ion.