

## Note for instructors and acknowledgments

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### Note for instructors

**Suggested plan for executing the experiments:** The whole set of experiments is prepared for a duration of almost one semester. The first lab meeting may be reserved to teach the chemistry principles behind the experiments which are in chapter 1. The second lab meeting may be used to introduce the basic experimental techniques in chapter 2 including the demonstration of the techniques by the instructor. Students learning may be assessed through quizzes. Then the students may start to practice the analyses one group of cations at a time.

Students may be asked to complete the first column, "net ionic equations, and observations from the expected reaction", of the datasheet of the relevant group as a pre-lab and couple it with a pre-lab quiz to force the students to understand the experiments before performing them. The post-lab assignment may be filling the second column "actual observations and conclusions" of the relevant datasheet at the completion of the lab activity. Start with the analysis of a known sample containing all ions belonging to the group, followed by a sample containing at least one ion from the group (unknown to students). Group-I analyses can be completed in one lab meeting of about three hours duration. Groups II and III need two lab meetings each. Further, one ion may be removed from groups II and III to save some time, e.g. chromium in group III and tin in group IV may be removed, if needed, as they are relatively difficult for students to identify and the contempt taught through them are repeated in the analyses of some other ions in the same group. Instructors may choose to demonstrate the flame tests in groups IV and V, leaving the analyses of calcium and barium without the flame test for students which can be easily completed in one lab meeting. This approach also minimizes the fire hazard associated with the flame test.

As a lab exam, a sample containing at least one ion from each of the groups I, II, III, and IV (unknown to students) be assigned to each student for the analysis in a time of three to four lab meetings. Students may be asked to fill column 1 of each datasheet again, this time as a pre-lab exam assignment, which may be complemented with a pre-lab exam quiz. Post-lab exam assignment may be filling the second column of the four datasheets as each step of the analysis completes. Tell the students that the data gathered in a lab needs to be discriminated in the form of a scientific report. The data gathered in analytical labs need to be discriminated in the form of a lab report. So, the students may be asked to prepare a lab report based on their findings, systematically explaining the analysis of each ion, supported with reaction equations, what they were expecting to observe, and what their conclusions are supported by the evidence gathered, concluding a summary of the ions identified in the unknown sample.

**Preparation of the cation solutions:**  $\text{Ba}(\text{NO}_3)_2$ ,  $\text{Ca}(\text{NO}_3)_2 \cdot 4 \text{H}_2\text{O}$ ,  $\text{Cd}(\text{NO}_3)_2 \cdot 4 \text{H}_2\text{O}$ ,  $\text{Cu}(\text{NO}_3)_2 \cdot 3 \text{H}_2\text{O}$ , and  $\text{Ni}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$  dissolved in distilled water;  $\text{AgNO}_3$ ,  $\text{Cr}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ ,  $\text{Fe}(\text{NO}_3)_3 \cdot 9 \text{H}_2\text{O}$ ,  $\text{Ce}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ , dissolve in 0.1 M  $\text{HNO}_3$ ;  $\text{Bi}(\text{NO}_3)_3 \cdot 5 \text{H}_2\text{O}$  dissolves in 3M  $\text{HNO}_3$ , and  $\text{SnCl}_4 \cdot 4 \text{H}_2\text{O}$  dissolves in 2.5M  $\text{HCl}$ . Prepare a 0.5M stock solution of each ion needed and then mix the appropriate amount of each with 0.1 M  $\text{HNO}_3$  or distilled water, depending on the solubilities of these ions, to make a solution that is 0.1M with respect to each ion in it.

Some cations do not mix well in solution initially. Heat and stir solutions until cations dissolve sufficiently into the solution.