

Investigation 8-A

Predicting

Performing and recording

Analyzing and interpreting

Communicating results

The Solubility of Ionic Compounds

In this investigation, you will work with a set of solutions. You will chemically combine small quantities, two at a time. This will help you determine which combinations react to produce a **precipitate**. A precipitate is an insoluble solid that may result when two aqueous solutions chemically react. *The appearance of a precipitate indicates that an insoluble compound is present.* Then you will compile your data with the data from other groups to develop some guidelines about the solubility of several ionic compounds.

Problem

How can you develop guidelines to help you predict the solubility of ionic compounds in water?

Prediction

Read the entire Procedure. Predict which combination of anions and cations will likely be soluble and which combination will likely be insoluble. Justify your prediction by briefly explaining your reasoning.

Materials

12-well or 24-well plate, or spot plate
toothpicks
cotton swabs or coarse paper towelling
wash bottle with distilled water
piece of black paper
piece of white paper
labelled dropper bottles of aqueous solutions that contain the following cations:
 Al^{3+} , NH_4^+ , Ba^{2+} , Ca^{2+} , Cu^{2+} , Fe^{2+} , Mg^{2+} , Ag^+ , Na^+ , Zn^{2+}
labelled dropper bottles of aqueous solutions that contain the following anions:
 CH_3COO^- , Br^- , CO_3^{2-} , Cl^- , OH^- , PO_4^{3-} , SO_4^{2-} , S^{2-}

Safety Precautions



- Do not contaminate the dropper bottles. The tip of a dropper should not make contact with either the plate or another solution. Put the cap back on the bottle immediately after use.
- Dispose of solutions as directed by your teacher.
- Make sure that you are working in a well-ventilated area.
- If you accidentally spill any of the solutions on your skin, wash the area immediately with plenty of cool water.

Procedure

1. Your teacher will give you a set of nine solutions to test. Each solution includes one of five cations or four anions. Design a table to record the results of all the possible combinations of cations with anions in your set of solutions.
2. Decide how to use the well plate or spot plate to test systematically all the combinations of cations with anions in your set. If your plate does not have enough wells, you will need to clean the plate before you can test all the possible combinations. To clean the plate, first discard solutions into the container provided by your teacher. Then rinse the plate with distilled water, and clean the wells using a cotton swab.
3. To test each combination of anion and cation, add one or two drops into your well plate or spot plate. Then stir the mixture using a toothpick. Rinse the toothpick with running water before each stirring. Make sure that you keep track of the combinations of ions in each well or spot.



Why is it necessary to clean the well or spot plate as described in step 2?

- Examine each mixture for evidence of a precipitate. Place the plate on a sheet of white or black paper. (Use whichever colour of paper helps you see a precipitate best.) Any cloudy appearance in the mixture is evidence of a precipitate. Many precipitates are white.
 - If you can see that a precipitate has formed, enter “I” in your table. This indicates that the combination of ions produces an insoluble substance.
 - If you cannot see a precipitate, enter “S” to indicate that the ion you are testing is soluble.
- Repeat steps 2 to 4 for each cation solution.
- Discard the solutions and precipitates into the container provided by your teacher. Rinse the plate with water, and clean the wells using a cotton swab.
- If time permits, your teacher may give you a second set of solutions to test.
- Add your observations to the class data table. Use your completed copy of the class data table to answer the questions below.

Analysis

- Identify any *cations* that
 - always appear to form soluble compounds
 - always appear to form insoluble compounds

- Identify any *anions* that
 - always appear to form soluble compounds
 - always appear to form insoluble compounds
- Based on your observations, which sulfates are insoluble?
- Based on your observations, which phosphates are soluble?
- Explain why each reagent solution you tested must contain both cations and anions.
- Your teacher prepared the cation solutions using compounds that contain the nitrate ion. For example, the solution marked Ca^{2+} was prepared by dissolving $\text{Ca}(\text{NO}_3)_2$ in water. Why were nitrates used to make these solutions?

Conclusions

- Which group in the periodic table most likely forms cations with salts that are usually soluble?
- Which group in the periodic table most likely forms anions with salts that are usually soluble?
- Your answers to questions 7 and 8 represent a preliminary set of guidelines for predicting the solubility of the compounds you tested. Many reference books refer to guidelines like these as “solubility rules.” Why might “solubility guidelines” be a better term to use for describing solubility patterns?

Application

- Predict another combination of an anion and a cation (not used in this investigation) that you would expect to be soluble. Predict another combination that you would expect to be insoluble. Share your predictions, and your reasons, with the class. Account for any agreement or disagreement. **Do not test your predictions without your teacher’s approval.**