Mystery Anions

Strand Nomenclature, Chemical Formulas, and Reactions

Topic Investigating bonding, nomenclature, and formula writing

Primary SOL CH.3 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include

a) nomenclature

Related SOL CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include

a) designated laboratory techniques;
b) safe use of chemicals and equipment;
c) proper response to emergency situations.

Background Information

An ion is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge. The name was given by physicist Michael Faraday for the substances that allow a current to pass ("go") between electrodes in a solution, when an electric field is applied. It is the transliteration of the Greek participle ἰόν, *ión*, "going."

This simple lab will give students a chance to see that unknown compounds can be identified according to the chemical behaviors of their anions. The lab can be used at the same time students are memorizing the polyatomic ions.

Materials

- Safety goggles and apron
- Distilled water
- Sodium carbonate
- 0.2 *M* $Ba(OH)_2$ [or $Ca(OH)_2$] solution
- 6.0 *M* HCl solution
- Sodium chloride
- *0.1 M* silver nitrate solution
- Magnesium sulfate solid
- *0.2 M* $BaCl_2$ solution
- Sodium iodide
- Bleach
- Dropper
- Starch solution
- Test tubes

Vocabulary

atom, bent, bond, covalent, electron, linear, molecule, nonpolar, polar, trigonal planar, trigonal pyramidal, tetrahedral, valence electron

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction

1. Explain to students that this lab will introduce them to qualitative analysis, the area of chemistry concerned with the identification of substances by their chemical reactions. Students will observe the reactions of some simple salts and will identify unknown samples by testing their reactivity.
2. Review all safety rules and precautions needed in the following experiments.
3. Review all waste-disposal procedures needed in the following experiments:
   - Place all solutions and precipitates containing silver in labeled waste jars.
   - Dispose of all solutions not containing silver by pouring them down the sink.
   - Do not leave insoluble solids in the sink, but dispose of them in the trash can.

Procedure

Experiment 1: The Carbonate Ion, CO_3^{2-}

1. Place a pea-sized amount of sodium carbonate solid in a small, clean test tube that has been rinsed with distilled water.
2. Add to it 1 or 2 drops of 6.0 *M* HCl solution. *CAUTION! Strong acid.* Record your observations.
3. Confirm the presence of CO_2 by dripping a drop of 0.2 *M* $Ba(OH)_2$ solution down the inside of the test tube as the gas bubbles are forming. Watch carefully for the precipitate of barium carbonate in the drop of solution running down the side of the test tube. [You can substitute $Ca(OH)_2$ solution for the $Ba(OH)_2$ solution, in which case you would have a precipitate of calcium carbonate.]

Experiment 2: The Chloride Ion, Cl^{-}

1. Place a pea-sized amount of sodium chloride solid in a small, clean test tube that has been rinsed with distilled water.
2. Add 15 drops distilled water.
3. Then, add 3 or 4 drops of 0.1 M silver nitrate solution, and mix the contents. Observe the formation of a white precipitate of silver chloride. Record your observations.
4. Now, test your tap water for the presence of the chloride ion. Place about 2 mL of tap water (without NaCl) into a clean, rinsed test tube, and add the silver nitrate solution. Look carefully for precipitate. You should look through the test tube the long way—through the opening—and compare what you see to a test tube containing only distilled water. What can you conclude about the presence of chloride ions in the tap water?

Experiment 3: The Sulfate Ion, SO_4^{2-}

1. Place a pea-sized amount of magnesium sulfate solid in a small, clean test tube that has been rinsed with distilled water.

2. Add about 1 mL of distilled water.
3. Then, add a few drops of 0.2 *M* $BaCl_2$ solution, and mix the contents. Observe the formation of a precipitate of barium sulfate. Record your observations.

Experiment 4: The Iodide Ion, I^-

1. Place a pea-sized amount of sodium iodide solid in a small, clean test tube that has been rinsed with distilled water.
2. Add 1 mL of distilled water.
3. Then, add 5 drops of bleach. *CAUTION! Avoid getting bleach on your skin.* Mix the contents.
4. Add a dropper-full of starch solution to the mixture, and record your observations. Confirm the presence of I^- by observing the reaction between the starch and the reaction mixture. Record your observations.

Experiment 5: An Unidentified Ion

1. Give students an unidentified sample of one of the ions studied in the previous experiments, along with the necessary materials to carry out tests to identify the ion.
2. Allow students to carry out the experiments to identify the ion, making sure they use all appropriate safety precautions.
3. Have students record their observations in their notebooks. Emphasize that they must write down exactly what they do in the lab and all their observations.
4. Have students turn in their lab reports with the mystery ion identified and their supporting evidence cited.

Assessment

- **Questions**
  - How is the result of each experiment similar? Different?
  - What is the chemical formula for each reactant and product?
- **Journal/Writing Prompts**
  - Using your knowledge of the procedures and your observations, relate each experiment to the value of this chemistry in everyday life.

Extensions and Connections (for all students)

- Demonstrate the testing of several other mystery anions, such as those detailed below, and have students record their observations. Alternatively, have students research other possible tests for these and/or other anions. Hold a class discussion on the results and conclusions.

The Carbonate Ion, CO_3^{2-} and Hydrogen Carbonate Ion, HCO_3^-

1. Place a pea-sized amount of baking soda in a small, clean test tube that has been rinsed with distilled water.
2. Add to it 1 or 2 drops of sulfuric acid (H_2SO_4). *CAUTION! Strong acid.* Record your observations.

3. Confirm the presence of CO_2 by dripping a drop of $Ba(OH)_2$ solution down the side of the test tube as the gas bubbles are forming. Watch carefully for precipitate of barium carbonate in the drop of solution running down the side of the test tube.

The Chloride Ion, Cl^-

1. Place a pea-sized amount of sodium chloride in a small, clean test tube that has been rinsed with distilled water.
2. Take the tube to the fume hood, and carefully add 1 or 2 drops of sulfuric acid. *CAUTION! Avoid breathing the gas formed.*
3. Carefully lower a piece of moist pH indicator paper into the tube as the gas evolves. Indicator paper is impregnated with a colored compound which is sensitive to acids and bases. It is used to categorize solutions and gases as strongly acidic (red), neutral (no significant color change), or basic (blue). Record your observations.
4. Write a balanced chemical equation to describe the reaction taking place.

The Chloride Ion, Cl^-

1. Place a pea-sized amount of NaCl in a small, clean test tube that has been rinsed with distilled water.
2. Add 15 drops of distilled water and one drop of 3.0 *M* nitric acid (HNO_3) solution. *CAUTION! Strong acid.*
3. Then, add 3 or 4 drops of 0.1 *M* silver nitrate solution, and mix the contents. What happens? Record your observations.
4. Write a balanced chemical equation for the observed reaction. The purpose of the nitric acid in this reaction is to prevent the precipitation of undesired silver salts, like AgOH, which can occur with nonacidic conditions. It is not a reactant in the balanced net ionic equation for this reaction of chloride ion and silver nitrate.

The Chloride Ion, Cl^-

1. To test your tap water for the presence of chloride ion, place about 2 mL of *tap* water (without NaCl) into a clean, rinsed test tube
2. Add 1 drop of 3.0 *M* HNO_3 solution.
3. Then, add the silver nitrate. Look carefully for precipitate. You should look through the test tube the long way—through the opening—and compare what you see to a test tube containing only distilled water. What can you conclude about the presence of chloride ions in the tap water?
4. Write a balanced chemical equation for the observed reaction.

The Sulfate Ion, SO_4

1. Place a pea-sized amount of Epsom salts (magnesium sulfate) in a small, clean test tube that has been rinsed with distilled water.
2. Add 1 or 2 drops of sulfuric acid. Compare your observations with those made above for the carbonate ion, and record them in your notebook.
3. Write a balanced chemical equation for the observed reaction.

The Sulfate Ion, SO_4

1. Place a pea-sized amount of Epsom salts (magnesium sulfate) in a small, clean test tube that has been rinsed with distilled water.
2. Add about 1 mL of distilled water, and mix the contents.
3. Add 1 drop of 3.0 M nitric acid solution and then 1 or 2 drops of 0.2 M $BaCl_2$ solution. Compare the result of this experiment to those seen above for the carbonate ion.
4. Write a balanced chemical equation for the observed reaction.

The Iodide Ion $I^–$

1. Place a pea-sized amount of sodium iodide (NaI) in a small, clean test tube that has been rinsed with distilled water.
2. Add 1 mL of distilled water, and mix the contents.
3. Then, add 5 drops of bleach. *CAUTION! Avoid getting bleach on your skin.* Record your observations.
4. Write a balanced chemical equation for the observed reaction.
5. Confirm the presence of I_2 and I by observing the reaction between a cornstarch packing peanut and the reaction mixture in your test tube. Tear off a piece of a packing peanut, and push it into the solution with a stirring rod. Record your observations.

The Iodide Ion $I^–$

1. Place a pea-sized amount of sodium iodide (NaI) in a small, clean test tube that has been rinsed with distilled water.
2. Add 1 mL of distilled water, and mix the contents.
3. Add 1 drop of 3.0 M HNO_3 solution and then 3 or 4 drops of 0.1 M silver nitrate solution, and record your observations.
4. Write a balanced chemical equation for the observed reaction.

The Iodide Ion $I^–$

1. Place a very small amount of NaI in a small, clean test tube.
2. In the fume hood, carefully add 1 or 2 drops of sulfuric acid. *CAUTION! Avoid breathing the gases formed.* Record your observations.
3. Write a balanced chemical equation for the observed reaction.
4. Confirm the presence of I_2 and I by observing the reaction between a cornstarch packing peanut and the reaction mixture in your test tube. First, add about 1 mL of distilled water, and mix the contents. Then, tear off a piece of a packing peanut, and push it into the solution with a stirring rod. Record your observations.

Strategies for Differentiation

- Have students use a draw/paint program to complete Procedure #3.
- Provide construction paper circles to represent valence electrons for Procedure #3.
- Have students use a glue stick to create the Lewis dot diagrams for atoms and molecules.
- Create a virtual model kit or find one on the Internet for students to manipulate. Consider using the draw tool in Word.

- Create a digital table that allows students to identify the following: Name, Formula, Space Filling, Structural formula, Ball and Stick, and Electron-Dot Diagram.
- Create a digital table that allows students to identify the following: Substance, Lewis dot structure, Name of shape, Drawing of ball and stick model (label regions of partial positive and partial negative charges), Polarity, and Solubility in water.