Mystery Iron Ions

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;
b) balancing chemical equations;
c) writing chemical formulas;
d) bonding types;
e) reaction types; and
f) reaction rates, kinetics, and equilibrium.

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

A chemical reaction is a process that leads to the transformation of one set of chemical substances to another. Chemical reactions can be either spontaneous, requiring no input of energy, or nonspontaneous, typically following the input of some type of energy, such as heat, light or electricity. Classically, chemical reactions encompass changes that strictly involve the motion of electrons in the forming and breaking of chemical bonds; though, the general concept of a chemical reaction, in particular the notion of a chemical equation, is applicable to transformations of elementary particles, as well as nuclear reactions.

Students will use a double replacement reaction to determine the charge on the iron ion in an iron (III) chloride solution. The reaction is complete when the NaOH solution has no more metal ions with which to react. The indicator phenolphthalein will be used to show when excess hydroxide ions have been added.

Materials

- 1 mL of phenolphthalein indicator (0.13 g of solid indicator dissolved in a 50% ethanol/water mixture) or universal indicator
- 2 mL of 0.1 *M* $FeCl_3$ solution (0.82 g of solid iron(III) chloride dissolved in 30 mL of solution)
- 10 mL of 0.1 *M* NaOH solution (0.60 g of NaOH dissolved in 150 mL of solution)
- 24-well plates
- Toothpicks
- Thin-stem dropper pipettes
- Safety goggles and apron

Vocabulary

average, balance, charge, data table, double replacement reaction, drop, formula, ion, mole, oxidation, pipette, ratio, roman numeral, solution, transition metal

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

Introduction

1. Explain to students that in this experiment, they will determine the formula for a transition metal salt and find out whether the compound is iron(II) chloride or iron(III) chloride.

Procedure

Have students do the experiment, using the following steps:

1. Prepare a data table to organize your observations.
2. Fill a clean, dry pipette with the mystery iron chloride solution (0.1 *M* $FeCl_3$), and add five drops of the solution to each of four wells in the well plate. Make all the drops the same size by holding the pipette at the same angle for all drops.
3. Place one drop of the phenolphthalein indicator into the wells, and stir to mix well.
4. Fill another clean, dry pipette with the sodium hydroxide solution (0.1 *M* NaOH), and add it drop by drop to the first well. Stir the solution with a clean toothpick after adding each drop. Keep count of the number of drops you are adding to the well.
5. Continue adding the NaOH solution until the pink color of the indicator phenolphthalein just begins to show up clearly. The pink color change indicates that all of the iron chloride has reacted.
6. Record in your data table the number of drops of NaOH that you added to the iron chloride solution.
7. Repeat the procedure in steps 4–6 for the solution in the other three wells. Be sure to use a clean toothpick for each trial. Be as consistent as possible when judging the appearance of the pink color.
8. Dispose of the chemicals as directed by your teacher.

Assessment

- **Questions**
  - What is a balanced equation for a double replacement reaction between sodium hydroxide and iron(II) chloride? *($FeCl_2 + 2\ NaOH \rightarrow Fe(OH)_2 + 2\ NaCl$)*
  - What is a balanced equation for a double replacement reaction between sodium hydroxide and iron(III) chloride? *($FeCl_3 + 3\ NaOH \rightarrow Fe(OH)_3 + 3\ NaCl$)*
  - Assuming that all of the drops were the same size, how do the numbers of moles of compound in each drop of the solution compare? *(Drops of equal size will contain an equal number of moles of the compound.)*
  - What is the average number of drops of NaOH that were needed to react fully with the iron chloride solution? *(Answers will vary but should average about 15 drops. This gives a ratio of five drops iron solution to 15 drops of the NaOH solution.)*
  - Based on your answers to the questions above, how many moles of NaOH are needed to react with each mole of iron chloride?

  - Compare your answers to the previous question with your balanced equations in questions 1 and 2. Was your iron chloride compound iron(II) chloride or iron(III) chloride? *(From the 5:15, or 1:3, ratio, students should interpret that they have an iron(III) chloride solution.)*
  - Share your data with other lab groups. What is a class average for the ratio of moles of NaOH to moles of iron chloride?
  - Compare the class average with your results. Using the class average as the accepted value, what is your percent error?
- **Journal/Writing Prompts**
  - Explain some possible sources of error in this experiment.

Extensions and Connections (for all students)

- Using the same procedures, identify an unidentified solution of copper chloride as either copper(I) chloride or copper(II) chloride.

Strategies for Differentiation

- Have students use small, sealed, plastic dropper bottles instead of thin-stem dropper pipettes.
- Have students use an electronic spreadsheet to record class data.
- Have students use calculators to calculate data averages.
- Have students use rubber number stamps instead of writing numbers on enlarged data table.
- Have students model the double replacement reactions in this lab by wearing labels/signs (iron ions, chloride ions, sodium ions and hydroxide ions) and arranging themselves to model the reactants. Have them rearrange themselves to form the products.
- Invite a speaker from the water treatment plant to talk about the impact of metal ion content in drinking water.
- Have students discuss the possible sources of error and how the procedure would be modified to fix the error. Have one group member report the group's possible sources of error. Post results on a large poster for whole class discussion.
- Have small groups compare their results to the class average.