Activity of Metals Demonstration and Inquiry

Introduction

Chemical reactions are not formulas on a piece of paper—they are dynamic and exciting events! The demonstration of aluminum with copper(II) chloride showcases many exciting "signs" of a chemical reaction. It may also generate many questions about why metals react, how they react, and the ease with which some metals react and others do not. How could this general reaction be used to determine the relative reactivity of different metals?

Concepts

- Chemical reactions
- Activity of metals
- Single replacement reactions
- Oxidation and reduction

Background

The usefulness of metals in structural and other applications depends on their physical and chemical properties. Although iron is the most common metal used in manufacturing, it must be protected against corrosion because iron rusts easily. Copper is used in electrical wiring because it conducts electricity extremely well and resists corrosion better than many metals. Gold is a highly valuable jewelry metal because it is essentially unreactive. A ranking of metals in order of their ten- dency to undergo oxidation or corrosion, that is, to lose electrons and form metal ions, is called an activity series.

Inquiry Approach

The purpose of this guided-inquiry activity is observe the reaction of aluminum with copper(II) chloride, explore the evidence for the changes that take place in this chemical reaction, and design an experiment to investigate patterns or trends in the reactivity of metals.

Demonstration Questions

1. Observe and record the "signs" of a chemical reaction when aluminum metal is added to a solution of copper(II) chloride. Be as specific as possible!

2. (a) What are the possible or likely products of the reaction of aluminum metal and copper(II) chloride? (b) Describe the evidence (observations) supporting the identification of these products. (c) What are some additional tests or experiments that could be used to confirm the identity of the products?

3. Write a balanced chemical equation for the reaction of aluminum and an aqueous solution of copper(II) chloride.

4. No evidence of a chemical reaction is observed when a piece of copper metal is placed in aluminum chloride or aluminum nitrate solution. Which metal, aluminum or copper, is a more "active" metal?

Inquiry Design and Procedure

1. Form a working group with two other students and discuss the following questions relating to the reactivity of metals.

- Would you expect common metals such as iron or tin to react with copper(II) chloride? How about silver metal? Explain.

- Based on general knowledge of the properties and uses of metals, rank the following metals in order of their predicted activity: aluminum copper, gold, iron, magnesium, silver, sodium, tin, zinc.

- The reaction of aluminum with copper(II) chloride is classified as a single replacement reaction. Write a simple

descriptive definition of a single replacement reaction based on this reaction.

• “Single replacement reactions will occur spontaneously in one direction only.” Explain why this statement is true.

2. Complete the following “if, then” statement to predict how the activity of metals can be studied. If a _____ active metal is placed in a solution containing the _____ of a _____ active metal, then the metal will _____ and a new _____ will be observed.

3. Read the list of Materials that may be provided along with the Safety Precautions for their use. Design an experiment to

determine the activity of copper, iron, magnesium, silver, and zinc.

4. Write a detailed, step-by-step procedure for the experiment. (The experiment should be done on a microscale level using

about 1 mL of each solution and small pieces of metals in a well plate.) Verify the procedure and the required safety precautions with your instructor.

5. What are some variables that might affect the test results? How can these variables be controlled?

6. Carry out the experiment and record observations in an appropriate data table or worksheet.

Materials

Copper strips, Cu Distilled water and wash bottle

Copper(II) sulfate solution, $CuSO_4$

0.2 M, 4 mL Forceps or tweezers

Iron strips, Fe Marking Pen

Iron(II) sulfate solution, $FeSO_4$

0.2 M Paper towels

Magnesium ribbon, Mg Pipets, Beral-type

Magnesium nitrate solution, $Mg(NO_3)_2$

0.2 M Reaction plate, 24-well

Silver nitrate solution, $AgNO_3$

0.2 M Sandpaper (optional)

Zinc strips, Zn Scissors

Zinc sulfate solution, $ZnSO_4$

0.2 M Toothpicks (optional)

Safety Precautions

Silver nitrate is slightly toxic by ingestion and will stain skin and clothing. Copper(II) nitrate and iron(II) sulfate are toxic by ingestion. Metal pieces may have sharp edges—handle with care. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the lab. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Post-Lab Questions

1. Which metals reacted with the most and the fewest metal ion solutions, respectively?

2. Because silver metal is expensive, it was not provided in this experiment. Based on the observed reactions of Cu, Fe, Mg, and Zn with silver nitrate, explain why it was not necessary to test silver in order to determine its activity.

3. Rank the metals Cu, Fe, Mg, Ag, and Zn in order from most active (first) to least active (last).

4. Write a balanced, net ionic equation for each observed reaction of a metal with a metal ion. Hint: The general form of the net ionic equation is shown below—remember to balance the charges.

$M(s) + Nx+(aq) \rightarrow My+(aq) + N(s)$