What Is a Chemical Reaction?
Student Laboratory Kit

Introduction

We live in a world of change. Within our bodies, we depend on complex chemical changes to breathe, to see, to move, indeed to grow. What is a chemical change? How can we identify a chemical change? What kinds of evidence can we gather to determine that a chemical change has indeed occurred, whether in nature or in the laboratory?

Concepts

- Chemical change
- Chemical properties
- Chemical reaction
- Law of conservation of mass

Background

A chemical change is defined as a change in the composition and properties of a substance. The transformation of old materials (reactants) into new substances (products) as a result of a chemical change is called a chemical reaction. Both in the natural world and in the laboratory we recognize that a chemical reaction has occurred by observing the appearance of products with physical and chemical properties different from the reactants from which they were made.

There are many types of observable changes that are used to identify that a chemical reaction has occurred. Signs of chemical change include:

1. Formation of a solid precipitate upon mixing of two solutions.
2. Release of gas bubbles that are not due to a physical change (boiling or sublimation).
3. A color change that does not result from dilution or color mixing.
4. A temperature change that is not caused by external heating or cooling.

These signs of change illustrate the dynamic nature of chemical reactions. Chemical reactions arise due to the rearrangement of atoms and molecules. Compounds are formed when atoms combine to form molecules. When the forces or bonds linking atoms together within molecules break, compounds can also decompose to reform their constituent elements. Molecules of one compound can exchange atoms or groups of atoms with other elements or compounds to form new compounds.

We cannot see these rearrangements at the atomic or molecular level. What evidence do we have for them? The law of conservation of mass states that in any physical or chemical reaction, mass is neither created nor destroyed—it is conserved. This implies that atoms are not gained or lost in a chemical reaction, they are only rearranged.

Experiment Overview

The purpose of this experiment is to examine the chemical properties of hydrochloric acid and copper chloride and to identify the signs of chemical change in the reactions that they undergo. An optional demonstration activity may be performed to determine if the law of conservation of mass applies to a sample chemical reaction in one of these series.

Pre-Lab Questions

1. What does the term corrosive mean in referring to the safety hazard of hydrochloric acid?
2. Which of the following everyday processes represent chemical changes: a nail rusts, ice melts, wood burns, a banana ripens, and sugar dissolves in water?
3. Milk stored beyond its expiration date eventually turns sour. This is an example of a chemical change. What signs of chemical change are observed when milk sours?

**Materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum, foil, Al, 1-cm square piece</td>
<td>Balance, centigram (0.01 g precision)</td>
</tr>
<tr>
<td>Aluminum, shot, Al, 2 small pieces</td>
<td>Beaker, 150-mL (for rinse water)</td>
</tr>
<tr>
<td>Ammonium hydroxide solution, NH₄OH, 3 M, 1 mL</td>
<td>Distilled water and wash bottle</td>
</tr>
<tr>
<td>Cupric chloride solution, CuCl₂, 0.5 M, 6 mL</td>
<td>Forceps or tongs</td>
</tr>
<tr>
<td>Hydrochloric acid solution, HCl, 2 M, 6 mL</td>
<td>Litmus paper, blue</td>
</tr>
<tr>
<td>Magnesium ribbon, Mg, 1-cm piece</td>
<td>Paper towels</td>
</tr>
<tr>
<td>Silver nitrate solution, AgNO₃, 0.1 M, 2 mL</td>
<td>Pipets, Beral-type, graduated, 5</td>
</tr>
<tr>
<td>Sodium carbonate solution, Na₂CO₃, 0.5 M, 1 mL</td>
<td>Reaction plate, 24-well</td>
</tr>
<tr>
<td>Sodium bicarbonate, NaHCO₃, 0.1 g</td>
<td>Spatula</td>
</tr>
<tr>
<td>Sodium hydroxide solution, NaOH, 2 M, 1 mL</td>
<td>Thermometer</td>
</tr>
<tr>
<td>Zinc, mossy, Zn, 2 small pieces</td>
<td></td>
</tr>
</tbody>
</table>

**Safety Precautions**

Hydrochloric acid and sodium hydroxide are corrosive to skin and eyes. Ammonium hydroxide is also irritating to eyes and lungs. Cupric chloride is highly toxic by ingestion and silver nitrate will stain skin and clothes. Magnesium is a flammable solid and zinc metal dust may also be flammable; do not use near flames. 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 laboratory.

**Procedure**

**General Guidelines**

1. Place the 24-well reaction plate on a piece of white background paper, as shown.

2. Use a thermometer to measure the temperature of each solution after each reaction. Briefly rinse the thermometer with distilled water and pat it dry between steps.

3. Record all immediate changes in each reaction step. If evidence of reaction continues beyond 1–2 minutes, proceed with the next step in the sequence. Record the final appearance of each mixture before rinsing and washing the reaction plate.

4. When adding a solid to a reaction well, always add a small amount (about the size of a pea) from the end of a spatula or with forceps (in the case of metal pieces).

**Part A. Reactions of Hydrochloric Acid**

*Record all observations in Data Table A.*

5. Using a Beral-type pipet, add 1 mL (20 drops) of hydrochloric acid to each well, A1–A6. Record the color and appearance of the hydrochloric acid solution.

6. Measure and record the initial temperature of the solution in well A1. *Note: Assume that all solutions in wells A1–A6 are at the same initial temperature.*
7. Test the solution in well A1 using a piece of blue litmus paper. Note the initial color, then add 1 mL of sodium hydroxide solution using a Beral-type pipet. Immediately place the thermometer back in the well and record any temperature change. After one minute, test the solution again with a fresh piece of blue litmus paper.

8. To well A2, add a small amount of solid sodium bicarbonate. Observe and record all changes, including the temperature. Once any initial evidence for reaction has subsided, continue adding sodium bicarbonate in small amounts until a total of three portions have been added.

9. Use a Beral-type pipet to add 1 mL (20 drops) of silver nitrate solution to well A3. Record all observations.

10. Use forceps to add one small piece of mossy zinc to well A4. Record all observations.

11. Use forceps to add one small piece of aluminum shot to well A5. Record all observations.

12. To well A6, add one small piece of magnesium ribbon. Record all observations.

13. Using forceps, remove any pieces of unreacted metal from wells A4–A6. Rinse the metals with water and dispose of them according to your teacher’s instructions.


**Part B. Reactions of Cupric Chloride**

*Record all observations in Data Table B.*

15. Using a Beral-type pipet, add 1 mL (20 drops) of cupric chloride to each well, B1–B6. Record the color and appearance of the solution and measure its initial temperature in one of the wells.

16. Use forceps to add one small piece of aluminum shot to well B1. Record all observations, including the temperature.

17. Add a small piece of crumpled aluminum foil to well B2. Record all observations.

18. Use forceps to add one small piece of mossy zinc to well B3. Record all observations.

19. Use a Beral-type pipet to add 1 mL (20 drops) of ammonium hydroxide solution to well B4. Record all observations.

20. Use a Beral-type pipet to add 1 mL (20 drops) of sodium carbonate solution to well B5. Record all observations.

21. Use a Beral-type pipet to add 1 mL (20 drops) of silver nitrate solution to well B6. Record all observations.

22. Using forceps, remove any pieces of unreacted metal from wells B1–B3. Rinse the metals with water and dispose of them according to your teacher’s instructions.

23. After noting any changes in the final appearance of the mixtures in wells B1–B6, wash the contents of the reaction plate down the drain with a large amount of excess water.

© 2007 Flinn Scientific, Inc. All Rights Reserved. Reproduction permission is granted only to science teachers who have purchased What Is a Chemical Reaction? Catalog No. AP6269, from Flinn Scientific, Inc. No part of this material may be reproduced or transmitted in any form or by any means, electronic or mechanical, including, but not limited to, photocopy, recording, or any information storage and retrieval system, without permission in writing from Flinn Scientific, Inc.
## What Is a Chemical Reaction?

### Data Table A. Reactions of Hydrochloric Acid

<table>
<thead>
<tr>
<th>Reaction Well</th>
<th>Reagents</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HCl + NaOH</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HCl + NaHCO₃</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HCl + AgNO₃</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>HCl + Zn</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>HCl + Al</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>HCl + Mg</td>
<td></td>
</tr>
</tbody>
</table>
### Data Table B. Reactions of Cupric Chloride

Initial appearance and temperature of CuCl₂ solution? ____________________________

<table>
<thead>
<tr>
<th>Reaction Well</th>
<th>Reagents</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CuCl₂ + Al (shot)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CuCl₂ + Al (foil)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CuCl₂ + Zn</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CuCl₂ + NH₄OH</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CuCl₂ + Na₂CO₃</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CuCl₂ + AgNO₃</td>
<td></td>
</tr>
</tbody>
</table>

### Optional Demonstration Activity—Conservation of Mass

Your teacher may perform an optional demonstration activity to test the law of conservation of mass.

**Initial mass of flask assembly** ________

(before mixing)

**Final mass of flask assembly** ________

(after mixing)

Change in mass = | final mass − initial mass | ____
Post-Lab Questions

1. Summarize the observations of chemical change in the reactions of HCl and CuCl₂, respectively. All reactions should be listed; some reactions may appear more than once.

<table>
<thead>
<tr>
<th>Signs of Change</th>
<th>Reactions of HCl</th>
<th>Reactions of CuCl₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitate formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas bubbles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No observable change</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Compare and contrast the reactions of Al, Mg, and Zn with HCl.

3. Based on the observed reactions of HCl and CuCl₂ with different metals, predict whether CuCl₂ will react with Mg.

4. Compare the reactions of CuCl₂ and HCl with AgNO₃. Propose a hypothesis to account for the reaction product. \textit{Hint:} What is the likely chemical formula for the product?

5. Compare the reactions of CuCl₂ with Al shot and Al foil. Discuss some possible reasons for any differences in the reaction of the two forms of aluminum.

6. \textit{(Optional)} Discuss the results of the conservation of mass demonstration. Does the law of conservation of mass apply to chemical reactions?
Teacher’s Notes
What Is a Chemical Reaction?

Materials Included in Kit
- Aluminum foil, Al, 1 sheet
- Aluminum shot, Al, 30 g
- Ammonium hydroxide solution, NH₄OH, 3 M, 25 mL
- Cupric chloride solution, CuCl₂, 0.5 M, 125 mL
- Hydrochloric acid solution, HCl, 2 M, 100 mL
- Magnesium ribbon, Mg, 30-cm strip*

*Cut into individual 1–2 cm pieces for student use.

Additional Materials Needed (per lab group)
- Balance, centigram (0.01 g precision), 3
- Beakers, 150-mL, 15
- Distilled water and wash bottles
- Forceps or tongs, 15
- Silver nitrate solution, AgNO₃, 0.1 M, 75 mL
- Sodium carbonate solution, Na₂CO₃, 0.5 M, 25 mL
- Sodium bicarbonate, NaHCO₃, 5 g
- Sodium hydroxide solution, NaOH, 2 M, 25 mL
- Zinc, mossy, Zn, 15 g
- Litmus paper, blue, 1 vial
- Pipets, Beral-type, graduated, 75
- Paper towels
- Reaction plates, 24-well, 15
- Spatulas, 15
- Thermometers, 15

Optional Demonstration Activity—Conservation of Mass
1. Use a graduated cylinder to add 10 mL of cupric chloride to a 125-mL Erlenmeyer flask.
2. Rinse the graduated cylinder with distilled water and use it to add 3 mL of silver nitrate solution to a small test tube.
3. Carefully place the test tube into the Erlenmeyer flask, taking care not to spill the contents of the test tube in the process. The test tube should be standing upright (at an angle) in the flask.
4. Cap the Erlenmeyer flask with a rubber stopper and measure the mass of the entire assembly (flask + test tube + contents + stopper). Do not allow the contents of the test tube and flask to mix prior to measuring the initial mass.
5. Hold the flask in one hand so that the stopper will NOT fall out. Gently invert the flask several times to allow the two solutions to mix.
6. After the two solutions have mixed, measure the mass of the entire assembly again. Do not take apart the system prior to measuring the final mass.

Safety Precautions
Hydrochloric acid and sodium hydroxide are corrosive to skin and eyes. Ammonium hydroxide is also irritating to eyes and lungs. Cupric chloride is highly toxic by ingestion and silver nitrate will stain skin and clothes. Magnesium is a flammable solid and zinc metal dust may also be flammable. Do not allow students to handle metals with bare hands and do not use near flames. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Disposal
Please consult your current Flinn Scientific Catalog/Reference Manual for general guidelines and specific procedures governing the disposal of laboratory waste. Unreacted metal may be disposed of in the trash according to Flinn Suggested Disposal Method #26a. The contents of the well plates may be disposed of down the drain with excess water according to Flinn Suggested Disposal Method #26b. The mixtures remaining after the conservation of mass experiment should be filtered to separate the insoluble silver chloride product. Silver chloride may be disposed of according to Flinn Suggested Disposal Method #26a. The remaining filtrate may be disposed of down the drain with excess water according to Flinn Suggested Disposal Method #26b.
Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constance, change, and measurement

Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Lab Hints

- This kit contains enough materials for a class of 30 students working in pairs. Materials are also provided to perform the optional demonstration activity for the class. The microscale nature of this lab makes it easy to explore a wide variety of chemical reactions in a typical 50-minute lab period.
- Digital thermometers are more effective than bulb thermometers in 24-well reaction plates. Special microscale bulb thermometers are also available. Graduated Beral-type pipets make it easy to add 1 mL without counting drops.
- One of the more surprising observations for students is the temperature decrease in the reaction of HCl with NaHCO₃. If the reaction is demonstrated prior to the experiment, students will almost always guess that the temperature should increase, given the vigorous fizzing and effervescence that takes place. Try this out beforehand—it may serve as a good unexpected or “discrepant” event to keep the students honest.

Teaching Tips

- This experiment is designed as a general introduction to the nature and kinds of chemical reactions. It integrates observation and measurement skills with new concepts of chemical properties and chemical change. Students practice critical thinking skills as they analyze the results and draw conclusions about patterns in chemical reactivity.
- To maintain the introductory nature of this student laboratory kit, the use of chemical equations has not been included. More advanced or honors chemistry students may be motivated to write chemical equations for the observed reactions. Balanced chemical equations for all of the reactions are provided in the Supplementary Material.

Answers to Pre-Lab Questions  (Student answers will vary.)

1. What does the term corrosive mean in referring to the safety hazard of hydrochloric acid?
   A corrosive liquid, such as hydrochloric acid, will cause skin burns and destroy body tissue.

2. Which of the following everyday processes represent chemical changes: a nail rusts, ice melts, wood burns, a banana ripens, and sugar dissolves in water?
   Chemical changes are observed when a nail rusts, wood burns, and a banana ripens.

3. Milk stored beyond its expiration date eventually turns sour. This is an example of a chemical change. What signs of chemical change are observed when milk sours?
   The following observations provide evidence for the nature of chemical change when milk sours: sour milk has a different smell and tastes sour, indicating the formation of a new substance with different physical properties. A precipitate is also observed as the milk “curdles.”
Teacher’s Notes continued

Sample Data *(Student data will vary.)*

Data Table A. Reactions of Hydrochloric Acid

<table>
<thead>
<tr>
<th>Reaction Well</th>
<th>Reagents</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HCl + NaOH</td>
<td>Initial HCl solution was clear and colorless and turned blue litmus paper pink. Temperature increased from 22 °C to 27-°C within 1 minute when NaOH was added. Final solution was clear (no solid) and did not change the color of blue litmus paper.</td>
</tr>
<tr>
<td>2</td>
<td>HCl + NaHCO₃</td>
<td>Solid NaHCO₃ dissolved upon being added to HCl. Mixture fizzed and bubbled and the temperature decreased from 22 °C to 19 °C. Subsequent additions of NaHCO₃ caused same general reaction, although amount of fizzing subsided. Final temperature was 15.-°C; bubbles were present at the bottom of the well.</td>
</tr>
<tr>
<td>3</td>
<td>HCl + AgNO₃</td>
<td>A cloudy white solid formed immediately upon addition of AgNO₃ to HCl. The temperature of the solution did not change.</td>
</tr>
<tr>
<td>4</td>
<td>HCl + Zn</td>
<td>The piece of zinc metal began to slowly disappear or disintegrate as bubbles of gas were formed and released from the surface of the metal. The temperature increased from 22 °C to 26 °C. Final appearance consisted of powdery black solid in a clear and colorless solution.</td>
</tr>
<tr>
<td>5</td>
<td>HCl + Al</td>
<td>No evidence of reaction observed after 1–2 minutes. Very slowly, over 5 minutes time, a few tiny bubbles were observed on the surface of the metal. No noticeable change in the appearance of the metal.</td>
</tr>
<tr>
<td>6</td>
<td>HCl + Mg</td>
<td>Vigorous reaction, lots of bubbling, small puffs of gas immediately evident. Temperature increased from 22 °C to 36 °C. The magnesium metal piece disappeared. Final solution clear and colorless, with a few bubbles remaining on the bottom of the well plate.</td>
</tr>
</tbody>
</table>
Data Table B. Reactions of Cupric Chloride

<table>
<thead>
<tr>
<th>Reaction Well</th>
<th>Reagents</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CuCl₂ + Al (shot)</td>
<td>Initial solution was pale blue in color; initial temperature 22 °C. Metal turned dark and became coated with reddish-brown powder that flaked off easily. Solution turned green. Dark solid settles on bottom of well. Temperature increased to 35 °C.</td>
</tr>
<tr>
<td>2</td>
<td>CuCl₂ + Al (foil)</td>
<td>Foil turned coppery brown within 1 minute, solution turned green, and a few bubbles were seen. Temperature increased to 35-36 °C within 3 minutes. Large amount of dark reddish-brown solid flaked off and settled. Final solution was pale gray.</td>
</tr>
<tr>
<td>3</td>
<td>CuCl₂ + Zn</td>
<td>Metal became coated with dark red, powdery solid that flaked off easily. Solution turned green. No temperature change.</td>
</tr>
<tr>
<td>4</td>
<td>CuCl₂ + NH₄OH</td>
<td>A precipitate formed quickly as NH₄ was added but redissolved instantly and the solution turned a deep, royal blue color. No temperature change. Final solution was royal blue, slightly cloudy.</td>
</tr>
<tr>
<td>5</td>
<td>CuCl₂ + Na₂CO₃</td>
<td>Finely divided turquoise precipitate formed immediately and settled on bottom of well plate. Solution above it was pale blue and cloudy. No temperature change.</td>
</tr>
<tr>
<td>6</td>
<td>CuCl₂ + AgNO₃</td>
<td>Chunky white precipitate formed immediately. Solution was milky blue. No temperature change.</td>
</tr>
</tbody>
</table>

Optional Demonstration Activity—Conservation of Mass

Initial mass of flask assembly \(115.78 \text{ g}\) (before mixing)

Final mass of flask assembly \(115.79 \text{ g}\) (after mixing)

Change in mass = | final mass - initial mass | = 0.01 g
Teacher’s Notes continued

Answers to Post-Lab Questions (Student answers will vary.)

1. Summarize the observations of chemical change in the reactions of \( \text{HCl} \) and \( \text{CuCl}_2 \), respectively. All reactions should be listed; some reactions may appear more than once.

<table>
<thead>
<tr>
<th>Signs of Change</th>
<th>Reactions of HCl</th>
<th>Reactions of CuCl(_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitate formation</td>
<td>AgNO(_3)</td>
<td>Na(_2)CO(_3) and AgNO(_3)</td>
</tr>
<tr>
<td>Gas bubbles</td>
<td>NaHCO(_3), Zn, and Mg</td>
<td>Al foil</td>
</tr>
<tr>
<td>Color change</td>
<td>Litmus paper</td>
<td>Al shot and Al foil, Zn, and NH(_3)</td>
</tr>
<tr>
<td>Temperature change</td>
<td>Increase with NaOH, Mg, and Zn; decrease with NaHCO(_3)</td>
<td>Al shot and Al foil</td>
</tr>
<tr>
<td>No observable change</td>
<td>Al</td>
<td>None</td>
</tr>
</tbody>
</table>

2. Compare and contrast the reactions of Al, Mg, and Zn with HCl.

*The reactions of HCl with Mg and Zn were qualitatively similar—bubbles were observed, temperature increased, metal began to disintegrate or dissolve. In all cases these changes were more rapid and more pronounced with Mg than with Zn. Al did not appear to react at all with HCl, although a trace of bubbles was observed after 5 min.*

3. Based on the observed reactions of HCl and CuCl\(_2\) with different metals, predict whether CuCl\(_2\) will react with Mg.

*In the case of HCl, the pattern of metal reactivity was Mg > Zn >> Al. Since both Zn and Al reacted with CuCl\(_2\), it is likely that Mg, being more reactive than Zn and Al, would react with CuCl\(_2\) as well.*

4. Compare the reactions of CuCl\(_2\) and HCl with AgNO\(_3\). Propose a hypothesis to account for the reaction product. Hint: What is the likely chemical formula for the product?

*Both HCl and CuCl\(_2\) reacted with AgNO\(_3\) immediately to form a white precipitate. Since the common “ingredient” in HCl and CuCl\(_2\) is the chlorine atom (or chloride ion), and metals are known to combine with nonmetals, one possible hypothesis is that a common insoluble product, AgCl, is formed.*

5. Compare the reactions of CuCl\(_2\) with Al shot and Al foil. Discuss some possible reasons for any differences in the reaction of the two forms of aluminum.

*The reactions of CuCl\(_2\) with Al shot and Al foil were qualitatively similar; although the changes were more rapid and more pronounced with Al foil than with Al shot. The metal foil provides a greater surface area to react with the solution and is much thinner, so reaction occurs more rapidly.*

6. *(Optional)* Discuss the results of the conservation of mass in demonstration. Does the law of conservation of mass apply to chemical reactions?

*The difference in mass before and after reaction was very small, 0.01 g. This difference is identical to the precision of the balance, which is ±0.01 g, and is thus likely due to experimental error. Mass is conserved in the chemical reaction.*
Teacher’s Notes continued

Supplementary Material

Reactions of HCl
1. \( \text{HCl(aq)} + \text{NaOH(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)} \)
2. \( \text{HCl(aq)} + \text{NaHCO}_3(s) \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2(g) \)
3. \( \text{HCl(aq)} + \text{AgNO}_3(aq) \rightarrow \text{AgCl(s)} + \text{HNO}_3(aq) \)
4. \( 2\text{HCl(aq)} + \text{Zn(s)} \rightarrow \text{ZnCl}_2(aq) + \text{H}_2(g) \)
5. \( \text{HCl(aq)} + \text{Al(s)} \rightarrow \text{no reaction} \)
6. \( 2\text{HCl(aq)} + \text{Mg(s)} \rightarrow \text{MgCl}_2(aq) + \text{H}_2(g) \)

Reactions of CuCl₂
1. \( 3\text{CuCl}_2(aq) + 2\text{Al(s)} \rightarrow 2\text{AlCl}_3(aq) + 3\text{Cu(s)} \)
2. Same as above
3. \( \text{CuCl}_2(aq) + \text{Zn(s)} \rightarrow \text{ZnCl}_2(aq) + \text{Cu(s)} \)
4. \( \text{CuCl}_2(aq) + 4\text{NH}_3(aq) \rightarrow \text{Cu(NH}_3)_4^{2+}(aq) + 2\text{Cl}^-(aq) \)
5. \( \text{CuCl}_2(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow 2\text{NaCl(aq)} + \text{CuCO}_3(s) \)
6. \( \text{CuCl}_2(aq) + 2\text{AgNO}_3(aq) \rightarrow \text{Cu(NO}_3)_2(aq) + 2\text{AgCl(s)} \)

What Is a Chemical Reaction?—Student Laboratory Kit is available from Flinn Scientific, Inc.

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APS269</td>
<td>What is a Chemical Reaction?—Student Laboratory Kit</td>
</tr>
</tbody>
</table>