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| Chemistry | Mr. Rodrigo |
| Name |  |
| Date and Period  |  |

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| **Experiment 2** | Single replacement reaction |

Watch aluminum foil disappear as it’s added to a green-blue solution of copper (II) chloride. Observe color changes, production of a gas, formation of solid metallic copper, and a drastic change in temperature.

Aluminum foil is added to an aqueous solution of copper (II) chloride causing a single replacement oxidation– reduction reaction to take place.

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| 2Al(s) + 3CuCl2(aq) | → | 2AlCl3(aq) + 3Cu(s) |
|  *silver green-blue* |  | *colorless reddish* |

The oxidation of aluminum metal to aluminum (III) (Al0 to Al3+), which is visible by the dissolving of the aluminum foil to form aluminum chloride, is represented by the oxidation half-reaction below. The simultaneous reduction of copper (II) ions to copper metal (Cu2+ to Cu0) will occur and solid copper metal precipitates from solution according to the reduction half-reaction below. As the copper (II) ions are reduced to copper, the green-blue solution color will fade until the solution is completely color- less—the indication that the reaction is complete and all of the copper (II) ions have been reduced.

 Al(s) → Al3+ (aq) + 3e– Oxidation Half-Reaction

 Cu2+(aq) + 2e– → Cu(s) Reduction Half-Reaction 2Al(s) + 3Cu2+(aq) → 2Al3+(aq) + 3Cu(s) Overall Balanced Equation

It can be observed that hydrogen gas is simultaneously released from the reaction when aluminum metal foil is added to copper (II) chloride solution. If the pH of the copper (II) chloride solution is measured, it is found to be slightly acidic. Hence there are free hydrogen ions in solution, which cause the side reaction of hydrogen ions with the aluminum surface to form hydrogen gas and aluminum ions. Due to the limited concentration of hydrogen ions, this reaction only consumes a small amount of the aluminum.

2Al(s) + 6 H+(aq) → 2Al3+(aq) + 3H2(g)

## Materials

Graduated cylinder, 250-mL

Spatula stirring rod

Thermometer

Beakers, 600-mL, 3

Aluminum foil, 6" x 12", 2 pieces

Copper (II) chloride solution ( CuCl2 ), 1.0 M

Water, distilled or deionized

pH paper (optional)

## Safety Precautions

**Copper (II) chloride solution is toxic by ingestion**. Small volumes of hydrogen gas are produced from the reaction. Hydrogen is a highly flammable gas; keep flammable materials away from the reaction mixture. **Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron**. Please review Material Safety Data Sheet for further safety information. This activity requires the use of hazardous components and/or has the potential for hazardous reactions. Please review the Safety Precautions section and relevant Material Safety Data Sheets before beginning this activity.

## Procedure

1. **Put on safety goggles, apron, and gloves; ensure that all hair is tied back; and remove loose jewelry. Follow all safety guidelines.**
2. Obtain a 600-mL beaker.
3. Use a graduated cylinder to measure 140 mL of 1.0 M CuCl2 solution. Pour this into the beaker.
4. Measure and add 140 mL of distilled or deionized water to the beaker. The solution is now 0.5 M CuCl2. (Optional: measure the pH by using pH paper or pH meter)
5. Cut a piece of aluminum foil approximately 15 cmX 30 cm. Loosely crumple the foil enough to fit into the beaker. Place it to the side.
6. Measure the temperature of the solution before adding the foil. Record it on the data table.
7. Place the piece of crumpled foil into the beaker, using a stirring rod to push it down completely into the solution. Measure the temperature of the reaction mixture and record the information in your data table.
8. Measure the temperature every 60 seconds until the temperature has stabilized or the reaction has gone to completion. (Optional: measure the pH by using pH paper or pH meter at the end of the reaction)
9. Graph the information on the provided sheet.

**Calculations**

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| **Time (s)** | **Temperature (°C)** | **pH (optional)** |
| Before addition of Al |  |  |
| 0 |  |  |
| 60 |  |  |
| 120 |  |  |
| 180 |  |  |
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| **Time (s)** | **Temperature (°C)** | **pH (optional)** |
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