**A Green(er) Redox Reaction**

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

*Created by 2010 summer workshop participants: Lisa G. Borgatti, Carol Mutchler, Tracy*

**Teacher Background Information:**

This lab replaces the traditional quantitative oxidation-reduction (redox) reaction between copper solid and aqueous silver nitrate. Typically, this lab is done at the end of a large unit covering types of reactions and stoichiometry. This exercise will be used to show a redox reaction between solid magnesium metal and an aqueous solution of zinc chloride. The students will calculate the theoretical yield and using that information calculate the percent yield.

**Safety Information:**

Zinc chloride has serious health warnings. If it comes into contact with the skin it needs to be washed with soap and water for several minutes. If it comes into contact with the eyes wash for 15 minutes in the eyewash and seek immediate medical attention. Gloves should be used when handling zinc chloride.

**Educational Goals:** Students will understand…

* The process of oxidation-reduction.
* How to carry out calculations involving stoichiometry to find the theoretical yield of a product.
* Using actual data to calculate percent yield.

**Student Objectives:** Students will…

* Look at an oxidation-reduction reaction in a single displacement reaction
* Calculate theoretical results through stoichiometry and calculate percent yield.
* Compare the toxicity data between the copper/magnesium chloride reaction and the more traditional example of copper and silver nitrate.
* Practice lab safety

**Materials: (per lab group of 2 students)**

* 125mL of 0.15M solution of zinc chloride (ZnCl2)
* 0.15g of magnesium ribbon (Mg)
* DiH2O
* Electronic balance
* 250-ml beaker
* Glass stir rod
* Forceps
* Filter (vacuum filtration recommended)
* Filter paper
* 250 ml Erlenmeyer flask

**Time Required:** 2 class periods (90 minutes) + drying time

**NGSS Standards Met:**

* **HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties
* **HS-PS1-12.** Use evidence to illustrate that some chemical reactions involve the transfer of electrons as an energy conversion occurs within a system.

**Key Terms:** green chemistry principles, oxidation-reduction reactions, chemical equations, stoichiometry, chemical reactions

**Teacher Prep:**

Teacher should prepare enough solution to provide students with 125mL 0.15M solution of zinc chloride (ZnCl2 FW=136.29 g/mol) per group

**Keys for Success**:

The magnesium is losing electrons and therefore being oxidized and the zinc ions in solution are gaining electrons therefore being reduced. In this reaction, one point the teacher could make is that zinc ions are present in the water but cannot be seen because they are in the ionic state, and when they receive electrons from the Magnesium, the zinc now becomes an atom and can be seen in its solid state. Additionally: include any suggested links for videos/background reading for students.

**Student Prerequisites:**

Students should have studied writing chemical equations, stoichiometry, chemical reactions and oxidation-reduction reactions.

**Disposal Information:** The MgCl2(aq) formed may be disposed of down the drain.

**Greener Redox Student Lab**

**Introduction:**

The magnesium is losing electrons and therefore being oxidized and the zinc ions in solution are gaining electrons therefore being reduced. In this reaction, zinc ions are present in the water but cannot be seen because they are in the ionic state, and when they receive electrons from the Magnesium, the zinc now becomes an atom and can be seen in its solid state.

**Materials:** (per lab group)

* 125mL of 0.15M solution of zinc chloride (ZnCl2)
* 0.15g of magnesium ribbon (Mg)
* DiH2O
* Electronic balance
* 250-ml beaker
* Glass stir rod
* Forceps
* Filter (vacuum filtration recommended)
* Filter paper
* 250 ml Erlenmeyer flask

**Procedure:**

1. Obtain 0.15g magnesium metal and polish with steel wool until shiny.
2. Measure 125mL of 0.15M ZnCl2 into a beaker.
3. Place Mg strip into beaker and allow to react for 20 minutes. During this time, you should be stirring every 2 minutes.
4. After 20 minutes remove the Mg strip and wash any solid off into the beaker.
5. Set the Mg aside to dry.
6. Set up the funnel system and pour the contents of the beaker through the filter. Using a wash bottle, wash the remaining contents of the beaker into the filter. When the filtering is complete, set the filter paper aside to dry overnight.
7. Find the mass of the Mg strip.
8. The next day, find the final mass of the filter paper.

**Data:**

|  |  |
| --- | --- |
| Object | Mass (g) |
| Mass of Mg strip start |  |
| Mass of Mg strip finish |  |
| Mass of Mg reacted |  |
| Mass of filter paper |  |
| Mass of filter paper + zinc |  |
| Mass of solid zinc formed |  |

**Follow-up Questions:**

1. Write a balanced equation for this reaction.
2. Which reactant was the limiting reactant?
3. What was the percent yield of your experiment? (Show your work)
4. What reactant was oxidized in this reaction? What reactant was reduced?
5. Explain the redox reaction that occurred in this experiment.
6. This experimental concept used to be shown using copper wire and a silver nitrate solution, explain why this reaction is a greener reaction.
7. List sources of error in this experiment.
8. Theoretically, what mass of zinc should have been produced (in grams)? (Show your work)

**Teacher’s Guide to Questions**

1. **Write a balanced equation for this reaction.**

Mg (s) + ZnCl2 (aq) 🡪 Zn (s) + MgCl2 (aq)

1. **Which reactant was the limiting reactant?**

Magnesium

1. **Theoretically, what mass of zinc should have been produced (in grams)? (Show your work)**

0.15g Mg x 1 mol Mg x 1 mol Zn x 65.41g Zn = 0.41g Zn

24.21g Mg 1 mol Mg 1 mol Zn

\*(if exactly 0.15g of Mg were used)

1. **What was the percent yield of your experiment? (Show your work)**

Percent Yield = \_\_Actual Mass Product \_\_

Theoretical Mass Product

Theoretical Yield = 0.41g Zn \*(if exactly 0.15g of Mg were used)

1. **What reactant was oxidized in this reaction? What reactant was reduced?**

Magnesium was oxidized. Zinc was reduced.

1. **Explain the redox reaction that occurred in this experiment.**

Solid magnesium metal was added to aqueous zinc chloride. The zinc has a higher electronegativity than the magnesium and therefore attracts two electrons from magnesium, which gives magnesium a positive charge. The magnesium acts as a reducing agent to reduce the zinc and the zinc is reduced, and in turn oxidizes the magnesium.

1. **This experimental concept used to be shown using copper wire and a silver nitrate solution, explain why this reaction is a greener reaction.**

Silver and copper are heavy metals, which are very toxic to both humans and the environment. Silver exposure can have serious health risks, including death. While zinc is also a heavy metal is it much less toxic to life forms.

1. **List sources of error in this experiment.**

Answers may vary