Investigating Electrolysis

Overview

In this activity, students will participate in a hands-on lab to help them visualize and understand the process of extracting copper from ore.

Topic: **Chemical Reactions**

Real World Science Topics

- Chemical Reactions
- Separation of Mixtures
- Mining

Objective

Students will be able to explain how copper is purified by electrolysis.

NGSS Three-Dimensions

MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms	**PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are re-grouped into different molecules, and these new substances have different properties from those of the reactants	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

Background Information

How is copper extracted?

There are three steps to extraction: Mining, Extraction, and Purification. Copper ore is first mined, or dug, from the ground. Then, the ore is contacted with a weak acid solution to dissolve the copper mineral and extract it from the rock. Finally, this solution containing copper is purified by electrolysis.

How is electrolysis used in mining?

Electrolysis uses a direct electric current to create a chemical reaction. This process is used to produce pure copper metal in the final stage of copper extraction from ores after being removed from the ground.

Key Vocabulary

Copper – Chemical element that is a ductile metal with very high thermal and electrical conductivity
Mining – A method to extract minerals or other geological materials from Earth
Electrolysis – Uses a direct electric current to cause a chemical reaction

Materials

- Safety equipment:
  - Latex/nitrile gloves
  - Safety goggles/glasses
- Images (below)
- *Investigating Electrolysis Procedure* handout
- Iron nail
- Copper strip
- Electrolytic solution – Copper Sulfate or any Copper salt solution
- 9V battery
- 250 mL beaker
- Insulated wire leads with alligator clips at both ends
- Uninsulated copper wire
- Popsicle stick (to suspend)

Safety Reminders:

- Students will be working with copper sulfate (or another copper salt solution). The solution will be acidic. Be sure to adhere to the following guidelines for safety:
  - Wear safety gloves and safety goggles to protect hands and eyes.
  - Tie back long hair.
  - Wear close-toed shoes.
  - Be sure to neutralize acidic solutions before disposal. Follow all recommended safety guide lines for disposing of chemical solutions after completing labs.

Note for the Teacher:

Most of the materials for this lab are available from local stores. Reagents may be purchased at a low cost from a supplier, such as Carolina Biological or Flinn Scientific.

Procedure

1. **Warm-Up Activity:** Share the images of mined minerals from Earth. Ask the students the following questions:
   - Do you think they are valuable?
   - What is each mineral in the picture?
   - Do you think the minerals can be changed to look different?
   - Reveal that they are images of copper, diamond, and gold. Ask students to match each manufactured mineral with its original mined form.

2. Clarify with students that minerals we mine from Earth are typically not ready to be used right away. Diamonds need to be cut and polished, gold is mixed with other metals to make it stronger, and copper is purified from ore.

3. Explain to students that they will be modeling one step of the copper mining process. When copper is extracted from ore, there are impurities that need to be removed. Copper is purified using electrolysis. A direct electric current creates a chemical reaction. During this process, the impurities are separated from the copper. Copper can also be plated onto other metals using electrolysis.

4. Assign students in to groups of three. Distribute lab procedure for students to review.

5. Ask students to underline equipment that will be used, box any times, and circle measurements needed.

6. Direct students' attention to Steps 4 and 5 of the lab procedure. Remind students that the purpose of this lab is to help them visualize and build understanding of a process for extracting copper from ore. Explain that there is a reason they are attaching the cable to the positive end of the battery rather than the negative end. The battery represents the rectifier (an electrical device that converts an alternating current into a direct current) and the steel is the anode. The copper plates to the steel nail because of the oxidation-reduction (redox) reaction occurring at the surface of the nail.

7. Guide students to begin their investigation using the provided protocol. Ask students to write down their observations as the reaction continues. *Note: Students should observe pieces of the copper separating from the strip and coating the nail.*

8. Evaluate: Two Truths and a Lie

Provide the three statements bulleted below and ask students to first identify which is incorrect, and then correct that statement.

- Electrolysis uses a direct electric current to create a chemical reaction
- Minerals always come from Earth is forms we immediately recognize
- Copper can be plated onto other materials

Then, ask students to use all three statements to write a summary of their lab investigation.

Extension Activity

Electrolysis can create completely new substances such as chlorine, aluminum, magnesium and calcium. Ask students to research how these substances are used in everyday life.

Additional Resources

http://mineralsciences.si.edu/
http://science.nasa.gov/science-news/science-at-nasa/2000/ast13nov_1/

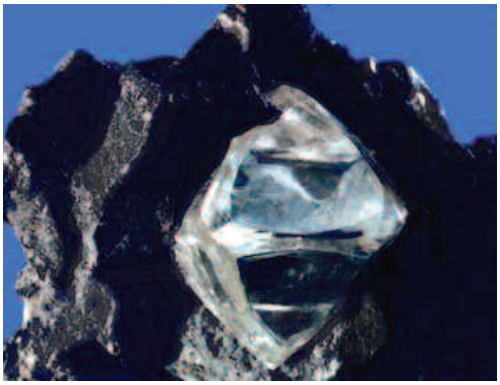
Images

Source:
https://en.wikipedia.org/wiki/Burra_Burra_Mine_(Tennessee)

Source:
https://upload.wikimedia.org/wikipedia/commons/0/06/Native_Copper_Macro_Digon3.jpg

Source:
https://upload.wikimedia.org/wikipedia/commons/e/e8/Gold_in_iron_oxide_(Highland_Mining_District,_Silver_Bow_County,_Montana,_USA)_(17157398426).jpg

Source:
https://upload.wikimedia.org/wikipedia/commons/3/32/Gold-269609.jpg



Source:
https://upload.wikimedia.org/wikipedia/commons/d/d7/Rough_diamond.jpg

Source:
https://upload.wikimedia.org/wikipedia/commons/f/f2/Diamonds.jpg

Investigating Electrolysis Procedure

Objective

Students will be able to explain how copper is purified by electrolysis.

Materials

- Safety equipment:
  - Latex/nitrile gloves
  - Safety goggles/glasses
- Iron nail
- Copper strip
- Electrolytic solution – Copper Sulfate or any Copper salt solution
- 9V battery
- 250 mL beaker
- Insulated wire leads with alligator clips at both ends
- Uninsulated copper wire
- Popsicle stick (to suspend)

Safety Reminder:
You will be working with copper sulfate (or another copper salt solution). The solution will be acidic. Be sure to wear proper equipment to protect your hands and eyes.

Procedure

1. Clean off the nail by polishing with some steel wool. Mass the nail using an electronic balance.
2. Stir copper sulfate in warm water until no more will dissolve.
3. Suspend the nail into an empty beaker using the uninsulated copper wire.
4. Attach one end of the black alligator clip to the copper wire supporting the nail and the other end to the negative end of the battery.
5. Place the copper strip into the empty beaker. Attach one end of the red alligator clip to the copper strip and attach the other end to the positive end of the battery.
6. Pour the copper sulfate solution into the beaker until the entire nail is submerged. Make sure it does not touch the copper strip.
7. Let it stand for 10-15 minutes and watch the set-up carefully. Record what you observe.

8. Record observations of the nail after the reaction. What do you notice about the size, color, and shape of the nail? What does the fluid around the nail look like?

9. Remove the nail from the beaker and carefully pat it dry with a paper towel.
10. Place the nail into a pre-weighed beaker. Then record the final mass of the nail.

Post-Lab Questions

1. Did a chemical reaction occur? Provide evidence to justify your answer.

2. What do you think was deposited on the nail? Provide evidence to justify your answer.

3. Why do you think an electric current was used?

4. Describe a real world application in which an industry would want to coat a surface with a metal. How could this reduce the cost of a luxury item?

5. During photosynthesis, plants, algae, cyanobacteria, and phytoplankton split water molecules. If the human-developed process of electrolysis can also split water molecules to produce oxygen and hydrogen, where on Earth and in our solar system could this be helpful?

6. Permanent hair removal is a cosmetic procedure that is becoming more common. One type of procedure involves inserting a tiny needle into an individual hair follicle. The needle vibrates, shaking water molecules and heating them up to destroy the hair follicle. How is that an example of electrolysis?

Source: Modified from http://www.omsi.edu/sites/all/FTP/files/chemistry/U5Electroplating_OpGuide.pdf