Instructor Notes

The Crandon Mine Controversy: Overview

In 1975, the Exxon Corporation discovered one of the largest zinc-copper sulfide deposits in North America near Crandon, WI. Exxon submitted numerous applications throughout the 1970s and 1980s for mining permits, but withdrew all of them because of strong regional opposition and falling mineral prices. In 1994, the Crandon Mining Company (a joint venture of Exxon and Canadian Rio Algom Limited) was formed, and it filed several documents with the Wisconsin Department of Natural Resources (WDNR) to extract 55 million tons of zinc-copper sulfide ore from the Crandon mining site. However, a moratorium was placed on the project, halting any further mine activity until the company could prove that other such operations had been successful in minimizing environmental damage. Rio Algom recently purchased Exxon's interest in the project and assigned the Crandon project to one of its subsidiaries, the Nicolet Minerals Company. Nicolet Minerals is currently in the process of attempting to prove that the proposed mining project at Crandon is environmentally sound.

The intent of this project is to examine the issue of whether or not mining should be allowed at Crandon and what the long-term effects of mining would be on both the environment and on area residents. Because the mine's goal is to obtain copper and zinc, the nature of these metals will be examined in terms of their chemical and physical properties, their common uses by humans, and their importance in the physiology of the human body.

The activity is written for workshop participants and may need modification for classroom use.

Suggested Background Readings

- An Introduction to Toxicology
- Principles of Environmental Site Assessment
- A Scientific View of Risk

National Science Education Standards for Grades 5–12

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry
  Conduct scientific investigations. Students dilute a stock copper sulfate solution down to 1 part per million (ppm) and 1 part per billion (ppb) to demonstrate how small these quantities are and how difficult it can be to identify these small amounts. Students perform a second investigation with U.S. pennies to learn about the chemistry of copper and zinc metals.

Use technology and mathematics to improve investigations. Students determine the number of grams of copper(II) in various solutions and the estimated percentages of copper and zinc in pre- and post-1982 pennies.

Recognize and analyze alternative explanations and models. Students analyze the Crandon mine scenario in terms of possible environmental effects and determine risks and benefits of the project by reviewing current scientific understanding, weighing the evidence, and examining the logic.

Communicate and defend a scientific argument. During a mock public hearing, students research a viewpoint and play a role of someone involved in the Crandon mine controversy. Students need to construct a reasoned argument, speak clearly and logically, and respond appropriately to critical comments.

Physical Science

- Chemical Reactions
  A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. Students learn the nature of chemical reactions during an investigation demonstrating that zinc reacts with hydrochloric acid to produce hydrogen gas.

Science in Personal and Social Perspectives

- Risks and Benefits
  Important personal and social decisions are made based on perception of benefits and risks. Students use techniques associated with risk/benefit analysis during a mock public hearing on the Crandon mine.

- Natural Resources
  Human populations use resources in the environment in order to maintain and improve their existence. Students discuss the use of metals like copper and zinc in our society and learn that our use of these natural resources affects both society and the environment.

- Environmental Quality
  Many factors influence environmental quality. Students learn that environmental quality is influenced by population growth and distribution, resource use, overconsumption, economics, and political viewpoints.

- Natural and Human-Induced Hazards
  Natural and human-induced hazards present the need for humans to assess potential danger and risks. While researching the Crandon mine controversy, students learn that many changes in the environment designed by humans bring benefits to society as well as cause risks to society. Humans need to assess potential risk and gain an understanding of the costs and trade-offs associated with these endeavors.

- Science and Technology in Local, National, and Global Challenges
  Individuals and society must decide on proposals involving the introduction of new technologies into society. Students understand the appropriateness and value of asking certain basic questions about establishing the Crandon mine: "What can happen?", "What are the odds?", and "How do scientists and engineers know what will happen?"

Safety

As the instructor, you are expected to provide participants with the necessary safety equipment (including personal protective equipment such as goggles, gloves, aprons, etc.) and appropriate safety instruction to allow them to work safely in the laboratory. Always follow local, state, and school policies. Read and follow all precautions on labels and MSDSs provided by the manufacturer for all chemicals used.

Procedure Notes and Outcomes

Participants are directed to some readings on the web. Participants should do most of the research on their own. The Internet is an incredible source of information, but one also needs to judge the quality of the information carefully. Evaluating information in terms of its source is part of the learning process.

One interesting aspect of this project is that it is ongoing. It involves a real-life situation of a type that could occur in almost any community. The controversy involves copper and zinc, resources that we all use.

The project begins with a map activity in which participants form groups and analyze the proposed mine area in terms of geological, geographical, and environmental features. Consideration will also be given to the effects on people of the area. The maps used include Wisconsin road maps, topographic maps, and maps from several online sources.

After a discussion about the groups of people who are affected by this controversy, participants are assigned roles for a mock public hearing to be held at the end of the project. Participants must then gather information to support their positions in the debate.

While the participants are gathering information about all aspects of the mining dilemma, class time will be spent examining the nature of copper and zinc. In an introductory exercise, participants list familiar uses for copper and zinc. Next participants are given pieces of copper and zinc and asked to describe the similarities and differences between the two metals. Participants also investigate pennies made before and after 1982, scoring the sides of each penny several times and putting them in dilute hydrochloric acid solution to watch their reactions.

The next class period introduces the importance of copper and zinc in the animal diet, including the basic physiology involved. Copper is part of enzymes that are used for the formation of hemoglobin, blood vessels, bones, and the myelin sheath. Copper is also essential for normal liver function and the synthesis of DNA. Requirements are approximately 1.5 mg for men and 1.2 mg for women per day. Participants are assigned some simple readings about the toxicology of copper and zinc compounds. At this point a relationship could be made between the idea of toxicology of these metal ions and the concept of measurements in parts per million (ppm) and parts per billion (ppb).

Next, participants conduct a lab dealing with the concepts of ppm and ppb. Participants are given a 10% solution of copper sulfate which has a copper ion concentration of 1 part in 10 parts of solution. They are asked to perform serial dilutions of the solution until reaching copper ion concentrations of 1/1,000,000 and 1/1,000,000,000. The participants use several methods to determine the point at which copper ions can no longer be detected in the solution.

During the course of this project, participants are assigned a variety of related readings having to do with mining, environmental controls and environmental justice, the chemistry and physiology of copper and zinc and their compounds, the economics of metals, and risk assessment.

The final role-playing activity is a mock public hearing in which representatives from all the concerned parties have the opportunity to speak. The end result will be a decision as to whether or not the mining permit should be granted.

Through this project, participants not only examine the controversy but also gain a basic understanding of the importance of copper and zinc to their daily lives. This project could be enlarged or reduced depending upon the type of class in which it is used, as well as the length of time available to study the problem. Teachers in areas outside of Wisconsin can tailor this project by using a scenario that is closer to home. Many parts of this project could easily fit other environmental health situations.

Extensions

If this activity were used in a chemistry class, many other activities could be added. Examples might include the nature of batteries; the nature of copper and zinc sulfides; the chemistry, including reactions, involved in sulfide mining and refining; and the nature of alloys.

A biology class might look more closely at the physiological and environmental effects of these metals.

Instructor Notes for Activity 1

The purpose of this activity is for participants to analyze a scenario in terms of possible environmental effects. Although they probably have minimal knowledge of the scope of the situation, they should be able to hypothesize potential effects on air, water, land use, and people. This initial brainstorming leads to a more in-depth look at risk/benefit analysis. Participants should decide what information they need to know. It might be of interest to take a vote in your class as to whether each participant would favor or be opposed to a mine given only the minimal information in the introduction. This would allow you to judge the impact of the various activities and research on the overall outcome of the permit hearing. It might even be interesting to take a school-wide vote by setting up a table in the lunchroom area.

Participants will learn how to analyze an environmental situation, to read and analyze different types of maps, and to begin the process of risk/benefit analysis.

Materials

Per class

- Wisconsin road map
- Wisconsin topographic maps of the Crandon area
  Topographic maps of the area are available from the Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, WI 53705-5100; 608/263-7389, or fax 608/262-8086.
- general Internet maps

Procedure Notes and Outcomes

Have participants brainstorm within their groups and answer questions 1–5 in the Activity Instructions: Activity 1. It would be a good idea to circulate among the groups to help them get started. The questions are very broad, and participants may have a hard time at first. When they have finished brainstorming, have each group read "Environmental Impact Report" at *http://www.crandonmine.com/eimaina.html*. Then have the participants discuss within their groups the last two questions on the handout. As an assignment for the next class, have each participant read "Project Issues" at *http://www.epa.gov/region5/crandon/issues/htm*.

Plausible Answers to Questions

1. What questions about copper and zinc sulfide mining in general, or the proposed Crandon mine in particular, might you want to ask?
   A simple but important question might be "What chemicals does this mining process use?" A few other possible questions might be "How big is the proposed mine? Is this an open pit or underground mining procedure? Is water used in the process? Where

does the waste water go? Where do the waste products from the mine go? How long will the mine operate? What will happen to the land after the mine closes? Who will work in the mine? How safe will it be to work in the mine?"

2. After looking at the maps of the region, what additional questions do you have about the Crandon area?
   Some possible questions would include "Where will the wastewater and chemicals go? What is the economic nature of the area? Is there any other major industry in the area? What are the major land uses at the present time? What is the general population of the area?"

3. Based on the maps of the region, what specific features of the region might be impacted by the proposed mining operation?
   Some features of the region include rivers, streams, and lakes close to the mining site; cities such as Crandon; and Mole Lake National Forest Lands, which would all be impacted by the proposed mining operation.

4. Based on the maps, consider what group(s) of people might be positively or negatively impacted by the mine. Who might be opposed to the mining operation?
   Some of the people impacted might be residents of Crandon; residents of Wisconsin, including resort owners and Native Americans in several adjacent communities; and people who hunt and fish. Participants may have differing opinions on who stands to benefit and who would be opposed to the operation.

5. List as many positive things as you can that might result from the mining operation. Then list as many negative things as you can.
   A few positives might be job opportunities, increased trade for area businesses, tax money for the community, and increased availability of copper and zinc. Negatives might include water pollution, noise pollution, and depletion of natural resources. A possible question might be "What happens when the mine closes?"

6. What questions were answered by the Environmental Impact Report?
   Answers will vary.

7. What new questions do you now have?
   Answers will vary.

Activity Instructions: Activity 1

The Crandon Mine Controversy

In 1975, the Exxon Corporation discovered one of the largest zinc-copper sulfide deposits in North America near Crandon, WI. Exxon submitted numerous applications throughout the 1970s and 1980s for mining permits, but withdrew all of them because of strong regional opposition and falling mineral prices. In 1994, the Crandon Mining Company (a joint venture of Exxon and Canadian Rio Algom Limited) was formed, and it filed several documents with the Wisconsin Department of Natural Resources (WDNR) to extract 55 million tons of zinc-copper sulfide ore from the Crandon mining site. However, a moratorium was placed on the project, halting any further mine activity until the company could prove that other such operations had been successful in minimizing environmental damage. Rio Algom recently purchased Exxon's interest in the project and assigned the Crandon project to one of its subsidiaries, the Nicolet Minerals Company. In this project you will be examining the environmental health issues involved with whether or not to allow Nicolet Minerals to begin mining.

Procedure

Study the maps and reading material provided by the instructor. Within your group, discuss questions 1–5. After reading the Crandon Mine Environmental Impact Report, discuss questions 6 and 7.

Questions

1. What questions about copper and zinc sulfide mining in general, or the proposed Crandon mine in particular, might you want to ask?
2. After looking at the maps of the region, what additional questions do you have about the Crandon area?
3. Based on the maps of the region, what specific features of the region might be impacted by the proposed mining operation?
4. Based on the maps, consider what group(s) of people might be positively or negatively impacted by the mine. Who might be opposed to the mining operation?
5. List as many positive things as you can that might result from the mining operation. Then list as many negative things as you can.
6. What questions were answered by the Environmental Impact Report?
7. What new questions do you now have?

Instructor Notes for Activity 2

The objective of this exercise is to have participants gain an understanding of the terms "parts per million" and "parts per billion" and the process of serial dilution and realize that small quantities may still represent large numbers of molecules.

Safety

As the instructor, you are expected to provide participants with the necessary safety equipment (including personal protective equipment such as goggles, gloves, aprons, etc.) and appropriate safety instruction to allow them to work safely in the laboratory. Always follow local, state, and school policies. Read and follow all precautions on labels and MSDSs provided by the manufacturer for all chemicals used.

Copper(II) sulfate pentahydrate ($CuSO_4$•$5H_2O$) is a strong irritant to the skin and mucous membranes. To avoid inhaling its dust, use copper(II) sulfate only where there is adequate ventilation. It can be harmful or fatal if taken internally; caution should be used in handling it. If contact with the skin occurs, flush with running water. Wash your hands after use. Follow local ordinances for disposal of copper(II) salts. It is recommended that unused copper(II) sulfate solution be left to evaporate to dryness.

Ammonia (NH_3), both in solution and in the vapor phase, can damage the eyes, so eye protection is required. Contact lenses should not be worn when working with NH_3-containing products, as gaseous vapors of NH_3 may condense on the contact lens and cause damage to the eye. Use NH_3 only in a well-ventilated area. Keep the container closed when not in immediate use. Should contact with the eyes occur, rinse the affected area with water for 15 minutes. Seek medical attention while rinsing is occurring. Dilution of concentrated NH_3 solutions must be carried out in a fume hood or other well-ventilated area. The NH_3 solution can be tightly capped and stored for future use. Discard the NH_3 solution by pouring it down the drain with large amounts of water.

Materials

Per person

- 24-well cell plate
- 2 Beral pipets or droppers
- copper sulfate solution that provides 1 g Cu^{2+}/100 g solution
  Dissolve 4 g copper(II) sulfate pentahydrate ($CuSO_4$•$5H_2O$) in distilled water and bring the volume to 100 mL.
- 10 mL concentrated ammonia (NH_3)
- 2 stirring rods
- (optional) LaMotte's copper reagent
  One bottle will be enough for a group of 30 people.

Procedure Notes and Outcomes

LaMotte's copper reagent (catalog #NC 9713524) is available in a 15-mL bottle from Fisher Scientific; 800/766-7000 (phone) or 800/926-1166 (fax).

Plausible Answers to Questions

1. Which well was the last one to show color in step 6? What was its concentration?
   Usually well 2. Its concentration was 1 part per 1,000.
2. Which well was the last one to show color in step 8? What was the concentration in this well?
   Usually well 3 (1 part per 10,000), possibly well 4 (1 part per 100,000).
3. Suggest a possible way of determining the copper(II) concentration in wells that don't show color to the naked eye.
   Testing with other chemicals, using test kits with colorimeters.
4. Obviously, copper(II) is still present in the wells that don't show color. Why might the copper(II) still be dangerous even though we can't detect it with the eye?
   The body requires only small amounts of Cu^{2+} on a daily basis—approximately 0.4 mg/day (children) and 1.2 mg/day (adults), which we usually get through our diet. Additional amounts, even though they might seem small, could be detrimental.
5. The stock solution you were given to work with contained 1 g copper(II) ion in 100 g solution, and 20 drops of solution weigh 1 g. Use this information to determine the following:
   a. How many grams of copper(II) were in the first well?
      0.01 g Cu^{2+}
   b. How many grams of copper(II) were in the well marked 1/1,000,000 (1 ppm)?
      1×10^{-6} g Cu^{2+}
   c. How many grams of copper(II) were in the well marked 1/1,000,000,000 (1 ppb)?
      1×10^{-9} g Cu^{2+}
   d. If 1 g copper(II) solution contains 9.5×10^{21} copper(II) ions, how many ions of copper are in the well marked 1/1,000,000,000?

$$\left(\frac{9.5 \times 10^{21}\ Cu^{2+} ions}{g\ Cu^{2+}} \times \frac{1 \times 10^{-9}\ g\ Cu^{2+}}{g\ solution} \right) = 9.5 \times 10^{12}\ Cu^{2+} ions\ per\ g\ solution$$

Extra Credit

1. Look in your readings and find the allowable concentration for copper ion in Wisconsin water. If you drank 500 g tap water containing that concentration of copper(II) ion, how many ions of copper(II) would you be putting into your body?
   If you drank 500 g tap water that contained Wisconsin's maximum allowable concentration of copper ion (42 ppb), you would be consuming approximately 2×10^{17} *ions of* Cu^{2+}.

$$\left(500\ g\ tap\ water \times \frac{42\ g\ Cu^{2+}}{1 \times 10^{9}\ g\ tap\ water} \times \frac{9.5 \times 10^{21}\ ions\ Cu^{2+}}{1\ g\ Cu^{2+}}\right) \approx 2.0 \times 10^{17}\ ions\ Cu^{2+}$$

2. Find the minimum daily requirement for copper(II) in the human body. How many glasses of water containing the maximum allowable level (42 ppb) would you have to drink to exceed the daily requirement?
   The minimum daily requirement for children is 0.4 mg/day and for adults is 1.2 mg/day. You would have to drink approximately 60 glasses of water per day to exceed the daily requirement.

Extension

Research copper as a nutrient. Elemental copper probably has little or no health risk, although reports are conflicting. Our daily diet must contain specific trace amounts of copper ion to stay healthy.

Activity Instructions: Activity 2

When studying the environmental effects of chemicals, it is common to use a form of concentration that accommodates the very dilute concentrations that are encountered. The terms parts per million (ppm) and parts per billion (ppb) are often used. Some chemicals can be toxic and/or cause chronic health effects even at these levels. In this activity you will perform dilutions that illustrate ppm and ppb to get a feel for how small these quantities are and how difficult it can be to detect these small amounts.

Safety

In a laboratory setting, you are ultimately responsible for your own safety and for the safety of those around you. It is your responsibility to specifically follow the standard operating procedures (SOPs) which apply to you, including all local, state, and national guidelines on safe handling, storage, and disposal of all chemicals and equipment you may use in the labs. This includes determining and using the appropriate personal protective equipment (e.g., goggles, gloves, apron). If you are at any time unsure about an SOP or other regulation, check with the course instructor.

Ammonia (NH_3), both in solution and in the vapor phase, can damage the eyes, so eye protection is required. Contact lenses should not be worn when working with NH_3-containing products, as gaseous vapors of NH_3 may condense on the contact lens and cause damage to the eye. Use NH_3 only in a well-ventilated area. Keep the container closed when not in immediate use. Should contact with the eyes occur, rinse the affected area with water for 15 minutes. Seek medical attention while rinsing is occurring. Dilution of concentrated NH_3 solutions must be carried out in a fume hood or other well-ventilated area.

Procedure

1. Using the Beral pipet, carefully place 20 drops of the stock copper sulfate solution, $CuSO_4$ (aq), into one of the wells of the well plate.
2. Now take 2 drops from the first well and place them in the second well. Add 18 drops of distilled water. Label the first well 1/100 and the second 1/1,000. Mix the solution in the second well with a clean, dry stirring rod.
   Rinse and dry the stirring rod between wells.
3. Take 2 drops from the second well and place them in the third well. Add 18 drops of water. Label this well 1/10,000. Mix this solution with a clean, dry stirring rod.
4. Repeat the procedure as many times as it takes to produce a well with 1/1,000,000 (1 ppm).
5. Repeat three more times to produce a well with a concentration of 1/1,000,000,000.

6. Place a piece of white paper under the well plate and determine how many cells have a blue color. List the lowest concentration that still shows blue color.
7. Now add 3 drops concentrated ammonia, NH_3 (aq), to each well. Mix each well, using a clean stirring rod for each well.
8. Now identify the lowest concentration that still has color. Adding the NH_3 produces a chemical complex of copper(II) and NH_3, $Cu(NH_3)_4^{2+}$, which produces a much deeper blue color. This represents a possible way of identifying copper(II) at lower concentrations. Consider that in some cases where your eye fails to see copper(II), some is still there. How might you identify what is there that you can't see?
9. If available, use the LaMotte's copper reagent to test for the lower levels of ppm/ppb by adding drops to the wells and comparing colors.

Questions

1. Which well was the last one to show color in step 6? What was its concentration?
2. Which well was the last one to show color in step 8? What was the concentration in this well?
3. Suggest a possible way of determining the copper(II) concentration in wells that don't show color to the naked eye.
4. Obviously, copper(II) is still present in the wells that don't show color. Why might the copper(II) still be dangerous even though we can't detect it with the eye?
5. The stock solution you were given to work with contained 1 g copper(II) ion in 100 g solution, and 20 drops of solution weigh 1 g. Use this information to determine the following:
   a. How many grams of copper(II) were in the first well?
   b. How many grams of copper(II) were in the well marked 1/1,000,000 (1 ppm)?
   c. How many grams of copper(II) were in the well marked 1/1,000,000,000 (1 ppb)?
   d. If 1 g copper(II) solution contains 9.5×10^{21} copper(II) ions , how many ions of copper are in the well marked 1/1,000,000,000?

Extra Credit

1. Look in your readings and find the allowable concentration for copper ion in Wisconsin water. If you drank 500 g tap water containing that concentration of copper(II) ion, how many ions of copper(II) would you be putting into your body?
2. Find the minimum daily requirement for copper(II) in the human body. How many glasses of water containing the maximum allowable level (42 ppb) would you have to drink to exceed the daily requirement?

Instructor Notes for Activity 3

The purpose of this lab is to have participants handle copper and zinc, observe the similarities and differences of these metals, look at the use of these metals in U.S. coinage, and learn something about their chemistry.

U.S. pennies are made of a combination of copper and zinc. In 1982, a change was made in the percentage composition. Remember that zinc reacts with hydrochloric acid (HCl) to produce hydrogen gas, while copper does not seem to react.

Safety

As the instructor, you are expected to provide participants with the necessary safety equipment (including personal protective equipment such as goggles, gloves, aprons, etc.) and appropriate safety instruction to allow them to work safely in the laboratory. Always follow local, state, and school policies. Read and follow all precautions on labels and MSDSs provided by the manufacturer for all chemicals used.

If you choose to use a concentrated solution of hydrochloric acid (HCl) to prepare the dilution needed for this activity, extreme caution should be used. Concentrated solutions of HCl are very corrosive. They can cause severe chemical burns. The vapor is extremely irritating to the skin, eyes, and respiratory system. Should contact occur, rinse the affected area with water for 15 minutes. If the contact involves the eyes, medical attention should be sought while the rinsing is occurring. When diluting acids, always add acid to water and not the reverse. The heat released in the dissolving process can cause splattering if the diluting is not carried out in the correct sequence. Excess quantities of the solutions used in this experiment can be safely and legally disposed of by flushing down the sink or stored for future use.

Participants must wear goggles. Acetone vapor can be irritating to some individuals and therefore acetone should be used in a well-ventilated area.

Materials

Per class

- small strips of copper and zinc metal polished with sandpaper or steel wool
- 250-mL beaker
- 50 mL 1.0 M HCl
- 100 mL 6.0 M HCl
- some type of conductivity apparatus
- pre- and post-1982 pennies (one of each per group)
- triangular files

- forceps
- acetone
- centigram balance

Procedure Notes and Outcomes

The intent of this activity is to help participants become familiar with the nature of the two metals and the uses of these metals in the world economy. A fun exercise would be for the participants to find the current price of these metals by searching the Internet. One possible source is *http://www.metalprices.com/.*

An adaptation to the penny investigation would be to give the participants a pile of pennies of various dates and ask them to determine any connections between date and mass.

Plausible Answers to Questions

1. What happened to the post-1982 penny in this activity?
   The inside seems to have reacted away.
2. Calculate how many grams of zinc were in your post-1982 penny.
   Find the difference between the initial and final weights. It should be approximately 2.25 to 2.45 g.
3. What percentage of the post-1982 penny was copper and what percent was zinc?
   The new percentage of zinc is approximately 97.5%. Participants will probably get anywhere from 85–95%, depending on how well they follow directions.
4. Why didn't the pre-1982 penny react even if it contained a small percent of zinc?
   The percentage of zinc is so small that no noticeable reaction occurs during the testing period.
5. Why do you think the government changed the percentages of copper and zinc in 1982?
   To save money, because the price of copper is much greater than the price of zinc. The amount of copper in pre-1982 pennies is worth more than $0.01.

Extra Credit

1. Find the present market prices of copper and zinc per ton.
   Check the Internet.
2. Assume that the pre-1982 percentages were 5% zinc and 95% copper, while the post-1982 pennies are 97.5% zinc and 2.5% copper. How much money does the government save for every million pennies ($10,000) made? Use the mass for each penny determined in the procedure and the market prices from extra-credit question 1 to do the calculation.
   This amount will vary from year to year depending on prices.

Activity Instructions: Activity 3

In this activity you will have the opportunity to compare two common metals, copper and zinc, which have many uses in our economy. This information will help you to understand why the Nicolet Minerals Company wants to open a mine in Crandon, WI. In addition, you will learn something about the physical and chemical properties of these two metals.

Safety

In a laboratory setting, you are ultimately responsible for your own safety and for the safety of those around you. It is your responsibility to specifically follow the standard operating procedures (SOPs) which apply to you, including all local, state, and national guidelines on safe handling, storage, and disposal of all chemicals and equipment you may use in the labs. This includes determining and using the appropriate personal protective equipment (e.g., goggles, gloves, apron). If you are at any time unsure about an SOP or other regulation, check with the course instructor.

A 6.0 M solution of HCl is corrosive and can cause chemical burns. Should contact occur, rinse the affected area with water for 15 minutes. If the contact involves the eyes, medical attention should be sought while the rinsing is occurring.

Participants must wear goggles. Acetone vapor can be irritating to some individuals and therefore acetone should be used in a well-ventilated area.

Procedure

1. Compare the strips of copper and zinc. Test each for conductivity. Then test for reaction with HCl by placing each strip in a beaker containing 1.0 M HCl for 20 seconds. List similarities and differences.
2. With a triangular file, score the edge of two pennies, one dated pre-1982 and one dated post-1982, in about four different places. Examine the score marks. Do you notice any difference in the two pennies?
3. Measure the mass of each scored penny and record its mass to two decimal places.
4. Place both pennies in a beaker containing 6.0 M HCl. What differences do you notice in the pennies' reaction to the acid?
5. Label the beaker and place it in a location designated by your teacher.
6. After the pennies have soaked for a day, use forceps to remove them from the beaker. Without touching the pennies, examine them carefully and record your observations.
7. With forceps carefully rinse each penny in a beaker of acetone. Remove the pennies and let the acetone evaporate. Measure and record the masses of the dry pennies.

Questions

1. What happened to the post-1982 penny in this activity?
2. Calculate how many grams of zinc were in your post-1982 penny.
3. What percentage of the post-1982 penny was copper and what percent was zinc?
4. Why didn't the pre-1982 penny react even if it contained a small percent of zinc?
5. Why do you think the government changed the percentages of copper and zinc in 1982?

Extra Credit

1. Find the present market prices of copper and zinc per ton.
2. Assume that the pre-1982 percentages were 5% zinc and 95% copper, while the post-1982 pennies are 97.5% zinc and 2.5% copper. How much money does the government save for every million pennies ($10,000) made? Use the mass for each penny determined in the procedure and the market prices from extra-credit question 1 to do the calculation.

Instructor Notes for Activity 4

In this role-playing activity, participants learn to research a controversial issue by examining several of the viewpoints involved and to evaluate information with respect to biases. Participants also begin to learn the process of risk assessment. The mock Mining Permit Hearing requires participants to actively participate in discussion and consider others' arguments. Participants are asked to come to a decision in the situation, which may not have one simple answer.

Procedure Notes and Outcomes

Let participants volunteer for a role in the activity or assign the roles at random. One advantage to assigning roles is that someone may have to represent a position in which he or she doesn't believe. Sometimes this results in the person doing more research and evaluating the situation more carefully.

For this particular activity it might be helpful to list some resources that participants could use to gather information. Listed below are examples for the Crandon scenario:

- Nicolet Minerals Company
- U.S. Environmental Protection Agency
- Wisconsin Department of Natural Resources (WDNR)
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- U.S. Bureau of Indian Affairs
- The Mayor of Crandon
- Members of the Town Board of Nashville
- The Wisconsin Governor's Office
- U.S. Bureau of Mines

Many of these organizations have websites. To gain quick access to some of these sites, visit the Risks & Choices site at *http://www.terrificscience.org/risks/dailyplanet/crandon/index.shtml*.

There are many possible roles, but each hearing should at least include the following: mining company officials, Wisconsin Department of Natural Resources officials, state legislators, Native American tribal members, townspeople from surrounding communities, resort owners, and interested people who live along the Wisconsin River. See the Handout: Hearing Roles for additional ideas.

To begin the hearing, let the Nicolet Minerals Company make an opening statement and follow that with questions from state legislators and WDNR officials. Next, allow each group 5 minutes to present their case, then open up the floor to questions and comments from all the participants. At the conclusion, some final statements from the mining company might be in order. Finally, let participants cast secret ballots for or against the mining permit, based not on their role in the activity but on their own personal appraisal of all the information that was presented in the hearing. Remind participants that the final issuing of a permit in Wisconsin is granted by the WDNR Board at the permit hearing, not by individual voters.

A follow-up class discussion should bring the whole unit to a conclusion. One way of getting ready for the final discussion is to have the participants complete the questions prior to coming to the next class.

Participants need to be aware that environmental issues rarely have perfect or clear-cut answers. Participants should also understand that in a democratic society, you do not always get what you want. In determining their final decisions, participants need to analyze the arguments that were the most effective. Participants should then analyze what part “good science” played in that final decision.

Answers to the questions will vary based on participants’ opinions and experience.

Activity Instructions: Activity 4

In order to begin mining, the Nicolet Minerals Company must obtain a permit from the state of Wisconsin. This role-playing activity is a mock public hearing to discuss whether or not the Nicolet Minerals Company should be given a permit to begin construction of a mine. You will research and play the role of someone involved in this controversy. See the Handout: Hearing Roles. After the Mining Permit Hearing, you will be asked to vote either "yes" or "no" on whether to issue a permit to the Nicolet Minerals Company.

Procedure

Listed below are a few guidelines for preparing yourself for the public hearing:

1. First analyze the position you are asked to represent.
   - Is your character for or against the proposed mine?
   - List as many reasons as you can for your assigned position.
   - Do your reasons have a solid basis or are they essentially emotional?
2. Try to list pros and cons to the proposed mine so that you will have an idea beforehand what the arguments will be during the meeting.
3. Try to gather information to support your arguments for or against the mine.
4. While emotional arguments can be seen as lacking substance, they can be effective in group situations. Consider how you might use this approach in developing your case.

Questions

Answer the questions below prior to the next class and come prepared to discuss them.

1. Did the final vote come out as you expected it to? Were you satisfied or dissatisfied with the result? Why?
2. What types of arguments were most effective in influencing your final decision? List several examples from the debate.
3. How much actual science was involved in the discussion? Which sides used science in their discussion? Give some examples.
4. When controversial, emotional issues are presented to the public, does science play a major role in decisions made? Explain.
5. Suggest how you might personally become involved in this scenario and then follow through.

Handout: Hearing Roles

Wisconsin Department of Natural Resources (WDNR) Board Member (Five Members)

Members of the WDNR Board are appointed by the Governor. They have the responsibility of overseeing the work of the WDNR and providing direction to them. As a WDNR Board member, your role in the Crandon Mine Controversy is to learn as much as possible about the mine project and to decide whether the Nicolet Minerals Company will receive a mining permit. You are not at the hearing to express your opinion. You should, however, feel free to question any of the witnesses in order to become better informed before you vote on the permit.

Nicolet Minerals Company Public Relations Director

You are to testify at the Mining Permit Hearing. Your testimony should be designed to convince the WDNR Board and other participants that the mine will be good for Crandon and Wisconsin. You should be prepared to respond to environmental, economic, social, and other concerns that will come up. You should be prepared to describe all the good things the mine will do for the area.

Nicolet Minerals Company Engineer

You are to testify at the Mining Permit Hearing. You should be prepared to explain how the mine will operate and how the mine will be designed to prevent any damage or danger to people, wildlife, or the environment. You want to convince the WDNR Board and other concerned people that the mine will be safe for everyone and that similar mines have been successful in causing minimal environmental damage.

Environmental Protection Agency (EPA) Environmental Scientist

You are a scientist working for the U.S. Environmental Protection Agency. Your role is to protect the environment from pollution or other damage. You are particularly concerned about the Wolf River, which has been designated as a National Wild and Scenic River. You should be prepared to testify at the hearing about the mining process that will be used and the mining industry's past record of protecting the environment while using this process. As a scientist, you should try to be fair and objective. Try to avoid expressing your personal opinions.

Member of the Wisconsin State Governor's Staff

You have been sent to the hearing by the Governor of Wisconsin. You are to testify at the hearing in support of the mining project. You should be prepared to convince the WDNR Board and other concerned people that the mine will be good for the Crandon area and for the state of Wisconsin.

State Legislator—For the Mine

You were elected to the State Legislature by the citizens in your legislative district. Your district is in rural northern Wisconsin, where good jobs are scarce and the economy is depressed. You should be prepared to testify at the Mining Permit Hearing in support of the mine. You want to convince the WDNR Board and others that the mine will cause no harm to the area and will help the local economy with jobs and increased revenue from taxes.

State Legislator—Against the Mine

You were elected to the State Legislature by the citizens in your legislative district. Your district is in the Madison area in southern Wisconsin. The proposed mine will have no direct effect on your district. The people who live in your district, however, use the Crandon area and the Wolf River for recreation. They do not want the environment to be damaged by mining. You should be prepared to testify at the Mining Permit Hearing against the mine.

Native American—Potawatomi

You are a member of the Potawatomi Tribe living in the Crandon area. You are opposed to the mine because you fear it may affect the environment. As a Native American, you use the land and water to hunt, fish, and gather wild rice. Selling wild rice is an important part of your income. Wild rice grows in the shallow water of local lakes and rivers. You should be prepared to testify against the mine project. You want to convince the WDNR Board that the mine will disrupt the environment and your way of life.

Native American—Sokoagan

You are a member of the Sokoagan Tribe living in the Crandon area. You are opposed to the mine because you fear it may affect the environment. As a Native American, you use the land and water to hunt, fish, and gather wild rice. Your tribe also owns and operates a gambling casino that depends on tourists who come to the Crandon area on vacation. You fear the mine may cause some tourists to go elsewhere. You should be prepared to testify against the mine project. You want to convince the WDNR Board that the mine will disrupt the environment and your way of life.

Crandon Town Chairperson

You are for the mining project. As the Town Chairperson, you believe the mine will help the economy by creating jobs and increasing revenue from taxes. You should be prepared to testify in support of the mine. You want to convince the WDNR Board and others that the mine will be good for Crandon. You should also be aware of and sensitive to the concerns of the residents of Crandon who oppose the mine and voted you into office. They could vote you out of office in the next election.

Crandon Resident Who Needs a Job

You live in Crandon and are an unemployed logger. You worked for 10 years cutting logs for pulpwood, but you were laid off when the price for paper pulpwood dropped. You support the mine because you believe you could get a good job working there. You have listened to the mining company plans and believe the mine will be good for Crandon's citizens without damaging the environment. You should be prepared to testify in support of the mine.

Crandon Resident Who Is an Environmentalist

You lived in a big city and moved to Crandon when you retired because you enjoy the natural beauty of the area and are willing to live a simpler lifestyle in order to enjoy that environment. You have observed and studied the forests, wildlife, and lakes of the area and understand how fragile the ecosystem is. You oppose the mine because you believe it will damage the environment. You should be prepared to testify against the mine because of the potential environmental damage.

Crandon Resident Who Owns a Restaurant

You own a restaurant in downtown Crandon. You have mixed feelings about the mine. You anticipate more business if the mine opens, but you also expect other restaurants to open and compete with yours. Your greatest concern is how long it will take to remove all the ore from the mine and how your business will be affected when the mine closes. You should be prepared to testify in support of protecting the local economy on a long-term basis.

Resort Owner on a Nearby Lake

You own a resort on a lake near Crandon. Your guests fish on the lake, hike in the forests, and relax in the quiet north woods. You fear that the mine might cause some of your patrons to go elsewhere. You should be prepared to testify in support of all the people who depend on tourism for their income and who fear tourism will decline if the mine opens.

Wisconsin River Resident

You live on the Wisconsin River between Rhinelander and Tomahawk. You have heard that the Crandon Mining Company wants to build a pipeline from Crandon to the Wisconsin River downstream from Rhinelander. They intend to dispose of mine wastes through this pipeline to the Wisconsin River. You should be prepared to testify against the mine project because you believe it will pollute the river.