FUTURE U.

Corrosion Report

Objectives

Students will create an experiment to assess which types of metal corrode the most quickly and whether coatings prevent or slow the rate of corrosion.

Overview

Students will be told that Boeing is recruiting their help in expanding their line of ocean vessels. In particular, Boeing would like their insight on the optimal ship construction materials that should be used to avoid corrosion. After considering the elements that must exist for rust to occur, students will construct an experiment that tests: A) the types of metals that rust most and/or the fastest and B) whether coatings may be effective in preventing rust. After forming a hypothesis, students will set up their experiment and data capture sheet and the classroom teacher will be left with further instructions on how to continue the experiment over the following two weeks.

Grade Range

5–8

Timing

60 minutes (Plus five minutes/day for the next two weeks and one wrap-up discussion, to be led by the classroom teacher.)

Materials Needed

- Access to a device with projection capabilities or printed versions of:
    - Warm Up Images
    - Boat Images
- Corrosion Factors handout, enough for half the class
- Experiment Packet (3 pages, stapled), one per student
- Educator Follow Up Sheet, one for the classroom teacher

Part A Experiment Materials

- Enough of the following for groups of four students:
    - 5 small cups (clear and not paper), beakers, or test tubes
    - One piece of each of the following wire types* (see further instructions below)
        - Steel
        - Silver

  - Zinc
  - Copper
  - Aluminum
- For the class to share:
  - Painter's tape, at least one roll
  - 4 liters of saltwater** (see further instructions below), separated into at least four different containers

Part B Experiment Materials

- Enough of the following for groups of four students:
  - 5 small cups (clear and not paper), beakers, or test tubes
  - 5 iron nails
- For the class to share:
  - Remaining saltwater from above
  - Acrylic paint, at least two small containers
  - Paint brushes, at least four
  - Vaseline, at least two containers
  - Cooking oil, at least two containers
  - Plastic wrap, one carton
  - Scissors, several pairs
  - Painter's tape, at least one roll

* Wire instructions:

**Saltwater Instructions: To prepare the saltwater, mix two tablespoons of salt per liter of tap water. You can mix this in advance and be prepared to explain how you created this solution!

- Cut each wire type in advance. Each one should be cut so that when it is placed in the cup, beaker, or test tube that students will be using, fingers can easily pull it out. It should be roughly the height of the container it will be placed in.
- Once the wires have been cut, place them in clearly labeled bags or containers (e.g. "Steel Wires," "Silver Wires", etc.)

Preparation

- Check with the classroom teacher about projection capabilities. In some cases, it may be easiest for you to send the images to the teacher in advance. In other cases, you may be able to easily connect your laptop.
- Copy and staple the Experiment Packet.
- This lesson requires a variety of materials. Try to organize the materials in advance and separate the Part A and Part B experiment materials. Place these in two different areas of the classroom before the session begins.
- Speak with the educator about continuing this experiment with the class and be ready to give him/her the Educator Follow Up sheet.

Next Generation Science Standards

Matter and its Interactions

- 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.
- MS-PS1.A: Structure and Properties of Matter. Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

Engineering Design

- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Procedure

1. **Warm-Up Activity:** Project or display the Warm-Up Images and encourage students to discuss similarities and differences among the images with a peer. Then call on a few students to share their observations.

   Next, write the word corrosion on the board. Explain that corrosion is a chemical reaction. It occurs when properties within a material (usually a metal) break down and deteriorate due to reactions with its environment. Rust is one common type of corrosion, and it is clear that a chemical reaction has occurred because it causes the object to change color.

2. Then project or display the Boat Images. Point to the top image and explain that this is a Boeing undersea vehicle called the Echo Voyager. Go on to tell the students that Boeing is recruiting the class' help as they expand their line of ocean vessels.

   Scroll down to the next row of images and tell the class that Boeing would especially like their insight about which ship construction materials would be optimal to avoid corrosion.

3. Divide students into partners and distribute a Corrosion Factors handout to each pair. Explain that scientists know there are a few factors that must be present for corrosion to occur. Encourage pairs to review the handout and develop a list of these factors. Then ask students to share their conclusions. Be sure they understand that water (or another electrolyte) and oxygen must be present for a metal to corrode.

4. Next, tell students that Boeing will be constructing their new fleet out of metal. The boats will operate both on top of the ocean and submerged within it, so minimizing corrosion is important. Today it will be up to the students to set up an experiment that will help them determine: A) what type of metal will corrode the least, and B) if any type of coating could further prevent corrosion from occurring.

5. Complete the following to prepare students for setting up their experiment:

   a. Divide the class into groups of four and distribute one Experiment Packet to each student.

   b. Read through the steps on page one of the Experiment Packet. As you do, show students where they can find the materials for Part A and Part B. Be sure to explain the different types of metals that the wires represent as well as the materials available for the coating.

   c. Give suggestions for where students can store their experiment-in-progress once Steps 1–5 are complete. (It may be helpful to check with the classroom teacher for suggestions.)

6. Then encourage groups to begin! Rotate around the classroom, help groups as needed, and give periodic reminders about how much time remains in the session.

7. **Wrap Up:** When there are just a few minutes left, explain that the groups will continue to track their experiment over the next two weeks. Once their experiment is complete, they will develop a recommendation for Boeing!*

   Also take a moment to remind students that there are many different careers related to underwater exploration. Ship engineers, marine engineers, naval architects, service technicians, and material fabricators are just some of the different jobs that contribute to boat development and construction. Encourage students to consider these careers if underwater exploration is of interest to them, and—no matter what—thank them for their contribution to this project!

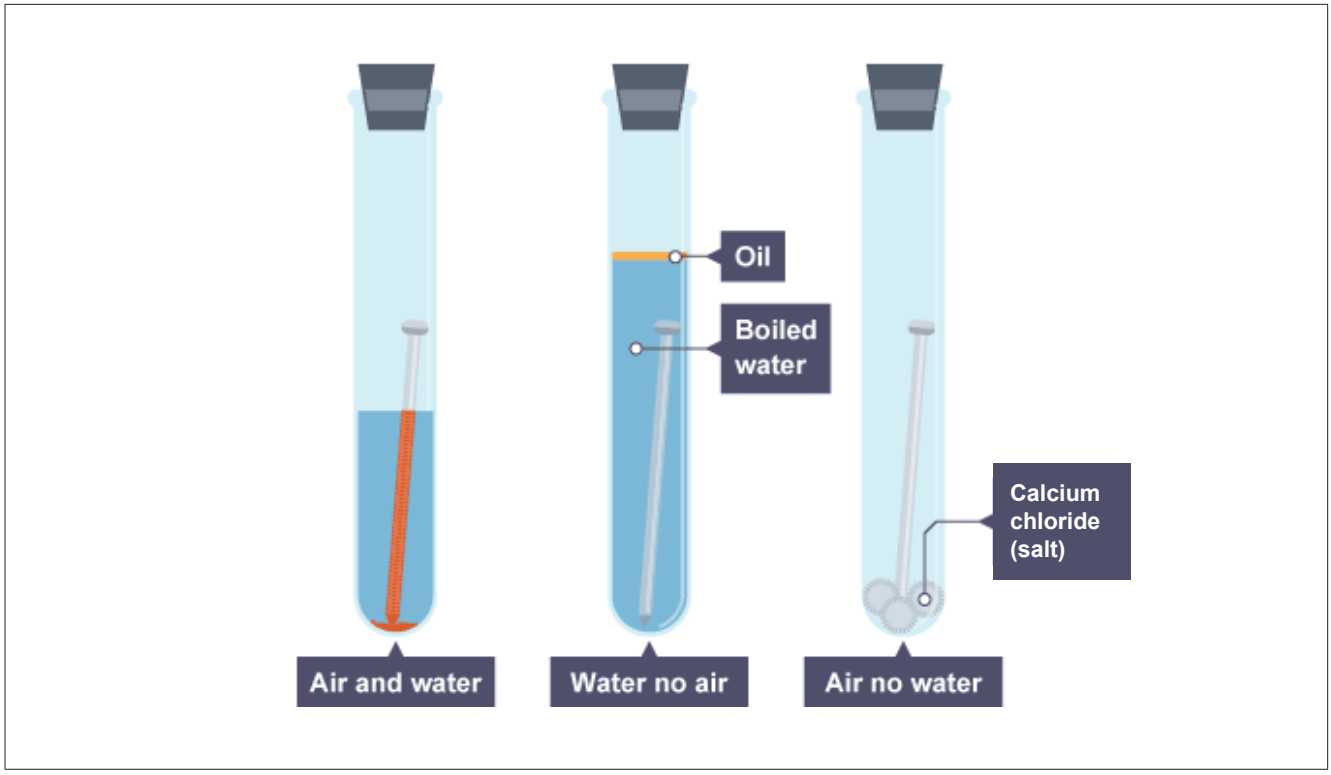
   *If the classroom teacher is willing to share the results with you over email, the students would likely be thrilled to receive a response from you that acknowledges their findings and their hard work!

Warm-Up Images

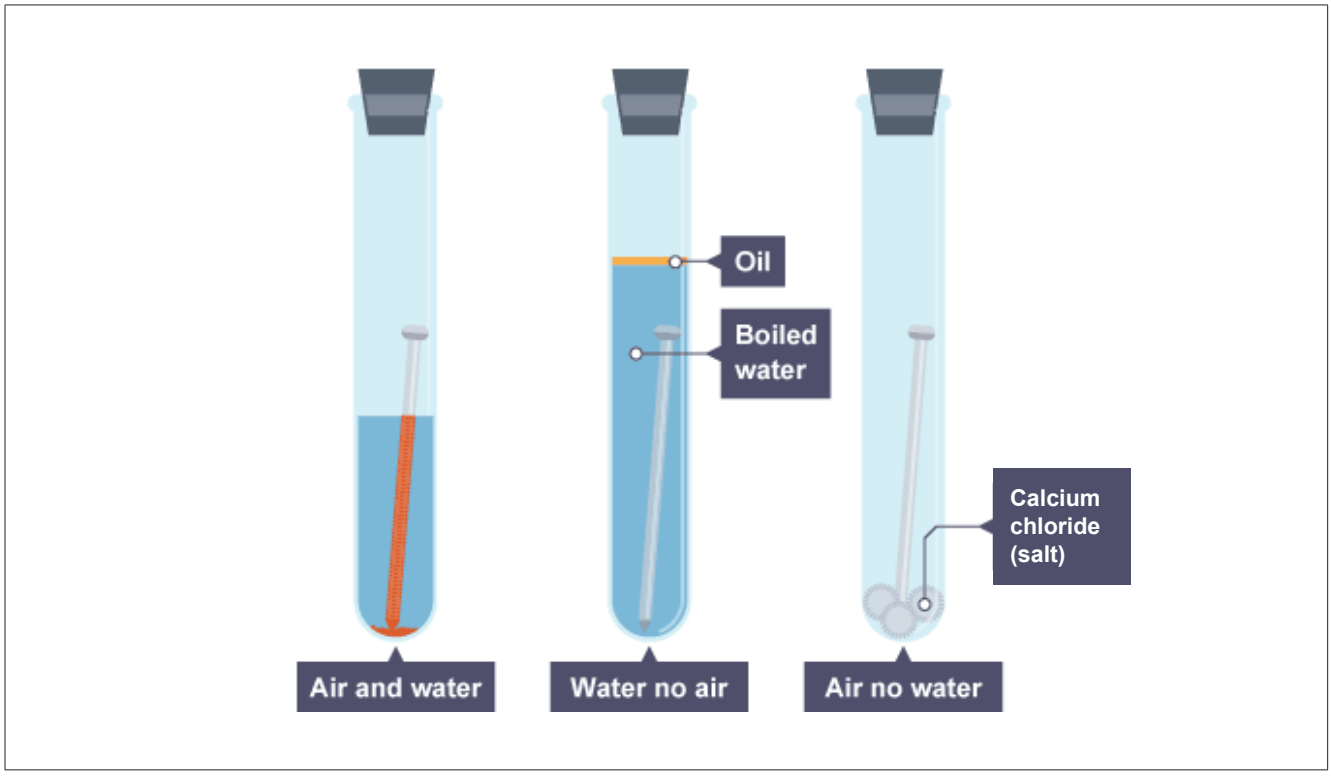
Boat Images

How can we prevent corrosion like this from occurring?

Corrosion Factors



Corrosion Factors



Your Job: Create an experiment that helps Boeing determine how to minimize corrosion on their next line of maritime vehicles. You will be testing:

A. What type of metal should be used to minimize corrosion?

B. Will a wire coating help further minimize corrosion?

Step 1: Hypothesize

Part A: Which metal do you think will corrode the least? Why?

_____

_____

_____

Part B: Would a coating on the metal help reduce corrosion? If so, which coating would be most effective? If not, why?

_____

_____

_____

Step 2: Experiment Set Up—Part A

Set up an experiment to test your hypothesis for Part A using the saltwater and different types of wire. Be sure to:

- ✓ Use the tape to label each container.
- ✓ Place each wire in a separate container.
- ✓ Cover each wire at least halfway with saltwater.
- ✓ Fill in Par*t A—Corrosion Tracker* (Packet Page 2) with the metals you will be testing.

Step 3: Experiment Set Up—Part B

Then, set up an experiment to test your hypothesis for Part B using the saltwater, nails, and coating materials. Be sure to:

- ✓ Select three or four different coatings to test.
- ✓ Cover each nail with a different coating, *except* for one nail. This uncoated nail will be your control, so you can compare the other nails' corrosion to it.
- ✓ Place each nail in a separate container.
- ✓ Use the tape to label each container.
- ✓ Cover each nail entirely with saltwater.
- ✓ Create your own tracker on the *Part B—Corrosion Tracker* (Packet Page 3), using Part A's tracker as your guide.

Step 4: Kick Off Your Observations

Record your observations on both charts for Day 1. Decide whether you will use words, pictures, or both. Think about which will allow you to share the most details!

Step 5: Continue Your Observations

Continue to observe and take notes on Charts A and B for the next 14 days. Leave any weekends blank. You will review your results at the end of the two-week period.

Part A—Corrosion Tracker: Metals

Experiment Packet, Page 2

Day	Metal:	Metal:	Metal:	Metal:	Metal:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Part B—Corrosion Tracker: Coatings

Experiment Packet, Page 3

Day	Metal:	Metal:	Metal:	Metal:	Metal:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Educator Follow Up

Thank you for taking the time to continue this experiment with your students! Over the next two weeks, it should take no more than five minutes daily for students to continue recording their observations.

Once two weeks have passed, encourage your students to share their findings. You may facilitate this through a class discussion or a written summary. Instructions to copy and distribute for a written summary are included on the bottom half of this page.

Questions to guide your class discussion include:

- Which metal(s) corroded the most? The fastest? How did the corrosion progress and what do the metals look like now?
- Which metal(s) corroded the least? What state are these metals in after two weeks in saltwater?
- What key takeaways do you have about coated metal? Is this something Boeing should consider in order to prevent corrosion on their vehicles?
- Based on these learnings, what materials do you recommend Boeing use to construct its new line of maritime vessels?
- What further research should be completed, if any, to deepen your understanding and help you develop an even more thorough recommendation?

Boeing Corrosion Report

Review your results and then work with your group to develop a written recommendation for Boeing. Your recommendation must include:

- Which metal(s) corroded the most? The fastest? Which metal(s) corroded the least? Provide specific details about the state of these metals and how their corrosion progressed.
- What key takeaways have you learned about coated metal? Is this something Boeing should consider to alleviate (or help) corrosion on their vehicles?
- Based on these learnings, what materials do you recommend Boeing use to construct its new line of maritime vessels?
- What further research should be completed, if any, to deepen your understanding on this subject?