What is Rust?

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Subject: Chemistry
Level: Middle and High School
Standards: *New York State- Intermediate Science (www.emsc.nysed.gov/ciai/)*
Standard 1- Analysis, Inquiry and Design
Standard 4- The Physical Setting
Standard 6- Interconnectedness: Common Themes
Standard 7- Interdisciplinary Problem Solving
Schedule: Two 40-minute class periods (one week apart)

Objectives:

Learn about how rust works and why it occurs. Students will understand rust as a chemical reaction.

Students will:

- Experiment with different metals and solutions
- Conduct three experiments in order to test the role of metal type or environment
- Observe the metals in various solutions over the next week
- Make predictions and test each substance using pH paper
- Answer questions pertaining to activity
- Explain why certain metals rust differently.

Vocabulary:

Element
Cathode
Corrosion
Anode
Electrolyte
Acidic

Materials:

For Each Pair:
Nails made from various metals
Common solutions with various pH levels (including salt solution)
Beakers

For Each Student:
Activity Sheet 1: *What is Rust?*

Safety:

Students should use caution when handling the rusty metals.

Science Content:

How does rust work?

Rust is the common name for a very common compound, iron oxide. Iron oxide, the chemical Fe_2O_3, is common because iron combines very readily with oxygen -- so readily, in fact, that pure iron is only rarely found in nature. Iron (or steel) rusting is an example of **corrosion** -- an electrochemical process involving an anode (a piece of metal that readily gives up electrons), an electrolyte (a liquid that helps electrons move) and a cathode (a piece of metal that readily accepts electrons). When a piece of metal corrodes, the electrolyte helps provide oxygen to the anode. As oxygen combines with the metal, electrons are liberated. When they flow through the electrolyte to the cathode, the metal of the anode disappears, swept away by the electrical flow or converted into metal cations in a form such as rust.

For iron to become iron oxide, three things are required: iron, water and oxygen. Here's what happens when the three get together:

When a drop of water hits an iron object, two things begin to happen almost immediately. First, the water, a good electrolyte, combines with carbon dioxide in the air to form a weak carbonic acid, an even better electrolyte. As the acid is formed and the iron dissolved, some of the water will begin to break down into its component pieces -- hydrogen and oxygen. The free oxygen and dissolved iron bond into iron oxide, in the process freeing electrons. The electrons liberated from the anode portion of the iron flow to the cathode, which may be a piece of a metal less electrically reactive than iron, or another point on the piece of iron itself.

The chemical compounds found in liquids like acid rain, seawater and the salt-loaded spray from snow-belt roads make them better electrolytes than pure water, allowing their presence to speed the process of rusting on iron and other forms of corrosion on other metals.

Preparation:

1. Photocopy print materials (*Activity Sheet 1*) for each student.
2. Make salt solution by adding approximately 1/4 cup salt to 4 cups water.
3. Make baking soda solution by adding approximately 1/3 cup baking soda to 4 cups water.
4. Label various metals and solutions so the students can choose what materials they would like to work with.

Classroom Procedure:

Day One

Engage (Time: 15 mins)

Discuss background information on rust, outlined in 'Science Content', with the students. Make sure the students understand the concepts they learned and can define the vocabulary terms pertaining to the activity. Ask them to make initial predictions on variables that might affect the rusting process.

Explore (Time: 25 mins)

Allow the student pairs to collect their materials and choose the metals they would like to work with. Students should follow the instructions outlined in Activity Sheet 1: What is Rust? They will be conducting three experiments in order to test the role of metal type or environment on the 'rusting' process. They will observe the metals' progress over the next week. Tell the students that all three experiments should be completed by the end of the class period. Assist as necessary.

Ask students to clean up their workstations. Make sure they have completed all three experiments. The following day, allow time for them to record their observations.

Day Two **(*This part of the activity should be resumed one week later)**

Explain (Time: 40 mins)

Review how rust works, as outlined in 'Science Content'. Now that the students have observed their metals in different solutions over the past week, discuss why certain environments lead to a faster corrosion, or rust, summarized in Activity Sheet 1.

Students will make predictions about, then test different substances' pH levels using pH paper, and identify whether it is an acid or a base. All questions on Activity Sheet 1 should be completed. Encourage group discussion. Assist as necessary.

Allow time for a question and answer session. Review the relevant terminology. Encourage class discussion and participation while reviewing the concepts learned.

Assessment:

The following rubric can be used to assess students during each part of the activity. The term "expectations" here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Engage	Explore	Explain
1	Shows leadership in the discussion and an understanding of chemical reactions and corrosion.	Completes work accurately while providing an explanation for what is observed. Works very well with partner.	Provides an in depth explanation of findings. Fills out worksheet clearly.
2	Participates in the brainstorm and shows an understanding of chemical reactions and corrosion.	Completes work accurately and works cooperatively with partner.	Provides clear explanation of findings. Fills out worksheet clearly.
3	Contributes to the discussion, but shows little understanding of chemical reactions and corrosion.	Works cooperatively with partner, but makes some mistakes with the procedure.	Provides a limited explanation of findings. Fills out some of the worksheet.
4	Does not participate in discussion. Shows no understanding of chemical reactions and corrosion.	Has trouble working with partner. Does little to complete the procedure.	Is not clear in explanation of findings. Does not fill out worksheet.

Safety:

Students should use caution when handling the rusty metals.

Acknowledgments:

How does rust work? *Howstuffworks.* 10 April 2007.
http://science.howstuffworks.com/question445.htm