

Reactivity of Iron

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Abstract

Our experience tells us that iron and steel are materials used in construction for their strength and toughness. However, we also know that iron reacts with its environment, usually in the form of corrosion. This demonstration shows that iron is actually quite reactive when present in small sections (with a high surface-to-volume ratio), both in a flame and in water.

Objectives: The student will be able to
Demonstrate the reactivity of iron in two environments (flame, water)
Observe two types of oxidation of iron

MatEd core competencies addressed (most important in bold)

- 0B Prepare tests and analyze data
- 4A Demonstrate effective work with teams
- 4B Determine and develop effective project interactions
- 5A Apply safe and environmentally appropriate methods of chemical handling
- 7A Illustrate the general nature of metals
- 7K Compare thermal properties of materials
- 8E Perform appropriate tests of metallic materials
- 9A Classify properties of steel**

Key Words: Iron, reactivity, steel wool, oxidation, rusting

Type of activity: Demonstration

Time required:
10 minutes plus discussion

Grade Levels:
High school and up

Equipment and Supplies needed:
One or two objects made of iron or steel to show the students
(hacksaw blade, wrench, etc)
2 pads of steel wool

Bunsen burner or propane torch
Tongs to hold the objects in the flame
Beaker of water

Instructor background and notes:

Steel wool is made from iron or steel wires or turnings. Steel wool pads also contain some oil from the production process. The combination of the fine wires and the oil makes steel wool quite flammable, as is seen in this demonstration. The demonstration is best for older students; younger ones may try it at home. The steel wool burns at a high temperature, which would cause serious burns if used carelessly.

The burning process is oxidation and the oxidation product is a vapor although sometimes drops of molten iron are also visible.

Steel wool in water corrodes. The corrosion process is also oxidation, and the standard corrosion products are rust (FeO , Fe_2O_3 , etc.) The corrosion process is not as colorful as the burning demonstration, but the result is similar.

In the discussion, the instructor can note the standard reactivity series, in which iron is more-or-less in the middle of more reactive and less reactive metals. Standard chemistry experiments make use of this reactivity series.

Experimental process

1. Beforehand (up to 24 hours before), place half of the pad of steel wool in the beaker of water. You will use it at the end of the activities below.
2. Discuss metals strength and stability, using your iron or steel examples.
3. Now discuss metals reactivity. Ask the students if they have experience with metals reacting.
4. Using the flame, place one or two of the solid steel or iron objects in the flame. Do they react? How? Have the students discuss.
5. Now put the other half of the pad of steel wool in the flame. Discuss why it reacts so much more readily than the solid objects.
6. Take out the steel wool that was in the beaker of water—did it react? How is that different than the steel wool in the flame?
7. Help the students understand that both in the flame and in the water, the iron reacted to oxidize into an iron oxide product (one molten or vapor, one as rust).
8. Discuss the effect of surface area on the potential for burning/corrosion—compare the large parts to the steel wool.

Further study

1. Research the products of the high temperature reaction that was demonstrated.
2. Investigate the process of corrosion. What are the corrosion products?
 1. Change the composition of the water by adding salt. What changes?
 2. Change the water in other ways you can think of. What is the result?
3. Investigate how steel wool was developed and how it is made.
4. How does this demonstration apply to machining steel—consider the turnings.

References

1. Additional module on the corrosion reaction are available in the MatEd module series, including "Metal Corrosion" and "Speed Rusting and Hot Hands."
2. How steel wool is made, <http://www.madehow.com/Volume-6/Steel-Wool.html>
3. Considerable amount of information on corrosion is available on the Internet.

Evaluation:

Student evaluation questions (discussion or quiz):

1. Why does the steel wool burn while larger parts made of iron not burn?
2. Why does the larger surface area of the steel wool make a difference?
3. What is the reaction product of the burning reaction?
4. What is the process for the burning reaction? For the corrosion reaction?
5. Under what circumstances might working steel (such as machining) be a fire hazard?

Instructor evaluation questions:

1. At what grade level was this module used?
2. Was the level and rigor of the module what you expected? If not, how can it be improved?
3. Did the activity work as presented? Did they add to student learning? Please note any problems or suggestions.
4. Was the background material sufficient for your background? Sufficient for your discussion with the students? Comments?
5. Did the activity generate interest among the students? Explain.
6. Please provide your input on how this module can be improved, including comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Course evaluation questions (for the students)

1. Was the activity clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. Was the importance of materials testing made clear?
6. What was the most interesting thing that you learned?