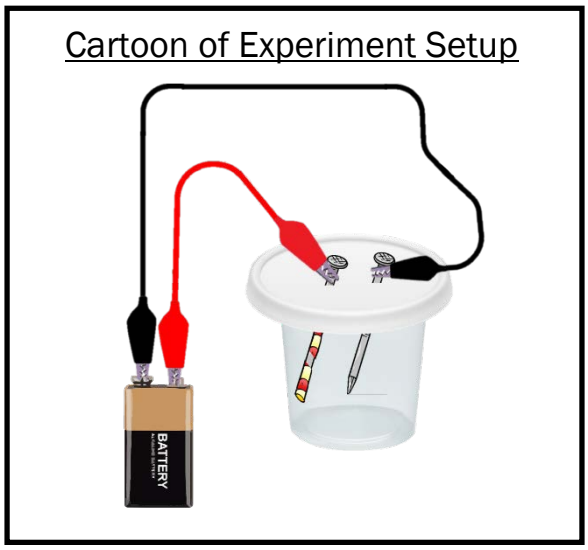
NailBreak



Time Required:

- ☐ 0-30 minutes
- ☒ 30-60 minutes
- ☐ 60-120 minutes (1-2 hours)
- ☐ 120-180 minutes (2-3 hours)
- ☐ 180-240 minutes (3-4 hours)
- ☐ > 4 hours

Materials Needed:

- Two finishing nails (about 2” in length)
- 2 Tablespoons of Table salt
- Water
- Plastic Lid (yogurt container lid works great)
- One Drinking Glass (a pint glass works well)
- Two Alligator Clips
- One 9V battery
- Small Drinking Straw or Electrical Tape
- Spoon

Optional Materials:

- 1.5 V AA Battery
- 2 Galvanized Nails
- Stopwatch

Concepts:

- ☒ Electrochemistry

Parental Supervision:

- ☐ Recommended for children under 5
- ☐ Recommended for children under 12
- ☒ Highly recommended for children under 12
- ☐ Recommended for children under 18
- ☐ Adults Only

Age Recommendation:

- ☐ 0-3
- ☐ 3-8
- ☒ 8-12
- ☒ 12-18
- ☒ Above 18

Safety:

The alligator clips must not touch each other!

Procedure:

1. Add the table salt to the drinking glass
2. Add about 2 cups of water to the drinking glass and stir the salt water mixture for about 30 seconds. Depending on the amount of salt and water, the solution may appear cloudy if all of the salt does not dissolve.
3. Push the two finishing nails through the plastic lid, making sure to have about ¼" of the nail head sticking up on the top of the lid.
4. Cover one of the nails with a small straw or electrical tape, having only 1/8" (3 mm) of the nail exposed (not covered).
5. Place the lid on top of the drinking glass, making sure that the section of exposed nail is submerged in the salt water solution.
6. Connect an alligator clip to the nail with the covering and connect it to the positive terminal of the 9 V battery.
7. Connect another alligator clip to the uncovered nail and connect to the negative terminal of the 9 V battery.
8. You should immediately see gas formation at the uncovered nail.
9. Let reaction go for about 30 minutes.
10. After about 30 minutes, you will see part of the nail fall off (30 – 40 minutes after connecting the terminals).
11. Disconnect the terminals, remove the lid and covering of the broken nail and inspect the nails.

Optional:

1. The experiment can be repeated with a 1.5 V battery instead of a 9 V battery.
2. Other nails can be used to see how long it takes to break them.

Clean Up:

The water in the drinking glass can be poured down the drain or flushed down the toilet.

What is going on?

The iron metal present in the nail is being oxidized (losing electrons). As the iron atoms are oxidized, they become soluble in the water, causing them to leave the nail and go into solution, which is the source of the color in the water. Some of the iron in the water is reduced (gains electrons) on the uncovered nail (black colored material on the nail). The bubbles that form occur from the reduction of protons (H^+) to hydrogen (H_2) at the cathode (electrode where the reduction occurs).

$$Fe \longrightarrow Fe^{2+} + 2\,e^-$$

Questions and Discussion

1. **Which of the nails if the anode (where the oxidation occurs)?**

   Answer: The covered nail is the anode, as it is being oxidized. The oxidation of the nail is the source of its ability to break.

2. **Why is table salt added to the water prior to adding the nails?**

Answer: Table salt acts as the electrolyte, aiding in the flow of charges in the water during the electrochemical reaction.

3. Can sugar be used in place of table salt in this electrochemical reaction?

Answer: No. When sugar dissolves in water, it does not dissociate into charged ions. This inability to create ions when dissolved will result in an incomplete circuit where charges will be unable to flow and the reaction will not work.