Inquiry Investigation 6-A

What Causes Rusting of Iron Nails?

Garden sheds, tools, lawn furniture, bicycles, and other items that are left outside can be quickly damaged by rust. The cost of the damage can add up to hundreds of dollars each year. In this investigation, you will find out whether certain conditions promote the rusting process.

Skill Check

Initiating and Planning

✓ **Performing and Recording**

✓ **Analyzing and Interpreting**

✓ **Communicating**

Safety Precautions

- Wear safety goggles and a lab apron.
- Clean up all spills immediately.
- Agitate the test tubes safely and effectively.

Materials

- fine sandpaper
- 3 clean, dry nails
- 3 clean, dry test tubes
- 3 clean, dry rubber stoppers
- water
- table salt
- test-tube rack

Set up the test tubes in this way. Leave them undisturbed for one or two days.

Science Skills

Go to **Science Skills Toolkit 7** for information about creating data tables.

Question

What conditions cause rust to form?

Procedure

1. Lightly sand each nail to remove any protective coating that the manufacturer may have added.
2. Place one clean, dry iron nail into each of three clean, dry test tubes. You will expose the iron to three different sets of conditions.
3. Stopper one test tube, and label it "dry." Add enough water to the other two test tubes so that the height of the water in each test tube is about 2 cm. Stopper the second test tube, and label it "water." Add a tiny pinch of salt to the third test tube, stopper the test tube, and label it "salt plus water." Lay the stoppered test tubes on their sides, and gently roll the test tubes to distribute the water and the salt. Carefully observe all three nails, and record your observations.
4. Place the test tubes upright in a test-tube rack. Allow them to sit unopened for one or two days.
5. Observe the three iron nails. Are there any similarities in their appearance? Are there any differences? Record your observations.

Analyze and Interpret

1. Identify the control that was used in this investigation.
2. Which set of conditions caused the greatest amount of rusting? Which set of conditions caused the least amount of rusting?

Conclude and Communicate

3. What advice would you give to a home-owner who wanted to minimize the damage caused by rusting?

Extend Your Inquiry and Research Skills

4. **Inquiry** Is oxygen necessary for rusting to occur? Write a hypothesis as a tentative answer to this question. Design an experiment you could perform to test your hypothesis.

Inquiry Investigation 6-B

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

✓ Communicating

Properties of Ionic and Molecular Compounds

You encounter hundreds of compounds every day. Although each compound has unique properties, there are some similarities in these properties that can help you to tell what kind of compound it is. In this investigation, you will test six different compounds to determine whether they are ionic or molecular.

Safety Precautions

- Wear safety goggles and a lab apron.
- Cautiously test for odour. Do not smell directly. Take a deep breath and hold it. Waft some air near the mouth of the test tube toward your nose, and then breathe out. This way, you should avoid inhaling any gas.
- Treat the hot plate carefully. Do not leave it turned on for more than 2 min. Allow it to cool for 15 min before moving it.
- To unplug the hot plate, do not pull on the cord. Pull on the plug.

Materials

- 6 test tubes
- 6 samples of compounds
- glass plate or watch glass
- scoop
- plastic water bottle
- hot plate
- aluminum foil
- distilled water
- conductivity tester
- tongs

Question

How can you use properties to identify compounds as ionic or molecular?

Procedure

1. Label six test tubes with the letters A to F. Place samples of six different compounds in the labelled test tubes. Use just enough of each compound to fill the rounded bottom of the test tube.
2. Prepare a table similar to the one shown. Your table should take up one full sheet of paper so that you have enough space for all your observations. Give your table a title.

Substance	A	B	C	D	E	F
Odour						
Crush						
Hardness						
Melting						
Solubility						
Conductivity						
TOTAL						

3. Perform each of the following tests on each compound. At each test step, analyze all the compounds before moving on to the next test. If a substance responds like an ionic compound, record a score of zero (0) in your table. If a substance responds like a molecular compound, record a score of one (1). Also record short, descriptive observations for each test in your table.

   Odour test: Take a deep breath and hold it. Waft some of the air near the mouth of the test tube toward your nose, and then breathe out. Does the compound have a noticeable odour?

Crush test: Place one or two grains of the compound on a glass plate or watch glass. Press on the compound with a scoop or another metal tool. Ionic compounds withstand considerable force and then crush suddenly into a gritty powder (score 0). Molecular compounds that are solids are often more flexible and crush like wax or plastic (score 1).

Hardness test: Rub some of each compound on a clear plastic water bottle. Ionic compounds are often hard enough to scratch the plastic (score 0). Molecular compounds are seldom hard enough to scratch the plastic (score 1).

Melting test: Your teacher will give you a cold hot plate. Spread a small square of aluminum foil over the surface of the hot plate. Carefully place one small piece (no larger than a half a grain of rice) of each substance on the aluminum. Place the samples as far apart as possible. Plug the hot plate in the electric outlet. Be sure to hold the plug away from the metal terminals. Turn on the hot plate. Ionic compounds do not melt, except at very high temperatures (score 0). Molecular compounds tend to melt and even vaporize at relatively low temperatures (score 1).Turn off the hot plate after 2 min. When the hot plate has cooled, pull out the plug. Do not pull on the cord.

Place each substance on a piece of aluminum foil that is placed on the hot plate.

Solubility test: Each test tube should still contain most of the original substance. Add 10 mL of water to each of the test tubes. Many ionic compounds will dissolve in water, although there are exceptions (score 0). Many molecular solids are insoluble in water (score 1), although again there are exceptions.

Conductivity test: Use a conductivity tester to test the conductivity of the solution in each test tube. When ionic compounds dissolve, the resulting solution will conduct electricity (score 0). When molecular compounds dissolve, the resulting solution will usually not conduct electricity (score 1). Make sure that you clean the probes of the conductivity tester between readings.

4. Clean up your work area. Dispose of all the compounds as indicated by your teacher. Return each piece of equipment to its place.

Analyze and Interpret

1. Add up the scores for each compound. A low score, near 0, indicates that the compound is ionic. A high score, near 6, indicates that the compound is molecular. What patterns do you see?
2. If a compound has a score of 2, 3, or 4, use your descriptive observations to help you decide whether it is ionic or molecular.

Conclude and Communicate

3. Your teacher will tell you the names and formulas of the compounds. Do the names reflect the ionic and molecular classifications that you suggested based on your observations?

Extend Your Inquiry and Research Skills

4. **Inquiry** If you could perform only two tests to identify ionic and molecular compounds, which two tests would you choose? Explain your thinking.
5. **Research** Do sports drinks contain ionic compounds? Which test would you perform to find out?

Data Analysis Investigation 6-C

Skill Check

Initiating and Planning

Performing and Recording

✓ **Analyzing and Interpreting**

✓ **Communicating**

Classification of Household Substances

There are numerous common household substances. As you saw for laboratory chemicals, these substances can also be classified according to whether or not they have ionic or molecular properties. A group of students studied the properties of common household substances. Some of their data are listed in the table below.

Properties of Common Substances

Materials	Melting Point (°C)	Solubility in Water	Conductivity of Solution
Baking soda	Decomposes	Yes	Yes
Cooking oil	−5	No	No
Table salt	801	Yes	Yes
Lip balm	40	No	No
Wax	50	No	No
Sugar	170	Yes	No
Dishwasher soap (powder)	851	Yes	Yes

Question

Which of these household substances have ionic properties, and which have molecular properties?

Analyze and Interpret

1. Examine the substances in the table above. Look for substances that have similar properties.
2. Based on the qualitative and quantitative data, sort the substances into two groups: "ionic properties" and "molecular properties." You may need to have a third group that cannot be identified as either.

Conclude and Communicate

3. Identify the substances that had molecular properties and the substances that had ionic properties. Were there substances that could not be classified? If so, explain why they could not be classified.

Extend Your Inquiry and Research Skills

4. **Research** Determine how the physical properties listed for these common household substances make them useful and/or hazardous in the home.