

SKILLcheck

- Observing
- Classifying
- Controlling variables
- Working cooperatively

Safety

- Handle hot objects with care.
- Keep hair and loose clothing away from the flame.

Materials

- 3 metal paper clips
- crucible tongs
- Bunsen burner
- heat-resistant pad
- beaker
- cold water

Blacksmiths use hardening and heat treatment to shape horseshoes and other metal objects in a process called tempering. In this investigation, you will demonstrate how these methods affect a smaller metal object—a paper clip.

Question

How do hardening and heat affect the properties of a metal?

Procedure

1. Take one of the paper clips. Bend it so you have almost a straight metal wire.
2. Bend the wire carefully at one point to make roughly a right angle. Now bend the wire at the same point, at a right angle in the other direction.
3. Count the number of times you can bend the wire before it breaks. Record the number.
4. Straighten a second paper clip. Bend it as you bent the first one but only half the number of times you took to break the first one.
5. Hold the second paper clip in your tongs and heat it in a Bunsen burner flame until it is glowing. Heat it for about 10 s more, and then hold it in the air to cool slowly. Place it on the heat-resistant pad and leave it to cool to room temperature. You will use this wire again in step 8.
6. Half fill the beaker with cold water. Using the third paper clip, repeat step 4. Heat this paper clip so it glows for about 10 s and then quickly put it into the cold water. Let it cool for about 1 min.
7. Retrieve the wire from the water, and count the number of right-angle bends you can make before it breaks. Record the number.
8. Use the wire from step 5. Count the number of right-angle bends you can make before this wire breaks. Record the number.
9. Clean up and put away your equipment.

Analyze

1. You compared the flexibility of a metal wire that was heated and allowed to cool slowly with the flexibility of another that was cooled rapidly.
 - (a) Which treatment resulted in a wire that was hard and brittle?
 - (b) Which treatment resulted in a wire that was more flexible?

Conclude and Apply

1. Write a short paragraph explaining the effect that hardening and heating can have on a metal.