Design Challenge Student Worksheet

Comparison of Wire

**Overview:** In this activity, you will determine which of a set of wires is a unique metal alloy called Nitinol. Nitinol is called a shape memory alloy (SMA) because it can “remember” its original shape under certain conditions after being bent, twisted, or stretched out of shape.

**Objectives:** Students will

1. Know that a shape memory alloy “remembers” original shape after being deformed.
2. Know that Nitinol can undergo phase changes while in the solid state, and these phases are temperature dependent.

**Materials:**

Plastic bag containing 3 different wires

2 – 150mL beakers

Ice

Hot plate

Candle or matches

Tongs

Thermometer

**Procedures:**

**Part 1:**
1. Read about the history of Nitinol wire and answer questions below.
   a. What two metals make up Nitinol?
   b. What is NITINOL an acronym for?
   c. What larger project was William J. Buehler working on when he discovered something unique about nickel-titanium alloys?
   d. What initially compelled Buehler to drop one of the cooled bars on the concrete floor?
   e. Why did Dr. Muzzey heat the demo wire with his pipe lighter?
   f. How do your answers in questions in d and e show that doing science involves curiosity, imagination, and creativity?
   g. Provide evidence from the reading that shows how science is NOT a solitary activity.

**Part 2:**
1. Your teacher has given your group a container with the following materials: Pieces of wire, beakers, water, ice, hot plate, candle, matches, tongs, plastic container, and thermometer.
2. Prepare two beakers of water—one that contains hot water (80º C or higher) and another that...
contains ice water. Deform each of your pieces of wire (bend, twist, pull, reshape, etc), place them in the hot water and record below your observations

3. Using tongs or tweezers, try to bend the wire while it is still in the hot water. Are any of the wires easily deformable at this temperature?

4. Now remove each piece of wire from the hot water USING TONGS or tweezers and drop them into the ice water WITHOUT deforming them. Observe the wires for a few moments as it cools down. Record your observations below.

5. Decide which of the wires the Nitinol wire is and check your choice with the teacher.

6. Read the information below:

How Nitinol Works

We're all familiar with such phase changes as the melting of ice or vaporization of water. Less known is that such phase changes can occur when both phases are solid such as the change from graphite to diamond. Many materials undergo such transformations, which involve rearrangement of the position of atoms, molecules, or ions within the crystal lattice. In a non-memory metal the strain of deformation is absorbed by the rearrangement of the crystals, and it is impossible to get the crystals back into exactly the original position. In Nitinol, the crystals stay in place; the atoms within the crystals rearrange themselves, and the distorted object reverts to its original shape.

Part 3:

1. Try to change the pre-set shape of your piece of Nitinol wire by holding it into a desired shape over a candle. DO NOT DO THIS WITH YOUR BARE HANDS! Follow direction below:
   a. Choose a simple shape, such as a loop or a horseshoe, and use your forceps to hold your piece of Nitinol wire in this shape. Hold both ends to maintain shape.
   b. Hold the wire in place as you place it in the flame. The wire will initially resist and attempt to return to its original shape, but you must continue to apply pressure and keep the wire held in its new position.
   c. As soon as you feel a release of tension as you are heating, you may remove the wire from the flame.
   d. Let the wire cool down before touching it.
   e. After the wire is completely cooled down straighten the wire out.
   f. Place the wire in the container of hot water from part 2. Does your wire remember the shape from Part 3?