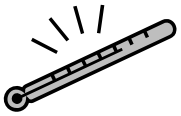
Taking Its Temperature

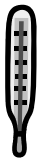


Nitinol, otherwise known as *memory metal*, will spring back to its original shape when it is heated above a certain temperature, called its ***transition temperature.*** The transition temperature can vary between about –140ºC (-220ºF; as cold as winter on Mars' poles) and 75ºC (167ºF; as hot as a cooked chicken out of the oven).

In this activity, you will determine the transition temperature of a piece of Nitinol wire.

Time: 20-30 minutes. Parents, please supervise children.

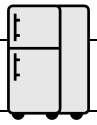
Materials



- Piece of Nitinol wire[1]
- Bowls or containers
- Cold Water and Hot water (you may need to heat this water above the temperature at which it comes out of the tap)
- Thermometer that measures temperatures from 0ºC to 100ºC

Pre-activity

Make a prediction. At what temperature do you think the Nitinol bounces back to its original shape? This chart may be helpful.

Temperature		Description
Celsius (ºC)	Fahrenheit (ºF)	
0 ºC	32 ºF	Ice cubes
3 ºC	37 ºF	The inside of your refrigerator 
22 ºC	72 ºF	Room temperature
37 ºC	99 ºF	Normal body temperature
39 ºC	102ºF	A hot tub 
49 ºC	120 ºF	Hot water from the tap
59 ºC	138 ºF	Swiss cheese melts 
75 ºC	167 ºF	Roast chicken coming out of the oven
100ºC	212 ºF	Boiling water 

Activity

[1] Nitinol wire may be purchased at the following websites, as well as other sources:
Educational Innovations: www.teachersource.com
Images SI, Inc.: www.imagesco.com
Livewire: www.tinialloy.com/livewire.html

- Bend the wire.
- Put it in hot water. Does it change shape?
  Be careful with very hot water.
- Measure the hot water's temperature. Record your data on the chart on the other side.
- Add some cold water. Does the wire change shape now? Record your data.
- Repeat, adding cold or hot water to change the temperature, until you have determined the transition temperature to within a few degrees.

  Question: How close was your prediction to your result?

Water Temperature	Did the wire change shape?

What's going on?

Nitinol is a mixture of two different metals, Nickel and Titanium. At a certain temperature, its ***transition temperature,*** it changes from one solid ***phase*** to another. Below this temperature, Nitinol is soft and bendable, and will hold its bent shape. Above this temperature, Nitinol is stiff, and if you try to bend it, it will spring back. When the change from one phase to another occurs, Nitinol bounces back to the original shape it was made in.

Scientists can set the transition temperature of Nitinol by changing the amounts of Nickel and Titanium in the alloy. It can vary from about 47% Nickel, 53% Titanium to about 51% Nickel, 49% Titanium.

Question: Nitinol is often used in orthodontic archwires. These are the wires that connect the brackets in braces. The orthodontist bends the wire into the current shape of a patient's teeth, and connects it to the

braces. Once in the patient's mouth, the wire warms up, tries to change shape, and pushes on the teeth. What do you think is the transition temperature of a Nitinol archwire?

Question: If Nitinol were used in a coffee pot or a teakettle so it would turn off at just the right temperature, what do you think its transition temperature would have to be?

Question: Flexon® eyeglasses frames are made out of Nitinol. They are in their high-temperature form, which is springy, at room temperature. This is why you can bend them around your finger without breaking them. How low do you think their transition temperature is?

Image Courtesy of Memry Corporation (www.memry.com)

(Answers at bottom of page)

For More Information

- Nitinol Movies! From NDC (Nitinol Devices and Components)
  http://www.nitinol.info/flash/index.html

- The Basics of Shape Memory, from the UltimateNiTi website:
  http://www.ultimateniti.com/documents.cfm?cid=12

Vocabulary

Nitinol: An alloy of Nickel and Titanium that returns to its previous shape when you heat it up.

Phase: A specific form of matter that exists within a certain range of temperature and pressure. This includes gas, liquid, solid and plasma. A material may have several solid phases that exist at different temperatures and pressures.

Transition temperature: The specific temperature at which Nitinol changes phases.

References:

Teaching General Chemistry: A Materials Science Companion. Arthur B. Ellis, Margret J. Gesselbracht, Brian J. Johnson, George C. Lisensky and William R. Robinson. Published by the American Chemical Society, 1993.

Dr. Robert W. Baker, DDS. Orthodontics Associates, Ithaca, NY. Personal communication.

Special thanks to Memry Corporation for use of images.

Question answers:

- The transition temperature of orthodontic archwires is usually about 80-90 °F (27-32 °C). This is a little lower than the temperature of the inside of your mouth (about 95 °F, or 35 °C).
- Coffee and tea brews well just below boiling temperature, at about 200 °F, or 93 °C.
- Nitinol eyeglass frames have a transition temperature much below freezing, so the transition doesn't happen in cold weather