Health and safety

This experiment involves using hot water and naked flames. Appropriate care should be taken for both of these. Participants should be aware that the metal will be hot when in the water or the flame and should handle it with care (using gloves or tweezers).

What happens in this experiment?

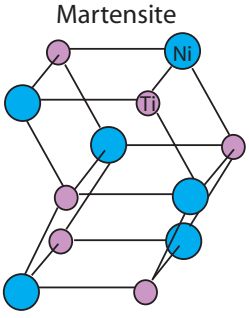
Most metals are very hard and take a lot of effort to deform, but once they have been moulded into shape they will stay like that until another force changes them. Memory metals, or 'shape memory alloys' (SMAs) are different. They can be 'programmed' to remember a specific shape and if the metal is bent or deformed it quickly returns to its original configuration.

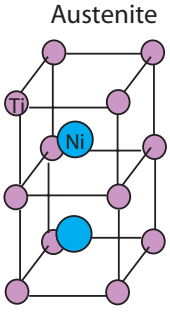
This is because memory metal has two distinct crystal structures at the nanoscale and can be made to flip between them. Both are regular lattices. The so-called 'parent' phase (or 'austenite' phase) occurs when the metal is at higher temperatures. When shaped at high temperatures the metal will 'remember' this shape. As the metal cools, its crystal structure changes to the second ('martensite') phase. Gentle heating of the metal makes it return to its original parent shape.

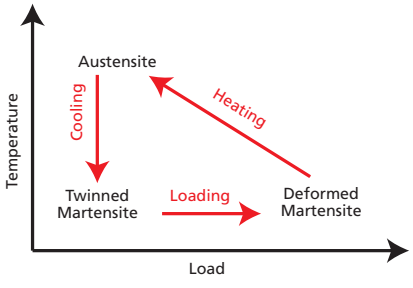
The memory metal that you have is called 'Nitinol' and it is an alloy of nickel and titanium.

The transformation in both directions (martensite to austenite and vice-versa) is instantaneous. By making small changes in the relative composition of the Nitinol, the temperatures at which the two phases occur can be changed.

The Nitinol provided is in its martensitic phase at room temperature. It can be deformed at will before being heated, which will force it to return to its parent phase.







Applications

Glasses which are made of memory metal take advantage of a phenomenon called 'pseudoelasticity'. In this instance, the metal is in its austenite phase at room temperature and the martensitic phase is brought about by applying a stress, rather than cooling. When the stress is removed, the metal reverts to its austenite phase and its associated shape.

Nitinol is used in orthodontics for braces. Once the Nitinol is placed in the mouth its temperature rises to ambient body temperature causing it to contract back to its original shape. This results in a constant force being applied to the teeth. Nitinol wires do not need retightening as often as they can contract as the teeth move, unlike conventional stainless steel wires.

Ideas for conducting the activity or discussion

- Memory metal is good fun - let the participants see how much they can deform the metal; provided they don't tie it in a knot, it should return to its original shape when put into hot water.
- Ask participants what they think memory metal could be used for? It can be used in glasses, and also in stents. Stents are medical devices that help to keep open vessels within the body (such as veins or arteries). They can be inserted collapsed (in their deformed state) and then gently heated to make them expand (into their memory state). This helps reduce tissue damage while the stent is being put in place.

Learning objectives or school curriculae

- Basic understanding of the crystal lattice structure of metals.
- Understanding of the practical applications of shape memory alloys.