

# Making solder

## Teacher notes

In this practical, students will:

- Use their scientific knowledge and understanding to explain what is meant by an alloy.
- Produce an alloy (solder).
- Analyse how the properties of solder differs from its constituent elements.
- (Extra) Calculate the density of their alloys and compare this with the densities of the constituent elements.

## How to use this experiment

This activity could open with a discussion about alloys:

- Do they know what an alloy is?
- What they are used for?
- Where we might see alloys in the world around us?

This is designed to gain some perception of the ideas students have about glass as a material. For reference the background notes below might help.

## Keywords

The keywords for this activity are:

- Mixture
- Metal
- Element
- Crystal

## Health, safety and technical notes

1. [Read our standard health and safety guidance.](#)
2. Wear eye protection throughout.
3. Lead, Pb(s), (TOXIC, DANGEROUS FOR THE ENVIRONMENT) – see CLEAPSS Hazcard HC056.
4. Tin, Sn(s) – see CLEAPSS Hazcard HC102A.
5. Carbon, C(s) – see CLEAPSS Hazcard HC021.
6. Some tongs in schools do not grip well and the hinges can stick. Technicians must check them before starting the experiment.
7. Casting sand may be available from school Design and Technology departments. If unavailable, a ceramic tile (eg old bathroom tile) could be used instead. If a tile is used, a sand tray will not be required.

## Curriculum range

This practical is really designed for secondary students and the aim is to gain some understanding of the way the materials are used to create artefacts. It links with:

- Setting up simple practical enquiries, comparative and fair tests;
- Reporting on findings from enquiries and observations, including oral and written explanations, displays or presentations of results and conclusions;
- Using straightforward scientific evidence to answer questions or to support their findings;
- Build a more systematic understanding of the chemistry of metals and alloys by exploring the way metals can be used to make a different substance with useful properties;
- Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience;
- Use appropriate techniques, apparatus, and materials during laboratory work, paying attention to health and safety;
- Make and record observations using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements;
- Present observations using appropriate methods;
- Interpret observations and identify patterns using those observations to draw conclusions;
- Present reasoned explanations, including explaining data in relation to predictions and hypotheses;
- Learn about the concepts of mixture, metal, element and crystal.

## Background notes

In its scientific usage, the term metal means a metallic element. An **alloy** is a mixture or solid solution composed of a metal and another element. But in everyday language, we often use the word metal to describe what an alloy is.

That is because a mixture of metallic elements is called an alloy. Iron is a metal element. Steel is a mixture of iron with other elements such as carbon, nickel, chromium, etc. and so is an alloy.

An alloy is a mixture of either pure or relatively pure chemical elements, forming an impure substance retaining the characteristics of a metal. Alloy constituents are usually measured by mass.

An alloy is distinct from an impure metal, such as wrought iron, in that, with an alloy, the added impurities are usually desirable and will typically have some useful benefit.

Alloys are made by mixing two or more elements; at least one of which being a metal. This is usually called the primary metal or the base metal, and the name of this metal may be the name of the alloy. The other constituents may or may not be metals but, when mixed with the molten base, they will be soluble, dissolving into the mixture.

Unlike pure metals, most alloys do not have a single melting point; rather, they have a melting range in which the substance is a mixture of solid and liquid. When the alloy cools

and solidifies (crystallizes), its mechanical properties will often be quite different from those of its individual constituents.

A metal that is normally very soft and malleable, such as aluminium, can be altered by alloying it with another soft metal, like copper. Although both metals are very soft and ductile, the resulting aluminium alloy will be much harder and stronger.

Adding a small amount of non-metallic carbon to iron produces an alloy called steel. Due to its very-high strength and toughness (which is much higher than pure iron), and its ability to be greatly altered by heat treatment, steel is one of the most common alloys in modern use. By adding chromium to steel, its resistance to corrosion can be enhanced, creating stainless steel, while adding silicon will alter its electrical characteristics, producing silicon steel.

Hence alloys may be a homogeneous solid solution, a heterogeneous mixture of tiny crystals, a true chemical compound, or a mixture of these. Alloys are used more extensively than pure metals because they can be engineered to have specific properties. This leads to a number of definitions of different types of alloys:

- **amalgam** an alloy containing mercury;
- **eutectic mixture** a mixture of substances having a melting point lower than that of any of its components;
- **microstructure** the fine structure of a pure metal or alloy, as revealed by magnifications of 25x or greater.

The alloy solder can be made by heating together the metals lead and tin.

In countries where lead is prohibited for use in school then the tin–silver–copper combination can be used as reliable and easy to work with as a replacement for the lead. If this is chosen as the route, then the formulation is 95.5% tin, 3.9% silver, 0.6% copper. It is known as SAC solder from the chemical symbols of each of the elements (Sn, Ag, Cu). In this case the quantities of metals per group should be 7.95 g tin, 0.325 g silver and 0.5 g copper.

Tin: lead solders, also called soft solders, with tin concentrations between 5% and 70% by weight. Alloys commonly used for electrical soldering are 60:40 Tin: lead (Sn: Pb) which melts at 188°C.

In plumbing in the past, a high proportion of lead was used, commonly 50:50. This made the alloy solidify more slowly, so that it could be wiped over the joint to ensure it was watertight, before soldering. Lead water pipes were displaced by copper when the significance of lead poisoning was fully appreciated but lead solder was still used until the 1980s. Since even small amounts of lead have been found detrimental to health lead in plumbing solder was replaced by silver (food grade applications) or antimony, with copper often added, and the proportion of tin was increased.

## Taking the work further

To more accurately determine the density of the solder.

To add in some mathematics you could get the students to weigh the alloy to find the mass. Then to work out its volume by displacement of water in a Measuring cylinder or a Eureka can.

They could then calculate the density from the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

They can then compare the density of the solder alloy with the lead and tin they added.