

Making solder

Student handout

In this practical I will be:

- Using my scientific knowledge and understanding to explain what is meant by an alloy.
- Producing an alloy (solder).
- Analysing how the properties of my alloy differ from its constituent elements.
- (Extra) Calculating the density of my alloy, and comparing this with the densities of the constituent elements.

Introduction

You are working on a piece of jewellery for a client which requires several delicate pieces of silver to be joined together. You know that plumbers often use join metal pipes in peoples' houses using a mixture of tin and lead, called solder.

Unfortunately, you don't know what the ratio of metals is best, so like all good science-artists, you decide to investigate further...

Procedure

Wear eye protection throughout.

Making the alloy

1. Weigh out 1 g each of lead and tin. Put the lead into the crucible, but keep the tin to one side.
2. If using casting sand, fill one of the sand trays with casting and push your finger into it to make an indent. This is your cast.
3. Put the crucible onto a pipe clay triangle. Make sure that it is stable on a tripod and mat.
4. Heat the crucible strongly with a Bunsen burner until the lead is molten. Add a spatula of carbon powder to the top of it to prevent a skin forming.
5. Add the tin and stir with a spatula until the metals are both molten and thoroughly mixed.
6. Move the Bunsen away from the tripod and put it onto a yellow flame. Wearing thermal protection gloves, pick up the crucible using the tongs, and pour the molten metal into the cast or onto a ceramic tile. NOTE: take great care as you do this to avoid splashing or dripping.
7. Let it cool down completely before you touch it.

Testing the alloy

1. To test hardness, try to scratch the alloy with the lead, and the lead with the alloy. The one which does not scratch is the hardest.
2. To test density, hold the lead in one hand and the alloy in the other. Which seems to be the heaviest/most dense?
3. To test melting point, put the alloy, a piece of tin and a piece of lead onto a sand tray. They should all be the same distance from the middle of the dish. Heat the dish gently in the middle. When two of the metals have melted, stop heating.

Questions

- Which metal is the hardest?
- Is the alloy harder or softer than either of the metals?
- Which seems to be the heaviest/most dense?
- Which metal melts first?
- Which metal melts second?

Going further

- Find the mass of a piece of the alloy.
- Work out the volume of the same piece by the displacement method.
- Then calculate the density using the formula:

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

- Compare the density of the solder alloy with the density of the starting metals.
- Try repeating the activity but varying the proportions of metals to tin and see if it makes a difference to the properties of the solder.

Background

In everyday language, we often use the word metal to describe what an alloy is. In its scientific usage, the term metal means a metallic element.

A mixture of metallic elements is called an alloy. So, iron (an element) is a metal; but steel (a mixture of iron with other elements such as carbon, nickel, chromium, etc.) 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.

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.

When the alloy cools and solidifies (crystallizes), its properties will often be quite different from those of its individual constituents.

The alloy solder can be made by heating together the metals lead and tin. Tin/lead solders, are also called soft solders, contain tin concentrations between 5% and 70% by weight.

Alloys commonly used for electrical soldering are 60:40 tin/lead (Sn/Pb). This type of solder melts at 188°C.

In plumbing, metal pipes are joined together with an alloy called solder. In the past, a high proportion of lead was used in the alloy, typically 50:50 tin: lead. This made the alloy solidify more slowly, so that it could be wiped over the joint to ensure it was watertight, before soldering.

When the significance of lead poisoning was fully appreciated lead water pipes were no longer used, and copper pipes were used instead. But lead solder was still used until the 1980s. More recently, research has shown that even small amounts of lead can be detrimental to health, so lead in plumbing solder was replaced by silver (food grade applications) or antimony, with copper often added, and the proportion of tin was increased.