

A smelter on a stick

Smelting iron ore to iron on a gas burner

Iron metal does not occur as such in nature. It reacts too easily with other elements to form compounds such as iron oxide, which are known as **iron ores**.

Demonstrate how iron ore can be smelted to iron, using a “micro-smelter” on a gas flame.

Hold a small wooden stick (e.g. a coffee stirrer) in a hot blue gas flame for a few seconds. Try to char it, rather than letting it burn too much, and put the flame out by wetting it. Explain that the black material you have made is charcoal, which was used to extract iron metal from iron ore in the days before industry used coke (made from coal), instead.

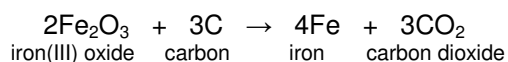
Dip the charcoal end of the stick into powdered iron (III) oxide (iron ore), until it has become coated with the powder.

Put the coated end of the stick into the hot blue flame and heat it until it glows orange.

Stub it out and grind the result to ash in a pestle and mortar, or by using a weight, as in the photograph.

Stroke the ash with a small bar magnet, and look for tiny crystals of iron sticking to the magnet.

Show pupils that the iron (III) oxide powder does not stick to the magnet, so a chemical change must have taken place, as follows:



Pupils may like to retain the iron crystals by picking them up on sticky tape and mounting them in their books.



Step 2 – dipping the charcoal stick into iron oxide powder



Step 3 – smelting iron oxide with charcoal



Step 1 – making a ‘charcoal stick’



Step 4 – picking up iron crystals with a magnet, after crushing (Photos: Heidi Dobbs, RSC)

The back up

Title: A smelter on a stick

Subtitle: Smelting iron ore to iron on a gas burner

Topic: A simple introduction to the smelting of metal ores by reducing them to the metal with charcoal.

Age range of pupils: 10 -14 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:

- handle simple equipment safely in the presence of an open flame;
- extract a small amount of iron metal from its powdered ore, by carrying out a non-reversible reaction;
- appreciate the difference between a metal and its ore;
- understand that iron is a single element, but that its ore is a compound;
- determine that iron is magnetic but that iron (III) oxide, as used in the laboratory, is not.

Context: This lesson can follow a classification exercise, such as Earthlearningidea "Found in the ground", where pupils are introduced to the differences between a metal and its ore.

Following up the activity: Pupils could be asked to:

- find out how iron is smelted on an industrial scale, and what other components are used in the process.
- list a number of other metals and find out which are their main ore minerals.

The teacher could carry out a demonstration of smelting lead from the ore, galena. This may be done IN A FUME CUPBOARD, with the crushed galena on a charcoal block and using a blowlamp to heat it. The transformation from a few angular brittle fragments of galena to a flowing globule of molten lead is fascinating.

Underlying principles:

- In the natural world, iron and most other metals are too reactive to occur as the native element (the exceptions are low-reactivity metals such as gold and silver).
- A source of carbon is needed for the metal ore to be reduced (by removal of oxygen) to the metal.
- The oxygen in the ore combines with the charcoal to form carbon dioxide gas.

- For centuries, charcoal was used to smelt iron, but it was largely superseded during the Industrial Revolution, when it was found that coke made from coal could be used instead.
- On an industrial scale, iron is smelted in blast furnaces using coke, and limestone is added, to combine with impurities in the iron ore. This forms slag, which is tapped off from a vent in the furnace before the molten iron is poured out.

Thinking skill development:

Linking the small scale activity to the real world of the blast furnace is a bridging activity.

Resource list:

- gas burner, or Bunsen burner and gas supply
- heat proof mat
- pestle and mortar or heavy weight
- powdered iron (III) oxide
- small wooden sticks, e.g. wooden splints or large coffee stirrers
- small bar magnet
- water, for quenching flame
- eye protection
- sticky tape

Risk assessment

There is a risk of damage to eyes and of burns. Eye protection should be worn during the activity. Hair should be tied back and inflammable clothing kept well clear of a naked flame. Water should be available in case of any minor burns. If the extension activity with lead ore is attempted, the same precautions should be taken and the activity **MUST** be performed in a fume cupboard to avoid inhalation of lead compounds.

Useful links: www.earthlearningidea.com "Found in the ground".

Source: This activity was devised by Jane Essex, of Keele University. The photographs were taken by Heidi Dobbs, of the Royal Society of Chemistry, during an activity session at the Black Country Museum in 2012.

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