The reaction between zinc and copper oxide

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In this experiment copper(II) oxide and **zinc** metal are reacted together. The reaction is **exothermic** and the products can be clearly identified. The experiment illustrates the difference in **reactivity** between zinc and **copper** and hence the idea of **competition** reactions.

Lesson organisation

This is best done as a demonstration. The reaction itself takes only three or four minutes but the class will almost certainly want to see it a second time. The necessary preparation can usefully be accompanied by a question and answer session. The zinc and copper oxide can be weighed out beforehand but should be mixed in front of the class.

If a video camera is available, linked to a TV screen, the 'action' can be made more dramatic.

Apparatus and chemicals

Eye protection

Bunsen burner
Heat resistant mat
Tin lid
Beaker (100 cm^3)
Circuit tester (battery, bulb and leads) (Optional)
Safety screens (Optional)
Test-tubes, 2 (Optional – see Procedure g)
Test-tube rack

Access to a balance weighing to the nearest 0.1 g

The quantities given are for one demonstration.

Copper(II) oxide powder (**Harmful, Dangerous for the environment**), 4 g
Zinc powder (**Highly flammable, Dangerous for the environment**), 1.6 g
Dilute hydrochloric acid, approx. 2 mol dm^{-3} (**Irritant**), 20 cm^3
Zinc oxide (**Dangerous for the environment**), a few grams
Copper powder (**Low hazard**), a few grams.
Concentrated nitric acid (**Corrosive, Oxidising**), 5 cm^3 (Optional – see Procedure g)

Technical notes

Copper(II) oxide (**Harmful, Dangerous for the environment**) Refer to CLEAPSS® Hazcard 26.
Zinc powder (**Highly flammable, Dangerous for the environment**) Refer to CLEAPSS® Hazcard 107
Dilute hydrochloric acid (**Irritant** at concentration used) Refer to CLEAPSS® Hazcard 47A and Recipe Card 31
Concentrated nitric acid (**Corrosive, Oxidising**) Refer to CLEAPSS® Hazcard 67
Copper powder (**Low hazard**) Refer to CLEAPSS® Hazcard 26
Zinc oxide (**Dangerous for the environment**) Refer to CLEAPSS® Hazcard 108.

Procedure

HEALTH & SAFETY: Wear eye protection throughout. Consider placing safety screens around the experiment (Samples of zinc can vary considerably in reactivity, depending on particle size and the state of surface oxidation.)

a Weigh out 2 g (0.025 mol) of copper oxide and 1.6 g (0.025 mol) of zinc powder.

b Mix thoroughly to give a uniformly grey powder.

c Pour the mixture in the shape of a 'sausage' about 5 cm long onto a heat resistant mat or clean tin lid.

d Heat one end of the 'sausage' from above with a roaring Bunsen flame until it begins to glow, then remove the flame. A glow will spread along the 'sausage' until it has all reacted. A white/grey mixture will remain.

e Heat this to show that the white powder (zinc oxide) is yellow when hot and white when cool.

f Pour the cool residue into a 100 cm^3 beaker and add a little dilute hydrochloric acid to dissolve the zinc oxide (and also any unreacted zinc and copper oxide), warming if necessary. Red-brown copper will be left. This can be rinsed with water and passed around the class for observation. Show that the powder conducts electricity using a circuit tester.

g If further confirmation of identity is required, treat a small amount of the red-brown powder with a few drops of concentrated nitric acid in a test-tube in a fume cupboard. A brown gas (NO_2, Very Toxic) is given off as the copper reacts and dissolves. After the reaction adding a little water makes the blue solution of copper(II) nitrate visible.

Teaching notes

The depth of discussion depends on the level of the students involved. Essentially it is a competition between metal(1) and metal(2) for oxygen in a reaction represented by:

Metal(1) + Metal(2) oxide → Metal(1) oxide + Metal(2)

The more reactive metal displaces the less reactive metal from its oxide, as in the case of zinc and copper(II) oxide, for example:

$Zn(s) + CuO(s) \rightarrow ZnO(s) + Cu(s)$

Demonstrate that zinc oxide goes yellow when heated and returns to white when cool to help confirm the identity of this product. (This phenomenon is caused by a change in crystal structure - a genuine example of a 'physical change'.)

Where appropriate, it could be pointed out that these reactions are redox reactions, the more reactive metal behaving as a reducing agent, and the metal oxide acting as an oxidising agent. This could be extended to consider these redox reactions in terms of the loss and gain of electrons by the metals.

Other metals can be used, but take care to compare like with like. Coarse magnesium powder, for example, gives a less vigorous reaction than powdered zinc. Finely powdered magnesium gives a very vigorous reaction and should only be attempted with great care. The reaction between aluminium powder and copper oxide is almost explosive and must not be attempted.

Reference

This experiment has been reproduced from Practical Chemistry:
http://www.practicalchemistry.org/experiments/intermediate/metals/the-reaction-between-zinc-and-copper-oxide,303,EX.html

Useful resource

A number of other experiments in this book explore the competition principle. Examples include:
Experiment 39: *Displacement reactions between metals and their salts*
Experiment 40: *Extracting metals with charcoal*
Experiment 43: *The thermite reaction*

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