39 Displacement reactions between metals and their salts

Some metals are more **reactive** than others. In this experiment, a strip of metal is added to a solution of a compound of another metal. A more reactive metal displaces (pushes out) a less reactive metal from its compound. In carrying out the experiment, students investigate **competition** reactions of **metals** and arrive at a **reactivity series** of the four metals they use.

Lesson organisation

There are many ways of carrying out this series of reactions. The one described here uses a spotting tile but the same procedure could be adapted for use with test-tubes. The advantages of the spotting tile method include:

- very small quantities of chemicals are used
- the whole set of experiments is displayed together, making comparison easier
- clearing-up afterwards is simple and avoids metal deposits being left in sinks.

Careful thought needs to be given to distribution of the chemicals to the class. Solutions could be distributed in test-tubes, or in small bottles fitted with droppers for sharing between several pairs of students. Metals could be issued in sets. The teacher should keep control of the magnesium ribbon, dispensing short lengths when required.

There should be no flames alight so that students are not tempted to burn pieces of magnesium and the teacher should be alert to the possibility of pieces of magnesium being removed from the laboratory.

The experiment should take about 30 minutes.

Apparatus and chemicals

Eye protection

Each student or pair of students will require:

Spotting tile, with at least 16 depressions (or two smaller tiles)
Dropping (teat) pipette
Beaker (100 cm^3)
Felt tip pen or other means of labelling

Access to about 5 cm^3 each of the following 0.1 mol dm^{-3} metal salt solutions:
Zinc sulfate (**Low Hazard** at this concentration),
Magnesium sulfate (**Low hazard**)
Copper(II) sulfate (**Low Hazard** at this concentration)
Lead(II) nitrate (**Toxic, Dangerous for the environment**)

Five samples, approximately 1 cm lengths or squares, of the following metals. The metals, except lead, present are **low hazard** as used here.
Zinc foil
Magnesium ribbon
Copper foil
Lead foil (**Toxic, Dangerous for environment**)

Technical notes

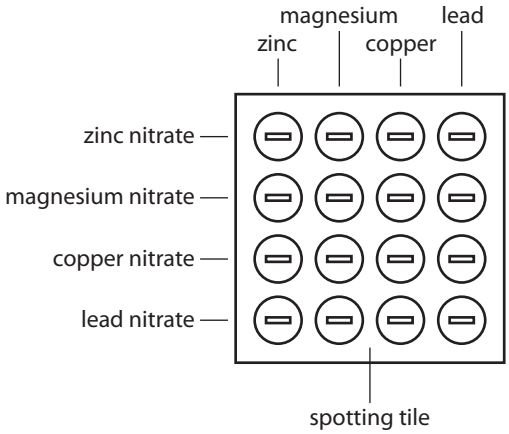
Zinc sulfate (**Harmful, Oxidising**) Refer to CLEAPSS® Hazcard 108.
Magnesium sulfate (**Low Hazard**) Refer to CLEAPSS® Hazcard 59B.
Copper(II) sulfate (**Harmful**) Refer to CLEAPSS® Hazcard 27B.
Lead nitrate (**Toxic, Dangerous for the environment**) Refer to CLEAPSS® Hazcard 57A.
Zinc foil (**Low Hazard**) Refer to CLEAPSS® Hazcard 107.
Magnesium ribbon (**Low Hazard**) Refer to CLEAPSS® Hazcard 59A.
Copper foil (**Low Hazard**) Refer to CLEAPSS® Hazcard 26.
Lead foil (**Toxic, Dangerous for Environment**) Refer to CLEAPSS® Hazcard 56.

1 Solutions may be dispensed in 5 cm^3 beakers to each pair of students or in small bottles fitted with droppers to groups of students.

2 Metals should be approximately 1 cm lengths or squares of ribbon or foil cleaned with emery cloth and as similar in size as possible.

Procedure

a Using a dropping pipette, put a little of the zinc nitrate solution in four of the depressions in the spotting tile, using the following illustration as a guide. Label this row with the name of the solution. Rinse the pipette well with water afterwards.



b Do this for each solution in turn , rinsing the pipette when you change solution.

c Put a piece of each metal in each of the solutions, using the illustration as a guide.

d Over the next few minutes observe which mixtures have reacted and which have not.

What to record

Record which metals react with the solutions. A table may be useful. Use a ✓ to show reactivity and a ✗ to show no reaction.

Solution / Metal	Zinc	Magnesium	Copper	Lead
Zinc nitrate				
Magnesium nitrate				
Copper nitrate				
Lead nitrate				

Teaching notes

Remind the class that they are looking for cases where one metal displaces another. Some of the solutions are slightly acidic so that bubbles of hydrogen are sometimes seen. Explain that this does not count as displacement of one metal by another.

It might be best to get the class to tell you what they think the order of reactivity is while they still have the evidence in front of them, so that apparent discrepancies can be resolved.

Reference

This experiment has been adapted from Practical Chemistry:
http://www.practicalchemistry.org/experiments/intermediate/metals/displacement-reactions-between-metals-and-their-salts,304,EX.html

Useful resource

A number of other experiments in this book also illustrate the competition principle. Examples include:
Experiment 40: *Extracting metals with charcoal*
Experiment 42: *The reaction between zinc and copper oxide*
Experiment 43: *The Thermite reaction*

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