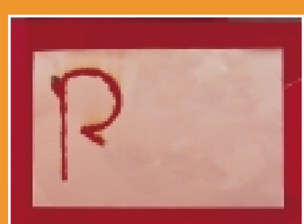
Chemistry demonstrations have an important role to play in teaching. They provide a visual attraction to the fun of chemistry and are a teaching aid for use with students.

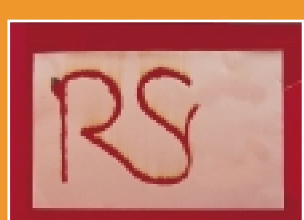
– They are often spectacular, stimulating and motivating.
– They allow students to see experiments which they would not be able to perform themselves, for reasons of skill, safety, expensive apparatus and materials or limited resources such as fume cupboards.
– They allow students to see a skilled practitioner at work.

The ideas behind the demonstrations in this book come from many sources. Some are original, but most have been collected from the literature and from chemistry teachers all over the world. As many come from more than one source, in general no attempt has been made to acknowledge the source – some were suggested by as many as thirty different people.

All the demonstrations have been compiled and rigorously tested by Ted Lister, The Royal Society of Chemistry Teacher Fellow 1993–94, at Warwick University to ensure reproducibility, and subsequently trialled by schools and colleges to produce a clear and concise set of instructions for teachers.



The illustrations on the left show "magic writing" created through the thermal decomposition of nitrates. A message is written on filter paper with a solution of sodium nitrate and is then dried. Applying a glowing taper to the start of the message makes the treated paper smoulder, and the message is revealed as the glow spreads its way through the treated paper only. For best effect use joined-up writing… a useful demonstration of the fire triangle: fuel, heat and oxygen, or for revising the equations for the decomposition of nitrates.



The illustrations on the right show the effect of adding dry ice to a measuring cylinder containing universal indicator and a weak alkali. Bubbles and a spectacular fog are produced, and the indicator changes colour from blue to orange as the acidic carbon dioxide gas dissolves in the water. It helps to use "bought" dry ice as that from a cylinder attachment floats and is less effective at saturating the solution. Other indicators can also be used such as phenolphthalein (pink to colourless), thymol blue (blue to yellow), phenol red (red to yellow) and bromothymol blue (blue to yellow).

The front cover illustration shows a "non-burning" £5 note. The note has been soaked in a mixture of ethanol and water, with the result that the alcohol burns but the note does not. Salt is added to colour the flame, which is otherwise almost invisible.

Classic Chemistry Demonstrations The Royal Society of Chemistry

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Introduction

Ted Lister

Since the curriculum development projects of the 1960s which stressed the importance of class practical work, demonstrations have gone somewhat out of fashion. However there are many reasons for carrying out demonstrations.

- They are often spectacular and therefore stimulating and motivating.
- They enable students to see experiments that they would not be able to perform themselves for a variety of reasons:
  - the experiment requires chemical skills that are beyond their own;
  - the experiment is potentially dangerous in unskilled hands;
  - the experiment requires expensive apparatus and/or chemicals; and
  - the experiment requires facilities, such as a fume cupboard, which are not available in sufficient numbers for class practical work.
- They allow students to see a skilled practitioner at work.

The ideas for the demonstrations in this book have come from a variety of sources. A few of them may be original, but most have been collected from the literature, both journals and books, (see the bibliography) and from chemistry teachers from all over the world. Many of the ideas come from more than one source and, in general, no attempt has been made to acknowledge the source. Variations on the "blue bottle" theme were suggested by at least 30 different people, for example!

Some of the demonstrations may be unfamiliar, others are classics. We have included many well known demonstrations because these will be useful to new chemistry teachers and to scientists from other disciplines who are teaching some chemistry.

All of the demonstrations have been tested at Warwick University by the author and have subsequently been trialled in schools and colleges where they have worked reliably. We had problems initially repeating some literature methods and often found that the temperature of the demonstration was critical. All of these experiments were carried out at room temperature (*ie* 15–25 °C) unless stated otherwise. Other factors can also affect the reproducibility of experiments, for example the exact degree of subdivision of powdered reagents. It is recommended that demonstrations are tried out thoroughly before doing them in front of an audience.

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List of demonstrations

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54. The ammonium dichromate 'volcano'

Topic

Exothermic reactions, general interest. It could be used to liven up an Earth science lesson but the resemblance to a volcano is coincidental.

Timing

About 2 min.

Level

Any for general interest. Post-16 if it is to be used along with thermodynamic calculations.

Description

A small conical heap of orange ammonium dichromate is ignited. It sparks and produces a large volume of green chromium(III) oxide as well as steam, resembling a volcano.

Apparatus

- Bunsen burner, heat-proof mat.
- Metal tray such as a large tea tray.
- Watch glass.
- Bell jar (optional).
- One 1 dm^3 flask (optional).
- One 250 cm^3 flask (optional).

Chemicals

The quantities given are for one demonstration.

- 10 g of **ammonium dichromate(VI)** (ammonium dichromate, $(NH_4)_2Cr_2O_7$).
- Wooden spill.
- A little **ethanol**.
- One piece of blue cobalt chloride paper.
- A little glass wool or mineral wool (optional).
- A few grams of silica gel granules (optional).
- Access to a fume cupboard (optional).

Method

The demonstration

Working in a fume cupboard, place a conical pile of about 10 g of ammonium dichromate on a heat-proof mat standing on a tray to collect the chromium oxide that shoots into the air. Soak about a 3 cm length of wooden spill in ethanol and stick this into the top of the pile so that about 2 cm protrudes to act as a wick. Light the wick. As the wick burns down into the ammonium dichromate, the compound begins to spark and decompose leaving behind a cone of green chromium(III) oxide that has a

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considerably larger volume than the original compound. Some of this oxide shoots into the air. The 'volcano' burns for between 30 seconds and one minute. Hold a watch glass above the 'volcano'; this becomes steamed up with water from the decomposition. Confirm that this is water with blue cobalt chloride paper.

The reaction may also be started by pointing a roaring Bunsen flame at the top of the pile of ammonium dichromate.

Visual tips

A portable fume cupboard gives all-round vision. If it is desirable to do the demonstration without a fume cupboard, place a large bell jar over the reaction. However, this soon steams up. Place matchsticks or something similar under the rim of the bell jar to allow the nitrogen produced in the reaction to escape.

Teaching tips

If appropriate, some students could be asked to predict the products given the formula of ammonium dichromate.

The demonstration could be used to enliven a lesson on thermodynamics (post-16) in which case students could be asked to calculate ΔH, ΔS and hence ΔG for the reaction. The values they should obtain are:

ΔH = –478 kJ mol^{-1}
ΔS = +217 J mol^{-1} K^{-1}
ΔG = –543 kJ mol^{-1}

They should be able to predict qualitatively that there is an entropy increase. The data required are given in the table.

	ΔH_f / kJ mol^{-1}	ΔS / J mol^{-1} K^{-1}
$(NH_4)_2Cr_2O_7$(s)	–1806	336 (estimated)
Cr_2O_3(s)	–1140	81
N_2(g)	0	192
H_2O(l)	–286	70

Post-16 students could also be asked to balance the equation using oxidation numbers.

Extensions

An alternative way of doing the experiment without a fume cupboard is as follows. Place about 3 g of ammonium dichromate in a 1 dm^3 conical flask. Place a loose plug of glass wool or mineral wool in the mouth of the flask to prevent loss of chromium(III) oxide. Start the reaction by heating the flask on a Bunsen burner with the tip of a roaring flame pointing at the pile of ammonium dichromate. Once the reaction has started, place the flask on a heat-proof mat in view of the audience. The flask will steam up somewhat and a little steam will escape. To confirm that this is a decomposition reaction rather than a combustion reaction, flush the flask with nitrogen from a cylinder and repeat the reaction. It will be unaffected.

It is possible to modify this method to suggest that a gas is formed. Replace the glass wool or mineral wool plug with a loose sandwich of glass wool and silica gel granules to absorb any steam *(see figure)*. Weigh the flask before and after the reaction. A weight loss will be observed suggesting loss of gas (although it is difficult to ensure that no steam escapes).

Calculation shows that 2.5 g of ammonium dichromate should produce about 240

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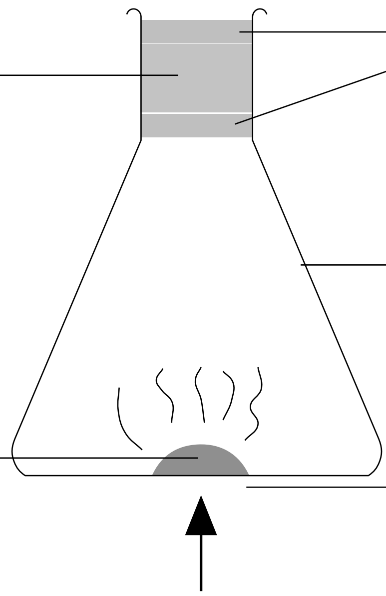
cm^3 of nitrogen. React 2.5 g of ammonium dichromate in a 250 cm^3 conical flask with a loose glass wool or mineral wool plug. Immediately the reaction has finished, place a lighted taper in the flask. The nitrogen will cause it to go out. Compare with a lighted taper in an air filled flask of the same size. It will burn for several seconds.



Alternative apparatus for volcano reaction

Theory

The reaction that occurs is:

$(NH_4)_2Cr_2O_7(s) \rightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(l)$

Further details

The value for the standard molar entropy of ammonium dichromate has been estimated by Latimer's rules, which state that the entropy of each atom of each element in a compound in $JK^{-1}\ mol^{-1}$ is given by:

$\Delta S^{\ominus} = (1.5R \ln A_r) - 3.92$

(where A_r is the relative atomic mass of the element and R the gas constant) and that the entropy of a compound is the sum of the entropies of all the elements in the compound.

For further details see W. M. Latimer, *J. Am. Chem. Soc.*, 1921, **43**, 818.

This rule may be found useful for estimating the entropies of other compounds which are not readily available in the literature.

Safety

Wear eye protection.

Dispose of the residue in a sealed plastic bag placed in the dustbin.

It is the responsibility of teachers doing this demonstration to carry out an appropriate risk assessment.