Activity 4: The heat is on! – can heat cause chemical breakdown?

Introduction: Try making your own lime from limestone – then find out how liming soil works.

Key Stage: Chemistry KS3

National Curriculum Ref: Sc3 1b, 1f, 3d.

Time: 10 - 15 minutes plus 10 minutes preparation

Pupil learning outcomes: Better understanding of: change of state; the evidence for particles; thermal decomposition; particle theory; dissolving; precipitation; cyclicity; acid + base → salt + water.

Context: The reactions involved in converting the raw material limestone into other useful products.

Common misconceptions: It is often not appreciated that calcium carbonate rocks (such as limestones) can be decomposed by heat, releasing a gas. Many people do not know that gases can be released by decomposing solids.

Resource list:

- Photograph of an old lime kiln

- Participant card per group
- Bunsen burner
- Tripod
- Gauze
- Tin lid
- Limewater
- Funnel
- Suction tube.
- Conical flask and bung
- Delivery tube
- Boiling tube
- Eye protection
- Powdered limestone (50/50 mix, $MgCO_3$ + $CaCO_3$, the magnesium carbonate decomposes more readily. Magnesium is found in dolomitic limestone so this is a justifiable 'fix'!)
- Soil
- Universal indicator

Lead-in: Introduce solid rock made of minerals (naturally occurring compounds). Is it possible to break this down using heat? If it is, how will we know that another solid material (a different compound) has been produced? How will we know if any liquid or gas has been produced? (Another solid (lime/quicklime) and a gas (carbon dioxide) are formed).

Activities: See the Participant cards for Activity 4.

Note: In Activity 4A, it is useful to use a 50/50, $MgCO_3$ + $CaCO_3$ mix instead of powdered limestone, as this decomposes more readily.

Follow up: The preparation for the plenary may include more discussion about the agricultural use of lime and the cement industry.

Extension 1: Demonstrate how slaked lime is made by dropping water onto the quicklime made by heating in Activity 4a. Then use Activity 4b to test whether lime (quicklime) or slaked lime is most efficient at adding alkali to soil water.

Extension 2: How could you tell where most of the CO_2 came from? Show heating without $CaCO_3$ (solid) to demonstrate that the Bunsen flame itself also produces CO_2 (gas).

The use of limestone on an industrial scale: Hope Valley Cement Works *(Activity 4)*

Extension 3: Ground limestone ($CaCO_3$) is frequently used on acid soils, rather than lime (CaO). It acts more slowly and the effects last longer in the soil.
This may be demonstrated by repeating Activity 4b, adding lime to one boiling tube as before, and ground limestone to the other, simultaneously.

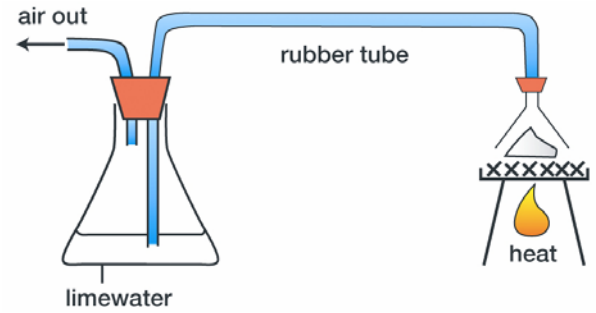
All photographs can be found in colour on the Earth Science Education Unit website

Activity 4: The heat is on! – Can heat cause chemical breakdown?

Introduction:
Try making your own lime from limestone – then find out how liming soil works.

Activity 4A: Making lime

- Set up the apparatus as shown in the diagram (do not let the funnel touch the tripod – it will shatter).



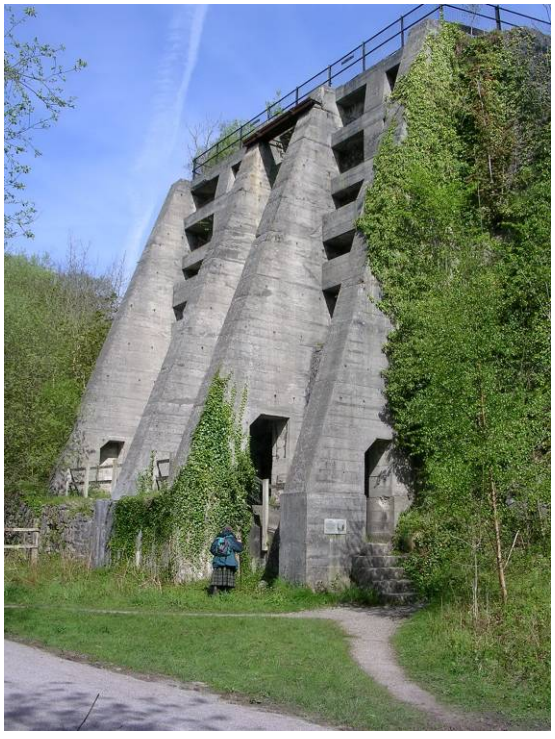
- Heat the limestone powder on top of the tin-can lid placed on a tripod gauze (eye protection)
- Does the gas dissolve into limewater making it cloudy (a white solid in suspension)?
- The remaining white solid on the tin-can lid is lime (calcium oxide).

Activity 4B: Using lime

- Mix soil with water in a boiling tube.
- When the soil has settled add Universal indicator. Record its colour.
- Add the material that you decomposed by heating (eye protection).
- Record how the colour of the indicator changes.

Activity 4C: Interpreting lime evidence

- If the gas released when limestone is heated dissolves into limewater to give a white solid (a calcium oxide precipitate) – this shows that it is carbon dioxide.
- Now complete this word equation:
  Limestone → Lime + ?
  (calcium carbonate) heat (?)
- When Universal indicator is added to soil water it goes green, showing it is acid/neutral/alkali. Which?
- When lime is added to soil, the colour changes to blue, showing it is acid/neutral/alkali. Which?
- This shows how using lime adds alkali to acidic soils, increasing their fertility.



An old lime kiln *(Activity 4)*

Soil liming is an important agricultural process now and in the past. In past times, where soil liming was needed, a lime kiln would be built. In the kiln limestone would be heated (using wood in early times, and later coal) as in Activity 4a. The calcium oxide formed usually had water added to it before being spread on the soil, as in Activity 4b. Ancient lime kilns can be found in many parts of the country (see photo). Today, the same process is used at lime manufacturing plants near limestone quarries and the lime is sold in bags for use by farmers and gardeners.

