

The heavy lift cup challenge

- Your task

Design and make a device to lift as heavy an object as possible at least 10 cm using, as an energy source, the reaction between 1 level teaspoon of bicarbonate of soda (sodium hydrogencarbonate) and 3 level teaspoons of citric acid. Once lifted, the object must stay there. As far as possible, the lifting device is to be constructed from 'junk' materials.

- Your final device must be loaded with chemicals, and be ready to start the experiment when the judges say so.

Based on a suggestion by P. Borrows.

Time

It is suggested that either:-

an entire morning be devoted to the problem (eg on the last day of term), which would allow 2 hours for practical activities and 30 minutes for judging

or

the problem be given to the class as a homework exercise 2 weeks or so before the judging. Judging could then take place in a normal double science lesson, allowing 45 minutes for repair and final adjustments, and 30 minutes for judging.

(The exercise is better as a pre-set problem for younger students.)

Group size

3–4

Equipment & materials

Eye protection.

Items from the 'junk' list (see 'In search of solutions additional handout') – to encourage creativity.

The judges will require access to a top-pan balance.

Per group

Standard masses (10 g & 100 g slotted masses, and 1 kg masses for the ambitious!), a metre or half-metre ruler, identical teaspoons (can be plastic).

Sodium hydrogencarbonate (maximum amount = 3 level teaspoons), citric acid (maximum amount = 9 level teaspoons), access to water.

Health & Safety notes

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be

obtained from reputable sources such as CLEAPSS [<http://science.cleapss.org.uk>] in England, Wales and Northern Ireland and, in Scotland, SSERC [<https://www.sserc.org.uk>].

Citric acid is an eye irritant. Eye protection should be worn.

It is the responsibility of the teacher to carry out a suitable risk assessment.

Curriculum links

Production of carbon dioxide gas.

Possible approaches

Perhaps guidance needed for younger age groups to say that water is needed for the reaction. The reaction might be used to do the lifting, or it could be used to start the lifting, *eg* to trigger movement of a counterbalance.

Evaluation of solution

These are suggestions only:

- 1 Any device which is, or which appears to be, unsafe should be disqualified immediately.
- 2 The final device must be loaded with chemicals, and be ready to start the experiment when the judges say so.
- 3 The judges will provide each group with the levelled teaspoons of chemicals for the test. (Judges may prefer to weigh out the relevant amounts.)
- 4 Although "standard" masses will be provided, groups do not have to use these as their load. However, it must be possible to remove the load from the lifting device, in order for the judges to check its mass. This must not destroy the lifting device. Thus, the mass of the device itself must not be counted towards the mass of the load.
- 5 The winner is that device which lifts the largest mass through at least 10 cm.
- 6 There is no penalty for lifting the object by more than 10 cm, as long as it stays at least 10 cm above its starting point.
- 7 In the event of a tie, the judges should take into account the elegance of the solution, given the requirement that the device shall be constructed mainly from 'junk' materials.

'The Heavy Lift Cup Challenge'! So far the best lift = 2 kilograms. If your students beat this, write to the Royal Society of Chemistry (Education Department) with details. The heaviest lift will be published from time to time in 'Education in Chemistry'.

Extension work

To increase the chemical content the task could be extended by prior (or subsequent) experimentation, to select best choice of gases/chemicals.

Credits

© Royal Society of Chemistry

Health & safety checked May 2018

Page last updated October 2018