# Kitchen currents

## - Your task

Design and build an electrical battery, which will give the highest current. The battery is to be constructed using materials only likely to be found in a kitchen.

- A diagram of your invention, with some explanation, will be needed.
- Your final battery must be ready to be connected to the ammeter used by the judges, at the appropriate time.

Based on a suggestion by P. Borrows.

## Time

60 minutes (this may be rather short to allow for full investigation).

## Group size

2–4.

## Equipment & materials

Eye protection.

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

**General**
A milliammeter (or multimeter) with 2 wires fitted, and crocodile clips at the other ends. Additional leads and clips so that a number of cells can be constructed. Bulb.

Something abrasive such as wire wool or glass paper to break oxide layers on metal surfaces used as electrodes.

The following additional items (**NB** this is not a final list, and not all of these items are required for a solution. The list can be varied as the judges think fit):-

Electrodes: Carbon electrodes(pencils)/all sorts of metal cutlery/off-cuts from copper pipes/brass curtain rings/aluminium foil.

Materials to try as 'ionic solution' in cell: Bicarbonate of soda/sodium chloride/washing powder/washing soda/bath salts/vinegar/lemonade/coca cola/bleach/couple of lemons/milk powder/sugar/flour. Students could bring in a selection of solutions from home.

## 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/*].

Bleach could be hazardous if full strength. Household bleach solutions (containing sodium chlorate(I) / sodium hypochlorite) sold for the domestic market is usually corrosive. Even quite dilute bleach is irritant if more than 0.15 M NaOCl. Chlorine gas may be given off when mixing vinegar and bleach, ensure laboratory is well-ventilated.

Washing soda (sodium carbonate) is an eye irritant.

Eye protection should be used for washing powder/soda and bleach and should be goggles (BS EN166 3) (not safety spectacles) for undiluted bleach solutions.

**Disposal:** Diluted bleach solutions are of low hazard, but for anything more than very small quantities of bleach, 'neutralise' with iron II salts or sodium thiosulphate and then wash to waste.

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

## Curriculum links

Simple electrolytic cells. Reactivity series. (16+ years could use salt bridges *etc.* 13–14 year olds could use 2 dissimilar metals in a single electrolyte.)

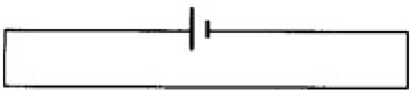
## Possible approaches

(The instructions are adequate for "high ability" groups but students of lower ability may need 'clues' to set them on the right course.) There could be three investigations:-

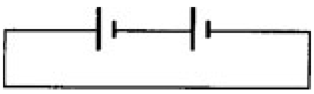
**i** which two metals are best? (Reinforcing the reactivity series.)
**ii** which electrolyte?
**iii** is it necessary to arrange for large area of electrodes or a "pile" effect (cells in series)?

This is a very successful problem and always produces results. It can be taken at many different levels, from pure trial & error, to sophisticated chemical thinking. As set out, it asks for the highest current, which is rather more sophisticated than the greatest voltage, because it raises issues of the internal resistance which is probably suitable for 16+ years who could appreciate the theoretical issues. 14–16 year olds would get a better start on the basis of voltage (see Kitchen potential experiment). The best electrolyte is bleach, but as this is hazardous it could be omitted with younger students. (With bleach you can get up to 0.5 A, without bleach currents seem to be in the milliamp range.) Constructing a battery of cells is a worthwhile technique. With a restricted range of (safe) chemicals, some teachers think this could be used with junior school students – they would need to be shown how to use the milliammeter, but after that it would be a matter of trial & error, controlling variables *etc.*

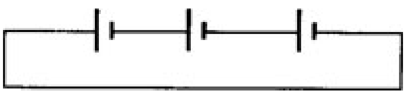
For cells connected in series: (Assume wires have no resistance.)



$$I\,(current) = \frac{V\ (voltage)}{r\ (r{=}internal\ resistance)}$$



$$I = \frac{2V}{2r}$$



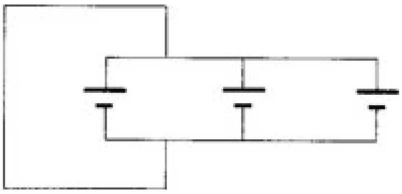
$$I = \frac{3V}{3r}$$

Current stays the same (*ie* it is no use putting cells in series in an attempt to increase the current).

For cells connected in parallel:

Voltage is same. (Assume wires have no resistance.)

Total resistance (R) of parallel 'network'



$$= \frac{r}{n} \frac{(internal\ resistance\ of\ cell)}{(number\ of\ cells)}$$

The greater the number of cells, the smaller the resistance of the parallel network, therefore the larger the current.

**NB** In practise, given the limitations of the 'junk' apparatus, it is difficult to get a number of cells that are all identical.

## Evaluation of solution

These are suggestions only:

**1** At the time of the judging, the group should disconnect the wires from their ammeter, and connect them instead to the judges' ammeter.
**2** The circuit will be complete, and the peak current is recorded.
**3** The winner is the group whose battery achieves the highest "peak current".
**4** In the event of a tie, the judges should take account of the non-messy "elegance" of the battery.

## Credits



*Health & safety checked May 2018*

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