OPEN-ENDED INVESTIGATION

Current in a salt solution

Background

In our first year of Advancing Physics AS-level we encouraged the students to undertake a wide range of projects in the Sensor Project coursework item. Many (inevitably) chose circuits to measure light intensity or temperature but a few chose to use some of the wide range of sensors that we have accumulated over the years. One student located a pH probe/conductivity meter and planned to calibrate it as part of a salinity meter. In the event the sensitivity of the probe was such that the smallest concentration of salt caused the output to saturate. Some two hours into a five-hour exercise he decided to construct his own salinity meter based on the probe.

As far as we could ascertain the probe was no more than two electrodes (albeit platinum) and a chamber into which the solution could flow. An ammeter completed the basis of the instrument. Within half an hour a macroscopic version of the probe had been constructed at minimal cost and went on to provide the basis for a good project.

The student pressed into service a small, transparent plastic box and aluminium cooking foil for the electrodes. The crocodile clips came in for a bit of a pounding in such a hostile corrosive environment but we buy them in bulk and they were still usable.

It struck me that this was an inexpensive GCSE Investigation with lots of scope – a good number of variables and a source of reasonable but 'messy' results – and a blessed relief from the 'resistance of a wire' 'investigation' (sic). Some collaboration with the Chemistry department may be mutually beneficial when discussing the reactions occurring at the electrodes.

Apparatus required

- Plastic container (sizes from 15 cm × 5 cm × 5 cm down to 5 cm × 3 cm × 2 cm have been found to give reasonable results). Ferrero Rocher chocolate containers work well and are transparent, allowing the solution to be readily observed. Small component trays also work well and require much less salt.
- Aluminium cooking foil for electrodes (copper electrodes also work)
- Crocodile clips (which enable contact with the foil and secure it against the edge of the container)
- Power supply (dry cells have worked well: 1.5 V to 6.0 V)
- Rheostat/Variable resistor (value depends on size of container and depth of solution). The main purpose of the variable resistor is as a 'ballast' resistor to allow a constant potential difference (p.d.) to be maintained across the solution.
- Switch to break circuit between readings
- Connecting wires six or seven per experiment
- Mass balance 0.1 g resolution should be sufficient
- Ammeter Digital ammeters with multiple ranges are ideal
- Salt About 20 g per experiment if large boxes are used

Teachers' notes

This was a worthwhile and rewarding exercise for most, if not all, students. Given that the apparatus is fairly readily available it makes an interesting alternative to the 'resistance of a wire' investigation whilst sharing much of its theoretical foundations. A word of caution: if p.d. is the selected variable be aware that a graph of current against p.d. does not pass through the origin—we found it to be linear but crossing the p.d. axis—some background research into voltameter cells may help to explain this. If p.d. is not selected as the variable it is important (for full marks) that measures are taken to keep the p.d. across the solution constant.

Sample results

The preliminary results obtained by a Year 10 student, Daniel Wilson at Christ College Brecon, are shown in table 1. There is plenty of scope for analysis here. The power source in this instance was 4 × 1.5 V dry cells.

A second student, Cheryl Wong, opted to vary the area of the aluminium electrodes. Her results

Table 1.

Mass of NaCl/g	Average current/A
1	0.19
2	0.28
4	0.58
8	1.01
16	1.89

are shown in table 2. Again, four dry cells were used and the mass of salt was fixed at 3.0 g.

Other students in the same group investigated the effect of temperature and distance between electrodes.

Table 2.

Size of electrodes		Average current/A
Dimensions/cm	Area/cm^2	
3.0 × 1.0	3.0	0.12
3.0 × 2.0	6.0	0.19
3.0 × 4.0	12	0.38
3.0 × 6.0	18	0.51
3.0 × 8.0	24	0.69
3.0 × 10.0	30	0.78
3.0 × 12.0	36	0.91

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