THE ROYAL SOCIETY OF CHEMISTRY

70. The electrolysis of water – exploding bubbles of oxygen and hydrogen

Topic

Electrolysis, combustion reactions.

Timing

About 10 min.

Level

Pre-16.

Description

A dilute solution of sodium sulphate containing a little universal indicator is electrolysed using platinum electrodes. The pH changes at the electrodes can be seen. The hydrogen and oxygen evolved at the electrodes are mixed and used to blow soap bubbles. These bubbles can be exploded giving a loud 'crack'.

Apparatus

- Variable DC power pack capable of supplying a current of at least 1 A at 12 V.
- Connecting leads and crocodile clips.
- Ammeter (0–1 A) (optional).
- Two pieces of platinum wire each about 10 cm long. Only one piece of platinum is essential, the other can be replaced with iron, copper or nichrome wire.
- One clear glass jar (about 400 cm^3) as used to store powders.
- One one-holed rubber bung to fit the jar.
- One short length of glass tube.
- One length of flexible plastic tubing.
- One 250 cm^3 beaker.
- Bunsen burner.
- Spatula with a spoon-type end or a teaspoon.

Chemicals

The quantities given are for one demonstration.

- About 10 g of sodium sulphate (Na_2SO_4).
- A little washing up liquid.
- A little universal indicator solution.

Method

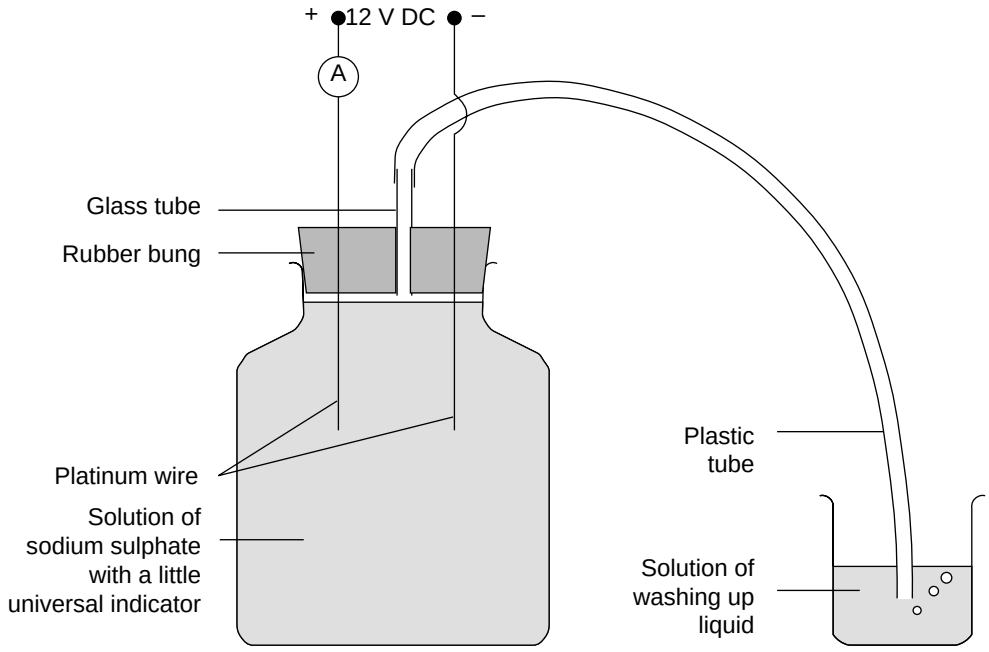
Before the demonstration

Set up the apparatus shown in the *figure*. The platinum wires can be inserted through the rubber bung by making holes with a piece of stiff wire that has been heated to red

heat in a blue Bunsen burner flame. Check that the apparatus is gas tight and seal the wires in with Vaseline or Blu-tac if necessary.

Make a solution of about 10 g of sodium sulphate in 500 cm^3 of water.

Light a Bunsen burner well away from the electrolysis apparatus!



Splitting water to produce hydrogen and oxygen

The demonstration

Fill the jar with sodium sulphate solution leaving only enough air space to fit the bung. Add a few drops of universal indicator solution to the solution so that the green colour is clearly visible. Fit the bung and connect the electrodes to a power pack set at 12 V DC. Connect an ammeter in series in the circuit if desired. Switch on the power pack; the current should be about 1 A. The indicator will turn blue around the cathode due to the formation of OH^-(aq) ions and yellow around the anode due to the formation of H^+ (aq) ions. Bubbles of oxygen will form at the anode and **hydrogen** at the cathode. Point out that there is about twice as much hydrogen as oxygen.

Observe these changes for a couple of minutes to allow air in the delivery tube to be displaced by the mixture of hydrogen and oxygen. Now place the end of the delivery tube in a beaker of water containing a little washing up liquid. Bubbles will form and collect at the surface of the water. Scoop up some bubbles in a spatula or spoon and hold them in the Bunsen flame. They will explode with a sharp crack, which is impressive considering the small amount of gas mixture. If the bubbles do not explode, wait a little longer for the gas mixture to displace the air from the delivery tube. Do not attempt to ignite bubbles at the end of the delivery tube.

Visual tips

A white background is essential if the colour changes are to be seen.

Teaching tips

Point out that electrical energy is required to split the water, that water is reformed in the explosion and that energy is given out. Producing hydrogen by electrolysis of

water for use as a fuel is one suggestion for an alternative fuel economy to that based on petrochemicals (provided that the electricity has not been generated by burning oil or gas!).

Theory

The electrode reactions are as follows:

at the anode:

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

at the cathode:

$4H_2O(l) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$

Overall:

$2H_2O(l) \rightarrow O_2(g) + 2H_2(g)$

Extensions

The gases could be collected in a separate experiment, using a Hoffman voltameter or an electrolysis cell, to confirm that the volume of hydrogen is double that of oxygen.

Further details

The anode must be made of platinum wire – other electrodes tend to react with the oxygen that is produced. Copper, iron or nichrome work satisfactorily as the cathode and can be used if only one piece of platinum is available. The apparatus could be modified to use platinum electrodes from a hydrogen electrode for example.

Safety

Wear eye protection.

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