Can water be broken down into its components by supplying energy?

CE 1.9.12

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Task

Break down water by applying a current, and investigate the reaction products

Equipment

Support base	02001.00	1
Support rod	02037.00	1
Bosshead	02043.00	1
Universal clamp	37715.00	1
U-tube with 2 side tubes, PN 19	36966.00	1
Carbon electrode, d = 7 mm, 2 out of	08155.00	(1)
Crocodile clips, bare, 4 out of	07274.03	(1)
Rubber stopper, 1 hole PN 19	39255.01	2
Connecting cable, red	07361.01	1
Connecting cable, blue	07361.04	1
Flat battery, 4.5 V	07496.01	1
Glass beaker, 250 ml, short	36013.00	2
Glass tube, with tip, l = 200 mm	36701.13	2
Rubber tubing (connecting tubing)	39282.00	1
Test tubes, 2 out of	37658.03	(1)
Test tube rack	37685.00	1
Wash bottle for dist. water	33931.00	1
Protective glasses	39316.00	1
Bunsen burner	32164.05	1
Rubber hose for burner	39284.01	1

Chemicals, other materials

Sodium hydroxide, flakes	30157.50	1
Glycerol	30084.25	1
Wooden splints, 1 out of	39126.10	(1)
Distilled water, tap water		

Hazards

— Sodium hydroxide is extremely caustic. Rinse spatters on skin or clothing with abundant water!
— During the experiment explosive mixtures are produced. Wear protective glasses!
— Lubricate rubber-glass connections with glycerol.

Set-up

1. Set up the support stand according to Fig. 1. Clamp the U-tube onto it in the middle. Connect the side arms of the U-tube to the glass tubes with tip ("Gas supply tubes") using pieces of connecting tubing.
2. Fill each of the large glass beakers two-thirds full with tap water, and place them under the gas supply tubes. Lower the U-tube until the gas supply tubes reach the bottom of the beakers.
3. Fill the two test tubes to the brim with tap water and place them into the test tube rack.

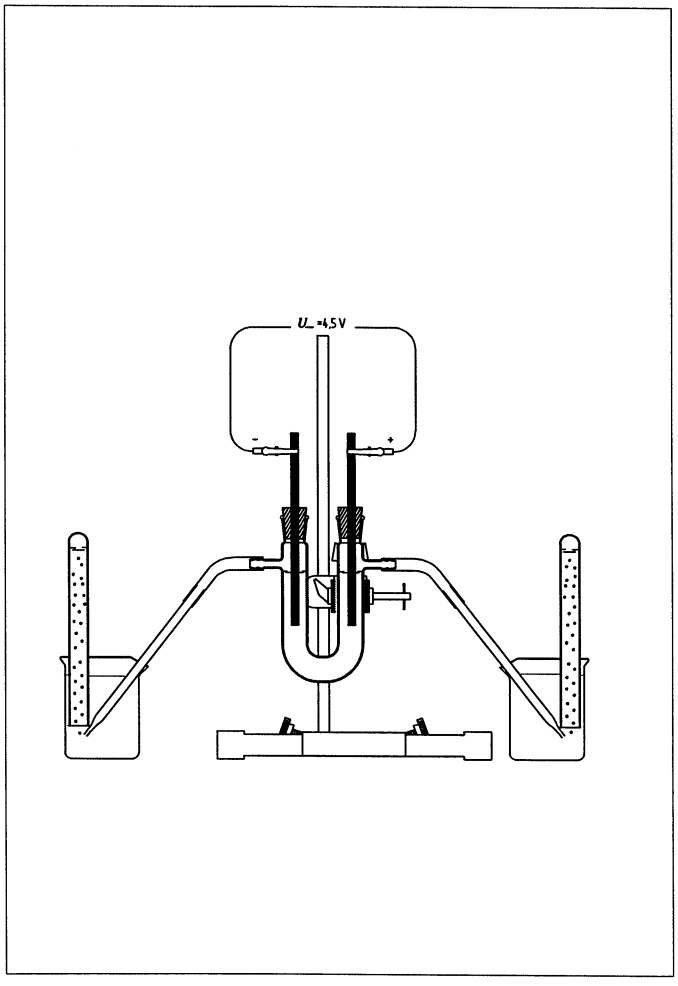
Procedure

1. Fill the U-tube up to its side tubes with the previously prepared sodium hydroxide solution. Twist the carbon electrodes (lubricate with glycerol) cautiously into the rubber stoppers and insert them into the U-tube. Connect the left electrode as cathode (-) and the right one as anode (+).
2. Apply a voltage of between 5 and 10 V for approximately one minute. Switch off the power supply briefly. Pick up the water-filled test tubes. Seal them with your thumbs and place them upside down over the ends of the gas supply tubes. In the process, no water may flow out of them.
3. Turn on the power supply again. Collect the gases being produced in the test tubes until one of them is completely full. Then switch off the power supply and compare the quantities of gas.
4. Perform the hydrogen-oxygen test with the gas collected at the cathode. Perform the smouldering splint test with the gas captured at the anode.

Waste disposal

Pour the sodium hydroxide solution from the U-tube into the collection container for acids and bases.

Fig. 1



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Evaluation

1. Note your observations.

2. Record the results of the smouldering splint and the hydrogen-oxygen tests.
   a) Smouldering splint test

   b) Hydrogen-oxygen test

Questions and exercises

1. Draw conclusions from your observations.

2. According to this result which substance class must water belong to?

3. Develop an experiment with which it could be shown that water belongs to this substance class.

4. Comment on the terms analysis and electrolysis.

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Learning objectives

— Water can be broken down into hydrogen and oxygen.
— Such a decomposition into the elements is termed analysis. Electrolysis is a special case of analysis using electric current.

Notes on set-up and procedure

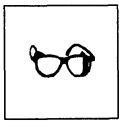
Preparation

Place dilute sodium hydroxide solution (9 gm NaOH flakes in 100 ml of water) in beakers in the students' working areas.

Remarks on the students' experiments

Ensure that the electrodes are connected correctly, particularly if this is the students' first performance of an electrolysis. The test tubes must not be confused: the smouldering splint test must not be conducted with hydrogen.





Hazards

— Sodium hydroxide is extremely caustic. Rinse spatters on skin or clothing with abundant water!
— During the experiment explosive mixtures are produced. Wear protective glasses!
— Lubricate rubber-glass connections with glycerol.

Evaluation

To 1. Note your observations.
After applying the voltage, gas bubbles develop at the electrodes. The gas collects in the test tubes. In the process, twice as much gas forms at the cathode as at the anode.

To 2. Record the results of the smouldering splint and the hydrogen-oxygen tests.
a) Smouldering splint test: A smouldering wooden splint flares up in the gas which formed at the anode.
b) Hydrogen-oxygen test: The gas which formed at the cathode burns with a whistling sound.

Questions and exercises

To 1. Draw conclusions from your observations.
Water can be broken down by supplied energy (in this case electricity). In the process, hydrogen (hydrogen-oxygen test) and oxygen (smouldering splint test) are formed. Water must contain hydrogen and oxygen in a (volume) ratio of 2 : 1.

To 2. According to this result, which class of substances must water belong to?
Since water is a compound of an element with oxygen, it must belong the substance class of the oxides. Accordingly, water would be hydrogen oxide.

To 3. Develop an experiment with which it could be shown that water belongs to this class of substances.
If water were formed in the reaction of hydrogen with oxygen (with the exclusion of other elements), it would have been demonstrated that water is hydrogen oxide.

To 4. Comment on the terms analysis and electrolysis.
Analysis: decomposition of substance into its components.
Electrolysis: analysis using an electric current.

Notes

The customary students' power supplies are appropriate for this experiment.
In reality, not water but rather sodium hydroxide solution is electrolysed in this experiment. However, this leads to the same result as in the hypothetical electrolysis of water.
The following processes occur here:

Anode: $4\ OH^- \rightarrow 2\ H_2O + O_2 + 4\ e^-$
Cathode: $4\ H_3O^+ + 4\ e^- \rightarrow 2\ H_2 + 4\ H_2O$

Remarks on the method

The students will surely point out that in this case not water but rather sodium hydroxide solution is electrolysed. In this context it can be stated that, due to the low conductivity of pure water, its electrolysis is difficult to perform. Sodium hydroxide solution is used to increase the conductivity (see Notes).
The term synthesis, which was immanently implied in the method used in this experiment, will be developed in a separate experiment.

Waste disposal

If the sodium hydroxide solution was not contaminated it can be stored in an appropriately labelled collection container and be used for similar experiments. Otherwise, pour it into the collection container for acids and bases.

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Space for notes