Student experiment (5th - 10th grade)	**Splitting water by electrolysis**	**Time:** max. 15 min.

Safety:

safety glasses, disposable gloves

Instruments:

- 2 plastic syringes (10ml) without plunger
- 2 safety pins
- 2 alligator clamps and 2 wires
- source of electricity
- electrolysis bath (small plastic container)
- 2 sleeves with retort stand clamps
- disposable gloves
- lighter
- wooden splint

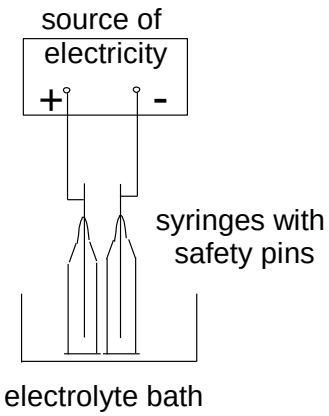
Chemicals:

- electrolyte: saturated sodium carbonate solution (H: 319; P: 260-305+351+338)

Preparation:

Carefully melt the safety pins into the holes of the syringes to act as electrodes (see graphic).

Experiment:



- Fill the electrolyte bath 2/3 full of sodium carbonate solution.
- Fill both syringes with sodium carbonate solution, making sure that no air is left in either (important!). Place them in the electrolyte bath with the open ends facing down, making sure that no air enters the open ends. Use your finger to block the ends as you place them into the bath. (Wear the disposable gloves for this!)

Experiment:

- Fasten the syringes firmly using the sleeves and a retort stand so that they will not tip over.
- Connect the electrodes to the electrical power source using the wires.
- Wait until the syringe on the negative pole has formed roughly 8 ml of gas and the positive pole syringe has formed about 3-4 ml of gaseous product.
- Remove the syringes from the cables.
- Take the syringe with the largest amount of gas out of the electrolyte bath and hold it upside down (!) over the flame of a lighter.
- Close the opening in the remaining syringe with your finger and carefully remove it from the bath. Turn it upright and quickly put a glowing wooden splint into the opening. What happens in both cases?

Observations:

The electrodes (safety needles) cause two gaseous products to form. The negative pole produces roughly twice as much gas as the positive pole (2:1 ratio). Both gases are colorless.
The gas from the negative pole causes a loud "pop" when a flame is brought near the mouth of the syringe. The gas from the positive pole causes a glowing wooden splint to glow more vigorously and start to burn.

Results:

The gases are hydrogen and oxygen, which can be shown by the typical tests used above. The "pop" of hydrogen gas and the more active flame in the presence of oxygen prove that water is composed of both hydrogen and oxygen.
During electrolysis, water is split into its constituent parts with the aid of an electric current. This occurs by passing an equal current through the submerged electrodes. Sodium carbonate increases the conductivity of water, which in its pure form is not very conductive. The electrical source results in a lack of electrons at the positive pole (anode) and a surplus of electrons at the negative pole (cathode). Because of this, positively-charged cations wander to the negatively-charged cathode and are reduced to their elemental form by the excess of electrons present there. In contrast, negatively-charged anions wander to the positively-charges anode, where they are oxidized to their elemental form by being stripped of the necessary amount of electrons to bring their charge to zero (neutral charge).

We can formulate the reactions as follows:

$$\text{minus pole (cathode): } 2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$$

$$\underline{\text{plus pole (anode): } 2\ OH^- - 2\ e^- \rightarrow 1/2O_2 + 4\ H_2O}$$

$$\text{overall reaction: } 2\ H_2O\ (l) \rightarrow 2\ H_2(g) + O_2$$

The OH^- ions come from the equilibrium of the soda with water:

$$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-.$$

Disposal:

The sodium carbonate solution can be reused several times. When no longer needed, it can be safely disposed of in the drain.
