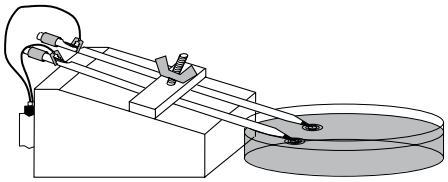
ICE Devices

Electrolysis Apparatus



This device allows one to easily set up an electrolysis demonstration on an overhead projector. While the actual chemistry might be too complicated for younger students, the phenomenon of electrolysis and conductivity of water could be shared with children of all ages. The evolution of gas bubbles and the different colors of an indicator produced at the anode and the cathode are a fascinating sight.

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Electrolysis Apparatus

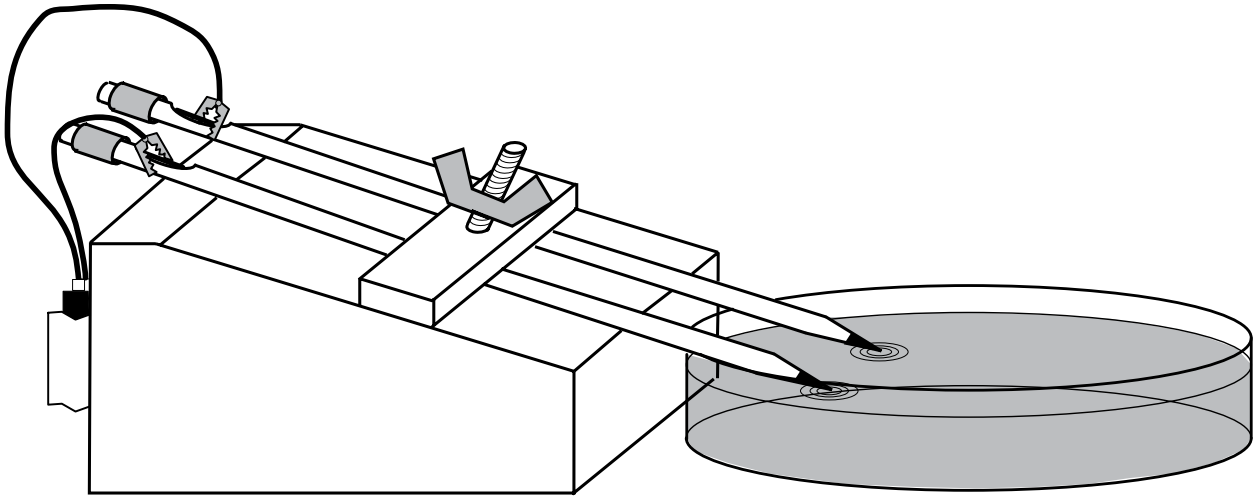
By William Fausey

This device allows one to easily set up an electrolysis demonstration on an overhead projector. While the actual chemistry might be too complicated for younger students, the phenomenon of electrolysis and conductivity of water could be shared with children of all ages. The evolution of gas bubbles and the different colors of an indicator produced at the anode and cathode are a fascinating sight.

The electrolysis of a KI solution has been written up by Ken and Doris Kolb [*J. Chem. Educ.* **1986**, *63*, 517]. Immediately upon immersion of the electrodes, there is a copious flow of hydrogen gas bubbles at the cathode and within a few seconds a yellow–brown iodine coloration at the anode. After 30–60 seconds a drop of phenolphthalein placed near the cathode turns that area of the solution bright pink. A squirt of 1% starch solution near the anode gives that area the blue-black color of the starch-iodine complex.

Electrolysis of $NaNO_3$ using various indicators was described by J. Skinner [*J. Chem. Educ.* **1981**, *58* , 1017]. Any dilute aqueous solution, e.g., simple tap water, can be electrolyzed in this way. The anode and cathode can be identified by adding a few drops of red cabbage juice indicator near each electrode.

The instructions here call for construction from a wooden block. It has been suggested that this device can also be made from a styrofoam block, such as used by florists to hold flower arrangements. However, in that case the apparatus may not stand up on its own, but will have to be held in your hand.



A completed electrolysis apparatus.

Materials

__ *2 × 4 wood block (6 cm × 3.5 cm × 8.5 cm)*
__ *2 cm × 0.5 cm × 8.5 cm wood strip, e.g., a tongue depressor or a paint stirrer cut to size*
__ *saw*
__ *hammer and small nail or awl*
__ *vise or C-clamps and work table*
__ *drill*
__ *9/16″-dia., 1/2″-dia. and 1/4″-dia. drill bits*
__ *1/4″-dia. 2″-long machine bolt*
__ *wing nut for 1/4″-dia. bolt*
__ *#5 or #6 self-starting screw, 1/2 to 3/8″ long*
__ *9V battery*
__ *9V battery holder (e. g. Radio Shack #270-326 or from an electronics supplier)*
__ *9V battery snap connector (e.g. Radio Shack #270-325 or from an electronics supplier)*
__ *2 ea. alligator clips (Radio Shack #270-375 or from an electronics supplier)*
__ *pliers*
__ *2 ea. sharpened pencils*
__ *petri dish [e. g. Flinn Scientific AP8170; also widely available online from lab supply houses]*
__ *red cabbage juice (keep refrigerated)*
__ *1 cup distilled water*
__ *blender*
__ *sieve*
__ *2-cup mixing bowl or beaker*

Procedure

Preparing the electrode holder

1. Drill a 1/4″ hole in the center of the wood strip (Figure 1). This strip will serve as the electrode (pencil) holder.

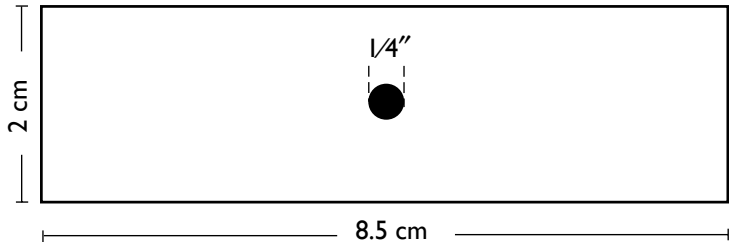


Figure 1. Drilling the wood strip.

2. Using a nail or awl start a small hole in the center of the 3.5 cm × 8.5 cm surface of the wood block (Figure 2).

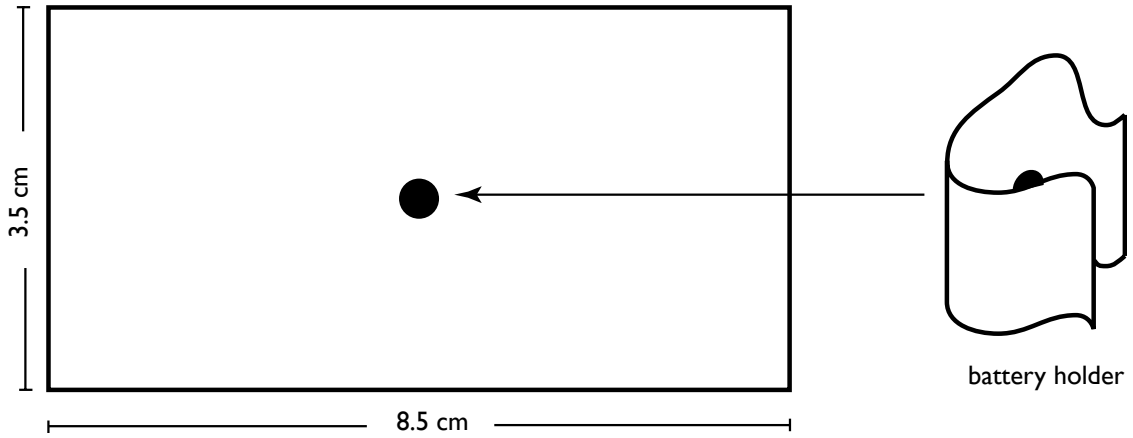


Figure 2. Making the hole for the battery holder.

3. Cut a wedge from the top of the wood block as shown in Figure 3.
4. Drill a 1/2″ hole perpendicular to the sloped surface all the way through the block. Countersink the hole (that is, drill the hole out from the other side) about half way using a 9/16″ drill bit.

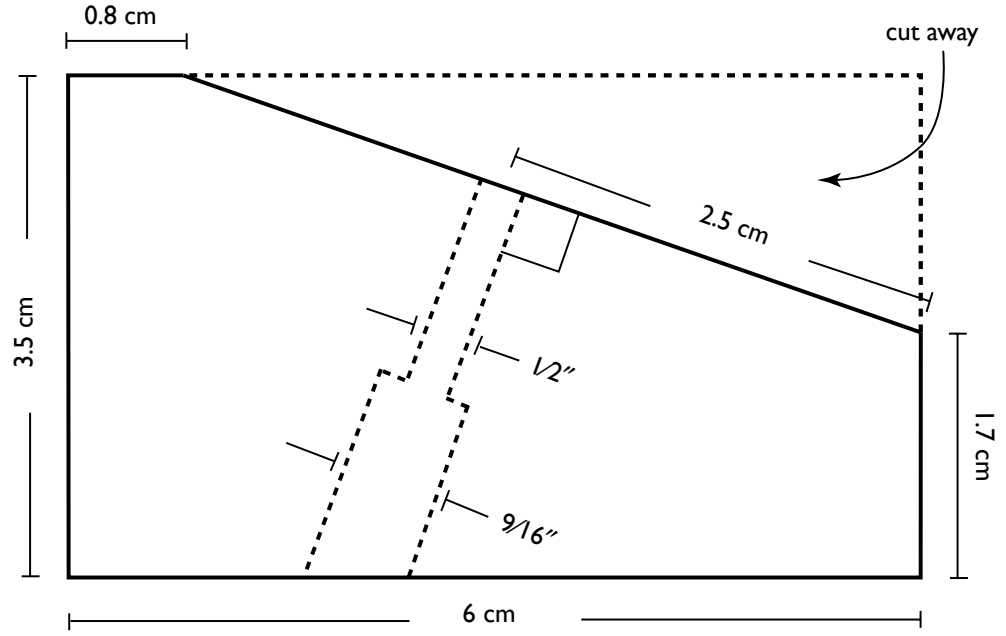


Figure 3. Cutting and drilling the wood block.

5. Attach the battery holder to the wood block, fixing it in place with the #5 or #6 self-starting screw (Figure 2).

6. Near the eraser end of each of the pencils, remove enough wood to expose the lead.
7. Insert the 1/4″ machine bolt from the bottom of the block. Place the pencils on the slanted surface with their sharpened ends pointing down. Insert the machine bolt into the hole of the wood strip, thread on the wing nut and tighten it down so that the pencils do not budge. The pencils should be fairly parallel to each other and about 3 cm apart.
8. Using the pliers, crimp the alligator clips to the wires on the battery clip.
9. Clamp the battery in the battery holder and attach the battery clip. Attach the alligator clips to the exposed pencil leads.

Making Cabbage Juice

1. Coarsely chop the red cabbage.
2. Place the cabbage into a blender or food processor. Add about 250 mL (1 cup) of distilled water and blend the mixture until the cabbage has been pulverized.
3. Pour the mixture through a sieve held over a container to catch the liquid. This strained liquid is the cabbage juice indicator. (**Note:** If left unrefrigerated, cabbage juice will spoil and become *very* smelly.)

Presentation

1. Place the petri dish with the solution that you will be electrolyzing on the overhead projector.
2. Place the electrode apparatus next to the petri dish so that the pencil leads are in the solution. Observe the electrolysis.
3. Place several drops of the red cabbage juice indicator into the solution near the electrodes.
4. Observe what happens near each electrode. Determine which electrode is the cathode and which one is the anode.

The actual reactions at the electrodes are:

Electrolysis of KI(aq)

(cathode) $4\,H_2O + 4\,e^- \longrightarrow 4\,OH^- + 2\,H_2$

(anode) $4\,I^- \longrightarrow 2I_2 + 4\,e^-$

Electrolysis of $NaNO_3$(aq)

(cathode) $4\,H_2O + 4\,e^- \longrightarrow 4\,OH^- + 2\,H_2$

(anode) $6\,H_2O \longrightarrow O_2 + 4\,H_3O^+ + 4\,e^-$