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Lab 03

Salad Dressing (Vinegar or Lemon) Clock

1. Principles of Operation:

Two different metals in an electrolyte will form an electrical cell. There will be a voltage difference between the metals and if a load is placed between the metals, there will be current flow.

So long as they are different, any two metals will do the job. However, because of their placement on the *electromotive table (see right insert)* some metals will produce more voltage than others. In particular, zinc (potential -0.76 volts relative to hydrogen) and copper (+0.34 volts relative to hydrogen) will give us a cell voltage of nearly one volt… if the cell were perfect, which it is not. In practice, the zinc-copper battery will give somewhere between 0.6 and 0.9 of a volt depending on the leakage current of the electrolyte.

The higher (most negative) of these elements will be oxidized (corroded) to provide the electrons to do the work, so the zinc will be consumed over time to make the cell do its work. The electron flow is FROM the copper cathode TO the zinc anode. Since the copper is now deficient in electrons (less negative) it becomes the positive terminal of the battery. The zinc, having an excess of electrons is the negative terminal of the battery.

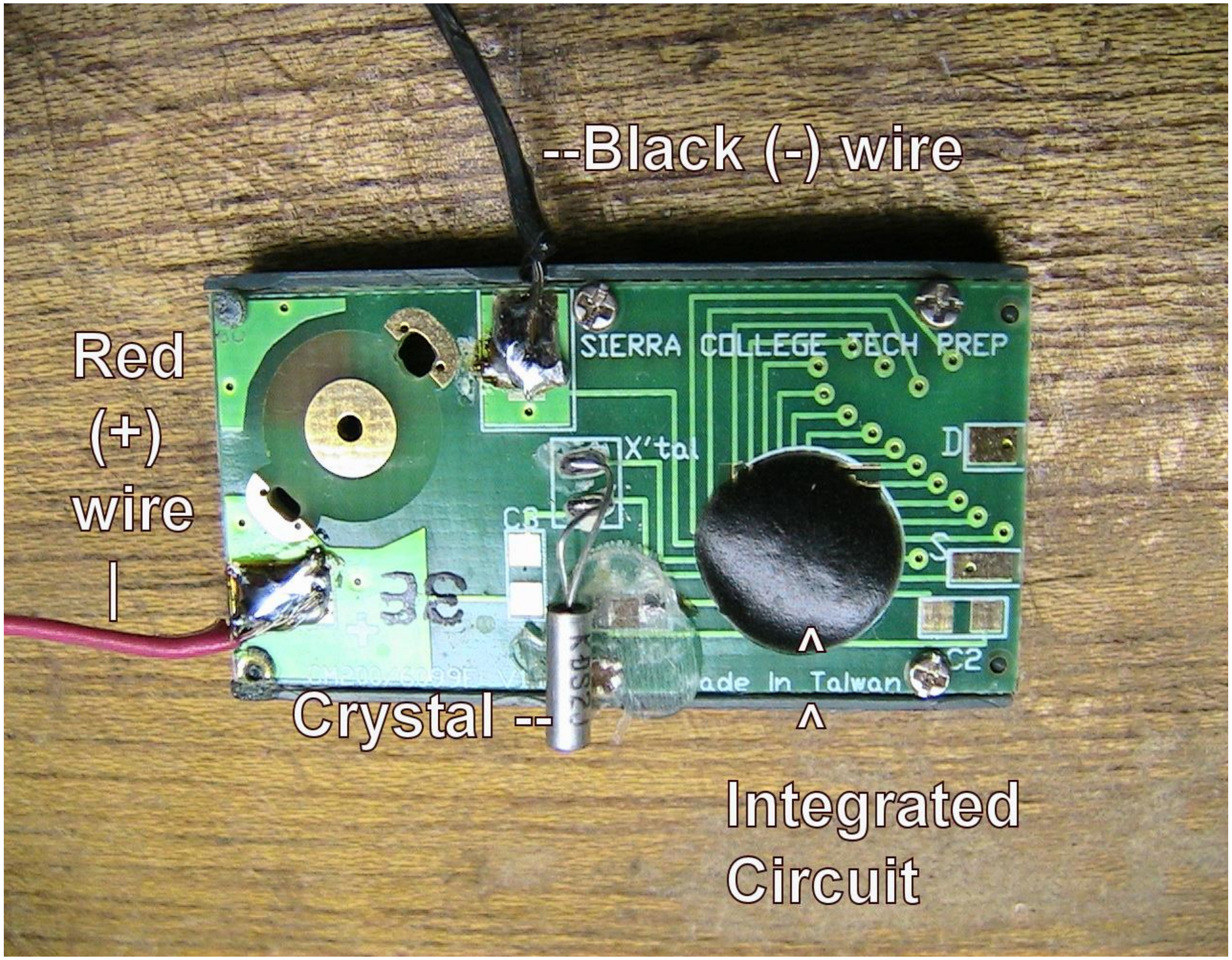
The *electrolyte* needs to provide hydrogen for the electron transfer process to work. In general, acid is used to provide the hydrogen ions. For example, a potato has a small amount of citric and phosphoric acids ($C_6H_8O_7$ and H_3PO_4) that will provide enough hydrogen ions for the cell to function. The problem with using a potato is that the potato decomposes ("rots") over time, rendering the clock inoperative.

There are a couple of other sources of acid in the cupboard. Lemon juice has citric acid and vinegar has acetic acid ($C_2H_4O_2$). Just a small amount of either diluted with water will power our clock.

TABLE I - ELECTROMOTIVE SERIES

METAL	NORMAL ELECTRODE POTENTIAL* (Volts)
Gold	+ 1.4
Platinum	+ 1.2
Iridium	+ 1.0
Palladium	+ 0.83
Silver	+ 0.8
Mercury	+ 0.799
Osmium	+ 0.7
Ruthenium	+ 0.45
Copper	+ 0.344
Bismuth	+ 0.20
Antimony	+ 0.1
Tungsten	+ 0.05
Hydrogen	+ 0.000
Lead	- 0.126
Tin	- 0.136
Molybdenum	- 0.2
Nickel	- 0.25
Cobalt	- 0.28
Indium	- 0.3
Cadmium	- 0.402
Iron	- 0.440
Chromium	- 0.56
Zinc	- 0.762
Niobium	- 1.1
Manganese	- 1.05
Vanadium	- 1.5
Aluminum	- 1.67
Beryllium	- 1.70
Titanium	- 1.75
Magnesium	- 2.38
Calcium	- 2.8
Strontium	- 2.89
Barium	- 2.90
Potassium	- 2.92

The current from our acid cell will be rather weak (microamperes if we are lucky) and less than one volt will not operate the "load" (clock module) that we have chosen for our circuit. In order to turn the one volt *cell* into a two volt *battery* we will simply put the two cells in *series* so that the cell voltages will add. In fact, the cell voltages will be somewhere around 0.8 volts (imperfect electrolyte) so that the resultant voltage will be somewhere around 1.6 volts. The clock module requires at least 1.5 volts, so we should have a little voltage to spare.



The digital clock module is a fairly simple timekeeping circuit comprised of one integrated circuit (IC) that does the entire job of setting the time, keeping the time, and driving the digits display -- all on a few microwatts of power (micro - one millionth).
The clock is shown here. Note that the integrated circuit is hidden under a lump of black sealant. This is generally done to prevent "reverse engineering" of a product (i.e. stealing somebody else's design and using it yourself).

The timekeeping is kept constant by a vibrating quartz crystal. The quartz crystal uses the *piezoelectric effect* where a voltage is used to excite the crystal into vibration. The crystal is cut from the quartz blank so that it oscillates exactly at 32768 Hz., which divided by 32768 ($32768 = 2^{15}$) gives a one pulse per second "beat" (tick- - -tock) to keep the clock on time.

2. Construction

A. Parts List

Quantity	Part Number	Description
1		Wooden Base
1		Digital Clock Module
1		Popsicle Stick
1		Vinegar or Lemon Juice
2		1” # 14 Copper House Wire (“Romex”)
2		1½” 4D galvanized finishing nail
2		1 ½” Plastic Vials
4”		Wire, #24 stranded, black
4”		Wire, #24 stranded, red
4”		Wire, #24 stranded,any color

B. Assembly

a. Drill two #52 ($^{1}/_{16}$”) holes into each of the two vial caps.

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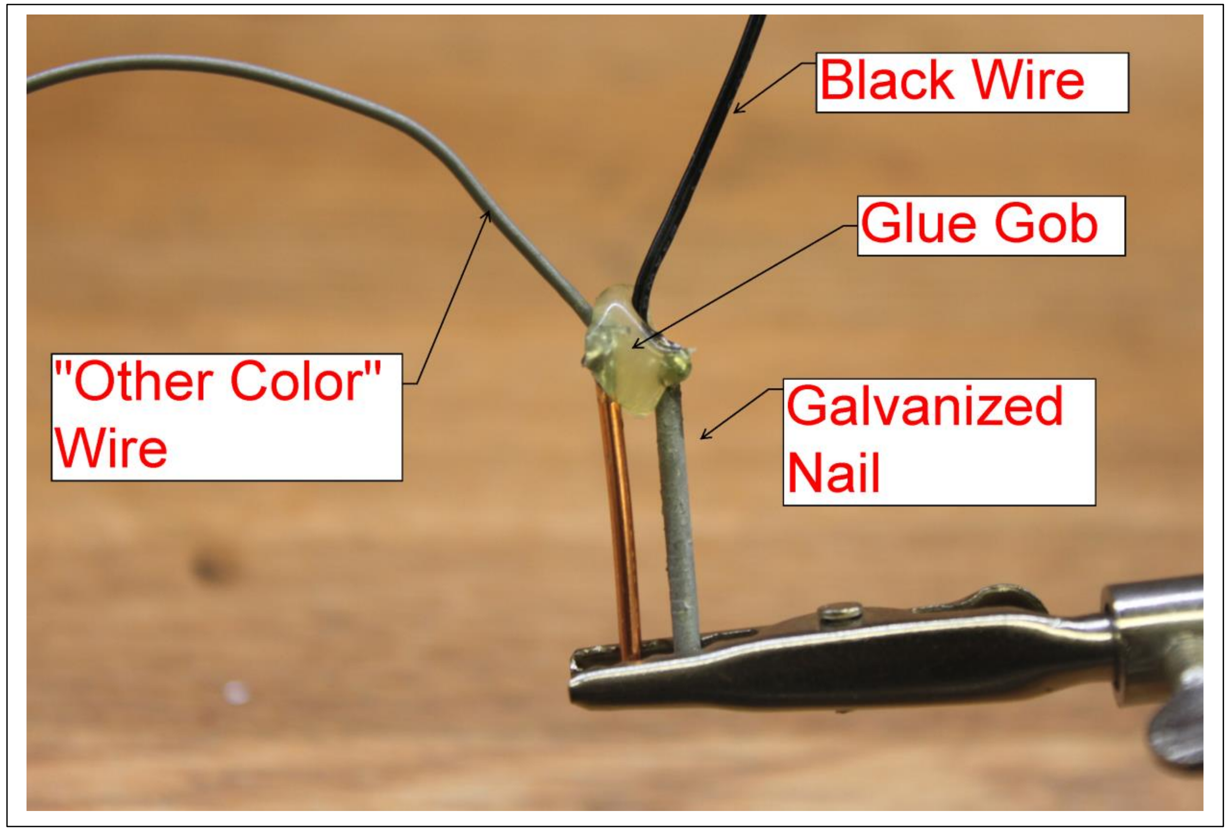
b. Use the soldering iron on fairly hot temperature and “tin” (coat with solder) one end of both copper wires.

c. Cut the tail (sharp pointed end) of the nail so that the remaining part of the nail is 1” long. Discard the tail.

d. Tin the cut end of the nail.

e. Strip both ends of all 3 wire about a quarter of and inch, twist the stripped ends together, and tin both ends of all 3 wires.

f. Position the solder end of one of the copper wires and the solder end of one of the nails in a third-hand alligator clip so that they are about a nail's width apart. Solder the black wire to the galvanized nail and the "other color" to the copper wire.



g. Keeping the two "electrodes" about a nail's width apart and being sure that the solder ends are not even close to touching one another, put a "gob" of hot glue over the wires and the top of the electrodes. When the glue is tacky-dry, put another identical gob on the other side of the electrodes and allow the glue to thoroughly dry.

h. Install the two wires into the bottom of one of the vial caps so that the wires exit on the top of the cap. Let the black wire go where it will.

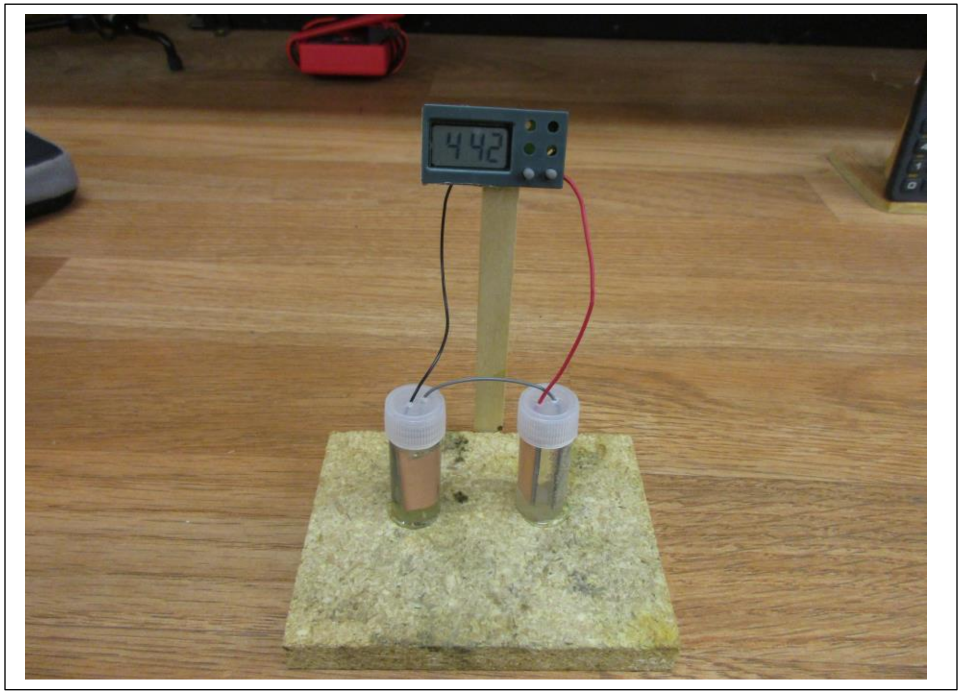
i. Take the "other color" wire loose end and insert it into the TOP of the remaining vial cover. Insert the red wire into the top of this cover.

j. Solder the red lead to the remaining copper wire and the "other color" to the remaining galvanized nail.

k. Make a "sandwich" of the copper wire and the galvanized nail as above, and put glue on these electrodes as above.

l. Stop at this point and have the instructor inspect your work.

m. Hot glue the two vials to the wooden base of the clock.



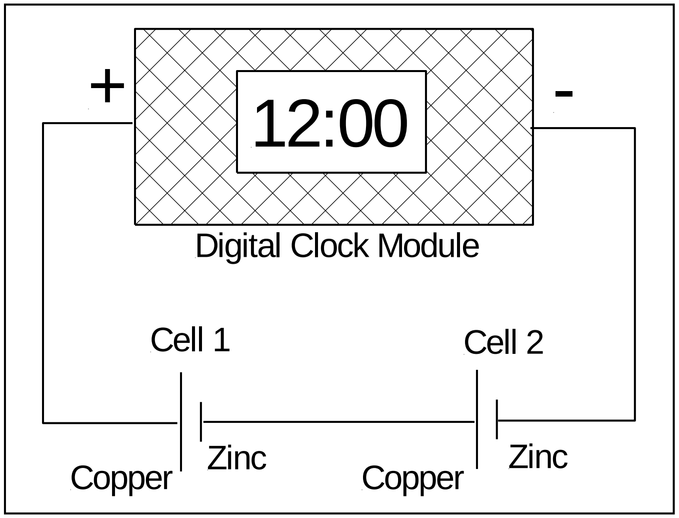
n. Solder the red wire to the (+) terminal on the clock module. Solder the black wire to the (-) terminal on the clock module.

o. Place 10 drops of plain white vinegar into each of the vials and fill the vial with water up ¾” from the bottom.

p. Insert the electrodes into their respective vials and see that the clock digits are showing.

q. Take the voltmeter and measure the voltage between the black and the red wires on the back of the clock module.

r. Schematic



s. 10. Hot glue a popsicle stick to the back edge (centered) of the wooden base. Be sure that the stick is vertical and at right angles to the base.

t. 11. Hot glue the clock to the top of the popsicle stick. If you forget which way "up" and "down" are, the little pushbuttons on the front of the clock should be at the bottom edge of the clock.

u. 12 Unsolder the red wire from the clock (+) termincal. . Insert a microammeter between the red wire and the (+) terminal. The microammeter should read somewhere around one microamp of current. Resolder the red wire to the (+) terminal

v. 13. This completes the construction of the clock.

3. Setting The Clock

1. Press S2 twice within a couple of seconds. Press S1 to set the month.

2. Press S2 again and set the date with S1.

3. Press S2 again and set the hour with S1.

4. Press S2 again and set the minutes with S1.

5. Press S2 and the hour/minutes that you set above will show. Press S1 to start the clock running. The colon will begin flashing.

6. To set the display to alternate between date and time, press S2. To return to month, date, or time only, press S2 again and again to cycle between these displays.

7. To display date for approximately one second and then return to time, press S1.