The Two-Potato Clock

Introduction

Demonstrate how a clock can be powered by two potatoes.

Concept

- Electrochemistry

Materials

The Two-Potato Clock
Potatoes (or lemons or other suggested sources), 2
Paper clip (or pen or pencil)
Assembly instructions (enclosed with The Two-Potato Clock)

Safety Precautions

Although this activity is considered nonhazardous, always follow proper laboratory safety procedures.

Procedure

Assemble The Two-Potato Clock according to the assembly instructions.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The remainder of the materials may be saved for future use.

Discussion

What causes the potatoes to act like electrical cells?

An electric cell is a device that changes chemical energy into electrical energy. It consists of two different metals called electrodes that are dipped into a solution capable of carrying an electrical current called an electrolyte.

Any solution that contains moveable free ions (charged atoms or molecules) is capable of carrying an electrical current, e.g., saltwater, tap water, sulfuric acid(aq) and sodium hydroxide(aq). Solutions that do not contain moveable free ions and therefore cannot conduct an electric current are called non-electrolytes, e.g., alcohol, distilled water, glycerin, and sugar water.

Each element has its own voltage and the difference between two of these voltages is called potential difference. The potential difference between two elements is the value of the voltage produced if those two elements were put in an electrochemical cell. The values of these voltages can be found and their potential differences can be calculated using a table of electrochemical series. Remember, the voltage is the unit measuring the push of electrons in an electric current, and an electric current is produced by a flow of electrons.

In the case of The Two-Potato Clock, the two different metals used are zinc and copper. The electrolyte used is a potato, lemon, or any other item that is capable of conducting an electric current. Most of the fruits that can be used are citrus fruits and contain an acid as their electrolyte called citric acid.

An electric current can be produced by using only one potato, but the voltage from only one cell would not be great enough to operate the clock. From an electrochemical series table, the voltage of copper is +0.34 and zinc is –0.76. Their potential difference is calculated by taking their difference [0.34 – (–0.76)] = 1.1 volts. This value is if only one cell (potato) was used and could be measured using a sensitive voltmeter.

In The Two-Potato Clock, we actually have two cells (potatoes) hooked together in series to make a battery. A battery is the term for two or more cells hooked together. Cells can be hooked together in two different ways, i.e., in series or in parallel. Our cells are connected in series which means there is only one possible path the electrons can take to complete the circuit. A parallel circuit has more than one path the electrons can take. Again, since we have two cells connected in series, the total voltage of our circuit would be two times the voltage of one cell or 2 × 1.1 = 2.2 volts. (This is only true for series cir-

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cuits.)

Since zinc has a lower voltage than copper, zinc is more chemically reactive and the zinc electrode (Zn) will dissolve in the electrolyte to produce zinc ions (Zn^{2+}) and two free electrons ($2e^-$). The free electrons are collected on the zinc electrode and thus give it a negative charge.

$$Zn(s) \rightarrow Zn^{2+} + 2e^-$$

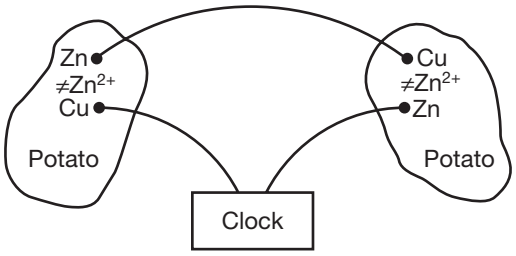
At the copper electrode (Cu), hydrogen ions (H^+) are taking electrons and producing hydrogen gas (H_2). The copper electrode loses electrons (e^-) and therefore has a positive charge.

$$2H^+(aq) + 2e^- \rightarrow H_2 \uparrow$$

The electrons that accumulate on the zinc electrode will travel through the wire to the copper electrode to replace the electrons the copper electrode is losing. In addition to the electrons moving, ions in the potatoes move to carry the current through the electrolyte (potato). Zinc ions (Zn^{2+}) will travel from the zinc electrode through the potato to the copper electrode where they will gain electrons to form zinc metal. The zinc metal formed will plate on the copper electrode. Over a long period of time, the zinc electrode will become noticeably smaller and the copper electrode will turn black due to the plating of zinc. The half reaction for the plating of zinc is as follows:

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$$

The flow of electrons and ions are illustrated in the following diagram.



The Two-Potato Clock is available from Flinn Scientific, Inc.

Catalog No.	Description
AP1939	The Two-Potato Clock

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.