Lemon Battery / Pickle Experiment Lesson Plan

Objectives:

- Students will be able to define electrical engineering.
- Students will be able to visualize the atomic nature of electricity.
- Students will be able to differentiate between series and parallel circuit setups.
- Students will be able to define voltage, current, and resistance.
- Students will experience the live effects of energy conversion.
    - Lighting LED with Lemon battery: CE-EE-LE (chemical energy to electrical energy to light energy)
    - Lights pickle up: EE-LE (electrical energy to light energy)
    - Power up motor with Lemon battery: CE-EE-ME (chemical energy to electrical energy to mechanical energy)

Overview:

The lesson will begin with the pickle demonstration as the “sponge activity.” We will then start the portion of the presentation that deals with the electrochemical pickle. After the portion of the presentation has concluded, we will provide the lemon battery materials to the students and instruct them to light up the LED with the materials in front of them. Before they begin, we will instruct the students to write down a plan of action. After the activity has concluded, we will instruct them to write down the results of their experiment. We will then resume the presentation and explain basic circuit theory to the students.

Background:

In this context, circuits are closed paths through which electricity runs. Circuits have many components. Where is there a circuit in your house? Anything that runs on electricity relies on circuitry. Most items, when plugged in, don’t start doing anything until you switch it on. The switch closes the circuit, which allows electricity to flow through the item, allowing it to do its job.

Electric eels have the ability to create an electric shock. This is a form of an electrochemical reaction, similar to how the pickle works. Batteries also work by an electrochemical reaction which causes electricity to flow from one side to another.

Materials:

- Pickle Experiment
    - One large pickle saturated with sodium and chloride ions (salt)
    - Two metallic nails (at least 2 inches in length)
    - Set of wires and male plug attachable to nearby wall outlet
    - Two pairs of wire clips
    - Circuit switch or breaker
    - Glass plate
    - Oven mitts or insulating gloves
    - Plastic blast shield for protection

- Lemon Battery
    - 3-4 lemons per group
    - Pennies
    - Paperclips
    - Alligator clips
    - LED lights
    - DC motor

Procedure:

1. Introduce the presenters
2. Sponge activity: pickle experiment
    a. Secure the nail at each end of the pickle. Make sure the nails are each embedded into the pickle at least 1 inch deep.
    b. Find a large table or suitable open space and place a glass plate on it. Place the nailed pickle on the glass plate.
    c. Prepare a circuit system for the pickle with the wires and clips. Do NOT attach anything to the power outlet from the wall yet. Attach a circuit wire to each nail with a clip. The wires must be connected to a circuit switch or a breaker. The switch should be turned off when assembling the system. Make sure the system is well placed so that people will not step on it accidentally
    d. Using either some kind of an adaptor or a modified male plug, make sure the wires are all connected and ready to be plugged into the wall outlet. The wall outlet should give off approximately 120 Volts. Allow the group leaders or instructors do this step, so that students can be a safe distance away from this potential electrical hazard.
    e. If you have reasons to believe that students may want to touch the pickle when the experiment is live (even after warning them before commencing the experiment), cover the experiment with a transparent blast screen.
    f. After making sure students are a safe distance (at least 3 to 5 feet) away from the pickle, you may turn the switch on for the circuit. The pickle should give a brilliant orange glow. You may want to turn the lights off in the room to better see the glow.
    g. Turn the switch off once the pickle loses the glow. Unplug the system from the power outlet, and then appropriately dismantle the circuits. Dispose the burnt pickle and clean up the experiment site.
3. Pickle PowerPoint
4. Independent study: Use lemon battery materials to light up LED.
    a. Provide materials to the students and have them write down what their approach will be.
    b. Allow the students to attempt to light up the LED with the materials in front of them.
    c. Have the students evaluate their original approach and discover what worked and what did not.
5. Lemon battery PowerPoint

6. Split the students into three groups: electron donors (+ ions), electron acceptors (- ions), and electrons. Start the electrons “attached” to the donors, but then tell the electrons to move to the acceptors, creating a “current.”
7. Show the students how mechanical energy can be converted to electrical energy by connecting a DC motor to an LED and lighting it up by spinning it. Pass it around the class.

Final Activity:

Tie the procedure with the background and objectives. Have groups discuss what worked and what did not. Discuss why lemons in series work and lemons in parallel does not (parallel lemons do not provide enough voltage). Explain why the penny and the paperclip are required for the experiment (electron donors and electron acceptors).

Assessment:

Have students fill out an anonymous survey of what they learned and the performance of the presenters.

Ideas:

- Motor (work)
- Battery to compare with lemon
- Breaking Bad battery scene (video attachment)

Forms of Energy

Energy

can be

Kinetic Energy

energy of movement

Potential Energy

stored energy

energy comes from moving

energy is stored to be used later

we experience energy in different ways

Thermal Energy

energy of moving particles (heat)

Mechanical Energy

energy of objects in motion

Electrical Energy

energy of particles moving through a wire

Magnetic Energy

energy causing push or pull

Sound Energy

form of energy we can hear

Light Energy

form of energy our eyes can detect

Chemical Energy

energy stored in food, fuel

Elastic Energy

energy stored in objects that are stretched

Nuclear Energy

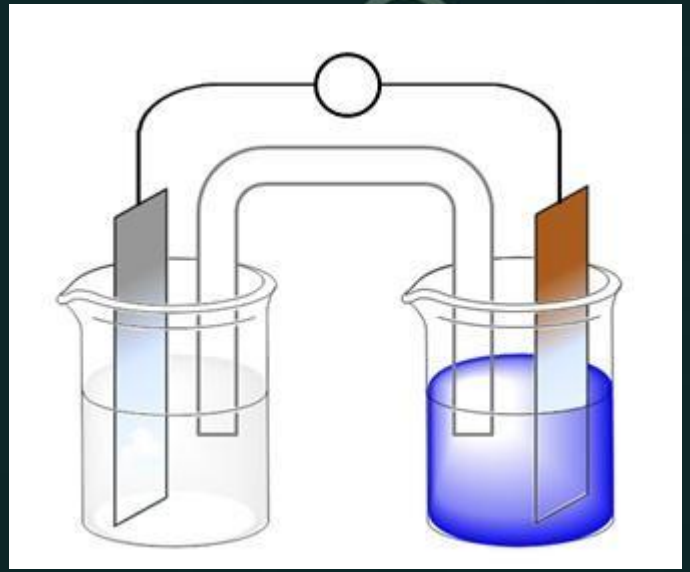
energy stored in centre of particles

Gravitational Energy

energy stored in an object when it is above the earth's surface

The Pickle Experiment

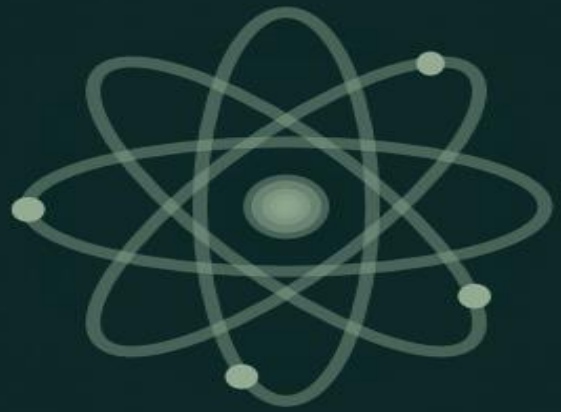
Electrochemistry



*What is **Electrochemistry**?*

Electrochemistry is the study of *chemical processes* that cause *electrons* to move.

Electrochemistry



"-Chemistry" **Part:**

Ion - an atom that is charged. Ex. Na+

"Electro-" **Part:**

- positive (anode) "+"
- negative (cathode) "-"

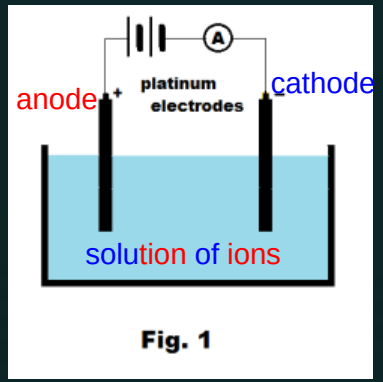
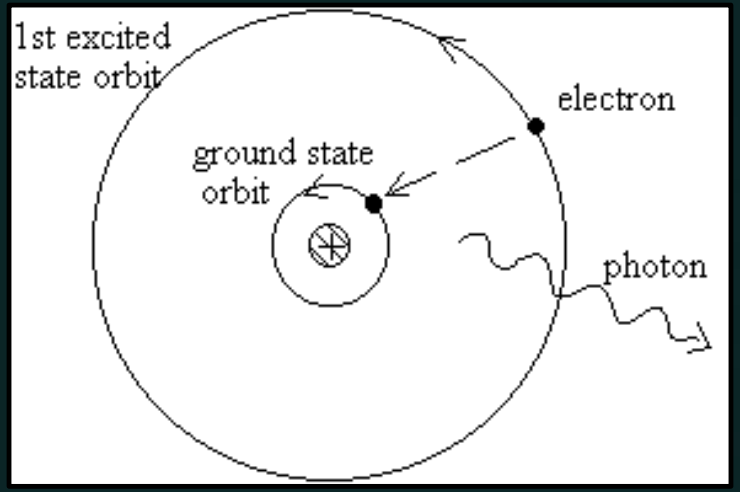


Fig. 1

Electrochemistry

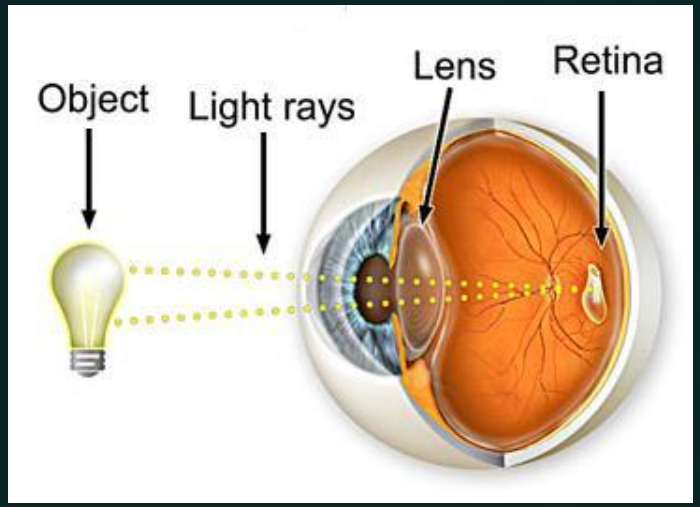
- The Flame Test
  - Na+:Bright Yellow flame
- Forms of energy
  - Electrical energy to Light energy.

How?



1. Valence (outer) electron gets excited.
2. Electron calms down again.
3. Photon is released.

What's Photon?

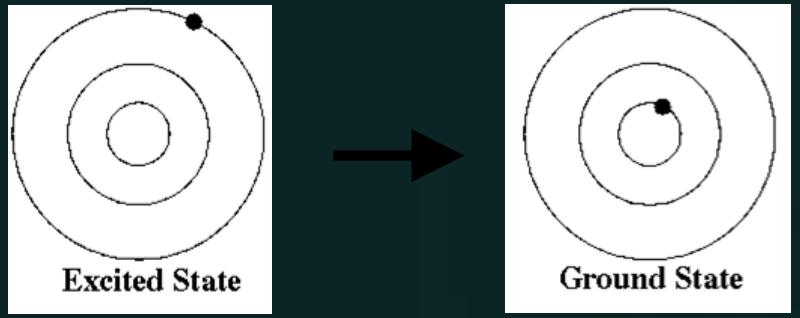


- Anything that you can "see."
- Pellets of energy.
- Your eye accepts photon, carries signal back to brain, and brain interprets that signal.

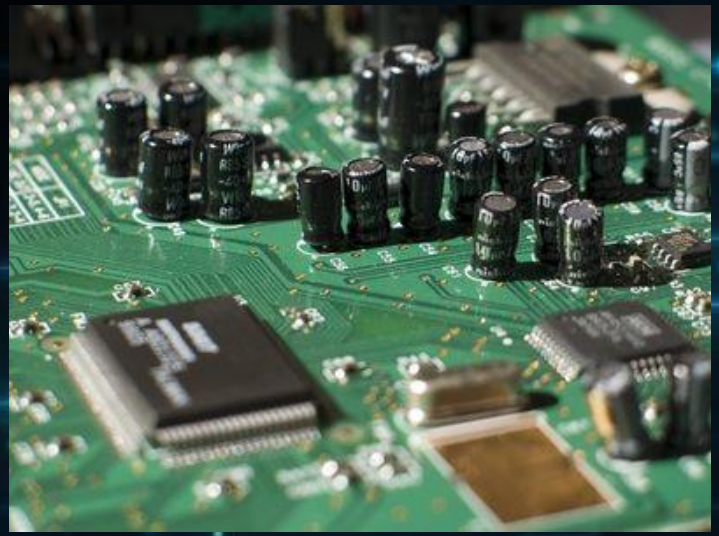
Our Experiment

- For our experiment we used 2 iron nails as the anode and the cathode
- The pickle contains Na+ ions that will glow when excited -> our light source.
- The wires were connected to opposing nails and the other ends were plugged into power outlet.

It's ALIVE!



- Photon is released.
- Many kinds of light are possible depending on the energy gap.



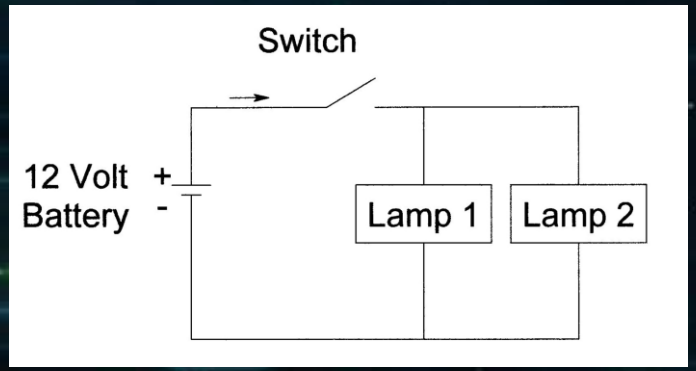
Lemon Battery

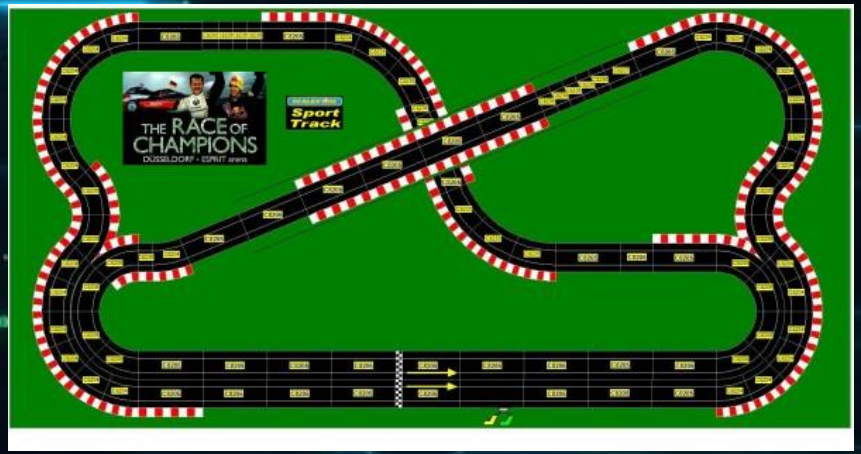
Circuits

Electricity: the flow of electrons to power devices

Voltage

Current

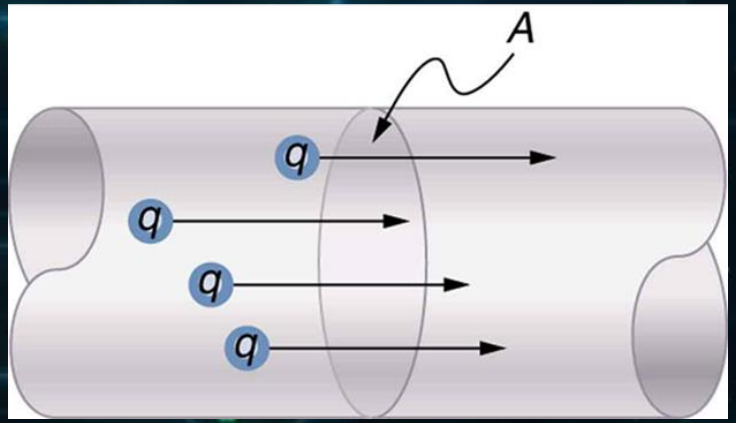




Voltage

Current

Current = Flow Rate



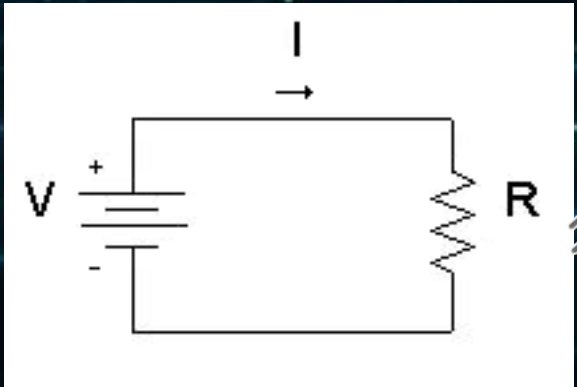
Resistance

Resistance = Load

Ohm’s Law

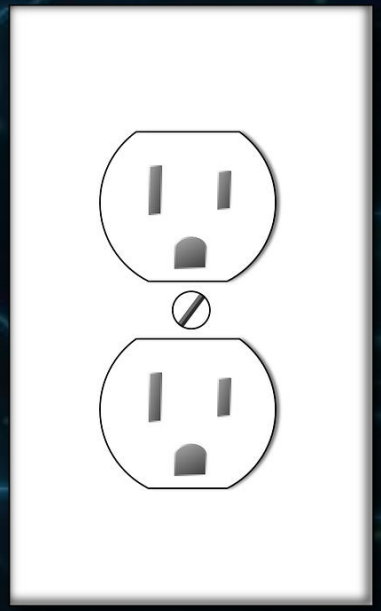
$$\Delta V = IR$$

voltage = current x *resistance*



Series and Parallel Explanation

VS

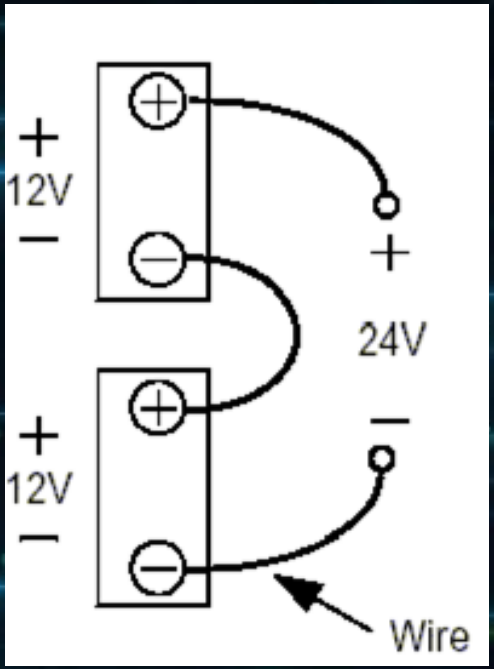


Series

Connect devices together in one path

Like a train

Voltage adds up

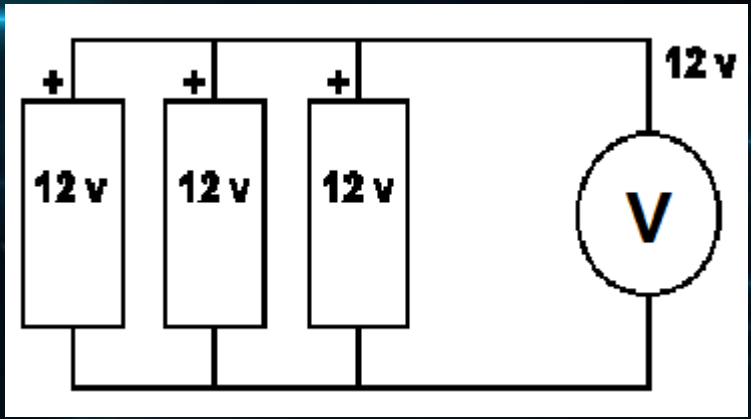


Parallel

Connect device with multiple paths

Voltage is same in each device

Current is split, batteries last longer



Lemon Battery

Acid-Base Reaction to create electricity
(Galvanic Cell)

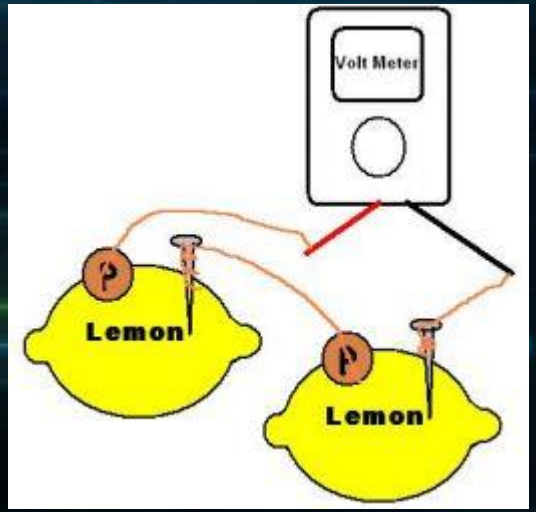
Copper (penny) is +

Aluminum (paper clip) is -

Pop Quiz!

Which leads to maximum voltage:

Series?



Parallel?