

Exploring Graphite Circuits

Overview:

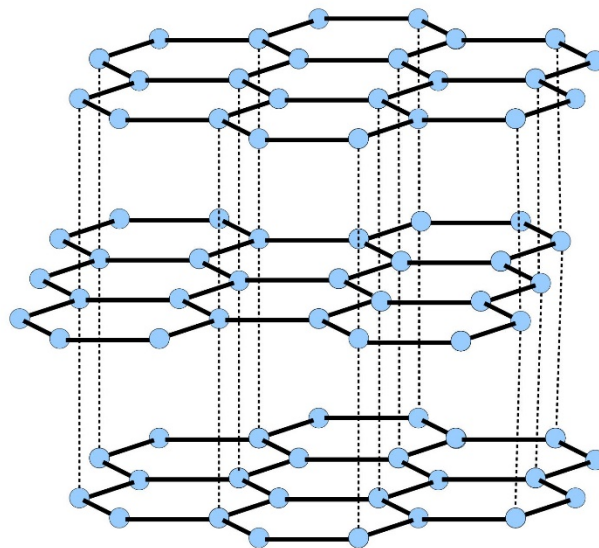
We will explore the conductive properties of graphite and graphene, and learn about the basics of circuits.

Essential Question.

Can we create a working circuit out of graphite lead that lights up an LED bulb, and what are the requirements to do so?

Background:

What we call “pencil lead” is actually a substance called graphite, which consists of many stacked sheets of carbon atoms. When the graphite is many sheets thick, it conducts electricity just like a metal. However, when graphite is thinned down to few layers, its properties change dramatically! Graphite’s sheets are very weakly bonded to one another, which allows them to be separated quite easily. This is what allows it to function as a pencil so well. In this lesson, we will be exploring circuits using graphite. The lightbulb in our circuit will get brighter as more current flows through the circuit, and will get dimmer as the resistance increases, and current decreases. Resistance can be measured with a multimeter, and the unit of resistance is the ohm.



Research Connection:

The discovery of graphene in 2004 has opened up an entirely new, exciting frontier of materials research. Scientists today study 2D materials, including graphene, exploring new quantum states of matter. Additionally, researchers can take these 2D materials and stack them onto each other, and observe how they affect the properties. The field of 2D materials offers many exciting possibilities for future technologies.

NGSS Standards:

Standard Number	Standard text
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
5-PS1-3	Make observations and measurements to identify materials based on their properties.
MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.

Materials:

- Light-emitting diode (LED)
- 9 volt batteries
- 2 AA batteries
- Alligator clip wires
- Graphite pencil
- Eraser
- Multimeter
- Resistors

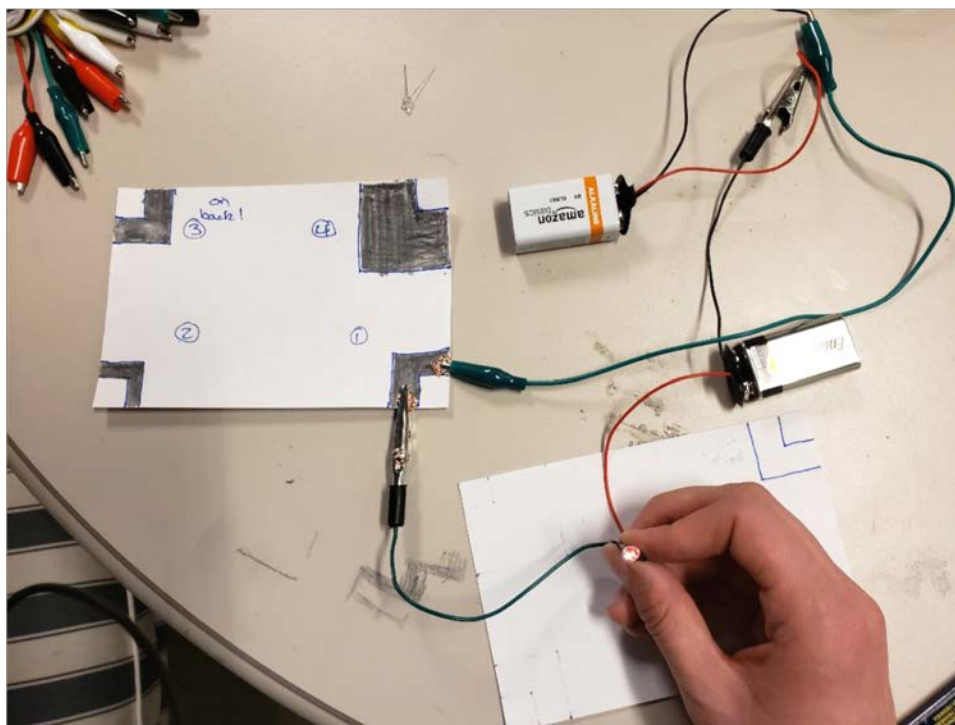
Procedure:

First, give an introduction to graphite and graphene. Discuss how the graphite easily separates into layers, which is why they can work in pencils. Explain how they act conductive like a metal, while the paper does not, so we can draw our own circuits right on the paper.

Split the kids up into groups of 4-5 people, and have the volunteers lead discussion and interaction within these smaller groups.

1. First, test the battery and explain how to properly connect the battery to the LED
 - a. Ask the kids if they have any idea how to properly connect the battery to the bulb. Explore touching the wires to the same lead on the battery, the same side on the LED, and different orientations of the LED.
 - b. Discuss with them the idea of a closed circuit, and how electricity flows.
 - c. Ask them if electricity can flow through any material, what type of material will work best, etc. Talk about conductors versus insulators.
2. Draw the first circuit!
 - a. Get out the first sheet of paper, and demonstrate how the circuits are to be drawn with the pencils.
 - b. Try attaching the wires just to the paper, not to the graphite. Ask them to predict what will happen.
 - c. Test the circuit with the clips and the battery, and show that the bulb lights up!
 - d. Try the circuit with one battery connected versus two, and observe the difference in brightness of the light bulbs.
 - e. Explain that this still creates a closed circuit, and electricity can flow through the

- f. Pass around the different sheets, and have the students draw the other patterns



3. Test different types of circuit drawings
 - a. Try a thinner pattern, thicker pattern, and one drawn on both sides of the paper
 - b. Test the resistance on each of the patterns! This may be a more useful test than just observing the brightness.
 - c. Try connecting two LEDs in series, and two in parallel. Predict what will happen. How does the brightness differ in each configuration, compared to your predictions?
4. Free drawing
 - a. Let the students design and test their own circuits. Try and help them understand why their circuits are or are not working.

Discussion

1. How does the length of the graphite circuit affect the brightness of the LED? What about the size of the lines?
2. Can we connect the bulb to just one side of the battery? Can we connect the battery to just one side of the bulb?
3. Does the orientation of the LED affect whether it will light up in the circuit?
4. What happens if we erase part of the circuit? Can electricity still flow?
5. When we connect multiple LEDs in series, what happens to the brightness?
6. When we connect multiple LEDs in parallel, what happens to the brightness?

Sources:

<https://lpmmc.cnrs.fr/spip.php?article407&lang=en>

Resources:

Introduction to graphene video

<https://www.youtube.com/watch?v=dTSnnlITsVg>