HOW A FUSE WORKS DEMONSTRATION KIT

Introduction

Students use electrical devices every day. An essential safety component of any electrical device is the fuse. Demonstrate what it means to "blow a fuse" and show why fuses are important safeguards against electrical fires.

Concepts

- Electrical circuit
- Fuses
- Ohm's law
- Short circuit

Materials (for each demonstration)

Aluminum strip, 2 mm × 10 cm*
Balloon*
Connector cords with alligator clips, 4*
Lamp receptacle*
Tape
Lantern battery, 6-V*
Miniature lightbulb, 6-V*
Scissors
Support stand and clamp

**Materials included in kit.*

Safety Precautions

Although latex (in balloons) is considered nonhazardous, not all health aspects of this substance have been thoroughly investigated. Latex may be an allergen. A 6-volt battery is not harmful, but small shocks are possible. Do not leave the short circuit wiring in place for more than 15 seconds. The battery can discharge quickly and the terminals and alligator clips can become very hot if connected for a longer duration. Disconnect the battery immediately once the balloon pops. When the balloon pops, be careful of flying particles. The demonstrator and all observers should wear safety glasses. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines.

Preparation

1. Cut a narrow strip of aluminum foil, 2 mm × 10 cm for each demonstration. *Note:* Cut the aluminum very thin—less than 2 mm wide if possible. The ends may be slightly wider so they do not break when the alligator clips are attached.
2. Screw a 6-V miniature lightbulb into the lamp receptacle.
3. Set up a support stand and clamp. This will allow students a better view of the balloon "fuse."

AP7365

Procedure

1. Blow up a balloon, leaving it slightly underinflated. *Note:* Overinflating the balloon may increase the chance of an unexpected "pop" while completing the circuit or adjusting the foil strip.
2. Tie the open end of the balloon in a knot.
3. Tape a 2 mm × 10 cm strip of aluminum foil to the widest part of the balloon, leaving 2–3 cm of the aluminum strip free at each end (see Figure 1). Make sure the center portion of the foil strip between the two pieces of tape is flat against the balloon.

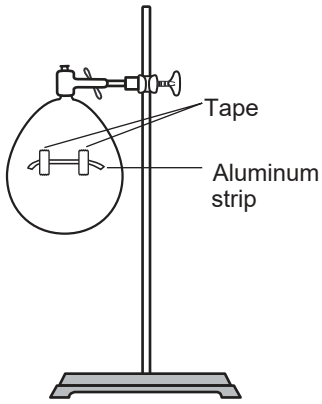


Figure 1.

4. Place the knot of the balloon in the clamp and tighten the clamp to secure the balloon for better viewing.
5. Using three connector cords with alligator clips, connect a 6-V lantern battery, the lightbulb, and the aluminum strip in series (see Figure 2). Be sure the metal of the alligator clips is not touching any part of the balloon.

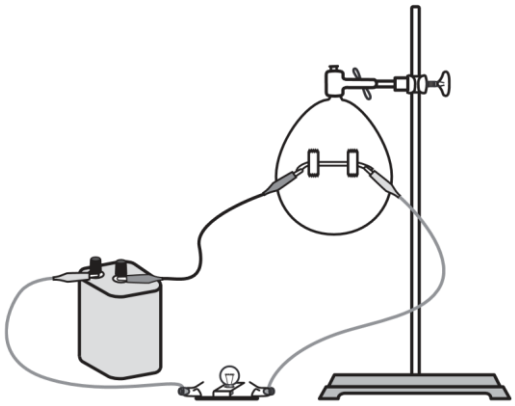


Figure 2.

6. The lightbulb should light, showing the circuit is complete.
7. Instruct students to "cup" their ears with their hands as protection from the loud "pop" of the balloon.

8. Standing away from the balloon, create a short circuit by attaching each end of a fourth connector cord to the clips on the lamp receptacle (see Figure 3). The bulb should go out or become very dim.

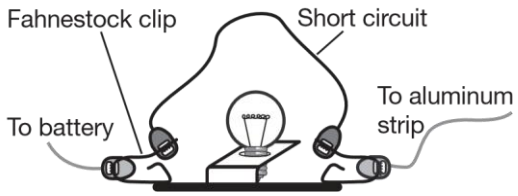


Figure 3.

9. Make note of the time the short circuit was created. The balloon should burst in a few seconds. *Note:* Do not leave the short circuit in place for more than 15 seconds. If the balloon does not burst, disconnect the wires from the battery first, and then check to make sure the aluminum strip is flat against the balloon. Adjust if necessary. Repeat steps 4–7.
10. Once the balloon pops disconnect the battery immediately.
11. Show students the broken aluminum strip.

Tips

- This kit contains enough materials to perform the demonstration seven times: a 12″ × 12″ sheet of aluminum foil, 20 balloons, 4 connector cords with alligator clips on each end, a lamp receptacle, two 6-V miniature lightbulbs and a 6-V battery
- A size 0 solid rubber stopper may be used to seal the inflated balloon rather than tying a knot. The stoppered end of the balloon can be secured in the clamp.
- When the short circuit is produced, the alligator clips will heat up. If either clip is touching the balloon, the latex may melt in that spot and cause the balloon to pop, instead of the aluminum strip “wire” causing the balloon to pop. While the effect may seem the same, the aluminum strip may not break in the former example.
- Stand away from the balloon when connecting the wire for the short circuit—the balloon may pop very quickly!
- Four 1.5-V batteries connected in series may be used in place of a 6-V lantern battery. Two or three 1.5-V batteries may also work; however, the balloon will most likely take longer than 15 seconds to pop.
- It is important to disconnect the battery immediately after the balloon pops. Even though the circuit is no longer complete when the aluminum strip breaks, if any exposed metal parts of the system touch other metal to complete a circuit, current may flow and cause parts of the circuit to overheat.
- Always wear safety glasses when working with an inflated balloon. Even peeling off a piece of tape to make an adjustment in the aluminum strip may cause the balloon to burst.
- The Fahnestock clips that are attached to the lamp receptacle allow for a short circuit to be made easily. Attach the two connecting cords for the original series circuit (step 5) to the bottom portion of the Fahnestock clips. Then attach each end of the fourth connecting cord to the top portion of the clips for the short circuit (step 7). See Figure 3.

Discussion

A fuse (fusible link) is a device designed to stop the flow of current when a circuit overheats. A circuit may get too hot either by carrying a load greater than it was designed for or by a *short circuit.* A short circuit may occur when wires lose part of their insulation or become frayed and touch each other. The path of the current is shortened, resulting in less resistance in the circuit. Less resistance results in more current flowing through the circuit than was intended. This can cause damage to the circuit from overheating, and may eventually start a fire or cause an explosion.

Electrical devices in a home, business, vehicle, and even handheld devices are protected by fuses. The fuse is part of the circuit it is designed to protect. Most fuses include a filament with a lower melting point than the rest of the wiring in the circuit. When a circuit overload occurs, the filament melts and breaks, creating an open circuit. In this demonstration, the balloon assembly represents the low-melting-point filament. When the short circuit is established, the aluminum strip heats up, melting the balloon. As the balloon bursts, it breaks the thin aluminum strip, interrupting the circuit. To reestablish current, the "blown" fuse must be removed and a new one inserted in its place. Most household circuits today as well as some electrical devices (such as a hair dryer) are protected by a circuit breaker. A circuit breaker causes a temporary interruption to the current flow, and can be reset once the problem in the circuit has been corrected.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Systems, order, and organization
Evidence, models, and explanation
Form and function

Content Standards: Grades 5–8

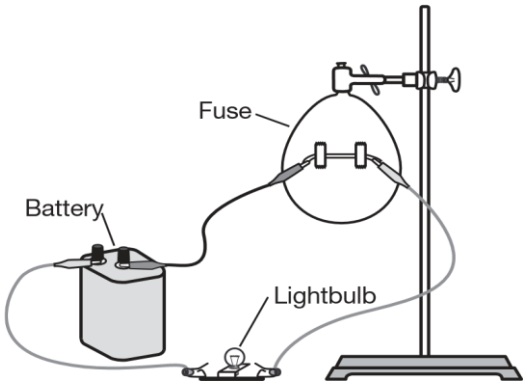
Content Standard B: Physical Science, properties and changes of properties in matter, motions and forces, transfer of energy
Content Standard E: Science and Technology

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, motions and forces, conservation of energy and increase in disorder, interactions of energy and matter
Content Standard E: Science and Technology

Answers to Worksheet Questions

Draw the completed circuit as it was initially set up by your instructor. Label the following: battery, lightbulb, fuse.



1. How was a short circuit created? Why is it called a short circuit?

   A connecting cord was attached to either side of the lightbulb. This allowed the current to bypass the lightbulb, following a path of less resistance—a "short-cut" so to speak.

2. Describe what happened after the short circuit was created. What is the purpose of the fuse?

   The wiring, including the aluminum strip, got hot. The increased heat melted the balloon, causing it to pop. The burst balloon caused the aluminum strip to break, stopping the flow of current and preventing a possible fire, just like a

3. Ohm's law describes the relationships between current (*I*), voltage (*V*), and resistance (*R*) and is represented by the equation $V = I \times R$. The lightbulb provides a certain amount of resistance in the circuit. What effect does creating a short circuit have on the current? Explain in terms of Ohm's law.

   Creating a short circuit bypasses the lightbulb, thus reducing the amount of resistance in the circuit. Less resistance results in more current since the voltage—supplied by the battery—remains the same.

4. When a fuse blew in a household circuit, a once-common practice to temporarily reestablish current was to place a penny in place of the melted filament until a new fuse could be obtained. Why is this procedure unsafe?

   The copper penny would have a higher melting point than the fuse. If the problem still existed, the circuit would continue to be overloaded and a fire could possibly result.

The How a *Fuse Works—Demonstration Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description

AP7365	How a Fuse Works—Demonstration Kit
AP1429	Lantern Battery, 6-V

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

Name: _____

How a Fuse Works Worksheet

Observations

Draw the completed circuit as it was initially set up by your instructor. Label the following: battery, lightbulb, fuse.

Discussion Questions

1. How was a short circuit created? Why is it called a short circuit?

2. Describe what happened after the short circuit was created. What is the purpose of the fuse?

3. Ohm's law describes the relationships between current (*I*), voltage (*V*), and resistance (R) and is represented by the equation $V = I \times R$. The lightbulb provides a certain amount of resistance in the circuit. What effect does creating a short circuit have on the current? Explain in terms of Ohm's law.

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