14 Hot Bulbs

LABORATORY

YASMIN KNEW THE *lights in her room transformed electrical energy into light energy. One time, she accidentally touched a light bulb of a lamp that she had just turned off, and it was quite hot. From science class, Yasmin knew that this meant that the light bulb had transformed some electrical energy into thermal energy. She wondered how much of the electrical energy supplied to the bulb had been transformed into light and how much into thermal energy.*

Lights are an essential part of most buildings. It should come as no surprise that light bulbs radiate visible light. But, light bulbs also transform energy into forms other than visible light. When evaluating how efficient a light bulb is at producing light, you must take into account any energy it emits that is not visible light. That energy can be considered "wasted." So, the more "wasted" energy a light bulb emits, the lower its energy efficiency.

In this activity, you will compare the efficiencies of two different types of light bulbs.

GUIDING QUESTION

How can we measure the efficiency of a light bulb?

MATERIALS

For each group of four students

1 9-volt battery harness with an LED and an incandescent bulb
2 bulb socket and thermometer holders
2 hot bulb trays
1 graduated cylinder (10-mL)
2 metal-backed thermometers
1 timer
1 9-volt battery
access to water

SAFETY

Do not try this investigation with any other kind of battery or electrical energy source. Never, under any circumstances, place plugged-in electrical appliances in or near water.

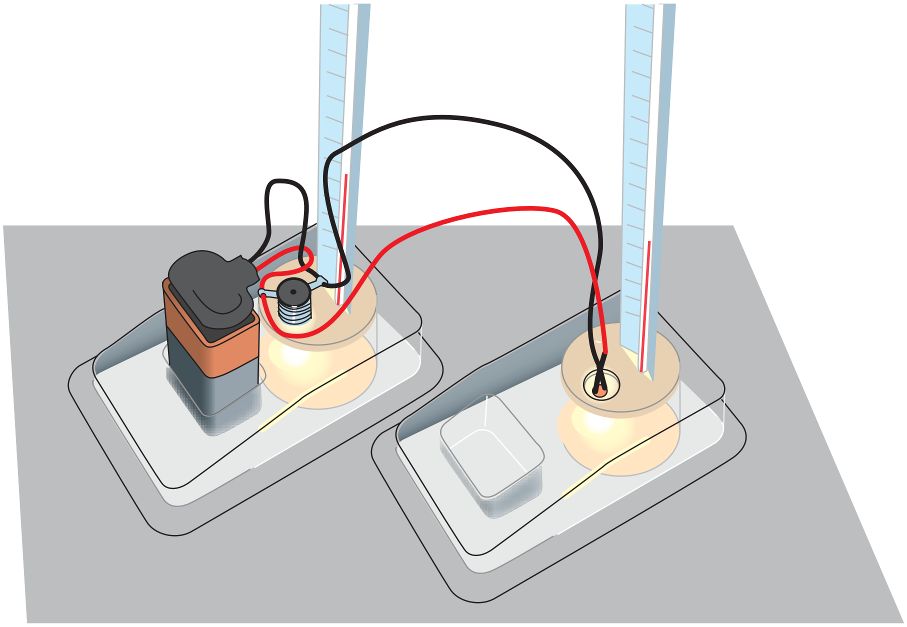
PROCEDURE

Part A: Comparing Bulbs

1. Examine the two bulbs and describe any major differences in your science notebook.
2. Connect the battery to the harness so that both bulbs light up. Describe any major differences you observe in your science notebook. When comparing brightness, make sure to look at the top of each bulb as well as at the sides. Once you are finished making observations, disconnect the battery.

Part B: Collecting Data

3. Using the graduated cylinder, carefully measure 9 mL of water and pour it into the circular cup of one of the hot bulb trays. Repeat this step for the other hot bulb tray.
4. As shown on the next page, carefully place the bulb socket and thermometer holders with the incandescent bulb into one hot bulb tray so that the bulb is submerged; do the same with the LED bulb and the other tray. Do not connect the battery yet.



5. Gently push a thermometer through the triangular hole in each bulb socket and thermometer holders until it hits the bottom of the cup.
6. Make a data table in your science notebook like the one below:

Light Bulb Data

Bulb	*Water volume (mL)*	*Time (min)*	*Initial temperature (°C)*	*Final temperature (°C)*	*Temperature change (°C)*
Incandescent					
LED					

7. Measure and record in the table the initial temperature of the water surrounding each bulb.
8. At the same time, start the timer and connect the battery to the harness so that the bulbs light up.
9. When the timer gets to exactly 3 min, disconnect the battery from the harness. Measure and record the temperatures of both water samples.
10. Calculate the temperature changes of the water in the two cups. Record the results in your data table.

Part C: Calculating Efficiency

11. Make a table in your science notebook like the one below:

Light Bulb Calculations

Bulb	Electrical energy supplied (joules)	Thermal energy released (joules)	Visible light energy emitted (joules)	Efficiency (%)
Incandescent				
LED				

For Procedure Steps 12–15, show your work in your science notebook, and then use the table you made in Step 11 to record the results of your calculations.

12. For each minute the bulbs are lit, the battery transfers about 114 joules of electrical energy to the incandescent bulb and about 18 joules of electrical energy to the LED. Calculate the electrical energy supplied to each bulb using the following equation:

    electrical energy supplied (joules) = time bulb is lit (min) × number of joules/min

13. Calculate the thermal energy released from each bulb using the following equation:

    thermal energy released (joules) = Δ temperature (°C) × mass of water (g) × 4.2 (joules/(g × °C))

    Hint: 1 mL of water has a mass of 1 g.

14. Calculate the amount of visible light energy emitted by each bulb using the following equation:

    light energy emitted (joules) = electrical energy supplied (joules) – thermal energy released (joules)

15. Calculate the light efficiency of each bulb using the following equation:

    efficiency of the bulb (%) = (light energy emitted/electrical energy supplied) × 100%

ANALYSIS

1. A typical incandescent light bulb is about 5% efficient at producing light energy. Does your calculation for light efficiency agree with this? Explain why you think your result is or is not close to 5%.
2. Are light bulbs better at emitting light energy or thermal energy? Explain using results from this experiment.
3. Do you think you would be more concerned about inefficient light bulbs in a home located in a hotter climate or a colder one? Explain.
4. Look at the table below, which compares an incandescent light bulb with other kinds of bulbs that are about the same brightness. Answer the following questions:
    a. Which is the best light bulb? Using the table, explain the evidence that helped you decide.
    b. What are the trade-offs of buying the light bulb that you identified in Step 4a?

Comparison of Equally Bright (1600 Lumens) Light Bulbs

CHARACTERISTICS	INCANDESCENT	COMPACT FLUORESCENT	HALOGEN	LED
Efficiency	5%	20%	9%	38%
Rate of energy use (W)	100	23	60	13
Cost per bulb	$1.00	$3.00	$2.00	$5.00
Electricity cost per 100 hours	$1.20	$0.28	$0.72	$0.16
Average lifetime (hours)	1,000	12,000	2,000	15,000
Total cost per 100 hours	$1.30	$0.31	$0.82	$0.19

Incandescent, compact fluorescent, halogen, and LED light bulbs.