Chapter 11: Electricity and Its Production

Mini Investigation: Building an LED Circuit, page 503

A. When one cell was connected to the LED, the LED did not light no matter which way they were connected.
B. When two cells and the LED were connected, the LED did light but only when connected in one way.
C. The electricity does flow in a particular direction. If it flowed in either direction, the LED would have lit regardless of the way it was connected. Step 2 of the investigation supported my statements.

Section 11.1: Electrical Energy and Power Plants

Tutorial 1 Practice, page 505

1. Given: $\Delta E = 120$ J; $\Delta t = 25$ s
Required: P
Analysis: $P = \dfrac{\Delta E}{\Delta t}$
Solution:

$$\begin{aligned} P &= \frac{\Delta E}{\Delta t} \\ &= \frac{120 \text{ J}}{25 \text{ s}} \\ P &= 4.8 \text{ W} \end{aligned}$$

Statement: The power rating of the digital camera is 4.8 W.
2. Given: $\Delta E = 198\ 000$ J; $\Delta t = 15$ min
Required: P
Analysis: $P = \dfrac{\Delta E}{\Delta t}$
Solution: First convert time to seconds to get the answer in joules per second (J/s), or watts (W):

$$\Delta t = 15 \cancel{\text{min}} \times \frac{60 \text{ s}}{1 \cancel{\text{min}}}$$
$$\Delta t = 900 \text{ s}$$

$$\begin{aligned} P &= \frac{\Delta E}{\Delta t} \\ &= \frac{198\ 000 \text{ J}}{900 \text{ s}} \\ P &= 220 \text{ W} \end{aligned}$$

Statement: The power required for the hair dryer to transform the energy is 220 W.

Tutorial 2 Practice, page 506

1. Given: $P = 7.0$ W; $\Delta t = 24$ h
Required: ΔE
Analysis: $P = \dfrac{\Delta E}{\Delta t}$

$$\Delta E = P\Delta t$$

Solution: Convert time to seconds to get the answer in joules:

$$\Delta t = 24 \cancel{\text{h}} \times \frac{3600 \text{ s}}{1 \cancel{\text{h}}}$$
$$\Delta t = 86\ 400 \text{ s}$$

$$\begin{aligned} \Delta E &= (7.0 \text{ W})(86\ 400 \text{ s}) \\ &= \left(7.0 \frac{\text{J}}{\cancel{\text{s}}}\right)(86\ 400 \cancel{\text{s}}) \\ &= 6.048 \times 10^5 \text{ J (two extra digits carried)} \\ \Delta E &= 6.0 \times 10^5 \text{ J} \end{aligned}$$

Statement: The compact fluorescent light bulb needs 6.0×10^5 J of energy to operate for 24 h.
2. To convert the answer from Question 1 to kilowatt hours, convert from joules:

$$6.048 \times 10^5 \cancel{\text{J}} \times \frac{1 \text{ kWh}}{3.6 \times 10^6 \cancel{\text{J}}} = 0.17 \text{ kWh}$$

The compact fluorescent light bulb needs 0.17 kWh of energy to operate for 24 h.

Research This: Power Plant Efficiency, page 507

A. Answers may vary. Sample answer:
I chose wind power plant technology for electricity generation. It has a thermal efficiency of 40%.
B. Improvements in the types of materials that can be used create wind turbines has increased the output of wind power technology plants. Lighter materials allow for larger blades and taller supports. Increased turbine height means the turbines can catch the stronger, higher altitude, winds. These changes have increased thermal energy output.
C. By building bigger and lighter turbines, other but similar plants could be improved. Fewer turbines would be needed to generate more electricity.

D. Answers may vary. Students' reports could include:
Hydro power plant efficiency could be improved by upgrading or "uprating" existing hydro power plants in the mechanics of generating the electricity and the electronics of operating the plant. Taller dams or water reservoirs would increase output of electricity. Heat capture mechanisms could be connected to cooling towers to convert heat energy to power other parts of the plant or to be used elsewhere.
Fossil fuel (such as coal) power plant efficiency could be improved by directing steam into pipes and increasing its pressure, allowing it to reach much higher temperatures. The higher temperatures make the transfer of energy more efficient.
Nuclear power plant efficiency could be improved by redesigning important components in the energy production process. For example, the uranium cylinders could become hollow tubes. The increased surface area would allow water to flow in and out of the cylinders, increasing heat transfer.
Solar power plant efficiency could be improved by using solar power towers instead of solar troughs to capture sun energy. In a trough system, many parabolic (half cylindrical troughs) solar panels, placed at a fixed angle, capture sun energy which is transferred to synthetic oil circulating through pipes. In a tower system, the sun energy is captured and reflected directly by movable solar panels to a tower that transmits the energy to a fluid. As with both systems, the heat is used to generate steam to run a turbine. The tower system is more efficient because it requires fewer solar panels than a trough system for the same energy output. Unused energy can be stored with the tower system, unlike the trough system.

Section 11.1 Questions, page 507

1. Answers may vary. Sample answer:
The statement "My washing machine consumes a large amount of electricity." uses the word electricity incorrectly. The statement should be "My washing machine requires a large amount of electrical energy per second in order to operate." Electricity refers to electrical energy and the movement of charge.

2. Given: ΔE = 19 200 J; Δt = 2.0 s
Required: P
Analysis: $P = \frac{\Delta E}{\Delta t}$
Solution:
$$\begin{aligned} P &= \frac{\Delta E}{\Delta t} \\ &= \frac{19\ 200\ \text{J}}{2.0\ \text{s}} \\ P &= 9600\ \text{W} \end{aligned}$$
Statement: The power of the starter is 9600 W.

3. Given: P = 1200 W; $\Delta E = 1.8 \times 10^5$ J
Required: Δt
Analysis: $P = \frac{\Delta E}{\Delta t}$
Solution:
$$\begin{aligned} P &= \frac{\Delta E}{\Delta t} \\ \Delta t &= \frac{\Delta E}{P} \\ &= \frac{1.8 \times 10^5\ \cancel{\text{J}}}{1200\ \frac{\cancel{\text{J}}}{\text{s}}} \\ \Delta t &= 150\ \text{s} \end{aligned}$$
To find the answer in minutes, convert from seconds:
$$\Delta t = 150\ \cancel{\text{s}} \times \frac{1\ \text{min}}{60\ \cancel{\text{s}}}$$
$$\Delta t = 2.5\ \text{min}$$
Statement: The food was in the microwave for 2.5 min.

4. Given: P = 380 W; Δt = 110 h
Required: ΔE
Analysis: $P = \frac{\Delta E}{\Delta t}$
$$\Delta E = P\Delta t$$
Solution: Convert time to seconds to get the answer in joules:
$$\Delta t = 110\ \cancel{\text{h}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}}$$
$$\Delta t = 396\ 000\ \text{s}$$

$$\begin{aligned} \Delta E &= (380\ \text{W})(396\ 000\ \text{s}) \\ &= \left(380\ \frac{\text{J}}{\cancel{\text{s}}}\right)(396\ 000\ \cancel{\text{s}}) \\ \Delta E &= 1.505 \times 10^8\ \text{J}\ \text{(two extra digits carried)} \end{aligned}$$

To find the answer in kilowatt hours, convert from joules:
$$1.505 \times 10^8\ \cancel{\text{J}} \times \frac{1\ \text{kWh}}{3.6 \times 10^6\ \cancel{\text{J}}} = 42\ \text{kWh}$$

Statement: The plasma television needs 1.5×10^8 J or 42 kWh of energy to operate for one month.

5. Given: P = 380 W; Δt = 110 h/month for 12 months

Required: ΔE

Analysis: $P = \frac{\Delta E}{\Delta t}$

$$\Delta E = P\Delta t$$

Solution: First find the total amount of television watched in hours. Then convert time to seconds to get the answer in joules:

$$\begin{aligned}\Delta t &= \frac{110 \text{ h}}{1 \cancel{\text{month}}} \times 12 \cancel{\text{months}} \\ &= 1320 \text{ h} \\ &= 1320 \cancel{\text{h}} \times \frac{3600 \text{ s}}{1 \cancel{\text{h}}} \\ \Delta t &= 4\,752\,000 \text{ s}\end{aligned}$$

$$\begin{aligned}\Delta E &= (380 \text{ W})(4\,752\,000 \text{ s}) \\ &= \left(380 \frac{\text{J}}{\cancel{\text{s}}}\right)(4\,752\,000 \cancel{\text{s}}) \\ \Delta E &= 1.806 \times 10^9 \text{ J} \text{ (two extra digits carried)}\end{aligned}$$

To find the answer in kilowatt hours, convert from joules:

$$1.806 \times 10^9 \cancel{\text{J}} \times \frac{1 \text{ kWh}}{3.6 \times 10^6 \cancel{\text{J}}} = 5.0 \times 10^2 \text{ kWh}$$

Statement: The plasma television needs 1.8×10^9 J or 5.0×10^2 kWh of energy to operate for one year.

6. Answers may vary. Sample answer:
I was disappointed that wind energy technology is so inefficient since it is in the news as a solution to our energy problems. I thought it would be more efficient if it is being promoted so much.