13.5 Section Review Answers

Student Textbook page 664

1. **K/U** $P = IV$, $P = \frac{V^2}{R}$, $P = I^2R$, $P = \frac{\Delta E}{t}$
2. **C** The bulbs in parallel (b) will be the brightest, since each of them will receive the same potential difference as that at the battery source. The bulbs in series (a), being equal resistances in series, will each receive only half of the potential difference of the battery, because the voltage drop across each must add up to the voltage of the source. If the voltage drop across each is half, the current they receive also must be half. Thus, the power supplied to them is only one quarter of that received by the bulbs in parallel.
3. **I** 1 kilowatt = 1000 J/s

   1 hour = 3600 s

   1 kilowatt-hour = 1000 J/s × 3600 s = 3 600 000 J = 3.6 MJ

Chapter 13 Review Answers

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Knowledge and Understanding

1. Potential energy is, in general, the energy stored by an object due to its position or condition. Potential difference is the potential energy possessed by one unit measure of the object. For example, gravitational potential difference is the potential energy of one unit of mass (in SI, 1.0 kg) due to its position with respect to the gravitational attraction of some large mass, such as Earth, acting on that mass. Electric potential difference is the potential energy of one unit of charge (in SI, 1.0 C) due to its position due to the attractive or repulsive forces exerted by other charges.
2. Electric current is conventional current flow, or the flow of positive charge. It travels from the positive terminal (anode) to the negative terminal (cathode). Electron flow is the flow of negative charge or electrons. It flows from the negative terminal (cathode) to the positive terminal (anode).
3. A light bulb is considered to be a non-ohmic resistor because its resistance changes with the amount of current that passes though it, due to its increase in temperature when it is turned on. If a graph of current against voltage is plotted for a light bulb, it will not form a straight line as ohmic conductors do. Instead, the line will rise

rapidly at first and then begin to level off as the current increases. Ohm's law therefore cannot be applied to this type of conductor.

4. The terminal voltage is the potential difference across the terminals of a battery when it has current flowing through it, because it is part of a circuit. It is the *emf* minus the voltage drop across the internal resistance of the battery. The *emf* of a battery is the potential difference across the terminals of a battery when it does not have current flowing through it, as determined when the battery is connected only to a voltmeter.

5. Length, temperature, cross-sectional area, and the nature of the material from which the conductor is made.

6. A cell is a single source of electrochemical energy, such as when two dissimilar metals are placed in an electrolyte. A battery is two or more cells connected in series, with the positive terminal of one cell connected to the negative terminal of the next one.

7. The resistivity of a conductor is a property of the material making up the conductor. It is an indication of the ability of the conducting material to carry a current. A low resistivity means that the material is a good conductor. You can predict the resistance of a conductor if you know its resistivity and dimensions.

8. The elementary charge is the smallest unit into which charge can be subdivided. This is contrary to the belief at the time that Benjamin Franklin and other physicists were studying electric charge. These early scientists believed that charge was a continuous fluid. Its particulate nature was demonstrated by Millikan. We now know that protons and electrons carry a charge of magnitude 1.602×10^{-19} C. (**Note:** Quarks, the constituents of protons and neutrons, have charges of $\pm e/3$ or $\pm 2e/3$. However, no one has ever isolated a quark, so it has not yet been demonstrated that the currently accepted unit charge can be subdivided.)

9. Conductors: Examples would be all of the metals.
   Insulators: Examples are glass, rubber, and air.
   Semiconductors: Examples are silicon and germanium.

10. Energy is the ability to do work. Power is the *rate* at which the work is done or the energy is transferred or transformed from one form into another.

11. Placing loads in parallel provides more pathways through which current can flow. Even though each pathway has some resistance, the overall or equivalent resistance is reduced.

12. In any circuit, the power output of the circuit can be determined by the potential difference across the whole circuit (which is the potential difference of the source) and the equivalent resistance of the circuit: $P = \frac{V_s}{R_{eq}}$. When there is only one resistor, R_1, in the circuit, the power output is $P = \frac{V_s}{R_1}$. When two more resistors are connected in series with the first, R_{eq} is the sum of all three, and thus greater than the first. Since this large R_{eq} is in the denominator of the power equation, the power output is smaller. When the two additional resistors are connected in parallel with the first, the equivalent resistance is smaller than any of the three resistors. Once more, since this small R_{eq} is in the denominator of the power equation, the power output is greater than in the original circuit.

13. Millikan's oil-drop experiment demonstrated that there is a fundamental unit of charge and this "elementary charge" cannot be subdivided. All charged particles carry an integral multiple of the elementary charge. Millikan and his assistant measured that charge to be 1.592×10^{-19} C, within 0.6% of the currently accepted value.

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14. The material must have a high resistivity constant and be very thin. Just because a material has a resistance of 144 Ω does not mean it has the property of being able to become hot enough to produce light. Most materials would not work. In the case of copper, for instance, the wire would have to be very long, and too much current would be required.

15. The potential difference of a single cell should be roughly 0.50 V to 0.55 V. The potential difference of the pile should be the sum of the individual cells or five times that of a single cell. The electrolyte should not have a significant effect on the cell potential. However, if you measured current, the electrolyte would affect that. For example, vinegar is a poor electrolyte compared to salt or sulfuric acid and should reduce the current.

16. Answers will vary, depending on each student's investigation and research.

17. The most current that can be drawn from the circuit is 15 A. Assuming that the source voltage is 120 V, the maximum power that the circuit can deliver is $15\ \text{A} \times 120\ \text{V} = 1800\ \text{W}$. Thus, in addition to the 450 W television set, the circuit could power no more than 13 100 W light bulbs, as $1800\ \text{W} - 450\ \text{W} = 1350\ \text{W}$.

18. **Note:** The answer given in the textbook for this question is incorrect. The correct answer appears below.

$$V_1 = (1.00\ \text{A})(300\ \Omega)$$
$$V_1 = 300\ \text{V}$$
$$I_2 = \frac{300\ \text{V}}{100\ \Omega}$$
$$I_2 = 3.00\ \text{A}$$
$$I_3 = 1.00\ \text{A} + 3.00\ \text{A}$$
$$I_3 = 4.00\ \text{A}$$
$$R_3 = \frac{120\ \text{V}}{4.00\ \text{A}}$$
$$R_3 = 30.0\ \Omega$$
$$\frac{1}{R_{1-2}} = \frac{1}{300\ \Omega} + \frac{1}{100\ \Omega}$$
$$\frac{1}{R_{1-2}} = \frac{4}{300\ \Omega}$$
$$R_{1-2} = 75.0\ \Omega$$
$$\frac{1}{R_{4-5}} = \frac{1}{90.0\ \Omega} + \frac{1}{18.0\ \Omega}$$
$$\frac{1}{R_{4-5}} = \frac{6}{90.0\ \Omega}$$
$$R_{4-5} = 15.0\ \Omega$$
$$R_{1-5} = 75.0\ \Omega + 30\ \Omega + 15\ \Omega$$
$$R_{1-5} = 120\ \Omega$$

$$V_6 = (6.00\ \text{A})(30.0\ \Omega)$$
$$V_6 = 180\ \text{V}$$
$$R_7 = \frac{300\ \text{V}}{6.00\ \text{A}}$$
$$R_7 = 50\ \Omega$$
$$V_s = 180\ \text{V} + 300\ \text{V}$$
$$V_s = 480\ \text{V}$$
$$V_{4,5} = 480\ \text{V} - 300\ \text{V} - 120\ \text{V}$$
$$V_{4,5} = 60\ \text{V}$$

$$R_4 = \frac{60.0\ \text{V}}{0.667\ \text{A}}$$
$$R_4 = 90.0\ \Omega$$
$$I_5 = 4.00\ \text{A} - 0.667\ \text{A}$$
$$I_5 = 3.333\ \text{A}$$
$$R_5 = \frac{60.0\ \text{V}}{3.333\ \text{A}}$$
$$R_5 = 18\ \Omega$$

$$R_{6-7} = 30.0\ \Omega + 50.0\ \Omega$$
$$R_{6-7} = 80.0\ \Omega$$
$$\frac{1}{R_{eq}} = \frac{1}{120\ \Omega} + \frac{1}{80.0\ \Omega}$$
$$\frac{1}{R_{eq}} = \frac{5}{240\ \Omega}$$
$$R_{eq} = 48.0\ \Omega$$
$$P = \frac{V^2}{R_{eq}}$$
$$P = \frac{(480\ \text{V})^2}{48.0\ \Omega}$$
$$P = 4800\ \text{W}$$

Communication

19. In a series circuit, the current is the same at every point in the circuit, and the sum of the potential differences across each resistance is the same as the potential difference of the source. In a parallel circuit, the potential difference is the same across every circuit element, and the sum of the currents in all branches is the same as the current through the source.

20. Bringing a device such as an electric razor from Europe, where the voltage is double that in North America, will produce these results. As the voltage here is half that in

England, the current supplied to the razor will also be half. The net effect will be that the razor will get only one quarter of the power that it needs. This will make it run weakly and slowly.

Making Connections

21. You are decreasing the resistance when you place the burner on high. This allows more current to flow and therefore produces more heat.

22. Answers will vary, depending on the appliances that students have in their homes.

23. **(a)** $I = \frac{P}{V} = \frac{25\ \text{MW}}{25\ \text{MV}} = 1.0\ \text{A}$

(b) $I = \frac{P}{V} = \frac{25 \times 10^6\ \text{W}}{25 \times 10^3\ \text{V}} = 1000\ \text{A}$

(c) $R = 1000\ \text{km} \times 0.0100 \frac{\Omega}{\text{km}}$

$R = 10.0\ \Omega$

With the current in (a)

$V = IR$

$V = 1.0\ \text{A} \times 10.0\ \Omega$

$V = 10\ \text{V}$

With the current in (b)

$V = IR$

$V = 1000\ \text{A} \times 10.0\ \Omega$

$V = 10\ 000\ \text{V}$