CHAPTER 15 Review

REFLECTING ON CHAPTER 15

- Materials are classified as conductors, insulators or semi-conductors depending on their ability to pass electric currents.
- The voltaic pile was the first battery. Its invention allowed physicists to carry out the first investigations with current electricity.
- Potential difference is a measure of the amount of energy that is available per unit charge. One volt is the potential difference that will provide one joule of energy to every coulomb of charge transferred.
- The rate at which charge moves through a circuit is called electric current. The unit of current, the ampere, is the current that transfers charge at the rate of one coulomb per second.
- Current is, by definition, the movement of positive charges. The movement of negative charge is called electron flow.
- Electric charge exists only in whole-number mulitples of the elementary charge, ($1\ e = 1.60 \times 10^{-19}$ C)
- When a current flows through a load, the resistance of the load converts electric energy to heat, light or other forms of mechanical energy. This results in a potential drop across the load.
- The resistance of a conductor of a particular material varies directly as its length and inversely as its cross-sectional area.
- Ammeters are connected in series with loads; voltmeters are connected in parallel with loads.
- Ohm's law describes the relationship between the potential difference across, the current through, and the resistance of a load.
- When loads are connected in series, the equivalent resistance is the sum of their resistances.
- When loads are connected in parallel, the equivalent resistance is the inverse of the sum of the inverses of their resistances.
- The electromotive force (*emf*) of a battery is the maximum potential difference that the battery can create. When a current flows, some of the *emf* is used to move the current through the internal resistance of the battery. The terminal voltage of the battery is the *emf* less the potential difference across the internal resistance. The terminal voltage is the potential difference available to the circuit to which the battery is attached.
- In a circuit composed of several loads, the equivalent resistance of the circuit is the resistance offered to the terminal voltage of the power supply by all the loads in the circuit.
- The power output (rate of energy transfer) of a circuit is measured in watts. Electric energy is sold in units called kilowatt hours (kW · h).

Knowledge/Understanding

1. Describe the difference between potential energy and potential difference.
2. What is the difference between electric current and electron flow?
3. Explain why a light bulb should actually be considered to be a non-ohmic resistor.
4. What is the difference between *emf* and terminal voltage?
5. List the four factors that affect the resistance of a conductor.
6. What is the difference between a battery and a cell?
7. What is meant by the resistivity of a conductor?
8. Define what is meant by the term "elementary charge."
9. Materials are classified by their ability to conduct electric current. Describe the three classifications of materials and give an example of a material in each group.
10. Explain the difference between power and energy.

11. Why does connecting loads in parallel reduce the equivalent resistance of a circuit?

12. A simple circuit consists of a resistance connected to a battery. Explain why connecting two additional resistances in series with the first reduces the power output of the circuit, yet if you connect the two additional resistances in parallel with the first load, the power output increases.

13. What is the significance of Millikan's oil-drop experiment?

Inquiry

14. A 100 W light bulb designed to operate at 120 V has a filament with a resistance of 144 Ω. What constraints are on the design of the filament? Why cannot just any 144 Ω resistance be used as a filament for the bulb?

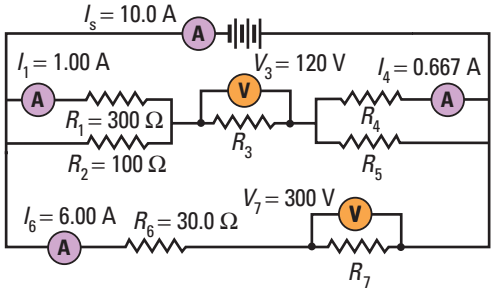
15. Make voltaic piles by using five pennies and five nickels separated by paper towels soaked in (a) salt water, (b) vinegar, and (c) dilute sulfuric acid.

- In each case, measure the potential difference of the pile with a voltmeter. Use the voltmeter to measure the potential difference of a single cell. What is the relationship between the values?
- How does the liquid (the electrolyte) on the paper towel affect the potential difference of the pile?

16. Research the design and make sketches of the (a) dry cell, (b) lead storage battery, and (c) nickel-cadmium battery. (This information is available on the Internet or in chemistry or physics textbooks.) Label and specify the material or chemical used for the anode, cathode, and electrolyte. What are the advantages and disadvantages of each type of cell or battery?

17. The electric circuit to which a television set is connected is protected by a 15 A circuit breaker. If the power rating of the set is 450 W, how many 100 W light bulbs can be operated as well on this circuit without overloading the circuit breaker?

18. In the circuit diagram below, values for some of the quantities for each part of the circuit are given. Calculate the missing currents, resistances, and the potential differences for each of the loads in the circuit. Find the equivalent resistance for the circuit and the power output for the circuit.



Communication

19. Describe how series and parallel circuits differ in terms of current flow and potential difference.

20. On a holiday to Canada, a resident of England decides to bring his electric razor. He has heard that the plugs are different so he buys an adapter that will fit into an electric socket in Canada. When he plugs in and turns on his razor in Canada, it runs very slowly and is very weak. Explain why.

Making Connections

21. When you turn up the heating element of an electric stove from low to high, are you increasing or decreasing the resistance of the circuit? Explain.

22. Find the power rating for several of the appliances you have in your home (TV, clothes dryer, electric kettle, iron, hair dryer, and vacuum cleaner, for example). Estimate, for each appliance, how long it is used per month. Make a data table with the column headings: Name of Appliance, Power Rating (kW), Time Used per Month (h), Energy Use per Month (MJ), Cost of Operation (find the charge per kW · h on your electric bill). If you know how, you could use an electronic spreadsheet to organize your calculations.

23. When electricity is transmitted over long distances, very high voltages are used. Consider a hydo-electric plant that has a power output of 25.0 MW. This power output can be achieved by transmitting a small current at a high voltage or a large current at a low voltage.
- **(a)** What would be the current if it was transmitted at a potential difference of 25.0 MV?
- **(b)** What would be the current if it was transmitted at a potential difference of 25 kV?
- **(c)** The transmission lines have a resistance of 0.0100 Ω/km. In each case, how much of the potential difference would be used to push the current through 1000 km of line?

Problems for Understanding

24. A light bulb is rated at 200 W for a 32.0 V power supply. What is its power output if it is inadvertently connected to a 120 V supply?

25. A 1400 W–120 V toaster requires 3.60 minutes to toast a slice of bread.
- **(a)** What current does it draw?
- **(b)** How much charge passes through the toaster in that time?
- **(c)** How much heat and light would be produced in that time?

26. The heating element of a stove operates at 240 V. How much electric energy is converted to heat if it takes 5.50 minutes to bring a pot of water to a boil? The element draws a current of 6.25 A.

27. How much does it cost to run a 15.0 Ω load for 12.0 minutes on a 125 V supply if the rate for electric energy is $0.0850/kWh?

28. The equivalent resistance of two loads connected in parallel is 25.0 Ω. If the resistance of one of the loads is 75.0 Ω, what is the resistance of the other load?

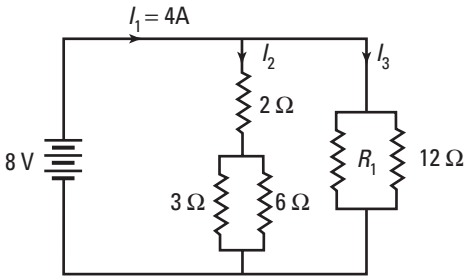
29. A load, R_1, is connected in series with two loads, R_2 and R_3, which are connected in parallel with each other. If the potential difference of the power supply is 180 V, find the current through and the potential difference across each of the loads. The loads have resistances of 25.0 Ω, 30.0 Ω and 6.00 Ω, respectively.

30. A motor draws a current of 4.80 A from a 36.0 V battery. How long would it take the motor to lift a 5.00 kg mass to a height of 35.0 m? Assume 100% efficiency.

31. A 45.0 m extension cord is made using 18 gauge copper wire. It is connected to a 120 V power supply to operate a 1.0×10^2 W-120 V light bulb.
- **(a)** What is the resistance of the extension cord? (Remember that there are two wires to carry the current in the cord.)
- **(b)** What is the resistance of the filament in the light bulb?
- **(c)** What is the current through the cord to the light bulb?
- **(d)** What is the actual power output of the light bulb?

32. When a battery is connected to a load with a resistance of 40.0 Ω, the terminal voltage is 24.0 V. When the resistance of the load is reduced to 15.0 Ω, the terminal voltage is 23.5 V. Find the *emf* and the internal resistance of the battery.

33. Find all of the missing currents and resistances and the equivalent resistance of the circuit.



34. Find all of the equivalent resistance of the circuit and the current through each resistor.