## 17.1 Batteries and Direct Current

1. **MC** When a battery is part of a complete circuit, the voltage across its terminals is its (a) emf, (b) terminal voltage, (c) power output, (d) all of the preceding. (b)
2. **MC** As a battery ages, its (a) emf increases, (b) emf decreases, (c) terminal voltage increases, (d) terminal voltage decreases. (d)
3. **MC** When four 1.5-V batteries are connected, the output voltage of the combination is 1.5 V. These batteries are connected in (a) series, (b) parallel, (c) a pair in series connected in parallel to the other pair in series, (d) none of the preceding. (b)
4. **MC** When helping someone whose car has a "dead" battery, how should your car's battery be connected in relation to the "dead" battery: (a) series, (b) parallel, or (c) either series or parallel would work fine? (b)
5. **MC** When several 1.5-V batteries are connected in series, the overall output voltage of the combination is measured to be 12 V. How many batteries are needed to achieve this voltage: (a) two, (b) ten, (c) eight, or (d) six? (c)
6. **CQ** Why does the battery design shown in Fig. 17.1> require a chemical membrane? to prevent the two ions from each electrode from mixing
9. ● (a) Three 1.5-V dry cells are connected in series. What is the total voltage of the combination? (b) What would be the total voltage if the cells were connected in parallel? (a) 4.5 V (b) 1.5 V
12. ●● Given three batteries with voltages of 1.0 V, 3.0 V, and 12 V, respectively, how many different voltages could be obtained by connecting one or more of the batteries in series or parallel, and what are these voltages? seven different voltages; see solution page
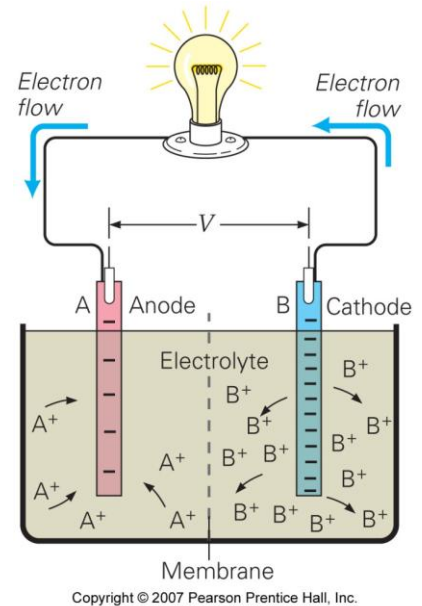
17.2 Current and Drift Velocity

14. **MC** In which of these situations does more charge flow past a given point on a wire: when the wire has (a) a current of 2.0 A for 1.0 min, (b) 4.0 A for 0.5 min, (c) 1.0 A for 2.0 min, or (d) all are the same charge? (d)
15. **MC** Which of these situations involves the least current: a wire that has (a) 1.5 C passing a given point in 1.5 min, (b) 3.0 C passing a given point in 1.0min, or (c) 0.5 C passing a given point in 0.10 min? (a)
16. **MC** In a dental X-ray machine, the movement of accelerated electrons is east. The current associated with these electrons is in what direction: (a) east, (b) west, or (c) zero? (b)
17. **CQ** In the circuit shown in Fig. 17.4a, what is the direction of (a) the electron flow in the resistor, (b) the current in the resistor, and (c) the current in the battery? (a) upward (b) downward (c) upward
18. **CQ** Drift velocity, the average speed of electrons in a complete circuit, is typically a few mm per second. Yet a lamp 3.0 m away from a light switch comes on instantaneously when you flip the switch. Explain this apparent paradox. electric field travels close to the speed of light
19. ● A net charge of 30 C passes through the cross-sectional area of a wire in 2.0 min. What is the current in the wire? 0.25 A

17.3 Resistance and Ohm's Law[*]

27. **MC** The ohm is just another name for the (a) volt per ampere, (b) ampere per volt (c) watt, or (d) volt. (a)
28. **MC** Two ohmic resistors are placed across a 12-V battery one at a time. The resulting current in resistor A is measured to be twice as that in B. What can you say about their resistance values? (a) $R_A = 2R_B$, (b) $R_A = R_B$, (c) $R_A = R_B/2$, or (d) none of the preceding. (c)
29. **MC** An ohmic resistor is placed across two different batteries. When connected to battery A, the resulting current is measured to be three times the current when the resistor is attached to battery B. What can you say about the battery voltages: (a) $V_A = 3V_B$ (b) $V_A = V_B$ (c) $V_B = 3V_A$ or (d) none of the preceding. (a)
30. **MC** If you double the voltage across an ohmic resistor while at the same time cutting its resistance to one-third its original value, what happens to the current in the resistor: (a) it doubles, (b) it triples, (c) it goes up by six times, or (d) can't tell from the data given? (c)
31. **CQ** If the voltage (V) were plotted on the same graph versus current (I) for two ohmic conductors with different resistances, how could you tell which is less resistive? the one with the shallower slope
32. **CQ** Filaments in lightbulbs usually fail just after the bulbs are turned on rather than when they have already been on for a while. Why? resistance is low and current is high at turn-on
33. **CQ** A wire is connected across a steady voltage source. (a) If that wire is replaced with one of the same

material that is twice as long and has twice the cross-sectional area, how will the current in the wire be affected? (b) How will the current be affected if, instead, the new wire has the same length as the old one but half the diameter? (a) same (b) one-quarter the current

39.   ● What voltage must a battery have to produce a 0.50-A current through a 2.0-Ω resistor? 1.0 V

40.   ● During a research experiment on the conduction of current in the human body, a medical technician attaches one electrode to the wrist and a second to the shoulder. If 100 mV are applied across the two electrodes and the resulting current is 12.5 mA, what is the overall resistance of the patient's arm? 8.00 Ω

41.   ●● A 0.60-m-long copper wire has a diameter of 0.10 cm. What is the resistance of the wire? 1.3×10^{-2} Ω

47.   ●● A copper wire has a 25-mΩ resistance at 20°C. When the wire is carrying a current, heat produced by the current causes the temperature of the wire to increase by 27 C°. (a) What is the change in the wire's resistance? (b) If its original current was 10.0 mA, what is its final current? (a) 4.6 mΩ (b) 8.5 mA

48.   ●● When a resistor is connected to a 12-V source, it draws a 185-mA current. The same resistor connected to a 90-V source draws a 1.25-A current. Is the resistor ohmic? Justify your answer mathematically. not ohmic, see ISM

17.4 Electric Power

55.   MC The electric power unit, the watt, is equivalent to what combination of SI units: (a) $A^2 \cdot \Omega$, (b) J/s, (c) V^2/Ω, or (d) all of the preceding? (d)

56.   MC If the voltage across an ohmic resistor is doubled, the power expended in the resistor (a) increases by a factor of 2, (b) increases by a factor of 4, (c) decreases by half, or (d) none of the preceding. (b)

57.   MC If the current through an ohmic resistor is halved, the power expended in the resistor (a) increases by a factor of 2, (b) increases by a factor of 4, (c) decreases by half, (d) decreases by a factor of 4. (d)

58.   CQ Assuming that the resistance of your hair dryer obeys Ohm's law, what would happen to its power output if you plugged it directly into a 240-V outlet in Europe if it is designed to be used in the 120-V outlets of the United States? power output would quadruple, and it would overheat and burn out

59.   CQ Most lightbulb filaments are made of tungsten and are about the same length. What would be different about the filament in a 60-W bulb compared with that in a 40-W bulb? the wire in the 60-W bulb would be thicker

60.   CQ Which one consumes more power from a 12-V battery, a 5.0-Ω resistor or a 10-Ω resistor? Why? 5.0 Ω; same voltage, more current

61.   ● A digital video disk (DVD) player is rated at 100 W at 120 V. What is its resistance? 144 Ω

62.   ● A freezer of resistance 10 Ω is connected to a 110-V source. What is the power delivered when this freezer is on? 1.2×10^3 W

68.   ●● An electric toy with a resistance of 2.50 Ω is operated by a 1.50-V battery. (a) What current does the toy draw? (b) Assuming that the battery delivers a steady current for its lifetime of 6.00 h, how much charge passed through the toy? (c) How much energy was delivered to the toy? (a) 0.600 A (b) 1.30×10^4 C (c) 1.94×10^4 J

77.   ●● A 20-Ω resistor is connected to four 1.5-V batteries. What is the joule heat loss per minute in the resistor if the batteries are connected (a) in series and (b) in parallel? (a) 1.1×10^2 J (b) 6.8 J

83.   ●●● Find the total monthly (30-day) electric bill (to the nearest dollar) for the following household appliance usage if the utility rate is \$0.12/kWh : Central air conditioning runs 30% of the time; a blender is used 0.50 h/month ; a dishwasher is used 8.0 h/month ; a microwave oven is used 15 min/day ; the motor of a frost-free refrigerator runs 15% of the time; a stove (burners plus oven) is used a total of 10 h/month ; and a color television is operated 120 h/month . (Use the information given in Table 17.2.) \$152

---

* Assume that the temperature coefficients of resistivity given in Table 17.1 apply over large temperature ranges.