Conceptual Questions

20.1 Current

1.

Can a wire carry a current and still be neutral—that is, have a total charge of zero? Explain.

2.

Car batteries are rated in ampere-hours ($A \cdot h$). To what physical quantity do ampere-hours correspond (voltage, charge, . . .), and what relationship do ampere-hours have to energy content?

3.

If two different wires having identical cross-sectional areas carry the same current, will the drift velocity be higher or lower in the better conductor? Explain in terms of the equation $v_{\mathrm{d}} = \frac{I}{\mathrm{nqA}}$, by considering how the density of charge carriers n relates to whether or not a material is a good conductor.

4.

Why are two conducting paths from a voltage source to an electrical device needed to operate the device?

5.

In cars, one battery terminal is connected to the metal body. How does this allow a single wire to supply current to electrical devices rather than two wires?

6.

Why isn't a bird sitting on a high-voltage power line electrocuted? Contrast this with the situation in which a large bird hits two wires simultaneously with its wings.

20.2 Ohm's Law: Resistance and Simple Circuits

7.

The IR drop across a resistor means that there is a change in potential or voltage across the resistor. Is there any change in current as it passes through a resistor? Explain.

8.

How is the IR drop in a resistor similar to the pressure drop in a fluid flowing through a pipe?

20.3 Resistance and Resistivity

9.

In which of the three semiconducting materials listed in Table 20.1 do impurities supply free charges? (Hint: Examine the range of resistivity for each and determine whether the pure semiconductor has the higher or lower conductivity.)

10.

Does the resistance of an object depend on the path current takes through it? Consider, for example, a rectangular bar—is its resistance the same along its length as across its width? (See Figure 20.33.)

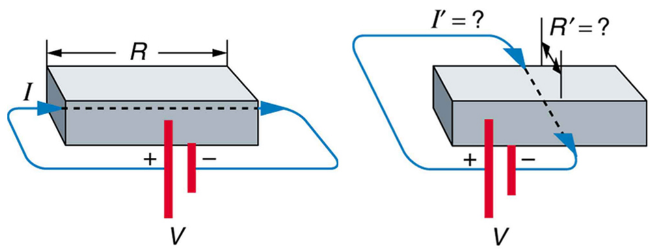

Figure 20.33 Does current taking two different paths through the same object encounter different resistance?

11.

If aluminum and copper wires of the same length have the same resistance, which has the larger diameter? Why?

12.

Explain why $R = R_0(1+\alpha\Delta T)$ for the temperature variation of the resistance R of an object is not as accurate as $\rho = \rho_0(1+\alpha\Delta T)$, which gives the temperature variation of resistivity ρ.

20.4 Electric Power and Energy

13.

Why do incandescent lightbulbs grow dim late in their lives, particularly just before their filaments break?

14.

The power dissipated in a resistor is given by $P = V^2/R$, which means power decreases if resistance increases. Yet this power is also given by $P = I^2R$, which means power increases if resistance increases. Explain why there is no contradiction here.

20.5 Alternating Current versus Direct Current

15.

Give an example of a use of AC power other than in the household. Similarly, give an example of a use of DC power other than that supplied by batteries.

16.

Why do voltage, current, and power go through zero 120 times per second for 60-Hz AC electricity?

17.

You are riding in a train, gazing into the distance through its window. As close objects streak by, you notice that the nearby fluorescent lights make *dashed* streaks. Explain.

20.6 Electric Hazards and the Human Body

18.

Using an ohmmeter, a student measures the resistance between various points on his body. They find that the resistance between two points on the same finger is about the same as the resistance between two points on opposite hands—both are several hundred thousand ohms. Furthermore, the resistance decreases when more skin is brought into contact with the probes of the ohmmeter. Finally, there is a dramatic drop in resistance (to a few thousand ohms) when the skin is wet. Explain these observations and their implications regarding skin and internal resistance of the human body.

19.

What are the two major hazards of electricity?

20.

Why isn't a short circuit a shock hazard?

21.

What determines the severity of a shock? Can you say that a certain voltage is hazardous without further information?

22.

An electrified needle is used to burn off warts, with the circuit being completed by having the patient sit on a large butt plate. Why is this plate large?

23.

Some surgery is performed with high-voltage electricity passing from a metal scalpel through the tissue being cut. Considering the nature of electric fields at the surface of conductors, why would you expect most of the current to flow from the sharp edge of the scalpel? Do you think high- or low-frequency AC is used?

24.

Some devices often used in bathrooms, such as hairdryers, often have safety messages saying "Do not use when the bathtub or basin is full of water." Why is this so?

25.

We are often advised to not flick electric switches with wet hands, dry your hand first. We are also advised to never throw water on an electric fire. Why is this so?

26.

Before working on a power transmission line, experts will touch the line with the back of the hand as a final check that the voltage is zero. Why the back of the hand?

27.

Why is the resistance of wet skin so much smaller than dry, and why do blood and other bodily fluids have low resistances?

28.

Could a person on intravenous infusion (an IV) be microshock sensitive?

29.

In view of the small currents that cause shock hazards and the larger currents that circuit breakers and fuses interrupt, how do they play a role in preventing shock hazards?

20.7 Nerve Conduction–Electrocardiograms

30.

Note that in Figure 20.25, both the concentration gradient and the Coulomb force tend to move Na^+ ions into the cell. What prevents this?

31.

Define depolarization, repolarization, and the action potential.

32.

Explain the properties of myelinated nerves in terms of the insulating properties of myelin.