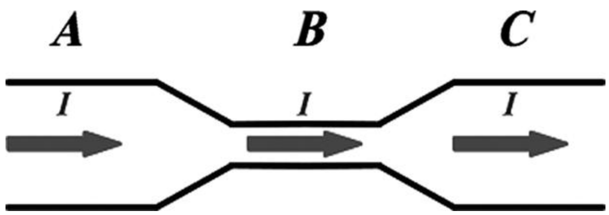
***Physics for Scientists and Engineers, 4e* (Knight)**
Chapter 27   Current and Resistance

27.1   Conceptual Questions

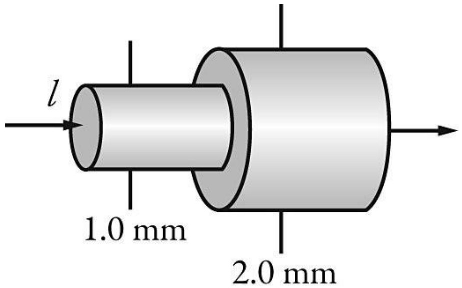
1) The figure shows a steady electric current passing through a wire with a narrow region. What happens to the drift velocity of the moving charges as they go from region *A* to region *B* and then to region *C*?



A) The drift velocity decreases from A to B and increases from B to C.
B) The drift velocity increases all the time.
C) The drift velocity remains constant.
D) The drift velocity decreases all the time.
E) The drift velocity increases from A to B and decreases from B to C.
Answer: E
Var: 1

2) When electric current is flowing in a metal, the electrons are moving
A) at nearly the speed of light.
B) at the speed of light.
C) at the speed of sound in the metal.
D) at the speed of sound in air.
E) at none of the above speeds.
Answer: E
Var: 1

3) The figure shows two connected wires that are made of the same material. The current entering the wire on the left is 2.0 A and in that wire the electron drift speed is v_d. What is the electron drift speed in the wire on the right side?



A) $4v_d$
B) $2v_d$
C) v_d
D) $v_d/2$
E) $v_d/4$
Answer: E
Var: 1

4) A narrow copper wire of length L and radius b is attached to a wide copper wire of length L and radius $2b$, forming one long wire of length $2L$. This long wire is attached to a battery, and a current is flowing through it. If the electric field in the narrow wire is E, the electric field in the wide wire is
A) E.
B) $2E$.
C) $4E$.
D) $E/2$.
E) $E/4$.
Answer: E
Var: 1

5) A cylindrical wire has a resistance R and resistivity ρ. If its length and diameter are BOTH cut in half,
(a) what will be its resistance?

A) $4R$
B) $2R$
C) R
D) $R/2$
E) $R/4$

(b) what will be its resistivity?

A) 4ρ
B) 2ρ
C) ρ
D) $\rho/2$
E) $\rho/4$

Answer: (a) B (b) C
Var: 1

6) You are given a copper bar of dimensions 3 cm × 5 cm × 8 cm and asked to attach leads to it in order to make a resistor.
(a) If you want to achieve the SMALLEST possible resistance, you should attach the leads to the opposite faces that measure

A) 3 cm × 5 cm.
B) 3 cm × 8 cm.
C) 5 cm × 8 cm.
D) Any pair of faces produces the same resistance.

(b) If you want to achieve the LARGEST possible resistance, you should attach the leads to the opposite faces that measure

A) 3 cm × 5 cm.
B) 3 cm × 8 cm.
C) 5 cm × 8 cm.
D) Any pair of faces produces the same resistance.

Answer: (a) C (b) A
Var: 1

7) A wire of resistivity ρ must be replaced in a circuit by a wire of the same material but 4 times as long. If, however, the resistance of the new wire is to be the same as the resistance of the original wire, the diameter of the new wire must be
A) the same as the diameter of the original wire.
B) 1/2 the diameter of the original wire.
C) 1/4 the diameter of the original wire.
D) 2 times the diameter of the original wire.
E) 4 times the diameter of the original wire.
Answer: D
Var: 1

8) As current flows through a uniform wire, the wire gets hotter because the electrons stop moving and therefore transform their lost kinetic energy into thermal energy in the wire.
A) True
B) False
Answer: B
Var: 1

9) When a potential difference of 10 V is placed across a certain solid cylindrical resistor, the current through it is 2 A. If the diameter of this resistor is now tripled, the current will be
A) 2/9 A.
B) 2/3 A.
C) 2 A.
D) 3 A.
E) 18 A.
Answer: E
Var: 1

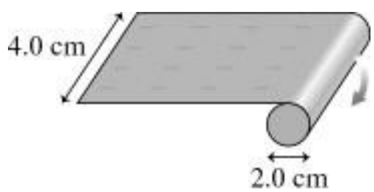
10) Two cables of the same length are made of the same material, except that one cable has twice the diameter of the other cable. When the same potential difference is maintained across both cables, which of the following statements are true? (There may be more than one correct choice.)
A) The same current flows through both cables.
B) Both cables carry the same current density.
C) The electrons have the same drift velocity in both cables.
D) The current in the thin cable is twice as great as the current in the thick cable.
E) The current in the thin cable is four times as great as the current in the thick cable.
Answer: B, C
Var: 1

27.2 Problems

1) An electric device delivers a current of 5.0 A to a device. How many electrons flow through this device in 10 s? ($e = 1.60 \times 10^{-19}$ C)
A) 0.20
B) 20
C) 2.0
D) 3.1×10^{20}
E) 31×10^{20}
Answer: D
Var: 5

2) In a certain electroplating process gold is deposited by using a current of 14.0 A for 19 minutes. A gold ion, Au^{+}, has a mass of approximately 3.3×10^{-22} g. How many grams of gold are deposited by this process?
A) 33 g
B) 16 g
C) 22 g
D) 28 g
E) 97 g
Answer: A
Var: 50+

3) The figure shows a 2.0-cm diameter roller that turns at 90 rpm. A 4.0-cm wide plastic film is being wrapped onto the roller, and this plastic carries an excess electric charge having a uniform surface charge density of 5.0 nC/cm^2. What is the current of the moving film?



A) 190 nA
B) 23 μA
C) 30 nA
D) 11 μA
Answer: A
Var: 50+

4) The current supplied by a battery as a function of time is $I(t) = (0.88\text{ A})e^{-t/(6.0\text{ hr})}$. What is the total number of electrons transported from the positive electrode to the negative electrode from the time the battery is first used until it is essentially dead? ($e = 1.60 \times 10^{-19}$ C)
A) 1.2×10^{23}
B) 4.4×10^{22}
C) 5.3×10^{23}
D) 3.3×10^{19}
Answer: A
Var: 50+

5) A gold wire that is 1.8 mm in diameter and 15 cm long carries a current of 260 mA. How many electrons per second pass a given cross section of the wire? ($e = 1.60 \times 10^{-19}$ C)
A) 1.6×10^{18}
B) 1.6×10^{17}
C) 1.5×10^{23}
D) 3.7×10^{15}
E) 6.3×10^{15}
Answer: A
Var: 50+

6) In an electroplating process, copper (ionic charge $+2e$, atomic weight 63.6 g/mol) is deposited using a current of 10.0 A. What mass of copper is deposited in 10.0 minutes? Avogadro's number is 6.022×10^{23} molecules/mol and $e = 1.60 \times 10^{-19}$ C.
A) 3.96 g
B) 2.52 g
C) 0.99 g
D) 1.52 g
E) 1.98 g
Answer: E
Var: 1

7) The current in a wire varies with time according to the equation $I(t) = 6.00$ A + (4.80 A/s)t, where t is in seconds. How many coulombs of charge pass a cross section of the wire in the time period between $t = 0.00$ s and $t = 3.00$ s?
Answer: 39.6 C
Var: 50+

8) If a current of 2.4 A is flowing in a cylindrical wire of diameter 2.0 mm, what is the average current density in this wire?
A) 7.6×10^{5} A/m^2
B) 5.2×10^{-6} A/m^2
C) 1.9×10^{5} A/m^2
D) 3.6×10^{5} A/m^2
E) 21×10^{-6} A/m^2
Answer: A
Var: 1

9) A proton beam that carries a total current of 1.3 mA has 10.0 mm diameter. The current density in the proton beam increases linearly with distance from the center. This is expressed mathematically as $J(r) = J_0\ (r/R)$, where R is the radius of the beam and J_0 is the current density at the edge. Determine the value of J_0.

A) 25 A/m^2

B) 6.2 A/m^2

C) 12 A/m^2

D) 17 A/m^2

Answer: A
Var: 50+

10) A certain fuse "blows" if the current in it exceeds 1.0 A, at which instant the fuse melts with a current density of620 A/cm^2. What is the diameter of the wire in the fuse?

A) 0.45 mm
B) 0.63 mm
C) 0.68 mm
D) 0.91 mm
Answer: A
Var: 50+

11) If the current density in a wire or radius R is given by $J = kr$, $0 < r < R$, what is the current in the wire?

A) $2\pi kR^3/3$

B) $3\pi kR^3/2$

C) $kR^3/3$

D) kR^2

E) $kR^2/2$

Answer: A
Var: 1

12) A silver wire has a cross sectional area A = 2.0 mm^2. A total of 9.4×10^{18} electrons pass through the wire in 3.0 s. The conduction electron density in silver is 5.8×10^{28} electrons/m^3 and $e = 1.60 \times 10^{-19}$ C. What is the drift velocity of these electrons?

A) 2.7×10^{-5} m/s

B) 9.1×10^{-5} m/s

C) 5.2×10^{-5} m/s

D) 1.1×10^{-5} m/s

E) 7.4×10^{-5} m/s

Answer: A
Var: 1

13) The diameter of a 12-gauge copper wire is 0.081 in. The maximum safe current it can carry (in order to prevent fire danger in building construction) is 20 A. At this current, what is the drift velocity of the electrons? The number of electron carriers in 1.0 cm^3 of copper is 8.5×10^{22} and $e = 1.60 \times 10^{-19}$ C.
A) 0.044 mm/s
B) 0.44 mm/s
C) 0.44 cm/s
D) 0.44 m/s
E) 4.4 cm/s
Answer: B
Var: 1

14) A wire has a cross-sectional area of 0.10 mm^2. If there are 4.0×10^{28} atoms per cubic meter in this wire, and if each atom contributes 2 free electrons, what is the drift velocity of the electrons when the current in the wire is 6.0 A? ($e = 1.60 \times 10^{-19}$ C)
A) 0.0047 m/s
B) 0.0092 m/s
C) 0.94 m/s
D) 0.019 m/s
Answer: A
Var: 1

15) Building codes usually limit the current carried by a No. 14 copper wire to 15 A. Many household circuits are wired with this size wire. What is the drift velocity of the electrons in this case? The diameter of this wire is 1.6 mm. Assume one conduction electron per atom in copper. The atomic weight of copper is 63.3 g/mol and its density is 8900 kg/m^3. Avogadro's number is 6.022×10^{23} molecules/mol and $e = 1.60 \times 10^{-19}$ C.
A) 5.51×10^{-4} m/s
B) 4.56×10^{-4} m/s
C) 1.65×10^{-3} m/s
D) 4.44×10^{-2} m/s
E) 4.89×10^{-5} m/s
Answer: A
Var: 1

16) The resistivity of gold is $2.44 \times 10^{-8}\ \Omega \cdot \mathrm{m}$ at room temperature. A gold wire that is 0.9 mm in diameter and 14 cm long carries a current of 940 mA. What is the electric field in the wire?
A) 0.036 V/m
B) 0.0090 V/m
C) 0.028 V/m
D) 0.046 V/m
E) 0.090 V/m
Answer: A
Var: 50+

17) A silver wire with resistivity $1.59 \times 10^{-8}\ \Omega \cdot m$ carries a current density of $4.0\ A/mm^2$. What is the magnitude of the electric field inside the wire?
A) 0.064 V/m
B) 2.5 V/m
C) 0.040 V/m
D) 0.10 V/m
Answer: A
Var: 7

18) A tube of mercury with resistivity $9.84 \times 10^{-7}\ \Omega \cdot m$ has an electric field inside the column of mercury of magnitude 23 N/C that is directed along the length of the tube. How much current is flowing through this tube if its diameter is 1.0 mm?
A) 18 A
B) 180 A
C) 29 A
D) 280 A
Answer: A
Var: 1

19) What length of a certain metal wire of diameter 0.15 mm is needed for the wire to have a resistance of 15 Ω? The resistivity of this metal is $1.68 \times 10^{-8}\ \Omega \cdot m$.
A) 16 mm
B) 16 cm
C) 1.6 m
D) 16 m
E) 160 m
Answer: D
Var: 1

20) A 2.0 mm diameter wire of length 20 m has a resistance of 0.25 Ω. What is the resistivity of the wire?
A) $5.0 \times 10^{-7}\ \Omega \cdot m$
B) $3.9 \times 10^{-8}\ \Omega \cdot m$
C) $4.0 \times 10^{-7}\ \Omega \cdot m$
D) $16 \times 10^{-8}\ \Omega \cdot m$
E) $0.25\ \Omega \cdot m$
Answer: B
Var: 1

21) What must be the diameter of a cylindrical 120-m long metal wire if its resistance is to be 6.0 Ω? The resistivity of this metal is $1.68 \times 10^{-8}\ \Omega \cdot m$.
A) 0.065 mm
B) 0.65 mm
C) 0.65 cm
D) 0.325 mm
E) 0.0325 mm
Answer: B
Var: 1

22) Nichrome wire, often used for heating elements, has resistivity of $1.0 \times 10^{-6}\ \Omega \cdot m$ at room temperature. What length of No. 30 wire (of diameter 0.250 mm) is needed to wind a resistor that has 50 ohms at room temperature?
A) 3.66 m
B) 2.45 m
C) 0.61 m
D) 6.54 m
E) 22.4 m
Answer: B
Var: 1

23) Calculate the current through a 10.0-m long 22 gauge (having radius 0.321 mm) nichrome wire if it is connected to a 12.0-V battery. The resistivity of nichrome is $100 \times 10^{-8}\ \Omega \cdot m$.
A) 17.5 A
B) 30.9 A
C) 61.8 A
D) 388 mA
E) 776 mA
Answer: D
Var: 1

24) How much current will be flowing through a 40.0 m length of cylindrical metal wire with radius 0.0 mm if it is connected to a source supplying 16.0 V? The resistivity of this metal is $1.68 \times 10^{-8}\ \Omega \cdot m$.
A) 1200 A
B) 9.5×10^{8} A
C) 68 nA
D) 710 A
Answer: A
Var: 1

25) When a voltage difference is applied to a piece of metal wire, a 5.0-mA current flows through it. If this metal wire is now replaced with a silver wire having twice the diameter of the original wire, how much current will flow through the silver wire? The lengths of both wires are the same, and the voltage difference remains unchanged. (The resistivity of the original metal is $1.68 \times 10^{-8}\ \Omega \cdot m$, and the resistivity of silver is $1.59 \times 10^{-8}\ \Omega \cdot m$.)
A) 21 mA
B) 19 mA
C) 11 mA
D) 5.3 mA
Answer: A
Var: 9

26) A cylindrical wire of radius 2.0 mm carries a current of 2.5 A. The potential difference between points on the wire that are 46 m apart is 3.7 V.
(a) What is the electric field in the wire?
(b) What is the resistivity of the material of which the wire is made?
Answer:
a) 0.080 V/m
b) $4.0 \times 10^{-7}\ \Omega \cdot m$
Var: 50+