Exam

Name_____

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1) A radiating body has a Kelvin temperature T_o, and its surroundings are at $500K\ (T_o > 500K)$. If the Kelvin temperature of the radiating body is increased to $4T_o$, the net rate at which the body radiates increases by a factor of 450. What was the original temperature T_o?

1) _____

2) Consider free electrons in metal as non-interacting particles. At room temperature (20°C), what is the root mean square velocity of free electrons? Assuming the distance between atoms is 1Å, estimate how long it takes for the free electron to jump to the nearest atomic site?

2) _____

3) At 10°C, 32 g of water is mixed with 430 g of ice at -5°C.
(a) What mass of water freezes?
(b) What is the change in entropy of the system?
(The heat capacity of water is $4190\,J/kg \cdot °C$, that of ice is $2090\,J/kg \cdot °C$, and the heat of fusion of water is $3.34 \times 10^5\,J/kg$.)

3) _____

4) A cylinder contains 7.1 moles of ideal gas, initially at a temperature of 97°C. The cylinder is provided with a frictionless piston, which maintains a constant pressure of $5.5 \times 10^5\,Pa$ on the gas. The gas is cooled until its temperature has decreased to $27°C$. For the gas $C_V = 12.24\,J/mol \cdot K$. The gas constant $R = 8.314\,J/mol \cdot K$. Calculate:
(a) the work W done by gas
(b) the net change in the internal energy, ΔU, of the gas, and
(c) the heat transfer Q.

4) _____

5) A block of a solid is known to contain many dipoles aligned in the same direction (such a material is known as an electret). In an electric field of magnitude $300\,N/C$, the block tends to orient itself so that the dipoles are aligned along the electric field lines. If 4.3 J are required to rotate the solid so that the dipole directions are reversed, and each dipole has dipole moment $4.7 \times 10^{-30}\,C\text{-}m$, how many dipoles are there in the block?

5) _____

6) A small metal sphere of mass 3.6 g and charge 6.3 µC is fired with an initial speed of $8.9\,m/s$ directly toward the center of a second metal sphere carrying charge $7.8\,µC$. This second sphere is held fixed. If the

6) _____

spheres are initially a large distance apart, how close do they get to each other? Treat the spheres as point charges.

7) A parallel-plate air capacitor is made from two plates 0.070 m square, spaced 6.3 mm apart. What must the potential difference between the plates be to produce an energy density of $0.037 \, \text{J}/\text{m}^3$?   7) _____

8) A proton is first accelerated from rest through a potential difference V and then enters a uniform 0.750-T magnetic field oriented perpendicular to its path. In this field, the proton follows a circular arc having a radius of curvature of 1.84 cm. What was the potential difference V?   8) _____

Figure 28.16
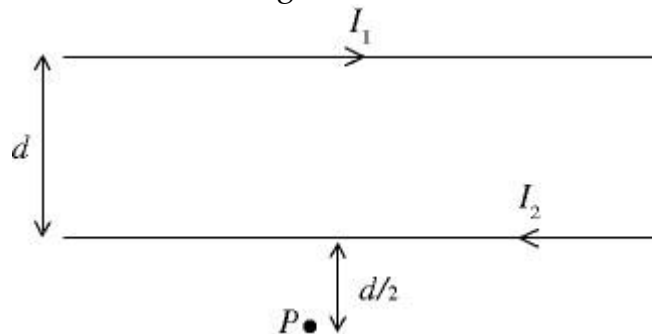
9) In Fig. 28.16, the two long straight wires are separated by a distance of $d = 0.80 \, \text{m}$. The currents are $I_1 = 5.0 \, \text{A}$ to the right in the upper wire and $I_2 = 9.0 \, \text{A}$ to the left in the lower wire. What is the magnitude and direction of the magnetic field at point P, that is a distance $d/2 = 0.40 \, \text{m}$ below the lower wire? (Note: $\mu_0 = 4\pi \times 10^{-7} \, \text{T} \cdot \text{m/A}$)   9) _____

Figure 26.15
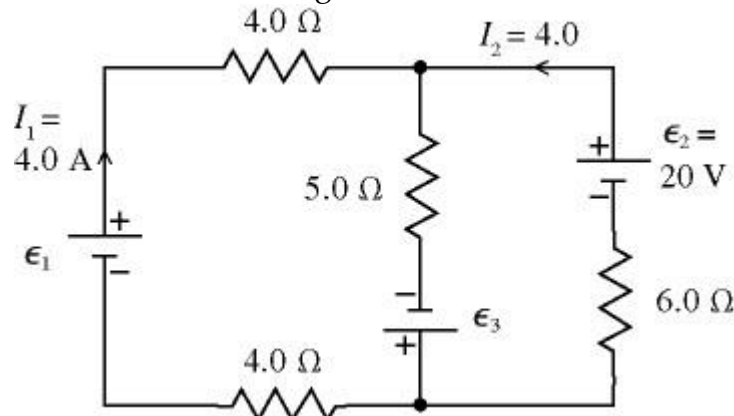
10) In Fig. 26.15, consider the circuit sketched. Note that two currents are shown. Calculate the emf's ε_1 and ε_3.   10) _____

11) A toroidal solenoid has a mean radius of 0.210 m, a cross-sectional   11) _____

area of 2.00×10^{-3} m, and 631 turns. What current is required to produce a stored energy of 0.0300 J? (Note: $\mu_0 = 4\pi \times 10^{-7}$ T•m/A)

12) A series ac circuit consists of a voltage source of frequency $f = 60$ Hz and source voltage amplitude 345 volts, a resistor of resistance $R = 945 \, \Omega$, a capacitor of capacitance $C = 7.7 \times 10^{-6}$ F, and an inductor of inductance L.
(a) What must be the value of L for the phase angle Φ to be zero?
(b) When L has the value calculated in (a), what is the current amplitude in the circuit?

12) _____

13) A laser beam has a wavelength of 633 nm and a power of 0.500 mW spread uniformly over a circle 1.20 mm in diameter. This beam falls perpendicularly on a perfectly reflecting piece of paper having twice the diameter of the laser beam and a mass of 1.50 mg.
(a) What are the amplitudes of the electric and magnetic fields in this laser beam?
(b) What acceleration does the laser beam give to the paper?

13) _____

Figure 33.7
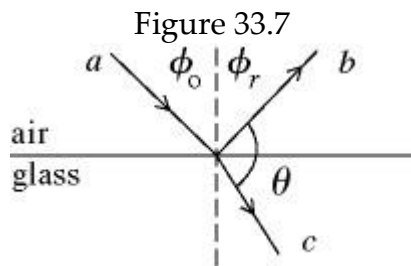
14) In Fig. 33.7, a ray of light in air is incident on a flat piece of glass, at an angle of $\phi_0 = 62°$ with respect to the normal. The glass has an index of refraction $n = 1.5$. What is the angle θ between the reflected (ray b) and refracted (ray c) rays?

14) _____

15) Monochromatic laser light of frequency 5.20×10^{14} Hz is shown on a pair of thin parallel slits, and the pattern is viewed on a screen 1.20 m away. The fifth bright fringes (not counting the central fringe) occur at ±2.12 cm on either side of the central bright fringe. The entire apparatus is now immersed in a transparent liquid. When the experiment is repeated, the fifth bright fringes now occur at ±1.43 cm from the central bright fringe.
(a) How far apart are the slits?
(b) What is the index of refraction of the liquid?

15) _____

16) Treat each of your eyes as a circular aperture of diameter 3.5 mm. Light of wavelength 500 nm is used to view two point sources that are 894 m distant from you. How far apart must these two point sources

16) _____

be if they are to be just resolved by your eye? Assume that the resolution is diffraction limited and use Rayleigh's criterion.

17) A compound microscope consists of an objective of focal length f_o and   17) _____
an eyepiece with magnification 25. The microscope is designed so that
the object is focused in a plane 24.0 cm away from the focal point of
the objective lens. When properly adjusted, the eyepiece and the
objective are 26.3 cm apart. What is f_o? (Assume that the eyepiece
magnification is based on an image at infinity and a near point at 25
cm.)

Figure 29.25

3.9 m/s

0.2 m

F_B ←   → F_{ext}

← 0.6 m →

magnetic
field region
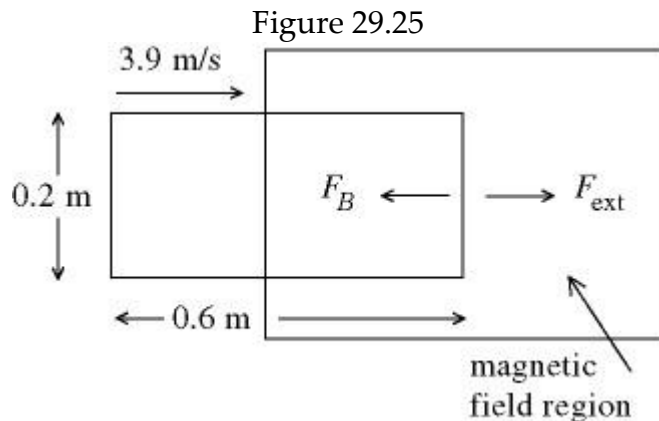
18) In Fig. 29.25, there is a uniform magnetic field of magnitude $B = 3.9$ T   18) _____
and directed into the plane of the paper in the region shown. Outside
this region the magnetic field is zero. A rectangular loop 0.20 m by
0.60 m and of resistance 6 Ω is being pulled into the magnetic field by
an external force, as shown.
(a) What is the direction (clockwise or counterclockwise) of the
current induced in the loop?
(b) Calculate the magnitude of the external force F_{ext} required to move
the loop at a constant speed of $v = 3.9$ m/s. The mass of the loop is
0.008 kg.

Figure 22.9
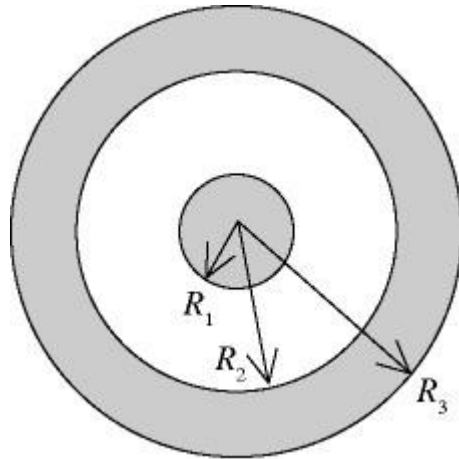
19) Two concentric spheres are shown in Fig. 22.9. The inner sphere is a   19) _____
solid nonconductor and carries a charge of +5.00 µC uniformly
distributed over its outer surface. The outer sphere is a conducting
shell that carries a net charge of -8.00 µC. No other charges are
present. The radii shown in the figure have the values $R_1 = 10.0$ cm, R_2
= 20.0 cm, and $R_3 = 30.0$ cm.
(a) Find the total excess charge on the inner and outer surfaces of the
conducting sphere.
(b) Find the magnitude and direction of the electric field at the
following distances r from the center of the inner sphere: (i) $r = 9.5$ cm,
(ii) $r = 15.0$ cm, (iii) $r = 27.0$ cm, (iv) $r = 35.0$ cm.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Figure 21.11
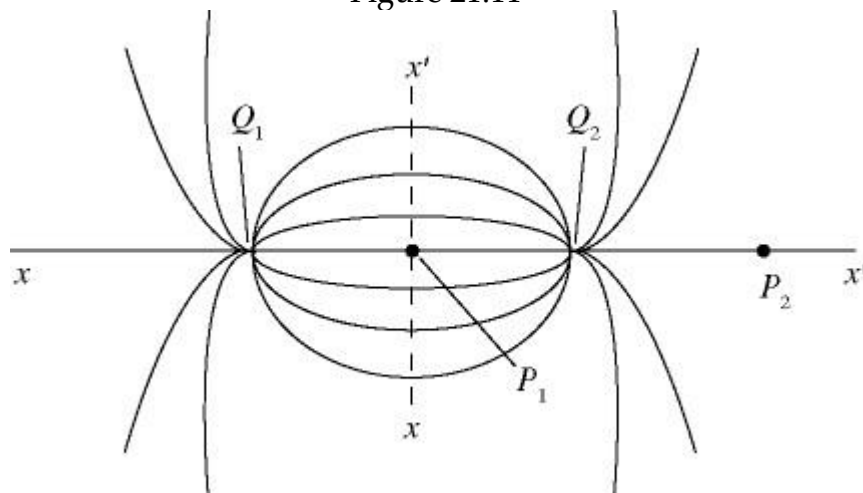
20) In Fig. 21.11, the electric field lines arising from two charges Q_1 20) _____
and Q_2 are shown. From this drawing we can see that

A) the electric field could be zero at P_1.

B) $|Q_1| > |Q_2|$

C) the electric field could be zero at P_2.

D) both Q_1 and Q_2 have the same sign.

E) None of these is true.

21) When an ideal gas is expanded in volume at constant pressure, the average kinetic energy of the gas molecules   21) _____

A) does not change.

B) increases.

C) decreases.

D) may either increase or decrease, depending on whether or not the process is carried out adiabatically.

E) may or may not change, but insufficient information is given to make such a determination.

22) A point charge Q is located a short distance from a point charge $3Q$, and no other charges are present. If the electrical force on Q is F, the electrical force on $3Q$ is: 22) _____

A) $F/\sqrt{3}$

B) F

C) $\sqrt{3}F$

D) $F/3$

E) $3F$

23) Which of the following statements about Gauss's law are correct? (There may be more than one correct choice.)   23) _____

A) If there is no charge inside of a Gaussian surface, the electric field must be zero at points of that surface.

B) If a Gaussian surface is completely inside an electrostatic conductor, the electric field must always be zero at all points on that surface.

C) Gauss's law is valid only for symmetric charge distributions, such as spheres and cylinders.

D) The electric flux passing through a Gaussian surface depends only on the amount of charge inside that surface, not on its size or shape.

E) Only charge enclosed within a Gaussian surface can produce an electric field at points on that surface.

Figure 20.2a

P (vertical axis)

b

a

c

640 K

0.03 m³   0.22 m³

V (horizontal axis)
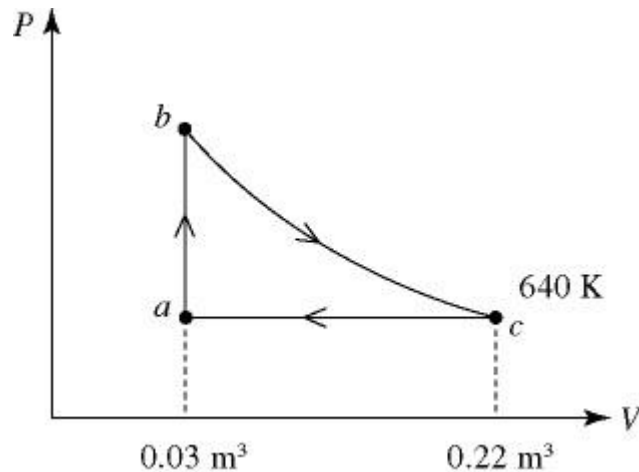
24) A heat engine takes 8.0 moles of an ideal gas through the reversible   24) _____
cycle *abca*, on the *pV* diagram, as shown. The path *bc* is an isothermal
process. The temperature at *c* is 640 K and the volumes at *a* and *c* are
0.03 m^3 and 0.22 m^3, respectively. The molar heat capacity of the gas, at
constant volume, is $18 \text{ J/mol} \cdot \text{K}$. In Fig. 20.2a, for the path *ab*, the heat
absorbed by the gas, in kJ, is closest to:

    A) -90

    B) -130

    C) 130

    D) 90

    E) zero

25) Which of the following is a TRUE statement?   25) _____

    A) It is impossible to transfer heat from a cooler to a hotter body.

    B) It is possible for heat to flow spontaneously from a hot body to a cold one
or from a cold one to a hot one, depending on whether or not the process is
reversible or irreversible.

    C) The Second Law of Thermodynamics is a consequence of the first law of
thermodynamics.

    D) It is not possible to convert work entirely into heat.
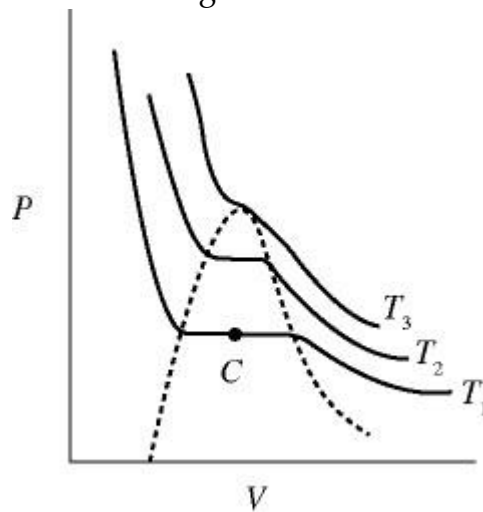
    E) All of these statements are false.

Figure 19.1

p (Pa x 10⁴)
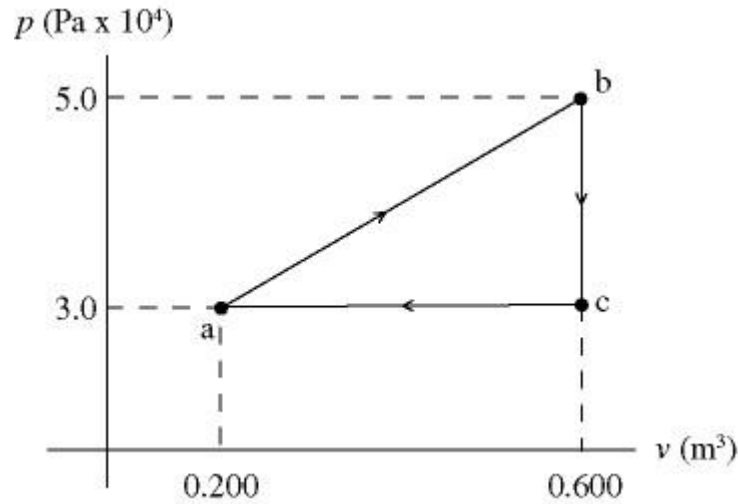
26) In Figure 19.1, the highest temperature reached by the gas during the   26) _____
cycle is closest to:

    A) 289°C

    B) 15.8°C

    C) 96.3°C

    D) 208°C

    E) 481°C

Figure 18.2

27) Figure 18.2 is a typical pV diagram for a non-ideal gas. Which of the   27) _____
following is an accurate statement concerning this information?

    A) At point C the material is a mixture of liquid and vapor.

    B) T_3 is the boiling temperature of the material.

    C) These curves are called isobars.

    D) At temperature T_3 no phase changes occur.

E) $T_1 > T_2 > T_3$

28) A ray in air is incident on a glass plate whose index of refraction is 1.58. The angle of refraction is one-half the angle of reflection. The angle of refraction is closest to:

    A) 34°

    B) 32°

    C) 36°

    D) 38°

    E) 30°

28) _____

29) When light travels from air into water,

    A) its velocity changes, but its frequency and wavelength do not change.

    B) its wavelength changes, but its velocity and frequency do not change.

    C) its velocity, wavelength, and frequency all change.

    D) its frequency changes, but its velocity and wavelength do not change.

   E) its velocity and wavelength change, but its frequency does not change.

29) _____

Figure 17.4
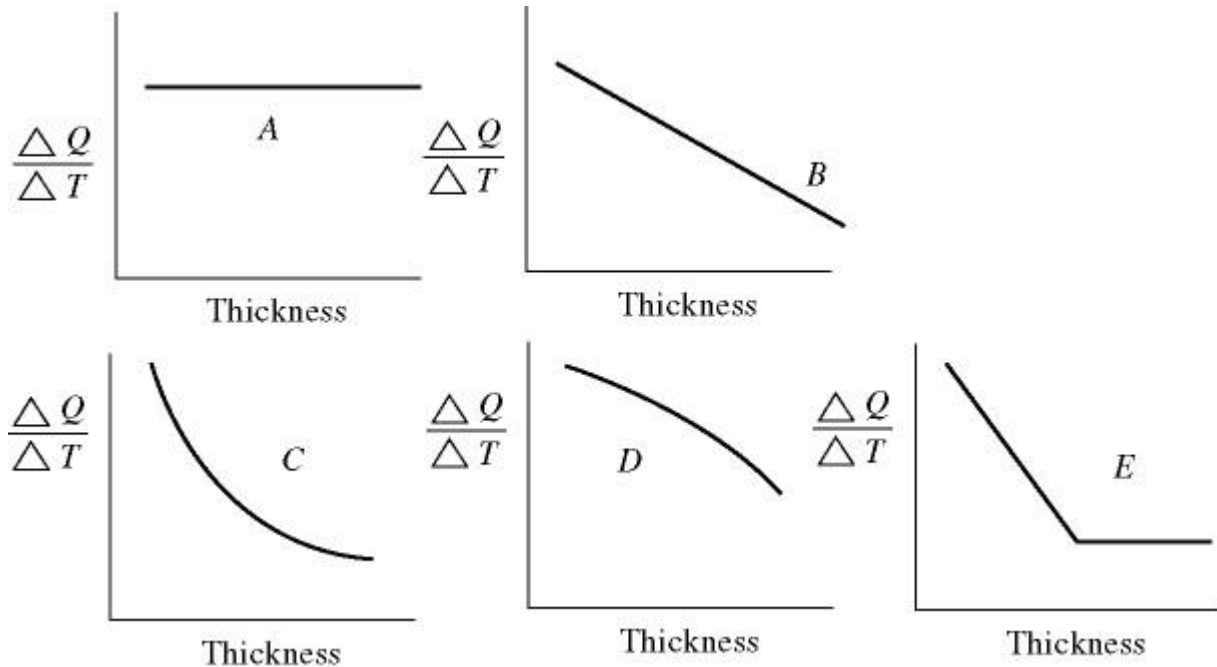
30) In Fig. 17.4, an architect is interested in estimating the heat loss (in kcal/sec) through a sheet of insulating material as a function of the thickness of the sheet. Assuming fixed temperatures on the two faces of the sheet, which of the graphs best represents the heat transfer as a function of the thickness of the insulating sheet?

30) _____

A) A

B) B

C) C

D) D

E) E

31) A conducting sphere of radius R carries an excess positive charge and   31) _____
is very far from any other charges. Which one of the following graphs
best illustrates the potential (relative to infinity) produced by this
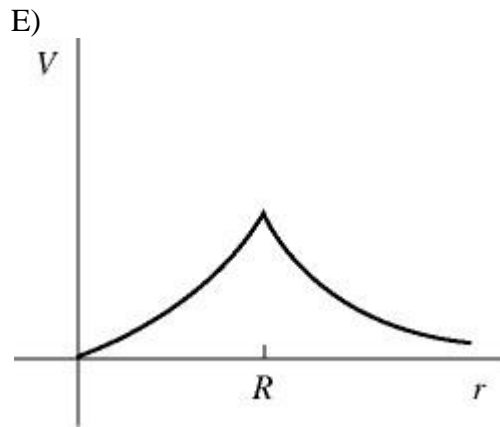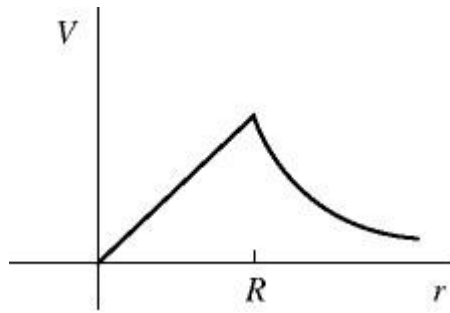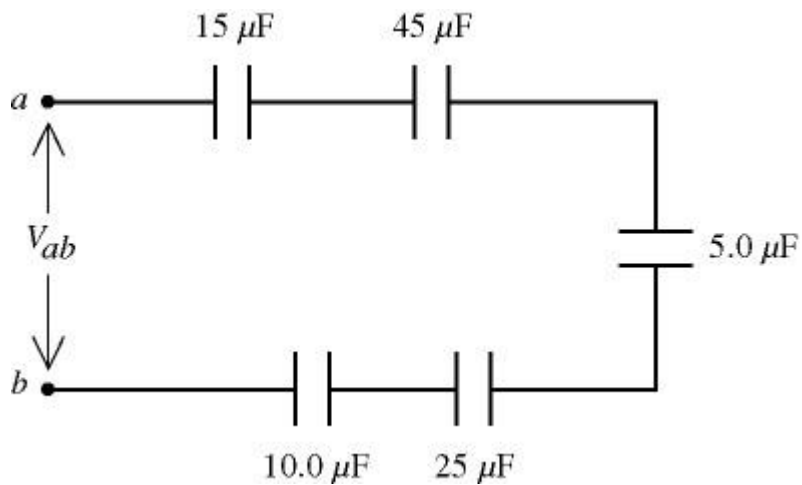sphere as a function of the distance r from the center of the sphere?

A)

B)

C)

D)

V

R   r

E)

V

R   r

Figure 24.2

15 μF   45 μF

a

V_{ab}

5.0 μF

b

10.0 μF   25 μF
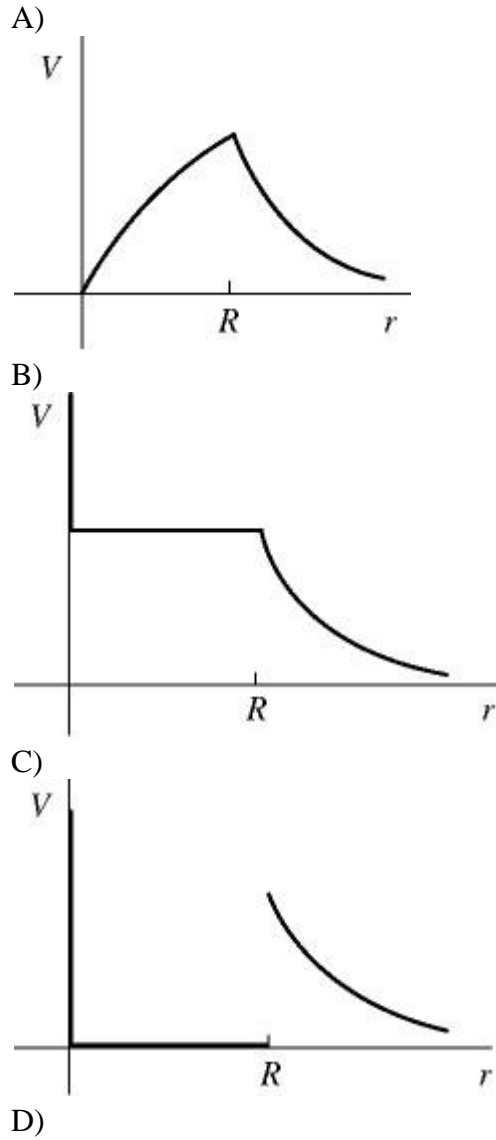
32) Five capacitors are connected across a potential difference V_{ab} as shown in Fig. 24.2. Because of the dielectrics used, each capacitor will break down if the potential across it exceeds 30.0 V. The largest that V_{ab} can be without damaging any of the capacitors is closest to:

    A) 150 V
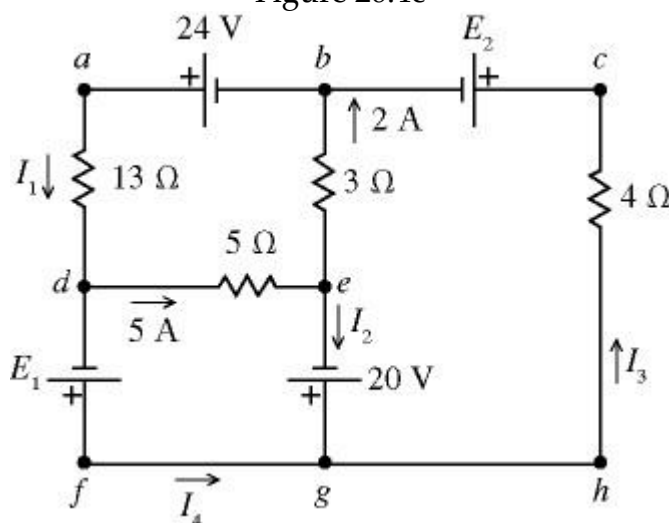
    B) 6.00 V

    C) 579 V

    D) 30.0 V

32) _____

E) 64 V

33) The heater element of a 120-V toaster is a 2.7-m length of nichrome wire, whose diameter is 0.50 mm. The resistivity of nichrome at the operating temperature of the toaster is $1.3 \times 10^{-6} \, \Omega \cdot m.$ The toaster is operated at a voltage of 120 V. The power drawn by the toaster is closest to:

33) _____

    A) 780 W
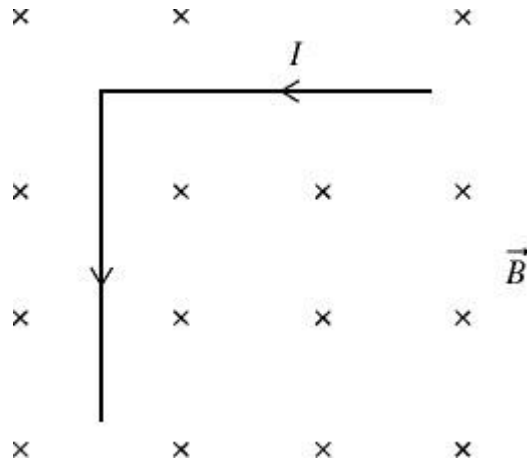   B) 890 W
    C) 860 W
    D) 830 W
    E) 810 W

Figure 26.4c

34) A multiloop circuit is given. It is not necessary to solve the entire circuit. In Fig. 26.4c, the emf ε_1 is closest to:

34) _____

    A) 5 V
    B) 45 V
    C) -5 V
    D) 51 V
    E) -51 V

Figure 27.4

35) An L-shaped metal machine part is made of two equal-length segments that are perpendicular to each other and carry a 4.50-A current as shown in Fig. 27.4. This part has a total mass of 3.80 kg and a total length of 3.00 m, and it is in an external 1.20-T magnetic field that is oriented perpendicular to the plane of the part, as shown. The magnitude of the *net* magnetic force that the field exerts on the part is closest to:

35) _____

    A) 22.9 N
    B) 8.10 N
    C) 11.5 N
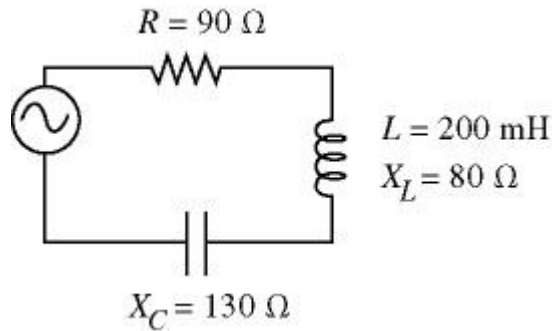   D) 16.2 N
    E) 32.4 N

Figure 28.6d
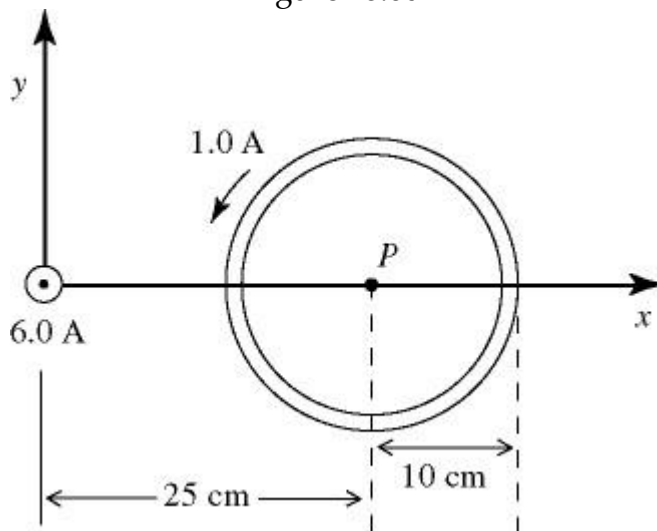
36) A long straight wire on the z-axis carries a current of 6.0 A in the positive direction. A circular loop in the xy-plane, of radius 10 cm, carries a 1.0-A current, as shown. Point P, at the center of the loop, is

36) _____

25 cm from the z-axis. In Fig. 28.6d, an electron is projected from P with a velocity of 1.0×10^6 m/s in the negative x-direction. The y-component of the force on the electron is closest to:

    A) $+4.0 \times 10^{-18}$ N

    B) -2.0×10^{-18} N

    C) $+2.0 \times 10^{-18}$ N

    D) -4.0×10^{-18} N

    E) zero

37) A capacitor is charging in a simple R-C circuit with a dc battery.   37) _____
Which one of the following statements about this capacitor is accurate?

    A) The magnetic field between the capacitor plates is increasing with time because the charge on the plates is increasing.

    B) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the magnetic flux between the plates is changing.

    C) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the electric flux between the plates is changing.

    D) There is no magnetic field between the capacitor plates because no charge travels between the plates.

    E) There is a magnetic field between the capacitor plates because charge travels between the plates by jumping from one plate to the other.

38) An L-R-C circuit has $L = 0.600$ H, $C = 5 \times 10^{-5}$ F and resistance R. What   38) _____
resistance must be used to cause the resonant frequency to be 70% of what it would have been with no resistance in the circuit?

    A) 156 Ω

    B) 122 Ω

    C) 72 Ω

    D) 216 Ω

    E) 102 Ω

Figure 31.2c

$$R = 90 \ \Omega$$

$$\mathord{\mathop{\text{WW}}}$$

$$L = 200 \ \text{mH}$$
$$X_L = 80 \ \Omega$$

$$X_C = 130 \ \Omega$$

39) A series ac circuit is shown. The inductor has a reactance of 80 Ω and   39) _____
an inductance of 200 mH. A 90-Ω resistor and a capacitor whose
reactance is 130 Ω, are also in the circuit. The rms current in the circuit
is 1.3 A. In Fig. 31.2c, the phase angle of the circuit is closest to:

    A) -29°

    B) -61°

    C) +90°

    D) 61°

    E) 29°

40) Electromagnetic standing waves are set up in a conducting cavity   40) _____
resonator in the form of a hollow metal box. The waves bounce back
and forth between two parallel surfaces separated by 0.80 cm. What is
the minimum resonant frequency for such a resonator?

    A) 12.4 GHz

    B) 3.30 GHz

    C) 15.5 GHz

    D) 18.8 GHz

    E) 4.42 GHz