15. The electron volt is a measure of
    (A) charge
    (B) energy
    (C) impulse
    (D) momentum
    (E) velocity

16. A solid conducting sphere is given a positive charge *Q*. How is the charge *Q* distributed in or on the sphere?
    (A) It is concentrated at the center of the sphere.
    (B) It is uniformly distributed throughout the sphere.
    (C) Its density decreases radially outward from the center.
    (D) Its density increases radially outward from the center.
    (E) It is uniformly distributed on the surface of the sphere only.

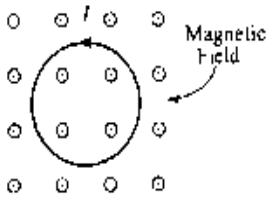
17. A parallel-plate capacitor is charged by connection to a battery. If the battery is disconnected and the separation between the plates is increased, what will happen to the charge on the capacitor and the voltage across it?
    (A) Both remain fixed.
    (B) Both increase.
    (C) Both decrease.
    (D) The charge increases and the voltage decreases.
    (E) The charge remains fixed and the voltage increases.

18. Which two arrangements of resistors shown above have the same resistance between the terminals?
    (A) I and II
    (B) I and IV
    (C) II and III
    (D) II and IV
    (E) III and IV

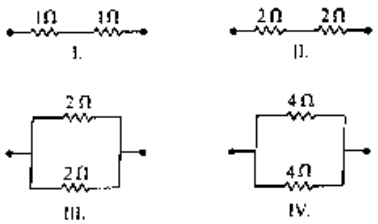
Questions 19-20. A point *P* is 0.50 meter from a point charge of 5.0 x 10^{-8} coulomb.

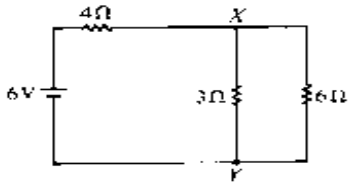
19. The intensity of the electric field at point *P* is most nearly
    (A) 2.5 x 10^{-8} N/C
    (B) 2.5 x 10^{1} N/C
    (C) 9.0 x 10^{2} N/C
    (D) 1.8 x 10^{3} N/C
    (E) 7.5 x 10^{8} N/C

20. The electric potential at point *P* is most nearly
    (A) 2.5 x 10^{-8} *V*
    (B) 2.5 x 10^{1} *V*
    (C) 9.0 x 10^{2} *V*
    (D) 1.8 x 10^{3} *V*
    (E) 7.5 x 10^{8} *V*



21. There is a counterclockwise current *I* in a circular loop of wire situated in an external magnetic field directed out of the page as shown above. The effect of the forces that act on this current is to make the loop
    (A) expand in size
    (B) contract in size
    (C) rotate about an axis perpendicular to the page
    (D) rotate about an axis in the plane of the page
    (E) accelerate into the page

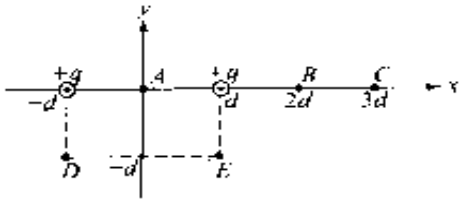




22. In the circuit shown above, what is the value of the potential difference between points *X* and *Y* if the 6-volt battery has no internal resistance?
    (A) 1 V
    (B) 2 V
    (C) 3 V
    (D) 4 V
    (E) 6 V

23. One joule of work is needed to move one coulomb of charge from one point to another with no change in velocity. Which of the following is true between the two points?
    (A) The resistance is one ohm.
    (B) The current is one ampere.
    (C) The potential difference is one volt.
    (D) The electric field strength is one newton per coulomb.
    (E) The electric field strength is one joule per electron.

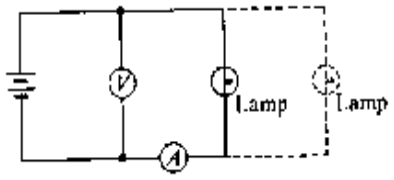
Questions 24-25



Two positive charges of magnitude q are each a distance *d* from the origin *A* of a coordinate system as shown above.

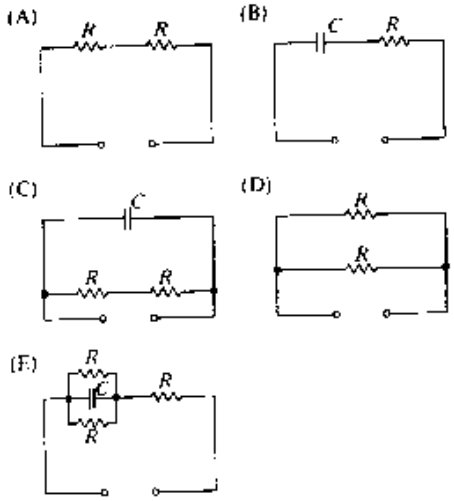
24. At which of the following points is the electric field least in magnitude?
    (A) *A*
    (B) *B*
    (C) *C*
    (D) *D*
    (E) *E*

25. At which of the following points is the electric potential greatest in magnitude?
    (A) *A*
    (B) *B*
    (C) *C*
    (D) *D*
    (E) *E*



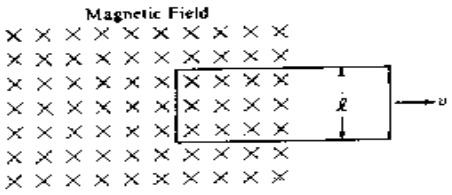
26. A lamp, a voltmeter *V*, an ammeter *A*, and a battery with zero internal resistance are connected as shown above. Connecting another lamp in parallel with the first lamp as shown by the dashed lines would
    (A) increase the ammeter reading
    (B) decrease the ammeter reading
    (C) increase the voltmeter reading
    (D) decrease the voltmeter reading
    (E) produce no change in either meter reading

Questions 27-28 relate to the five incomplete circuits below composed of resistors R, all of equal resistance, and capacitors *C*, all of equal capacitance. A battery that can be used to complete any of the circuits is available.



27. Into which circuit should the battery be connected to obtain the greatest steady power dissipation?

28. Which circuit will retain stored energy if the battery is connected to it and then disconnected?

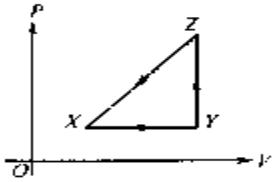


29. The figure above shows a rectangular loop of wire of width ℓ and resistance *R*. One end of the loop is in a uniform magnetic field of strength *B* at right angles to the plane of the loop. The loop is pulled to the right at a constant speed *v*. What are the magnitude and direction of the induced current in the loop?

	Magnitude	Direction
(A)	$B\ell vR$	Clockwise
(B)	$B\ell vR$	Counterclockwise
(C)	$B\ell v/R$	Clockwise
(D)	$B\ell v/R$	Counterclockwise
(E)	0	Undefined

32. An ideal gas is made up of *N* diatomic molecules, each of mass *M*. All of the following statements about this gas are true EXCEPT:
    (A) The temperature of the gas is proportional to the average translational kinetic energy of the molecules.
    (B) All of the molecules have the same speed.
    (C) The molecules make elastic collisions with the walls of the container.
    (D) The molecules make elastic collisions with each other.
    (E) The average number of collisions per unit time that the molecules make with the walls of the container depends on the temperature of the gas.

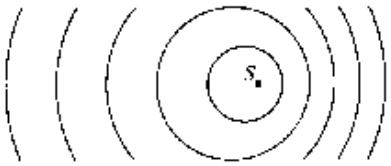
Questions 33-34



A thermodynamic system is taken form an initial state *X* along the path *XYZX* as shown in the *PV*-diagram above.

33. For the process $X \rightarrow Y$, ΔU is greater than zero and
    (A) Q<0 and W=0
    (B) Q<0 and W>0
    (C) Q>0 and W<0
    (D) Q>0 and W=0
    (E) Q>0 and W>0

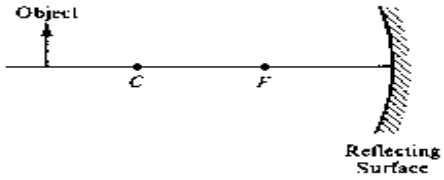
34. For the process Y→Z, Q is greater than zero and
    (A) W<0 and ΔU=0
    (B) W=0 and ΔU<0
    (C) W=0 and ΔU>0
    (D) W>0 and ΔU=0
    (E) W>0 and ΔU>0



35. A small vibrating object *S* moves across the surface of a ripple tank producing the wave fronts shown above. The wave fronts move with speed *v*. The object is traveling in what direction and with what speed relative to the speed of the wave fronts produced?

	Direction	Speed
(A)	To the right	Equal to *v*
(B)	To the right	Less than *v*
(C)	To the right	Greater than *v*
(D)	To the left	Less than *v*
(E)	To the left	Greater than *v*

36. The critical angle for a transparent material in air is 30°. The index of refraction of the material is most nearly
    (A) 0.33
    (B) 0.50
    (C) 1.0
    (D) 1.5
    (E) 2.0



37. An object is placed as shown in the figure above. The center of curvature *C* and the focal point *F* of the reflecting surface are marked. As compared with the object, the image formed by the reflecting surface is
    (A) erect and larger
    (B) erect and the same size
    (C) erect and smaller
    (D) inverted and larger
    (E) inverted and smaller

38. When one uses a magnifying glass to read fine print, one uses a
    (A) converging lens to produce a virtual image of the print
    (B) converging lens to produce a real image of the print
    (C) mirror to produce a virtual image of the print
    (D) diverging lens to produce a real image of the print
    (E) diverging lens to produce a virtual image of the print

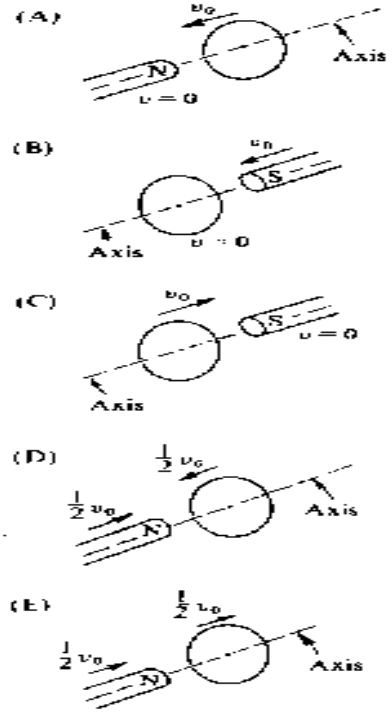
39. Two point sources in a ripple tank radiate waves in phase with a constant wavelength of 0.02 meter. The first-order interference maximum appears at 6° (use sin 6° = 0.1). The separation of the sources is most nearly
    (A) 0.001 m
    (B) 0.002 m
    (C) 0.06 m
    (D) 0.1 m
    (E) 0.2 m

41. Which color of light emitted from an atom would be associated with the greatest change in energy of the atom?
    (A) Blue
    (B) Green
    (C) Red
    (D) Violet
    (E) Yellow

46. Electrons that have been accelerated from rest through a potential difference of 150 volts have a de Broglie wavelength of approximately 1 Ångstrom (10^{-10} meter). In order to obtain electrons whose de Broglie wavelength is 0.5 Ångstrom (5×10^{-11} meter), what accelerating potential is required?
    (A) 37.5 V
    (B) 75 V
    (C) 300 V
    (D) 600 V
    (E) 22,590 V

50. An ideal gas confined in a box initially has pressure p. If the absolute temperature of the gas is doubled and the volume of the box is quadrupled, the pressure is
    (A) $\frac{1}{8}p$
    (B) $\frac{1}{4}p$
    (C) $\frac{1}{2}p$
    (D) p
    (E) $2p$

53. In each of the following situations, a bar magnet is aligned along the axis of a conducting loop. The magnet and the loop move with the indicated velocities. In which situation will the bar magnet NOT induce a current in the conducting loop?



54. A parallel-plate capacitor has a capacitance C_0. A second parallel-plate capacitor has plates with twice the area and twice the separation. The capacitance of the second capacitor is most nearly

(A) $\frac{1}{4}C_0$

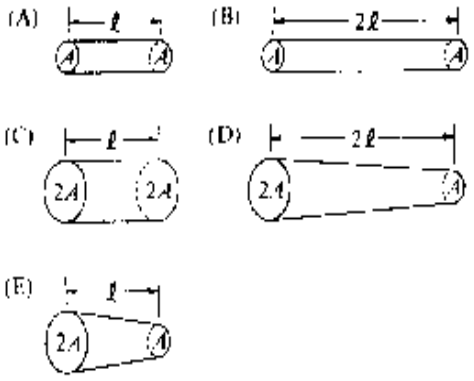
(B) $\frac{1}{2}C_0$

(C) C_0

(D) $2C_0$

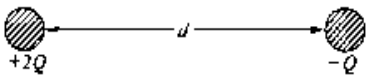
(E) $4C_0$

57. The five resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistively. Which has the greatest resistance?



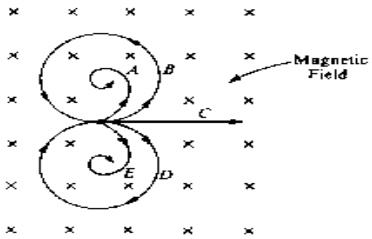
58. According to the Bohr model of the atom, electrons orbit the nucleus in definite orbits. According to the laws of classical physics, this model would be impossible because electrons

(A) the positively charged nucleus attracts the electrons
(B) Coulomb's law applies
(C) accelerating electrons radiate energy
(D) there is a centripetal force on the electrons
(E) angular momentum is conserved



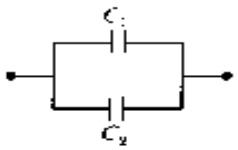
59. Two identical conducting spheres are charged to $+2Q$ and $-Q$, respectively, and are separated by a distance d (much greater than the radii of the spheres) as shown above. The magnitude of the force of attraction on the left sphere is F_1. After the two spheres are made to touch and then are reseparated by distance d, the magnitude of the force on the left sphere is F_1. Which of the following relationships is correct?

(A) $2F_1 = F_2$
(B) $F_1 = F_2$
(C) $F_1 = 2F_2$
(D) $F_1 = 4F_2$
(E) $F_1 = 8F_2$



60. Which of the paths above represents the path of an electron traveling without any loss of energy through a uniform magnetic field directed into the page?

(A) A
(B) B
(C) C
(D) D
(E) E



62. Two capacitors are connected in parallel as shown above. A voltage V is applied to the pair. What is the ratio of charge stored on C_2 to the charge stored on C_1, when $C_1 = 1.5C_2$?

(A) $\frac{4}{9}$

(B) $\frac{2}{3}$

(C) 1

(D) $\frac{3}{2}$

(E) $\frac{9}{4}$

63. Two long, parallel wires, fixed in space, carry currents I, and 12. The force of attraction has magnitude F. What currents will give an attractive force of magnitude 4F?

(A) $2I_1$ *and* $\frac{1}{2}I_2$

(B) I_1 *and* $\frac{1}{4}I_2$

(C) $\frac{1}{2}I_1$ *and* $\frac{1}{2}I_2$

(D) $2I_1$ *and* $2I_2$

(E) $4I_1$ *and* $4I_2$

69. An illuminated object is placed 0.30 meter from a lens whose focal length is -0.15. meter. The image is

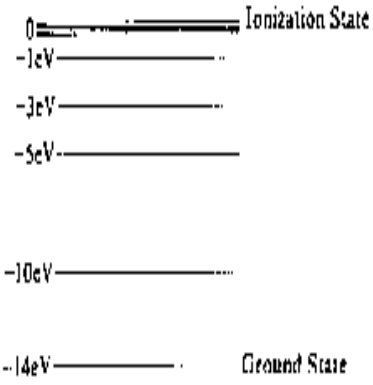
(A) inverted, real, and 0,30 meter from the lens on the opposite side from the object

(B) upright, virtual, and 0.30 meter from the lens on the opposite side, from the object

(C) upright, real, and 0110 meter from the lens on the same side as the object

(D) upright, virtual, and 0. 10 meter from the lens on the same side as the object

(E) inverted, real, and 0. 10 meter from the lens on the same side as the object



70. The energy level diagram above is for a hypothetical atom. A gas of these atoms initially in the ground state is irradiated with photons having a continuous range of energies between 7 and 10 electron volts, One would expect photons of which of the following energies to he emitted from the gas?

(A) 1, 2, and 3 eV only

(B) 4, 5, and 9 eV only

(C) 1, 3, 5, and 10 eV only

(D) 1, 5, 3, and 10 eV only

(E) Since the original photons have a range of energies, one would expect a range of emitted photons with no particular energies