## General Problems

52. How close must two electrons be if the electric force between them is equal to the weight of either at the Earth's surface?

53. A 3.0-g copper penny has a positive charge of 38 $\mu$C. What fraction of its electrons has it lost?

54. A proton ($m = 1.67 \times 10^{-27}$ kg) is suspended at rest in a uniform electric field $\vec{\mathbf{E}}$. Take into account gravity at the Earth's surface, and determine $\vec{\mathbf{E}}$.

55. Measurements indicate that there is an electric field surrounding the Earth. Its magnitude is about 150 N/C at the Earth's surface and points inward toward the Earth's center. What is the magnitude of the electric charge on the Earth? Is it positive or negative? [*Hint*: the electric field outside a uniformly charged sphere is the same as if all the charge were concentrated at its center.]

56. (*a*) Given the local electric field of 150 N/C, what is the acceleration experienced by an electron near the surface of the Earth? (*b*) What about a proton? (*c*) Calculate the ratio of each acceleration to $g = 9.8\ \text{m/s}^2$.

57. A water droplet of radius 0.018 mm remains stationary in the air. If the downward-directed electric field of the Earth is 150 N/C, how many excess electron charges must the water droplet have?

58. Estimate the net force between the CO group and the HN group shown in Fig. 16–62. The C and O have charges $\pm 0.40e$, and the H and N have charges $\pm 0.20e$, where $e = 1.6 \times 10^{-19}$ C. [*Hint*: do not include the "internal" forces between C and O, or between H and N.]

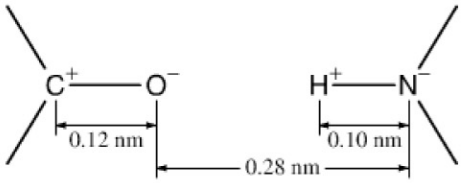


**FIGURE 16–62** Problem 58.

59. In a simple model of the hydrogen atom, the electron revolves in a circular orbit around the proton with a speed of $1.1 \times 10^6$ m/s. Determine the radius of the electron's orbit. [*Hint*: see Chapter 5 on circular motion.]

60. Suppose that electrical attraction, rather than gravity, were responsible for holding the Moon in orbit around the Earth. If equal and opposite charges $Q$ were placed on the Earth and the Moon, what should be the value of $Q$ to maintain the present orbit? Use these data: mass of Earth = $5.98 \times 10^{24}$ kg, mass of Moon = $7.35 \times 10^{22}$ kg, radius of orbit = $3.84 \times 10^8$ m. Treat the Earth and Moon as point particles.

61. An electron with speed $v_0 = 21.5 \times 10^6$ m/s is traveling parallel to an electric field of magnitude $E = 11.4 \times 10^3$ N/C. (*a*) How far will the electron travel before it stops? (*b*) How much time will elapse before it returns to its starting point?

62. A positive point charge $Q_1 = 2.5 \times 10^{-5}$ C is fixed at the origin of coordinates, and a negative charge $Q_2 = -5.0 \times 10^{-6}$ C is fixed to the $x$ axis at $x = +2.0$ m. Find the location of the place(s) along the $x$ axis where the electric field due to these two charges is zero.

63. A small lead sphere is encased in insulating plastic and suspended vertically from an ideal spring ($k = 126$ N/m) above a lab table, Fig. 16–63. The total mass of the coated sphere is 0.800 kg, and its center lies 15.0 cm above the tabletop when in equilibrium. The sphere is pulled down 5.00 cm below equilibrium, an electric charge $Q = -3.00 \times 10^{-6}$ C is deposited on it and then it is released. Using what you know about harmonic oscillation, write an expression for the electric field strength as a function of time that would be measured at the point on the tabletop (P) directly below the sphere.

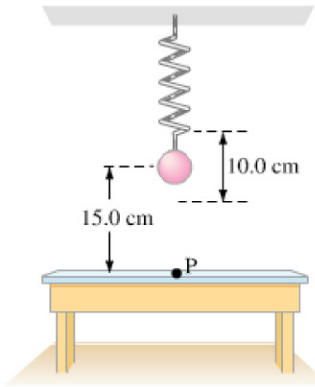


**FIGURE 16–63**
Problem 63.

64. A large electroscope is made with "leaves" that are 78-cm-long wires with tiny 24-g spheres at the ends. When charged, nearly all the charge resides on the spheres. If the wires each make a 30° angle with the vertical (Fig. 16–64), what total charge $Q$ must have been applied to the electroscope? Ignore the mass of the wires.

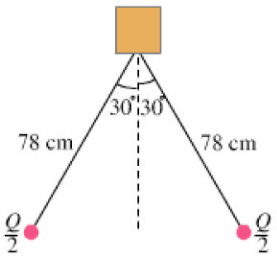


**FIGURE 16–64**
Problem 64.

65. Dry air will break down and generate a spark if the electric field exceeds about $3 \times 10^6$ N/C. How much charge could be packed onto a green pea (diameter 0.75 cm) before the pea spontaneously discharges? [*Hint*: Eqs. 16–4 work outside a sphere if $r$ is measured from its center.]

66. Two point charges, $Q_1 = -6.7\ \mu$C and $Q_2 = 1.8\ \mu$C are located between two oppositely charged parallel plates, as shown in Fig. 16–65. The two charges are separated by a distance of $x = 0.34$ m. Assume that the electric field produced by the charged plates is uniform and equal to $E = 73{,}000$ N/C. Calculate the net electrostatic force on $Q_1$ and give its direction.

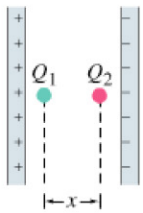


**FIGURE 16–65**
Problem 66.