GAUSS'S LAW APPLICATIONS IN SPHERICAL SYMMETRY SITUATIONS

37 • A thin nonconducting spherical shell of radius R_1 has a total charge q_1 that is uniformly distributed on its surface. A second, larger thin nonconducting spherical shell of radius R_2 that is coaxial with the first has a charge q_2 that is uniformly distributed on its surface. (*a*) Use Gauss's law to obtain expressions for the electric field in each of the three regions: $r < R_1$, $R_1 < r < R_2$, and $r > R_2$. (*b*) What should the ratio of the charges q_1/q_2 and the relative signs for q_1 and q_2 be for the electric field to be zero throughout the region $r > R_2$? (*c*) Sketch the electric field lines for the situation in Part (*b*) when q_1 is positive.

38 • A nonconducting thin spherical shell of radius 6.00 cm has a uniform surface charge density of 9.00 nC/m². (*a*) What is the total charge on the shell? Find the electric field at the following distances from the sphere's center: (*b*) 2.00 cm, (*c*) 5.90 cm, (*d*) 6.10 cm, and (*e*) 10.0 cm.

39 •• A nonconducting sphere of radius 6.00 cm has a uniform volume charge density of 450 nC/m³. (*a*) What is the total charge on the sphere? Find the electric field at the following distances from the sphere's center: (*b*) 2.00 cm, (*c*) 5.90 cm, (*d*) 6.10 cm, and (*e*) 10.0 cm. SSM

40 •• Consider the solid conducting sphere and the concentric conducting spherical shell in Figure 22-41. The spherical shell has a charge $-7Q$. The solid sphere has a charge $+2Q$. (*a*) How much charge is on the outer surface and how much charge is on the inner surface of the spherical shell? (*b*) Suppose a metal wire is now connected between the solid sphere and the shell. After electrostatic equilibrium is reestablished, how much charge is on the solid sphere and on each surface of the spherical shell? Does the electric field at the surface of the solid sphere change when the wire is connected? If so, in what way? (*c*) Suppose we return to the conditions in Part (*a*), with $+2Q$ on the solid sphere and $-7Q$ on the spherical shell. We next connect the solid sphere to ground with a metal wire, and then disconnect it. Then how much total charge is on the solid sphere and on each surface of the spherical shell?

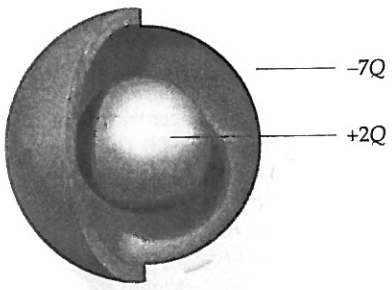

FIGURE 22-41
Problem 40

41 •• A nonconducting solid sphere of radius 10.0 cm has a uniform volume charge density. The magnitude of the electric field at 20.0 cm from the sphere's center is 1.88×10^3 N/C. (*a*) What is the sphere's volume charge density? (*b*) Find the magnitude of the electric field at a distance of 5.00 cm from the sphere's center.

42 •• A nonconducting solid sphere of radius R has a volume charge density that is proportional to the distance from the center. That is, $\rho = Ar$ for $r \leq R$, where A is a constant. (*a*) Find the total charge on the sphere. (*b*) Find the expressions for the electric field inside the sphere ($r < R$) and outside the sphere ($r > R$). (*c*) Sketch the magnitude of the electric field as a function of the distance r from the sphere's center.

43 •• A sphere of radius R has volume charge density $\rho = B/r$ for $r < R$, where B is a constant and $\rho = 0$ for $r > R$. (*a*) Find the total charge on the sphere. (*b*) Find the expressions for the electric field inside and outside the charge distribution. (*c*) Sketch the magnitude of the electric field as a function of the distance r from the sphere's center. SSM

44 •• A sphere of radius R has volume charge density $\rho = C/r^2$ for $r < R$, where C is a constant and $\rho = 0$ for $r > R$. (*a*) Find the total charge on the sphere. (*b*) Find the expressions for the electric field inside and outside the charge distribution. (*c*) Sketch the magnitude of the electric field as a function of the distance r from the sphere's center.

45 ••• A nonconducting spherical shell of inner radius R_1 and outer radius R_2 has a uniform volume charge density ρ. (*a*) Find the total charge on the shell. (*b*) Find expressions for the electric field everywhere.

GAUSS'S LAW APPLICATIONS IN CYLINDRICAL SYMMETRY SITUATIONS

46 • **CONTEXT-RICH, ENGINEERING APPLICATION** For your senior project, you are designing a Geiger tube for detecting radiation in the nuclear physics laboratory. This instrument will consist of a long metal cylindrical tube that has a long straight metal wire running down its central axis. The diameter of the wire will be 0.500 mm and the inside diameter of the tube will be 4.00 cm. The tube is to be filled with a dilute gas in which an electrical discharge (breakdown of the gas) occurs when the electric field reaches 5.50×10^6 N/C. Determine the maximum linear charge density on the wire if breakdown of the gas is not to happen. Assume that the tube and the wire are infinitely long.

47 ••• In Problem 46, suppose ionizing radiation produces an ion and an electron at a distance of 1.50 cm from the long axis of the central wire of the Geiger tube. Suppose that the central wire is positively charged and has a linear charge density equal to 76.5 pC/m. (*a*) In this case, what will be the electron's speed as it impacts the wire? (*b*) How will the electron's speed compare to the ion's final speed when it impacts the outside cylinder? Explain your answer.

48 •• Show that the electric field due to an infinitely long, uniformly charged thin cylindrical shell of radius a having a surface charge density σ is given by the following expressions: $E = 0$ for $0 \leq R < a$ and $E_R = \sigma a/(\epsilon_0 R)$ for $R > a$.

49 • A thin cylindrical shell of length 200 m and radius 6.00 cm has a uniform surface charge density of 9.00 nC/m². (*a*) What is the total charge on the shell? Find the electric field at the following radial distances from the long axis of the cylinder: (*b*) 2.00 cm, (*c*) 5.90 cm, (*d*) 6.10 cm, and (*e*) 10.0 cm. (Use the results of Problem 48.)

50 •• An infinitely long nonconducting solid cylinder of radius a has a uniform volume charge density of ρ_0. Show that the electric field is given by the following expressions: $E_R = \rho_0 R/(2\epsilon_0)$ for $0 \leq R < a$ and $E_R = \rho_0 a^2/(2\epsilon_0 R)$ for $R > a$, where R is the distance from the long axis of the cylinder.

51 •• A solid cylinder of length 200 m and radius 6.00 cm has a uniform volume charge density of 300 nC/m³. (*a*) What is the total charge of the cylinder? Use the formulas given in Problem 50 to calculate the electric field at a point equidistant from the ends at the following radial distances from the cylindrical axis: (*b*) 2.00 cm, (*c*) 5.90 cm, (*d*) 6.10 cm, and (*e*) 10.0 cm. SSM