40. Figure 26-36 shows a Thomson atom model of helium ($Z = 2$). Two electrons, at rest, are embedded inside a uniform sphere of positive charge $2e$. Find the distance d between the electrons so that the configuration is in static equilibrium.

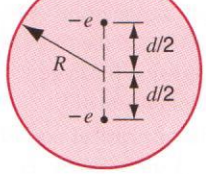

FIGURE 26-36. Exercise 40.

PROBLEMS

1. In Fig. 26-5, consider a point that is a distance z from the center of a dipole along its axis. (*a*) Show that, at large values of z, the magnitude of the electric field is given by

$$E = \frac{1}{2\pi\epsilon_0}\frac{p}{z^3}.$$

(Compare with the field at a point on the perpendicular bisector.) (*b*) What is the direction of $\vec{\mathbf{E}}$?

2. Show that the components of $\vec{\mathbf{E}}$ due to a dipole are given, at distant points, by

$$E_x = \frac{1}{4\pi\epsilon_0}\frac{3pxz}{(x^2+z^2)^{5/2}}, \qquad E_z = \frac{1}{4\pi\epsilon_0}\frac{p(2z^2-x^2)}{(x^2+z^2)^{5/2}},$$

where x and z are coordinates of point P in Fig. 26-37. Show that this general result includes the special results of Eq. 26-12 and Problem 1.

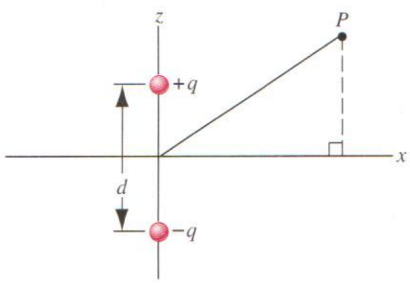

FIGURE 26-37. Problem 2.

3. Consider the ring of charge of Section 26-4. Suppose that the charge q is not distributed uniformly over the ring but that charge q_1 is distributed uniformly over half the circumference and charge q_2 is distributed uniformly over the other half. Let $q_1 + q_2 = q$. (*a*) Find the component of the electric field at any point on the axis directed along the axis and compare with the uniform case. (*b*) Find the component of the electric field at any point on the axis perpendicular to the axis and compare with the uniform case.

4. Figure 26-38 shows one type of electric quadrupole. It consists of two dipoles whose effects at external points do not quite cancel. Show that the value of E on the axis of the quadrupole for points a distance z from its center (assume $z >> d$) is given by

$$E = \frac{3Q}{4\pi\epsilon_0 z^4},$$

where Q $(=2qd^2)$ is called the *quadrupole moment* of the charge distribution.

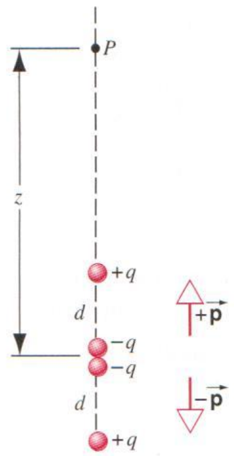

FIGURE 26-38. Problem 4.

5. Construct a distribution of point charges along the x axis so that, far from the charges, the electric field along the x axis falls off as $1/r^6$.

6. A "semi-infinite" insulating rod (Fig. 26-39) carries a constant charge per unit length of λ. Show that the electric field at the point P makes an angle of 45° with the rod and that this result is independent of the distance R.

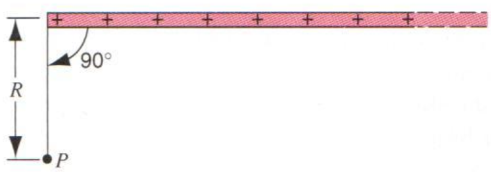

FIGURE 26-39. Problem 6.

7. A thin nonconducting rod of finite length L carries a uniform linear charge density $+\lambda$ on the top half and a uniform