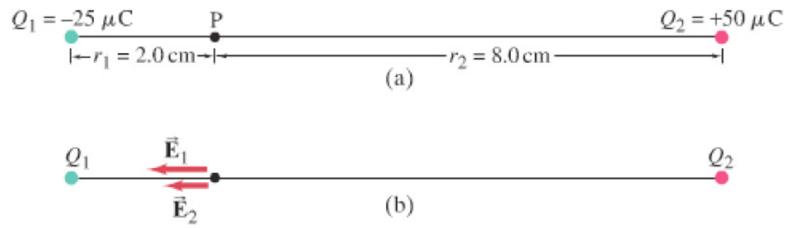

FIGURE 16–27 Example 16–8. In (b), we don't know the relative lengths of $\vec{\mathbf{E}}_1$ and $\vec{\mathbf{E}}_2$ until we do the calculation.

EXAMPLE 16–8 ***E* at a point between two charges.** Two point charges are separated by a distance of 10.0 cm. One has a charge of $-25\ \mu C$ and the other $+50\ \mu C$. (*a*) Determine the direction and magnitude of the electric field at a point P between the two charges that is 2.0 cm from the negative charge (Fig. 16–27a). (*b*) If an electron (mass $= 9.11 \times 10^{-31}$ kg) is placed at rest at P and then released, what will be its initial acceleration (direction and magnitude)?

APPROACH The electric field at P will be the vector sum of the fields created separately by Q_1 and Q_2. The field due to the negative charge Q_1 points toward Q_1, and the field due to the positive charge Q_2 points away from Q_2. Thus both fields point to the left as shown in Fig. 16–27b, and we can add the magnitudes of the two fields together algebraically, ignoring the signs of the charges. In (*b*) we use Newton's second law ($F = ma$) to determine the acceleration, where $F = qE$ (Eq. 16–5).

SOLUTION (*a*) Each field is due to a point charge as given by Eq. 16–4, $E = kQ/r^2$. The total field is

$$\begin{aligned} E &= k\frac{Q_1}{r_1^2} + k\frac{Q_2}{r_2^2} = k\left(\frac{Q_1}{r_1^2} + \frac{Q_2}{r_2^2}\right) \\ &= (9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2})\left(\frac{25 \times 10^{-6}\ \mathrm{C}}{(2.0 \times 10^{-2}\ \mathrm{m})^2} + \frac{50 \times 10^{-6}\ \mathrm{C}}{(8.0 \times 10^{-2}\ \mathrm{m})^2}\right) \\ &= 6.3 \times 10^8\ \mathrm{N/C}. \end{aligned}$$

(*b*) The electric field points to the left, so the electron will feel a force to the *right* since it is negatively charged. Therefore the acceleration $a = F/m$ (Newton's second law) will be to the right. The force on a charge q in an electric field E is $F = qE$ (Eq. 16–5). Hence the magnitude of the electron's initial acceleration is

$$a = \frac{F}{m} = \frac{qE}{m} = \frac{(1.60 \times 10^{-19}\ \mathrm{C})(6.3 \times 10^8\ \mathrm{N/C})}{9.11 \times 10^{-31}\ \mathrm{kg}} = 1.1 \times 10^{20}\ \mathrm{m/s^2}.$$

NOTE By carefully considering the directions of *each* field ($\vec{\mathbf{E}}_1$ and $\vec{\mathbf{E}}_2$) before doing any calculations, we made sure our calculation could be done simply and correctly.

EXERCISE G Given the same two charges Q_1 and Q_2 as in Fig. 16–27, determine the direction of each of the component electric fields $\vec{\mathbf{E}}_1$ and $\vec{\mathbf{E}}_2$, as well as of the total electric field for two positions: (*a*) a point just slightly to the left of Q_1, and (*b*) a point slightly to the right of Q_2. (*Hint*: Remember the $1/r^2$ factor).

EXAMPLE 16–9 ***E* above two point charges.** Calculate the total electric field (*a*) at point A and (*b*) at point B in Fig. 16–28 due to both charges, Q_1 and Q_2.

APPROACH The calculation is much like that of Example 16–4, except now we are dealing with electric fields instead of force. The electric field at point A is the vector sum of the fields $\vec{\mathbf{E}}_{A1}$ due to Q_1, and $\vec{\mathbf{E}}_{A2}$ due to Q_2. We find the magnitude of the field produced by each point charge, then we add their components to find the total field at point A. We do the same for point B.