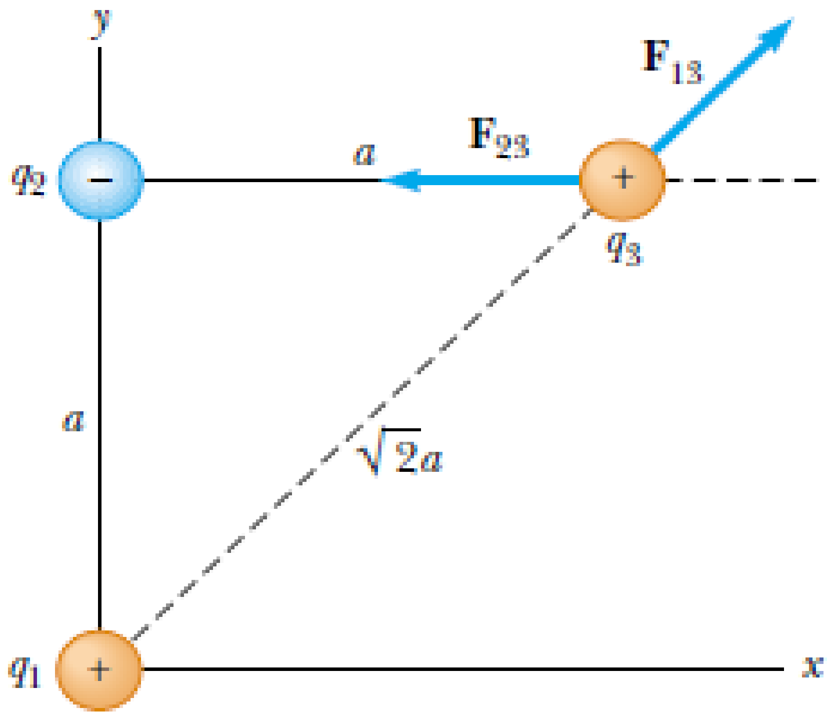
Soal & penyelesaian

Example 3a

Consider three point charges located at the corners of a right triangle as shown in Figure, where $q1 = q3 = 5.0\ \mu C$, $q2 = -2.0\ \mu C$, and $a = 0.10$ m. Find the resultant force exerted on $q3$.



$$F_{23} = k_e \frac{|q_2||q_3|}{a^2}$$

$$= (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(2.0 \times 10^{-6} \text{ C})(5.0 \times 10^{-6} \text{ C})}{(0.10 \text{ m})^2}$$

$$= 9.0 \text{ N}$$

$$F_{13} = k_e \frac{|q_1||q_3|}{(\sqrt{2}a)^2}$$

$$= (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(5.0 \times 10^{-6} \text{ C})(5.0 \times 10^{-6} \text{ C})}{2(0.10 \text{ m})^2}$$

$$= 11 \text{ N}$$

The repulsive force $\mathbf{F}_{13}$ makes an angle of 45° with the x axis. Therefore, the x and y components of $\mathbf{F}_{13}$ are equal, with magnitude given by $F_{13} \cos 45° = 7.9$ N.

Combining $\mathbf{F}_{13}$ with $\mathbf{F}_{23}$ by the rules of vector addition, we arrive at the x and y components of the resultant force acting on q_3:

$$F_{3x} = F_{13x} + F_{23x} = 7.9\text{ N} + (-9.0\text{ N}) = -1.1\text{ N}$$

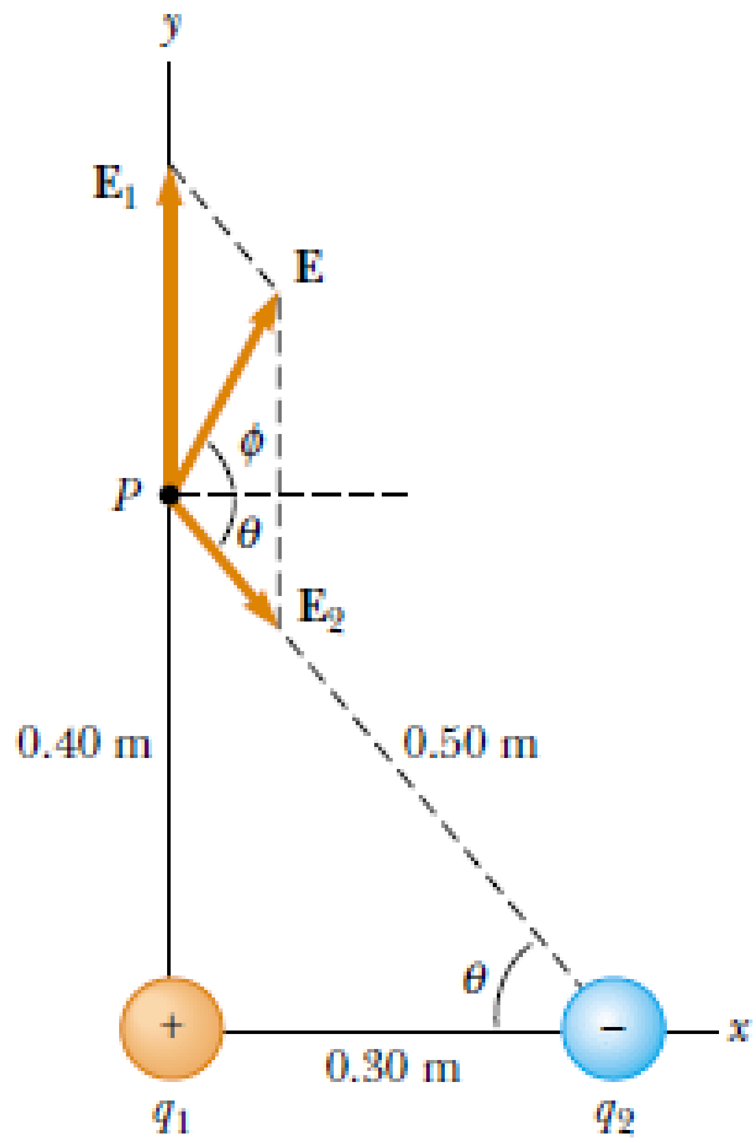
$$F_{3y} = F_{13y} + F_{23y} = 7.9\text{ N} + 0 = 7.9\text{ N}$$

We can also express the resultant force acting on q_3 in unit-vector form as

$$\mathbf{F}_3 = (-1.1\hat{\mathbf{i}} + 7.9\hat{\mathbf{j}})\text{ N}$$

Example 3b

A charge $q1$ = 7.0 µC is located at the origin, and a second charge $q2$ = -5.0 µC is located on the x axis, 0.30 m from the origin. Find the electric field at the point P, which has coordinates (0, 0.40) m.



$$E_1 = k_e \frac{|q_1|}{r_1^2} = (8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)\ \frac{(7.0 \times 10^{-6} \text{ C})}{(0.40 \text{ m})^2}$$
$$= 3.9 \times 10^5 \text{ N/C}$$

$$E_2 = k_e \frac{|q_2|}{r_2^2} = (8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)\ \frac{(5.0 \times 10^{-6} \text{ C})}{(0.50 \text{ m})^2}$$
$$= 1.8 \times 10^5 \text{ N/C}$$

The vector $\mathbf{E}_1$ has only a y component. The vector $\mathbf{E}_2$ has an x component given by $E_2 \cos\theta = \frac{3}{5}E_2$ and a negative y component given by $-E_2 \sin\theta = -\frac{4}{5}E_2$. Hence, we can express the vectors as

$$\mathbf{E}_1 = 3.9 \times 10^5 \hat{\mathbf{j}} \text{ N/C}$$

$$\mathbf{E}_2 = (1.1 \times 10^5 \hat{\mathbf{i}} - 1.4 \times 10^5 \hat{\mathbf{j}}) \text{ N/C}$$

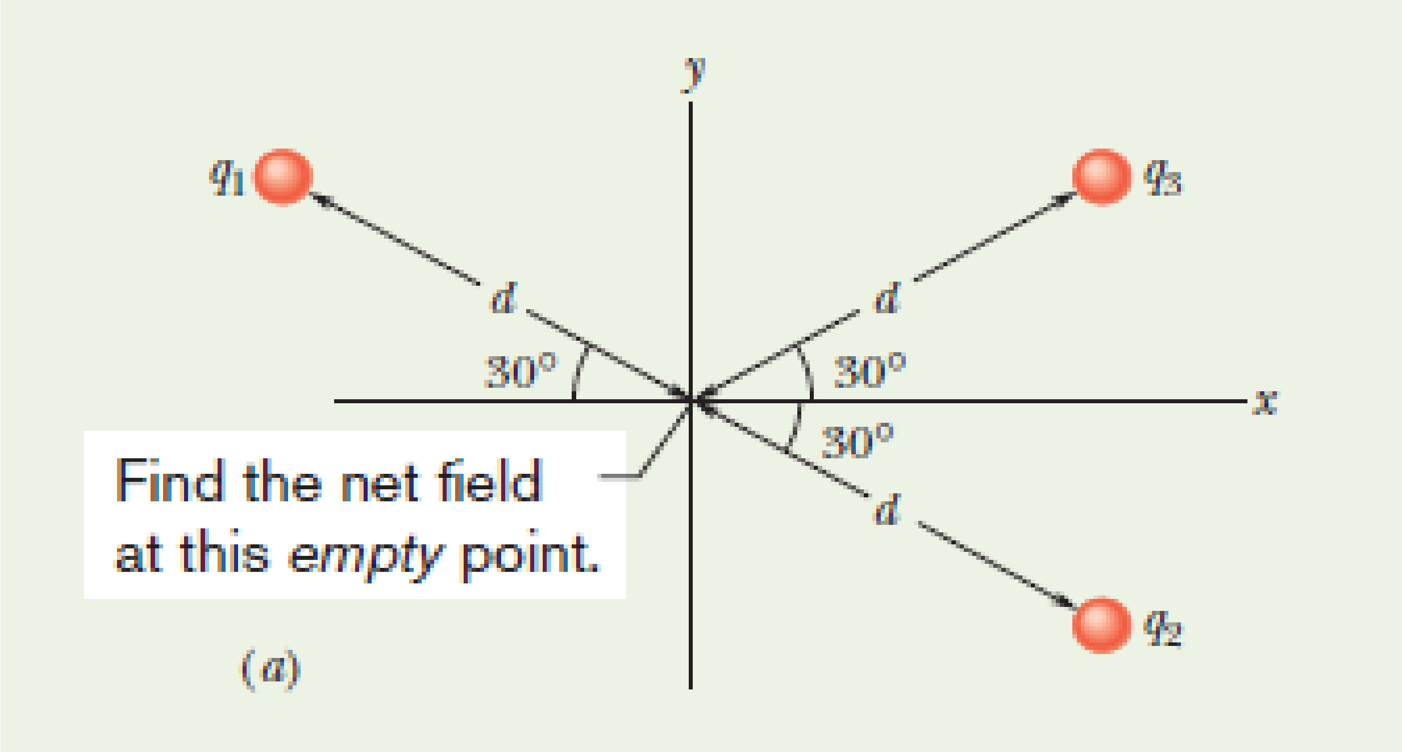
The resultant field $\mathbf{E}$ at P is the superposition of $\mathbf{E}_1$ and $\mathbf{E}_2$:

$$\mathbf{E} = \mathbf{E}_1 + \mathbf{E}_2 = (1.1 \times 10^5 \hat{\mathbf{i}} + 2.5 \times 10^5 \hat{\mathbf{j}}) \text{ N/C}$$

From this result, we find that $\mathbf{E}$ makes an angle ϕ of 66° with the positive x axis and has a magnitude of 2.7×10^5 N/C.

Example 4

Figure shows three particles with charges $q1 = +2Q$, $q2 = -2Q$, and $q3 = -4Q$, each a distance d from the origin. What net electric field is produced at the origin?



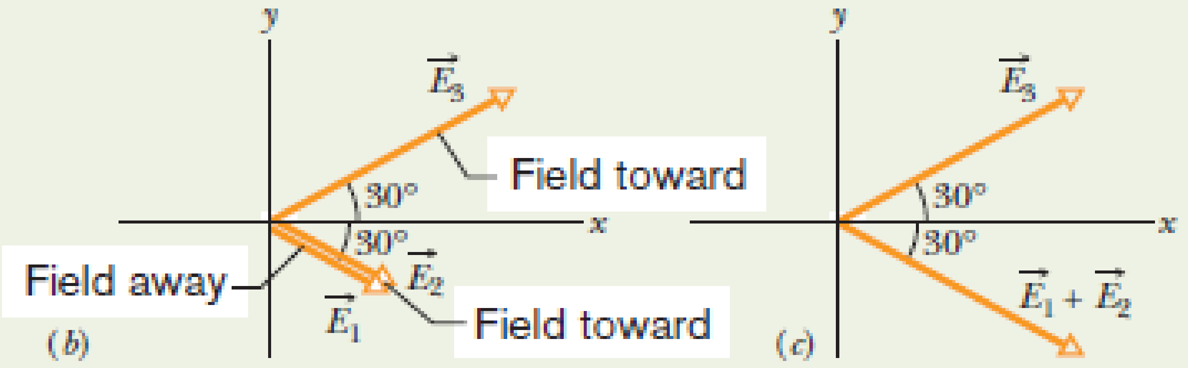
Charges $q1$, $q2$, and $q3$ produce electric field vectors E1, E2, and E3 respectively, at the origin, and the net electric field is the vector sum E = E1 + E2 + E3. To find this sum, we first must find the magnitudes and orientations of the three field vectors.

We next must find the orientations of the three electric field vectors at the origin. Because q_1 is a positive charge, the field vector it produces points directly *away* from it, and because q_2 and q_3 are both negative, the field vectors they produce point directly *toward* each of them. Thus, the three electric fields produced at the origin by the three charged particles are oriented as in Fig. 22-7*b*. (*Caution:* Note that we have placed the tails of the vectors at the point where the fields are to be evaluated; doing so decreases the chance of error. Error becomes very probable if the tails of the field vectors are placed on the particles creating the fields.)

$$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{d^2}.$$

$$E_2 = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{d^2}$$

$$E_3 = \frac{1}{4\pi\varepsilon_0}\frac{4Q}{d^2}.$$



$$E_1 + E_2 = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{d^2} + \frac{1}{4\pi\varepsilon_0}\frac{2Q}{d^2} = \frac{1}{4\pi\varepsilon_0}\frac{4Q}{d^2},$$

$$E = 2E_{3x} = 2E_3\cos 30^\circ = (2)\frac{1}{4\pi\varepsilon_0}\frac{4Q}{d^2}(0.866) = \frac{6.93Q}{4\pi\varepsilon_0 d^2}.$$

Example 6

How much work is done (by a battery, generator, or some other source of potential difference) in moving Avogadro's number of electrons from an initial point where the electric potential is 9.00 V to a point where the potential is -5.00 V? (The potential in each case is measured relative to a common reference point.)

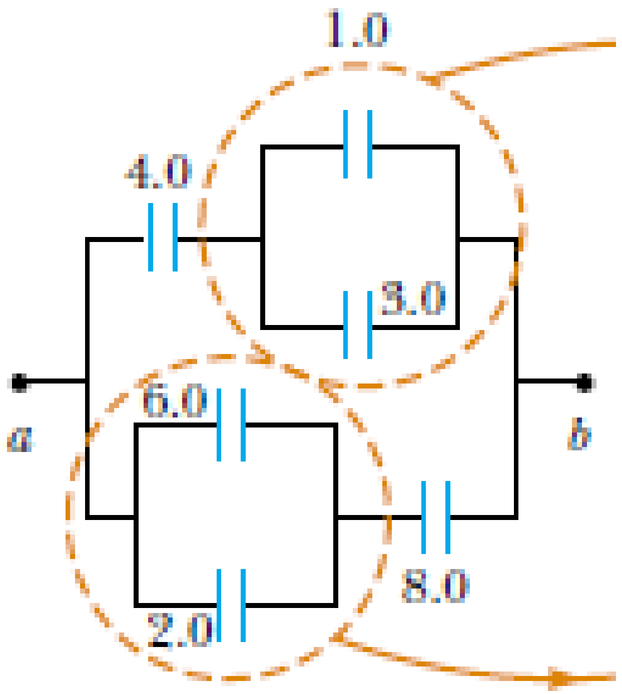
$\Delta V = -14.0 \text{ V}$ and $Q = -N_A e = -(6.02 \times 10^{23})(1.60 \times 10^{-19}) = -9.63 \times 10^4 \text{ C}$

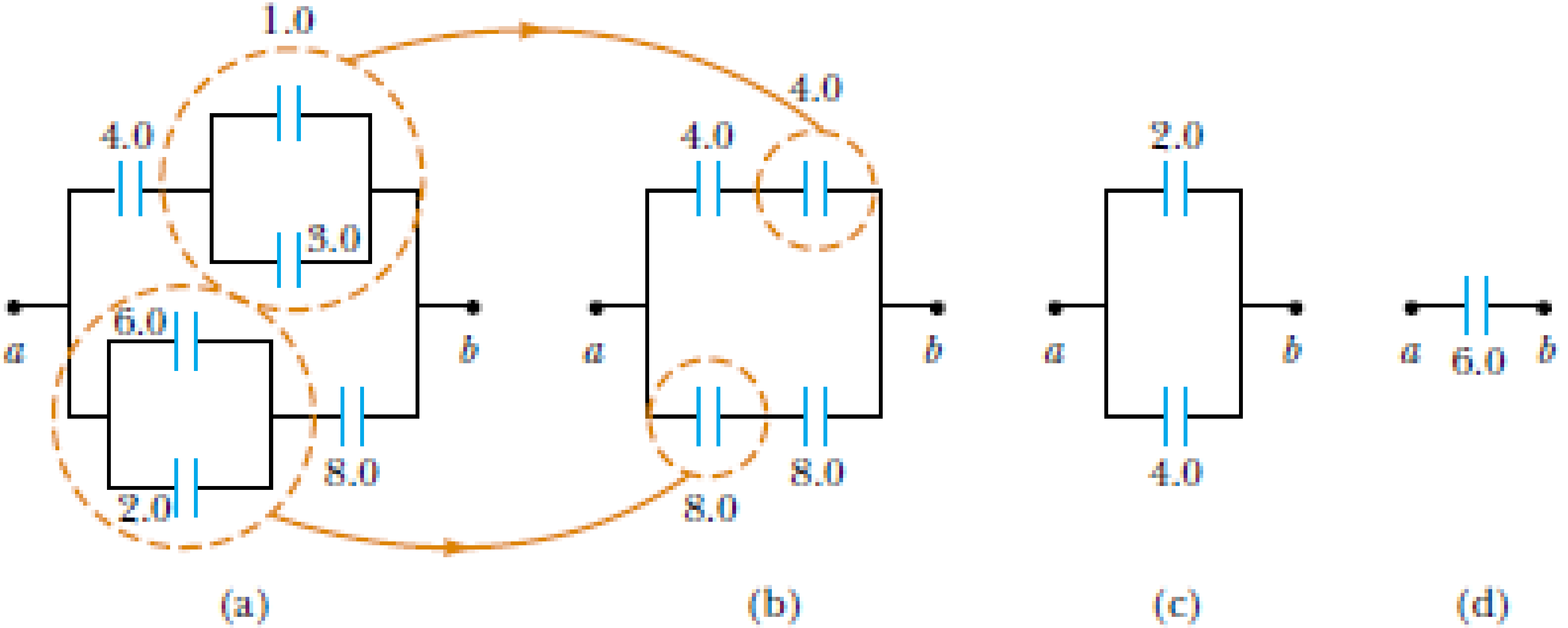
$\Delta V = \dfrac{W}{Q}$, so $W = Q\Delta V = (-9.63 \times 10^4 \text{ C})(-14.0 \text{ J/C}) = \boxed{1.35 \text{ MJ}}$

Kapasitansi

Example 2. Equivalent Capacitance

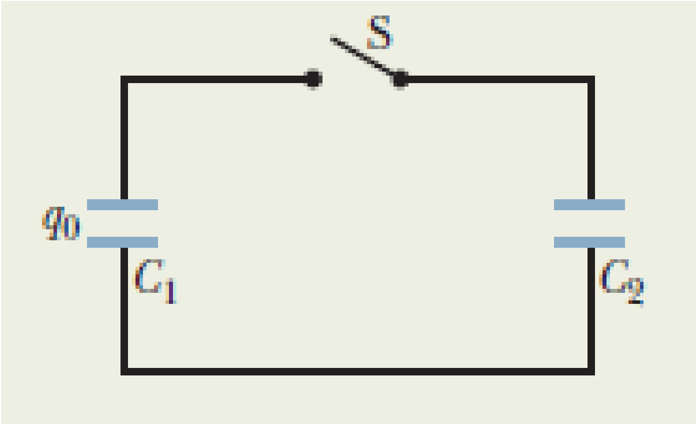
Find the equivalent capacitance between *a* and *b* for the combination of capacitors shown in Figure. All capacitances are in microfarads.




1.0
4.0
3.0
6.0
2.0
8.0
a
b
(a)
4.0
4.0
8.0
8.0
a
b
(b)
2.0
4.0
a
b
(c)
6.0
a
b
(d)

Example 3.

Capacitor 1, with $C1$ = 3.55 μF, is charged to a potential difference $V0$ = 6.30 V, using a 6.30 V battery. The battery is then removed, and the capacitor is connected as in Fig. to an uncharged capacitor 2, with $C2$ 8.95 μF. When switch S is closed, charge flows between the capacitors. Find the charge on each capacitor when equilibrium is reached.



$$q_0 = C_1V_0 = (3.55 \times 10^{-6}\text{ F})(6.30\text{ V})$$
$$= 22.365 \times 10^{-6}\text{ C}.$$

When switch S in Fig. 25-11 is closed and capacitor 1 begins to charge capacitor 2, the electric potential and charge on capacitor 1 decrease and those on capacitor 2 increase until

$$V_1 = V_2 \qquad \text{(equilibrium)}.$$

From Eq. 25-1, we can rewrite this as

$$\frac{q_1}{C_1} = \frac{q_2}{C_2} \qquad \text{(equilibrium)}.$$

Because the total charge cannot magically change, the total after the transfer must be

$$q_1 + q_2 = q_0 \qquad \text{(charge conservation)};$$

thus

$$q_2 = q_0 - q_1.$$

We can now rewrite the second equilibrium equation as

$$\frac{q_1}{C_1} = \frac{q_0 - q_1}{C_2}.$$

Solving this for q_1 and substituting given data, we find

$$q_1 = 6.35\ \mu\text{C}. \qquad \text{(Answer)}$$

The rest of the initial charge ($q_0 = 22.365\ \mu$C) must be on capacitor 2:

$$q_2 = 16.0\ \mu\text{C}. \qquad \text{(Answer)}$$

Ex 4. The Resistance of a Conductor

Calculate the resistance of an aluminum cylinder that has a length of 10.0 cm and a cross-sectional area of 2.00×10^{-4} m^2.

Repeat the calculation for a cylinder of the same dimensions and made of glass having a resistivity of 3.0×10^{10} Ωm.

$$R = \rho \frac{\ell}{A} = (2.82 \times 10^{-8}\ \Omega \cdot \text{m}) \left(\frac{0.100\ \text{m}}{2.00 \times 10^{-4}\ \text{m}^2} \right)$$

$$= \boxed{1.41 \times 10^{-5}\ \Omega}$$

$$R = \rho \frac{\ell}{A} = (3.0 \times 10^{10}\ \Omega\cdot\text{m}) \left(\frac{0.100\ \text{m}}{2.00 \times 10^{-4}\ \text{m}^2} \right)$$

$$= \boxed{1.5 \times 10^{13}\ \Omega}$$

Ex. 5 The Resistance of Nichrome Wire

a. Calculate the resistance per unit length of Nichrome wire, which has a radius of 0.321 mm.

b. If a potential difference of 10 V is maintained across a 1.0-m length of the Nichrome wire, what is the current in the wire?

The resistivity of Nichrome is $1.5 \times 10^{-6}\ \Omega m$

$$A = \pi r^2 = \pi(0.321 \times 10^{-3}\ \text{m})^2 = 3.24 \times 10^{-7}\ \text{m}^2$$

$$\frac{R}{\ell} = \frac{\rho}{A} = \frac{1.5 \times 10^{-6}\ \Omega \cdot \text{m}}{3.24 \times 10^{-7}\ \text{m}^2} = \boxed{4.6\ \Omega/\text{m}}$$

$$I = \frac{\Delta V}{R} = \frac{10\ \text{V}}{4.6\ \Omega} = \boxed{2.2\ \text{A}}$$

Ex 6. Power in an Electric Heater

An electric heater is constructed by applying a potential difference of 120 V to a Nichrome wire that has a total resistance of 8.00 Ω. Find the current carried by the wire and the power rating of the heater.

Solution Because $\Delta V = IR$, we have

$$I = \frac{\Delta V}{R} = \frac{120\ \text{V}}{8.00\ \Omega} = \boxed{15.0\ \text{A}}$$

We can find the power rating using the expression $\mathcal{P} = I^2R$:

$$\mathcal{P} = I^2R = (15.0\ \text{A})^2(8.00\ \Omega) = 1.80 \times 10^3\ \text{W}$$

$$\mathcal{P} = \boxed{1.80\ \text{kW}}$$