1. (a) \( Q = CV = (4.00 \times 10^{-6} \text{ F})(12.0 \text{ V}) = 4.80 \times 10^{-5} \text{ C} = 48.0 \mu \text{C} \)

(b) \( Q = CV = (4.00 \times 10^{-6} \text{ F})(1.50 \text{ V}) = 6.00 \times 10^{-6} \text{ C} = 6.00 \mu \text{C} \)

2. \( \mathcal{R} = \frac{\mathcal{E}_0 A}{d} \frac{\Delta V}{\Delta V} = \frac{\mathcal{E}_0}{A} \Delta V \)

\[ d = \frac{\mathcal{E}_0 (\Delta V)}{\sigma} = \frac{(8.85 \times 10^{-12} \text{ C}^2/\text{N m}^2)(150 \text{ V})}{(30.0 \times 10^{-9} \text{ C}/\text{m}^2)(1.00 \times 10^{-8} \text{ cm}^2/\text{m}^2)} = 4.42 \mu \text{m} \]

3. (a) \( C = \frac{ab}{k_e(6-a)} = \frac{(0.0700)(0.140)}{(8.99 \times 10^9)(0.140 - 0.0700)} = 15.6 \mu \text{F} \)

(b) \[ C = \frac{Q}{\Delta V} \quad \Delta V = \frac{C^2 \Delta V}{4.00 \times 10^{-6} \text{ C}} = \frac{4.00 \times 10^{-6} \text{ C}}{15.6 \times 10^{-12} \text{ F}} = 256 \text{ kV} \]

4. (a) Capacitors in parallel add. Thus, the equivalent capacitor has a value of

\[ C_{eq} = C_1 + C_2 = 5.00 \mu \text{F} + 12.0 \mu \text{F} = 17.0 \mu \text{F} \]

(b) The potential difference across each branch is the same and equal to the voltage of the battery.

\[ \Delta V = 9.00 \text{ V} \]

(c) \( Q_9 = CV = (5.00 \mu \text{F})(9.00 \text{ V}) = 45.0 \mu \text{C} \)

and \( Q_{12} = CV = (12.0 \mu \text{F})(9.00 \text{ V}) = 108 \mu \text{C} \)

5. (a) In series capacitors add as \( \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{5.00 \mu \text{F}} + \frac{1}{12.0 \mu \text{F}} \)

\[ C_{eq} = 3.53 \mu \text{F} \]

(c) The charge on the equivalent capacitor is

\[ Q_{eq} = C_{eq} \Delta V = (3.53 \mu \text{F})(9.00 \text{ V}) = 31.8 \mu \text{C} \]. Each capacitor of the series capacitors has this same charge on it.
(43) Continued

\[ Q_1 = Q_2 = 348 \mu C \]

(6) The potential difference across each is

\[ \Delta V_1 = \frac{Q_1}{C_1} = \frac{348 \mu C}{5.00 \mu F} = 6.96 V \]

\[ \Delta V_2 = \frac{Q_2}{C_2} = \frac{348 \mu C}{12.0 \mu F} = 2.90 V \]

(44)

(a) Capacitors 2 and 3 are in parallel and present equivalent capacitance \( \frac{1}{C} \). This is in series with capacitor 1, so the battery sees capacitance \[ \left( \frac{1}{3C} + \frac{1}{6C} \right)^{-1} = \frac{2}{C} \]

(b) If they are initially uncharged, \( C_1 \) stores the same charge as \( C_2 \) and \( C_3 \) together. With greater capacitance, \( C_3 \) stores more charge than \( C_2 \). Then \( Q_3 > Q_2 > Q_1 \)

(c) The \( \left( C_2 + C_3 \right) \) equivalent capacitor stores the same charge as \( C_1 \). Since it has greater capacitance, \( \Delta V = \frac{Q}{C} \) implies that it has smaller potential difference across it than \( C_1 \).

In parallel with each other, \( C_2 \) and \( C_3 \) have equal voltages:

\[ \Delta V_1 = \Delta V_2 = \Delta V_3 \]

(d) If \( C_3 \) is increased, the overall equivalent capacitance increases. More charge moves through the battery, and \( Q \) increases. As \( \Delta V_1 \) increases, \( \Delta V_2 \) must decrease so \( Q_2 \) decreases. Then \( Q_3 \) must increase even more: \( Q_3 \) and \( Q_1 \) increase; \( Q_2 \) decreases.

(47)

\[ \frac{1}{C_2} = \frac{1}{15} + \frac{1}{3} \rightarrow C_2 = 2.50 \mu F \]

\[ C_p = 2.50 + 6.00 = 8.50 \mu F \]

\[ C_{eq} = \left( \frac{1}{8.50 \mu F} + \frac{1}{20.0 \mu F} \right)^{-1} = 5.96 \mu F \]
(b) \( Q = C \Delta V = (6.96 \mu F)(15.0V) = 89.5 \mu C \) on 20.0 \( \mu F \)

\[ \Delta V = \frac{Q}{C} = \frac{89.5 \mu C}{20.0 \mu F} = 4.47V \]

\[ 15.0V - 4.47V = 10.53V \]

\( Q = C \Delta V = (6.00 \mu F)(10.53V) = 63.2 \mu C \) on 6.00 \( \mu F \)

\[ 89.5 - 63.2 = 26.3 \mu C \) on 15.0 \( \mu F \) and 3.00 \( \mu F \)

\[ C_S = \left( \frac{1}{5.00} + \frac{1}{1.00} \right)^{-1} = 2.92 \mu F \]

\[ C_P = 2.92 + 4.00 + 6.00 = 12.9 \mu F \]

\[ \Delta U = \frac{1}{2} C (\Delta V)^2 = \frac{1}{2} (3.00 \mu F)(12.0V)^2 = 216 \mu J \]

\( \Delta U = \frac{1}{2} C (\Delta V)^2 \)

The circuit diagram is shown at the right.

(a) \( C_P = C_1 + C_2 = 25.0 \mu F + 5.00 \mu F = 30.0 \mu F \)

\[ U = \frac{1}{2}(300 \times 10^{-6})(100)^2 = 0.150J \]

(b) \( C_S = \left( \frac{1}{C_1} + \frac{1}{C_2} \right)^{-1} = \left( \frac{1}{25.0 \mu F} + \frac{1}{5.00 \mu F} \right)^{-1} = 4.17 \mu F \)

\[ U = \frac{1}{2} C (\Delta V)^2 \]

\[ \Delta V = \sqrt{\frac{2U}{C}} = \sqrt{\frac{2(0.150)}{4.17 \times 10^{-6}}} = 2.68V \]

--- 3 ---
Originally, \( C = \frac{\varepsilon_0 A}{d} = \frac{Q}{(\Delta V) i} \)

(a) The charge is the same before and after immersion, with value
\[
Q = \frac{\varepsilon_0 A (\Delta V) i}{d} = \frac{(8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2)(25.0 \times 10^{-4} \text{ m}^2)(250 \text{ V})}{(1.50 \times 10^{-2} \text{ m})} = 369 \text{ pC}
\]

(b) Finally,
\[
C_f = \frac{K \varepsilon_0 A}{d} = \frac{Q}{(\Delta V) f} \quad C_f = \frac{80.0 (8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2)(25.0 \times 10^{-4} \text{ m}^2)}{(1.50 \times 10^{-2} \text{ m})} = 418 \text{ pF}
\]
\[
(\Delta V)_f = \frac{Q d}{K \varepsilon_0 A} = \frac{\varepsilon_0 A (\Delta V) i d}{K \varepsilon_0 A} = \frac{(\Delta V)_i}{K} = \frac{250 \text{ V}}{80.0} = 3.12 \text{ V}
\]

(c) Originally, \( U_i = \frac{1}{2} C (\Delta V)_i^2 = \frac{\varepsilon_0 A (\Delta V)_i^2}{2 d} \)

Finally,
\[
U_f = \frac{1}{2} C_f (\Delta V)_f^2 = \frac{K \varepsilon_0 A (\Delta V)_f^2}{2 d} = \frac{K \varepsilon_0 A (\Delta V)_i^2}{2 d K} = \frac{\varepsilon_0 A (\Delta V)_i^2}{2 d K}
\]
\[
\Delta U = U_f - U_i = -\frac{\varepsilon_0 A (\Delta V)_i^2 (K-1)}{2 d K}
\]
\[
\Delta U = -\frac{(8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2)(250 \text{ V})^2 (29.0)(25.0 \times 10^{-4} \text{ m}^2)}{2 (1.50 \times 10^{-2} \text{ m})(80.0)} = -45.5 \text{ nJ}
\]