4. The equivalent capacitance is

$$C_{\text{eq}} = C_3 + \frac{C_1 C_2}{C_1 + C_2} = 4.00\,\mu\text{F} + \frac{(10.0\,\mu\text{F})(8.00\,\mu\text{F})}{10.0\,\mu\text{F} + 8.00\,\mu\text{F}} = 8.44\,\mu\text{F}.$$

6. (a) The charge q_3 in the figure is $q_3 = C_3V = (2.00\,\mu\text{F})(100\text{ V}) = 2.00\times10^{-4}\text{ C}$.

(b) $V_3 = V = 100$ V.

(c) Using $U_i = \frac{1}{2}C_iV_i^2$, we have $U_3 = \frac{1}{2}C_3V_3^2 = 1.00\times10^{-2}\text{ J}$.

(d) From the figure,

$$q_1 = q_2 = \frac{C_1C_2V}{C_1+C_2} = \frac{(10.0\,\mu\text{F})(5.00\,\mu\text{F})(100\text{ V})}{10.0\,\mu\text{F}+5.00\,\mu\text{F}} = 3.33\times10^{-4}\text{C}.$$

(e) $V_1 = q_1/C_1 = 3.33\times10^{-4}\text{ C}/10.0\,\mu\text{F} = 33.3$ V.

(f) $U_1 = \frac{1}{2}C_1V_1^2 = 5.55\times10^{-3}\text{ J}$.

(g) From part (d), we have $q_2 = q_1 = 3.33\times10^{-4}\text{C}$.

(h) $V_2 = V - V_1 = 100\text{ V} - 33.3\text{ V} = 66.7$ V.

(i) $U_2 = \frac{1}{2}C_2V_2^2 = 1.11\times10^{-2}\text{ J}$.

14. Each capacitor has 12.0 V across it, so Eq. 25-1 yields the charge values once we know C_1 and C_2. From Eq. 25-9,

$$C_2 = \frac{\varepsilon_0 A}{d} = 2.21 \times 10^{-11}\ \text{F} ,$$

and from Eq. 25-27,

$$C_1 = \frac{\kappa\varepsilon_0 A}{d} = 6.64 \times 10^{-11}\ \text{F} .$$

This leads to

$$q_1 = C_1 V_1 = 6.64 \times 10^{-10}\ \text{C}, \quad q_2 = C_2 V_2 = 2.21 \times 10^{-10}\ \text{C}.$$

The addition of these gives the desired result: $q_{\text{tot}} = 8.85 \times 10^{-10}$ C. Alternatively, the circuit could be reduced to find the q_{tot}.

16. (a) We use Eq. 25-14:

$$C = 2\pi\varepsilon_0\kappa \frac{L}{\ln(b/a)} = \frac{(4.7)(0.10\ \text{m})}{2\left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\ln(3.8\ \text{cm}/3.6\ \text{cm})} = 0.48\ \text{nF}.$$

(b) The breakdown potential is (14 kV/mm) (3.8 cm – 3.6 cm) = 28 kV.

20. (a) We calculate the charged surface area of the cylindrical volume as follows:

$$A = 2\pi rh + \pi r^2 = 2\pi(0.20\ \text{m})(0.10\ \text{m}) + \pi(0.20\ \text{m})^2 = 0.25\ \text{m}^2$$

where we note from the figure that although the bottom is charged, the top is not. Therefore, the charge is $q = \sigma A = -0.50\ \mu\text{C}$ on the exterior surface, and consequently (according to the assumptions in the problem) that same charge q is induced in the interior of the fluid.

(b) By Eq. 25-21, the energy stored is

$$U = \frac{q^2}{2C} = \frac{(5.0\times10^{-7}\ \text{C})^2}{2(50\times10^{-12}\ \text{F})} = 2.5\times10^{-3}\ \text{J}.$$

(c) Our result is within a factor of 4 of that needed to cause a spark. Our conclusion is that it will probably not cause a spark; however, there is not enough of a safety factor to be sure.

39. **THINK** After the switches are closed, the potential differences across the capacitors are the same and they are connected in parallel.

EXPRESS The potential difference from a to b is given by $V_{ab} = Q/C_{\text{eq}}$, where Q is the net charge on the combination and C_{eq} is the equivalent capacitance.

ANALYZE (a) The equivalent capacitance is $C_{\text{eq}} = C_1 + C_2 = 4.0 \times 10^{-6}$ F. The total charge on the combination is the net charge on either pair of connected plates. The initial charge on capacitor 1 is

$$q_1 = C_1 V = \left(1.0\times10^{-6}\text{ F}\right)\left(200\text{ V}\right) = 2.0\times10^{-4}\text{ C}$$

and the initial charge on capacitor 2 is $q_2 = C_2 V = \left(3.0\times10^{-6}\text{F}\right)\left(200\text{ V}\right) = 6.0\times10^{-4}\text{ C}$. With opposite polarities, the net charge on the combination is

$$Q = 6.0 \times 10^{-4}\text{ C} - 2.0 \times 10^{-4}\text{ C} = 4.0 \times 10^{-4}\text{ C}.$$

The potential difference is

$$V_{ab} = \frac{Q}{C_{\text{eq}}} = \frac{4.0\times10^{-4}\text{C}}{4.0\times10^{-6}\text{F}} = 100\text{ V}.$$

(b) The charge on capacitor 1 is now $q_1' = C_1 V_{ab} = (1.0 \times 10^{-6}\text{ F})(100\text{ V}) = 1.0 \times 10^{-4}\text{ C}$.

(c) The charge on capacitor 2 is now $q_2' = C_2 V_{ab} = (3.0 \times 10^{-6}\text{ F})(100\text{ V}) = 3.0 \times 10^{-4}\text{ C}$.

LEARN The potential difference $V_{ab} = 100\text{ V}$ is half of the original $V = 200$ V, so the final charges on the capacitors are also halved.