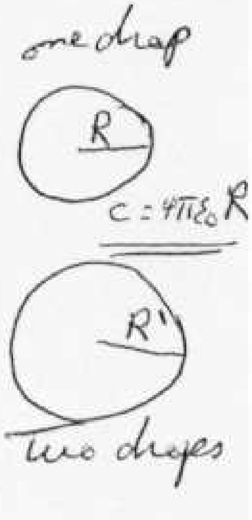
10E. A spherical drop of mercury of radius R has a capacitance given by $C = 4\pi\epsilon_0 R$. If two such drops combine to form a single larger drop, what is its capacitance?



26-10 The volume of each drop is $V = \frac{4\pi}{3} R^3$

After combination, the volume of the drop will be $\frac{4\pi}{3} R'^3$. But

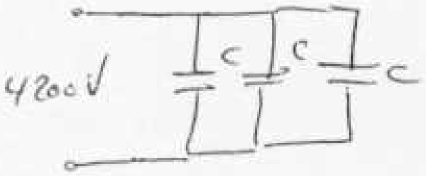
$$\frac{4\pi}{3} R'^3 = 2\left(\frac{4\pi}{3}\right) R^3$$

$$\Rightarrow \quad R' = 2^{1/3} R$$

The new capacitance will be

$$C' = 4\pi\varepsilon_0 R' = 2^{1/3} C$$

17E. Each of the uncharged capacitors in Fig. 26-28 has a capacitance of 25.0 μF. A potential difference of 4200 V is established when the switch is closed. How many coulombs of charge then pass through meter A?



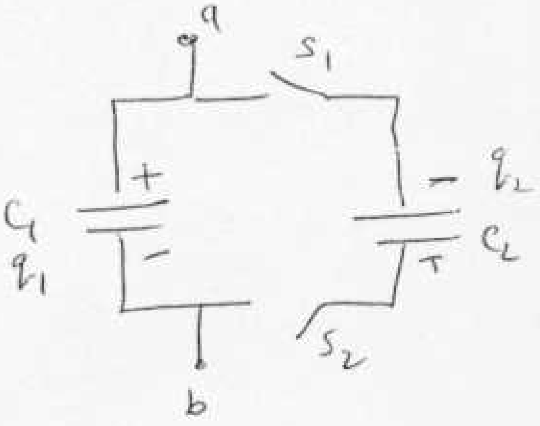
<u>26-17</u> $C_{eq} = C + C + C = 3C$

$q = C_{eq} V = 3CV$

$= 3(25\ \mu F)(4200V)$

$= 0.315C$

29P. In Fig. 26-33, capacitors $C_1 = 1.0\ \mu F$ and $C_2 = 3.0\ \mu F$ are each charged to a potential difference of $V = 100$ V but with opposite polarity as shown. Switches S_1 and S_2 are now closed. (a) What is now the potential difference between points a and b? What are now the charges on (b) C_1 and (c) C_2?



26-29 before Connection

$$q_1 = C_1 V = (1\mu F)(100) = 10^{-4}\,C$$

$$q_2 = C_2 V = (3\mu F)(100) = 3\times10^{-4}\,C$$

(a) after Connection

$$q_{total} = q_2 - q_1 = 2\times10^{-4}\,C.$$

for parallel connection $C_{eq} = C_1 + C_2 = 4\,\mu F$

$$\therefore\ V_{ab} = \frac{q_{total}}{C_{eq}} = \frac{2\times10^{-4}}{4\times10^{-6}} = \underline{50\ \text{Volts}}$$

(b) the charge on $C_1 \Rightarrow q_1' = C_1 V_{ab} = (1\mu F)(50)$

$$= \underline{5\times10^{-5}\,C}$$

(c) on C_2 - $q_2' = C_2 V_{ab} = (3\mu F)(50)$

$$= \underline{1.5\times10^{-4}\,C}$$

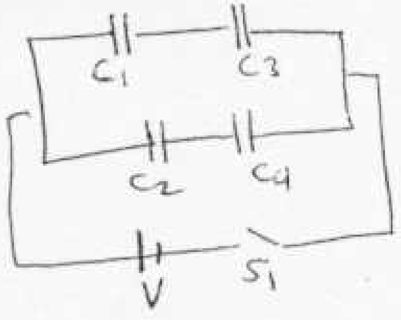
31P. In Fig. 26-35, battery B supplies 12 V. (a) Find the charge on each capacitor first when only switch S_1 is closed and (b) later when switch S_2 is also closed. Take $C_1 = 1.0\ \mu F$, $C_2 = 2.0\ \mu F$, $C_3 = 3.0\ \mu F$, and $C_4 = 4.0\ \mu F$.

$C_1 = 1\mu F$, $C_2 = 2\mu F$

$C_3 = 3\mu F$, $C_4 = 4\mu F$

$V = 12$ Volt

26-31



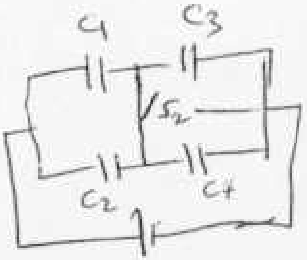
(a) If S_1 is closed

$$q_1 = q_3 = C_{13}V = \left(\frac{C_1C_3}{C_1+C_3}\right)V = \left[\frac{1\times 3}{(1+3)}\right]12\times10^{-6}$$

$$= \underline{\underline{9\ \mu C}}$$

$$q_2 = q_4 = \left(\frac{C_2C_4}{C_2+C_4}\right)V = \left[\frac{2\times 4}{(2+4)}\right]12\times10^{-6}$$

$$= \underline{16\ \mu C}$$



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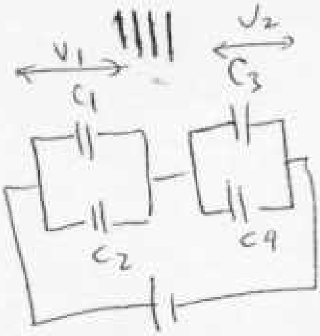


(b) when S_2 is closed

$$C_{12} = C_1 + C_2, \quad C_{34} = C_3 + C_4$$

$$C_{eq} = \frac{(C_1+C_2)(C_3+C_4)}{(C_1+C_2)+(C_3+C_4)}, \quad q_{total} = VC_{eq}$$

$$V_1 = \frac{q_{total}}{C_{12}} = \frac{(C_3+C_4)}{(C_1+C_2+C_3+C_4)}V = \frac{(3+4)}{(1+2+3+4)}(12)V$$

$$= \underline{\underline{8.4\ \text{Volts}}} \Rightarrow V_2 = 12 - 8.4 = \underline{3.6\ \text{Volts}}$$

$$\left.\begin{aligned} q_1 &= C_1V_1 = (1\mu F)(8.4) = 8.4\ \mu C \\ q_2 &= C_2V_1 = (2\mu F)(8.4) = 16.8\ \mu C \end{aligned}\right\} = q_{total}$$

$$\left.\begin{aligned} q_3 &= C_3V_2 = (3\mu F)(3.6) = 10.8\ \mu C \\ q_4 &= C_4V_2 = (4\mu F)(3.6) = 14.4\ \mu C \end{aligned}\right\} = q_{total}$$

check our results

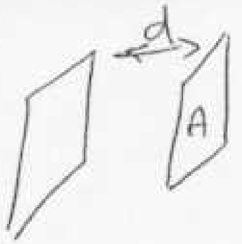
$$q_{total} = (12)\left[\frac{(1+2)(3+4)}{1+2+3+4}\right]$$

$$= 25.2\ \mu C$$

$$q_1 + q_2 = 25.2\ \mu C$$

$$q_3 + q_4 = 25.2\ \mu C$$

38E. A parallel-plate air-filled capacitor having area 40 cm^2 and plate spacing 1.0 mm is charged to a potential difference of 600 V. Find (a) the capacitance, (b) the magnitude of the charge on each plate, (c) the stored energy, (d) the electric field between the plates, and (e) the energy density between the plates.



$A = 40\,cm^2 = 40\times10^{-4}\,m^2$

$d = 1\,mm = 10^{-3}\,m$, $V = 600$ Volts

26-38 (a) $C = \frac{\varepsilon_0 A}{d} = \frac{(8.85\times10^{-12})(40\times10^{-4})}{10^{-3}\,m}$

$= \underline{3.5\times10^{-11}\,F} = \underline{35\,PF.}$

(b) $q = CV = (35\times10^{-12})(600) = \underline{21\,nC}$, $(n = 10^{-9})$

(c) $U = \frac{1}{2}CV^2 = \frac{1}{2}(35\times10^{-12})(600)^2$

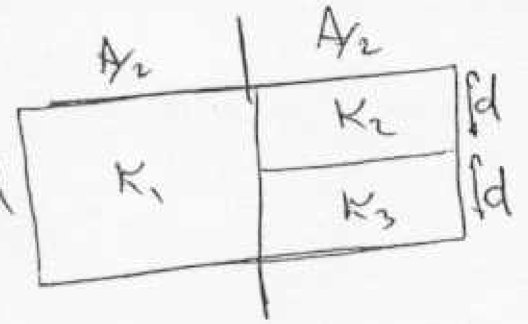
$= \underline{6.3\times10^{-6}\,J.}$

(d) $E = \frac{V}{d} = \frac{600}{10^{-3}} = 6\times10^{5}\,V/m$

(e) $u = \frac{U}{Volume} = \frac{6.3\times10^{-6}}{(40\times10^{-4})(10^{-3})} = 1.6\,\frac{J}{m^3}$

65P. What is the capacitance of the capacitor, of plate area A, shown in Fig. 26-39? (*Hint:* See Problems 63 and 64.)

26-65

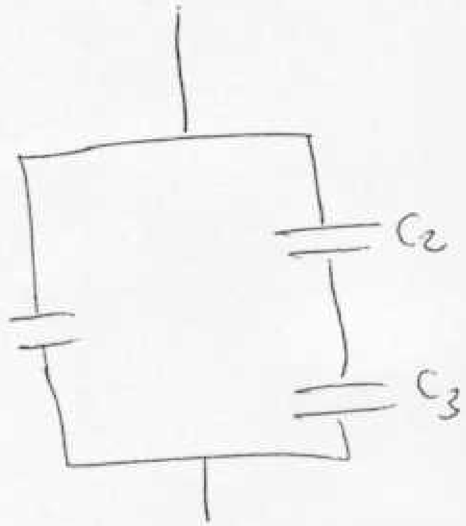


Consider $C_0 = \frac{\varepsilon_0 A}{2d}$

$$C_1 = K_1 \varepsilon_0 \frac{A/2}{2d} = \frac{K_1 C_0}{2} \quad , \quad C_2 = K_2 \varepsilon_0 \frac{A/2}{d} = K_2 C_0$$

$$C_3 = K_3 C_0$$

$$C_{23} = \frac{C_2 C_3}{C_2 + C_3}$$



$$C_{123} = C_1 + C_{23}$$

$$= \frac{K_1 C_0}{2} + \frac{K_2 C_0 K_3 C_0}{(K_2 + K_3) C_0}$$

$$= \frac{C_0}{2}\left[K_1 + \frac{2 K_2 K_3}{K_2 + K_3}\right]$$