KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTIONS (CHAPTER 26)

Q.1 A spherical drop of mercury of radius R has a capacitance given by C = $4\pi\varepsilon_0 R$. If two such drops combine to form a single larger drop what is its capacitance?

$$C_0 = 4\pi\epsilon_0 R$$

$$2\left(\frac{4}{3}\pi R^3\right) = \frac{4}{3}\pi R'^3 \Rightarrow R' = 2^{1/3} R$$

$$C = 4\pi\epsilon_0 (2^{1/3} R) \qquad (2^{1/3} = 1.26)$$

$$= 1.26 (4\pi\epsilon_0 R)$$

$$\boxed{C = 1.26\, C_0}$$

Q.2 Each of the uncharged capacitors in Figure 26.2 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?

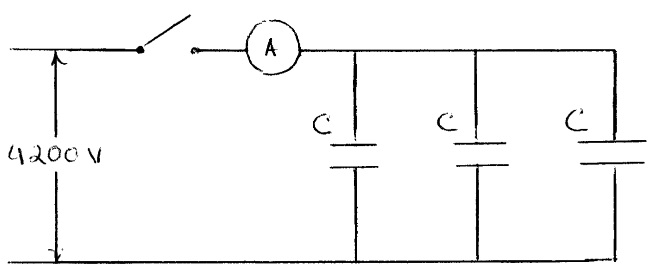


FIGURE 26.2

$$Q = 3CV = 3(25\,\mu F)(4200\,V) = 0.315 \text{ Coulomb}$$

$$\boxed{Q = 315\ mC}$$

Q.3 In Figure 26.3, capacitors $C_1 = 1.0$ μF and $C_2 = 3.0$ μF are 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?

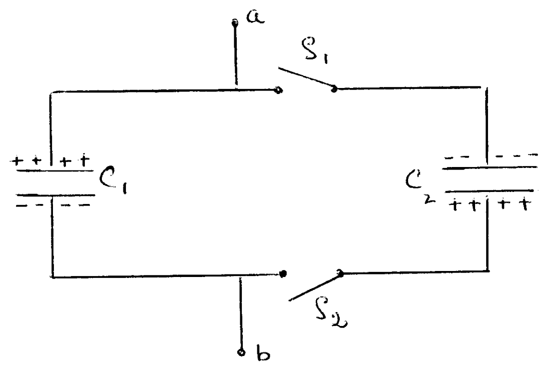


FIGURE 26.3

$C_1 = 1.0\mu F$, $C_2 = 3.0\mu F$, $V = 100$ Volts

(a) $q_1 = C_1 V = -100\mu C$, $q_2 = C_2 V = 300\mu C$

$q_1' + q_2' = 300 - 100 = 200\mu C$

$C_1 V + C_2 V = 200$

$1V + 3V = 200 \Rightarrow \boxed{V = 50 \text{ Volts}}$

(b) $q_1' = C_1 V = \boxed{50\mu C}$

$q_2' = C_2 V = \boxed{150\mu C}$

Q.4 In the Figure 26.4, battery B supplies 12V. (a) Find the charge on each capacitor first when only switch S_1 is closed and (b) later when switch S_2 is closed. Take $C_1 = 1.0\ \mu F$, $C_2 = 2.0\ \mu F$, $C_3 = 3.0\ \mu F$ and $C_4 = 4.0\ \mu F$.

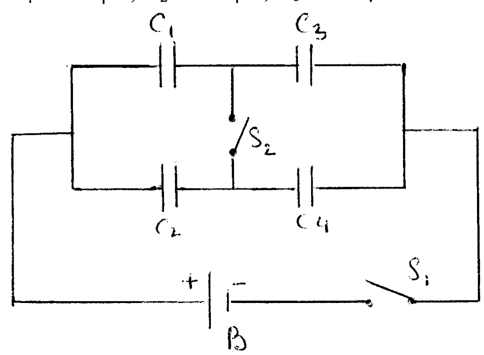


FIGURE 26.4

$\mathcal{E} = 12$ volts, $C_1 = 1.0\mu F$, $C_2 = 2.0\mu F$, $C_3 = 3.0\mu F$,
$C_4 = 4.0\mu F$.

(a) only S_1 closed

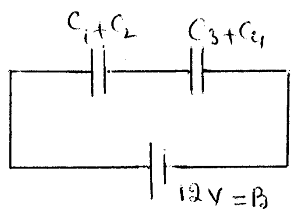
$$12 = \frac{q}{C_1} + \frac{q}{C_3} = \frac{q}{1} + \frac{q}{3}, \quad 4q = 36 \Rightarrow q = 9\mu C$$

$$\boxed{q_1 = q_3 = 9\mu C}$$

$$12 = \frac{q}{C_2} + \frac{q}{C_4} = \frac{q}{2} + \frac{q}{4}, \quad 3q = 48 \Rightarrow q = 16\mu C$$

$$\boxed{q_2 = q_4 = 16\mu C}$$

(b)



$$\frac{q}{C_1+C_2} + \frac{q}{C_3+C_4} = 12 \Rightarrow \frac{q}{3} + \frac{q}{7} = 12 \Rightarrow 7q + 3q = 252$$

$$\boxed{q = 25.2\mu C}$$

$$V_1 = \frac{25.2}{3} = 8.4 \text{ volts}, \quad V_2 = \frac{25.2}{7} = 3.6 \text{ volts}.$$

$q_1 = (C_1)(8.4) = \boxed{8.4\,\mu C}$

$q_2 = (C_2)(8.4) = \boxed{16.8\,\mu C}$

$q_3 = (C_3)(3.6) = \boxed{10.8\,\mu C}$

$q_4 = (C_4)(3.6) = \boxed{14.4\,\mu C}$

Q.5 A certain substance has a dielectric constant of 2.8 and a dielectric strength of 18 MV/m. If it is used as the dielectric material in parallel-plate capacitor, what minimum area should the plates of the capacitor have to obtain a capacitance of 7.0×10^{-2} μF and to ensure that the capacitor will be able to withstand a potential difference of 4.0 kV?

$K = 2.8$, dielectric strength, $E_{max} = 18$ MV/m

$V_{max} = 4.0$ kV, $d = \frac{V}{E} = \frac{4 \times 10^3}{10 \times 10^6} = 2.2 \times 10^{-4}$ m or 0.22 mm.

$$C = K \epsilon_0 \frac{A}{d}$$

$$7 \times 10^{-8} = K \epsilon_0 \frac{A}{d}$$

$$A = \frac{(7 \times 10^{-8}) \times (2.2 \times 10^{-4})}{(2.8)(8.85 \times 10^{-12})} = 0.63\ m^2$$

$$\boxed{A = 0.63\ m^2}$$