Recitation 8

Saturday, November 7, 2020 3:45 PM

1. You need a capacitance of 50 uF, but don't have a 50 uF capacitor. You do have a 30 uF capacitor. What additional capacitor do you need to produce a total capacitance of 50 uF? Should you join them in series or parallel.

In parallel, $C_{eq} = C_1 + C_2$.

For $C_{eq} = 50$:

$50 = 30 + C_2$

$C_2 = 20\ \mu F$ ✓

For series, $C_{eq} = \frac{(C_1)(C_2)}{C_1 + C_2}$

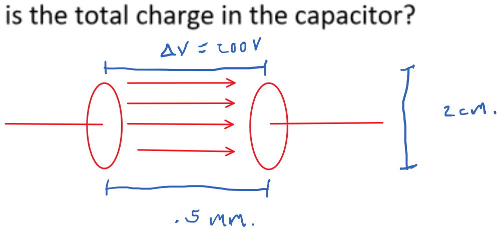
$50 = \frac{(30)\, C_2}{30 + C_2}$

$1500 + 50C_2 = 30C_2$

$20C_2 = -1500$

$\cancel{C_2 = -75\ \mu F}$

2. A 2.0 cm diameter parallel plate capacitor with a spacing of 0.50 mm is charged to 200 V.
    a. What is the total energy stored in the electric field?
    b. What is the total charge in the capacitor?



A.)

$C = \frac{\varepsilon_0 A}{d}$ (Physical capacitor)

$C = \frac{(8.85 \times 10^{-12})\left(\frac{1}{4}\pi(2\times10^{-2})^2\right)}{(.5 \times 10^{-3})}$

$C = 5.5578 \times 10^{-12}$ F

$C = 5557.8$ nF

$U = \frac{1}{2}CV^2$

$U = \frac{1}{2}(5.5578\times10^{-12})(200)^2$

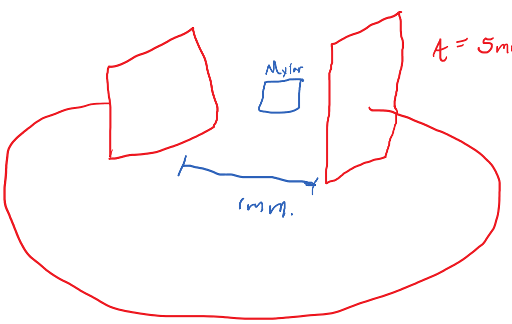
$U = 1.11156 \times 10^{-7}$ J.

B.)

$Q = CV$

$$Q = (5.5578 \times 10^{-12})(200)$$
$$Q = 1.11 \times 10^{-9} \ C$$

3. Two 5.0 mm by 5.0 mm electrodes are held 0.10 mm apart and are attached to a 9.0 V battery. Without disconnecting the battery , a 0.10 mm thick mylar sheet is inserted between the electrodes. What are the capacitors potential difference, electric field and charge
   a. Before the mylar is inserted
   b. After the mylar is inserted



$A = 5mm \times 5mm$

A.)

$$C_0 = \frac{\varepsilon_0 A}{d}$$
$$C_0 = \frac{(8.85 \times 10^{-12})(5 \times 10^{-3})^2}{(.1 \times 10^{-3})}$$
$$C_0 = 2.2125 \times 10^{-12} \ F$$

$$Q_0 = C_0 V$$
$$Q_0 = (2.2125 \times 10^{-12})(9)$$
$$Q_0 = 1.99 \times 10^{-11} \ C$$

$$E_0 = \frac{\sigma}{\varepsilon_0} \qquad \sigma = \frac{Q_0}{A}$$
$$E_0 = \frac{Q_0}{\varepsilon_0 A}$$
$$E_0 = \frac{(1.99 \times 10^{-11})}{(8.85 \times 10^{-12})(5 \times 10^{-3})^2}$$
$$E_0 = 90{,}000 \ \frac{N}{C}$$

B.)

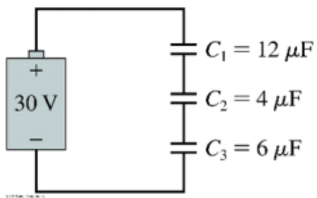
$$C_k = \frac{\varepsilon_0 A}{d} \qquad K = 3.1$$
$$C_k = (3.1)(2.2125 \times 10^{-12})$$
$$C_k = 6.85875 \times 10^{-12} \ F$$

$$E_A = \frac{V_A}{d}$$

$$90{,}000 = \frac{V_A}{(.1 \times 10^{-3})}$$

$$V_A = 9\,V$$

4. What are the charge on and the potential difference across each capacitor?



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{eq}} = \frac{1}{12} + \frac{1}{4} + \frac{1}{6}$$

$$\frac{1}{C_{eq}} = \frac{1}{12} + \frac{3}{12} + \frac{2}{12}$$

$$C_{eq} = \frac{1}{\left(\frac{6}{12}\right)}$$

$$C_{eq} = 2\ \mu F$$

A.)

$$Q = CV$$

$$Q = 2(30)$$

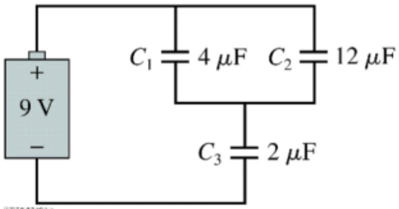
$Q = 60\ \mu C$ for all capacitors in series

B.)

$60 = 12V_1$ $\quad$ $60 = 4V_2$ $\quad$ $60 = 6V_3$

$V = 5V$ $\quad$ $V_2 = 15V$ $\quad$ $V_3 = 10V$

5. What are the charge and potential differences across each capacitor in the figure.



$C_{eq_{\parallel}} = 16\ \mu F$

$C_{eq} = \frac{16(2)}{18}$

$C_{eq} = \frac{16}{9}\ \mu F$

$Q_{total} = C_{eq} V$

$Q_{total} = \left(\frac{16}{9}\right)(9)$

$Q_{total} = 16\ \mu C$

$V_{eq_{\parallel}} = \frac{Q_{total}}{C_{eq_{\parallel}}}$

$V_{eq_{\parallel}} = \frac{16}{16}$

$V_{eq_{\parallel}} = 1V$

For C_1:

$V = 1V$

$Q = 4(1)$

$Q = 4\ \mu C$

For C_2:

$V = 1V$

$Q = 12(1)$

$Q = 12\ \mu C$

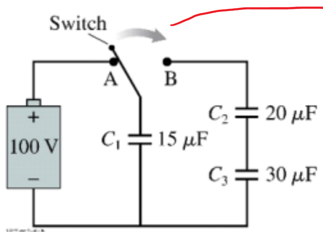
For C_3:

$Q = 16\ \mu C$

$V = \frac{16}{2}$

$V = 8V$

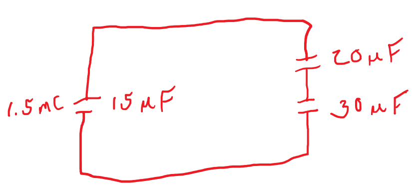
6. Initially, the switch in the figure is in position A an d capacitors C2 and C3 are uncharged. Then the switch is flipped position B. Afterward, what are the charge on and the potential difference across each capacitor.



$Q = CV$

$Q = 15(100)$

$Q = 1.5\ mC$



$C_{eq} = \frac{30(20)}{50}$

$C_{eq} = 12\ \mu F$

$\Delta V_{15}' = \Delta V_{12}'$

$\frac{Q_{15}'}{C_{15}} = \frac{Q_{12}'}{C_{12}}$

$Q_{12}' = Q_{15}'\left(\frac{C_{12}}{C_{15}}\right)$

$Q_{12}' = (.83)\left(\frac{12}{15}\right)$

$\left(1 + \frac{C_{12}}{C_{15}}\right) Q_{15}' = Q_{15}$

$\left(1 + \frac{12}{15}\right) Q_{15}' = Q_{15}$

$Q_{15}' = \frac{5}{9}(1.5\ mC)$

$Q_{15}' = .83\ mC$

$Q_{12}' = (.83)\left(\frac{12}{15}\right)$

$Q_{12}' = .66\,mC$

$Q_{15}' = \frac{\quad}{9}(1.0\,mC)$

$Q_{15}' = .83\,mC$

For C_2 and C_3:

$Q = .66\,mC$

For C_1:

$Q = .83\,mC$

For C_1:

$V = \frac{.83\,mC}{15\,\mu F}$

$V = 55.5\,V$

For C_2:

$V = \frac{.66\,mC}{20\,\mu F}$

$V = 33.3\,V$

For C_3:

$V = \frac{.66\,mC}{30\,\mu F}$

$V = 22.2\,V$