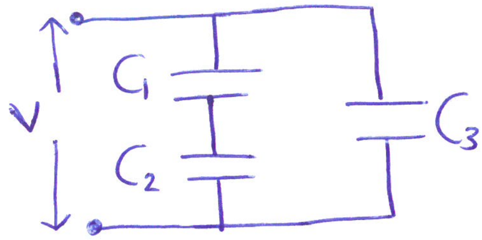
25-4 Find the equivalent capacitance of the combination in the following circuit. Assume that C_1 is 10.0 μF, C_2 is 8.0 μF, and C_3 is 4.0 μF.

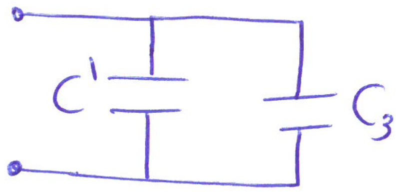


- C_1 and C_2 in Series

  C' = Equivalent capacitance of C_1 and C_2

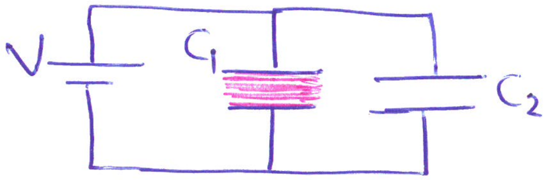
  $$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C' = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{10 \times 8}{8 + 10} = 4.4\ \mu F$$

- C' and C_3 in parallel



$$C'' = C' + C_3$$
$$= 4.4 + 4 = 8.4\ \mu F$$

25-14 In the below Figure, how much charge is stored on the parallel-plate capacitors by the 10.0 V battery? One is filled with air, and the other is filled with a dielectric for which $K = 3.00$; both capacitors have a plate area of $5.00 \times 10^{-3}\, m^2$ and a plate separation of 2.00 mm.



- Parallel plate capacitor

$$C = \frac{\varepsilon_0 A}{d}$$

⇒ C_1 = Dielectric parallel plate capacitor

$$C_1 = \frac{K \varepsilon_0 A}{d} = \frac{3 \times 8.85 \times 10^{-12} \times 5 \times 10^{-3}}{2 \times 10^{-3}} = 66.38 \times 10^{-12}\, F$$

$$\boxed{C_1 = 66.38\, pF}$$

⇒ $C_2 \equiv$ parallel plate capacitor filled with air $K = 1.00$

$$C_2 = \frac{K \varepsilon_0 A}{d} = \frac{1 \times 8.85 \times 10^{-12} \times 5 \times 10^{-3}}{2 \times 10^{-3}} = 22.13 \times 10^{-12}\, F$$

$$\boxed{C_2 = 22.13\, pF}$$

⇒ C_1 and C_2 in parallel, Voltage across C_1 and C_2 is the same, $V_{C_1} = V_{C_2} = 10.0\, V$

use $q = CV$

$q_2 = C_2 V_2$
$= 22.13 \times 10^{-12} \times 10$

$\boxed{q_2 = 221\, pC}$

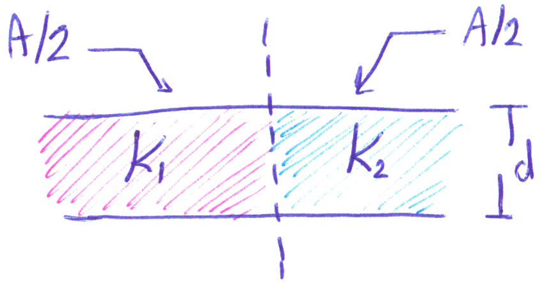
$q_1 = C_1 V_1$
$= 66.38 \times 10^{-12} \times 10$

$\boxed{q_1 = 664\, pC}$

$q_{total} = q_1 + q_2$

$\boxed{q_{total} = 885\, pC}$

25-18 The below Figure shows a parallel plate capacitor with a plate area $A = 5.56\ cm^2$ and separation $d = 5.56\ mm$. The left half of the gap is filled with material of dielectric constand $K_1 = 7.00$, the right half is filled with material of dielectric constant $K_2 = 10.0$. What is the capacitance?



- Parallel plate capacitor with dielectric material $C = \frac{K \epsilon_0 A}{d}$

⇒ Consider the two capacitors are in parallel ⇒ $C_{eq} = C_1 + C_2$

$$C_1 = \frac{K_1 \epsilon_0 A/2}{d} \quad , \quad C_2 = \frac{K_2 \epsilon_0 A/2}{d}$$

$$C = C_1 + C_2 = \frac{1}{2}(K_1 + K_2)\frac{\epsilon_0 A}{d}$$

$$= \frac{1}{2}(7+10)\frac{8.85 \times 10^{-12} \times 5.56 \times 10^{-4}}{5.56 \times 10^{-3}}$$

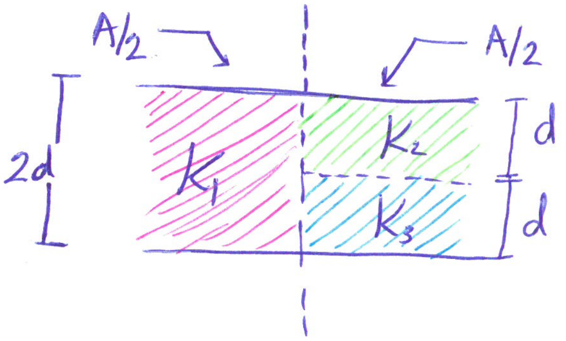
$$C = 7.52 \times 10^{-12}\ F$$

$$\boxed{C = 7.52\ pF}$$

$1m = 10^2\ cm$

$1m^2 = 10^4\ cm^2$

25-22 The below Figure shows a parallel-plate capacitor of plate Area $A = 12.5\,cm^2$ and plate separation $2d = 7.12\,mm$. The left half of the gap is filled with material of dielectric constant $K_1 = 21.0$; the top of the right half is filled with material of dielectric constant $K_2 = 42.0$, the bottom of the right half is filled with material constant $K_3 = 58.0$. What is the capacitance?



- parallel plate capacitor with dielectric material $\Rightarrow C = K\epsilon_0 A/d$

- Consider three capacitors $\Rightarrow$ C_2 & C_3 in Series and their combination in parallel with C_1

$$\Rightarrow C_1 = \frac{K_1 \epsilon_0 A/2}{2d} = \frac{21 \times 8.85\times10^{-12} \times 12.5\times10^{-4}}{2\times 7.12\times10^{-3}} = 16.3\,pF$$

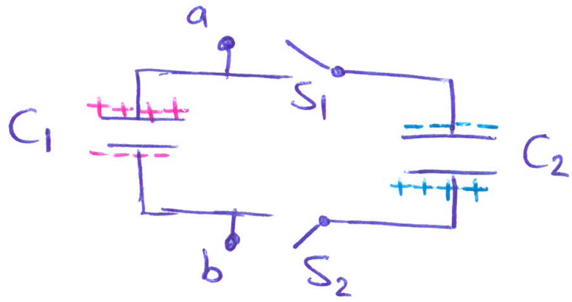
$$C_2 = \frac{K_2 \epsilon_0 A/2}{d} = \frac{42\times 8.85\times10^{-12}\times 12.5\times10^{-4}}{7.12\times10^{-3}} = 65.3\,pF$$

$$C_3 = \frac{K_3 \epsilon_0 A/2}{d} = \frac{58\times 8.85\times10^{-12}\times 12.5\times10^{-4}}{7.12\times10^{-3}} = 90.1\,pF$$

$\Rightarrow$ C_2 and C_3 in Series $\Rightarrow C' = \dfrac{C_2 C_3}{C_2 + C_3} = 37.9\,pF$

$\Rightarrow$ C' and C_1 in parallel $\Rightarrow C = C' + C_1 = 54.2\,pF$

25-39 In the below Figure, the capacitances are $C_1 = 1.0\mu F$ and $C_2 = 3.0\mu F$ and both capacitors are charged to a potential difference of $V = 200V$ 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 now is the charge on capacitor 1 and 2!



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

$$C_{eq} = C_1 + C_2 = 4.0\mu F$$

- $q_1 = C_1 V = 1 \times 10^{-6} \times 200 = 2.0 \times 10^{-4} C$

$$q_2 = C_2 V = 3 \times 10^{-6} \times 200 = 6.0 \times 10^{-4} C$$

With opposite polarities, the net charge on the combination is

$$Q = (6-2) \times 10^{-4} = 4 \times 10^{-4} C$$

- the potential difference from a to b is given by $V_{ab} = \frac{Q}{C_{eq}}$

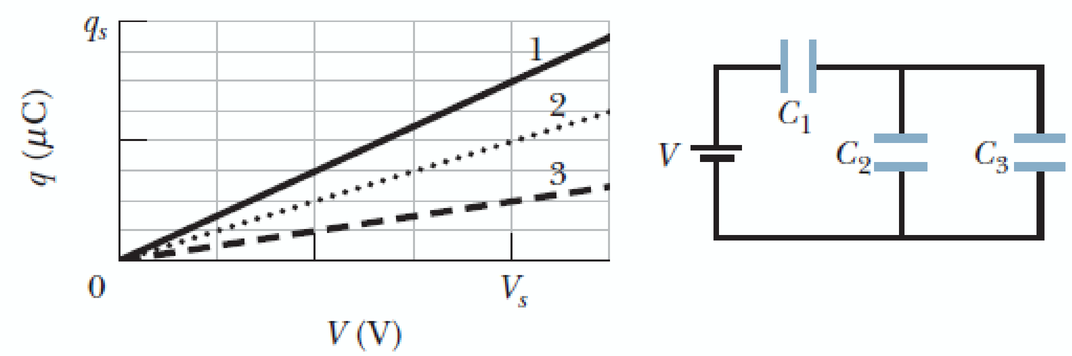
(a) $V_{ab} = \frac{Q}{C_{eq}} = \frac{4 \times 10^{-4}}{4 \times 10^{-6}} = 100.0 V$

(b). the charge on capacitor 1 is now $\Rightarrow q_1' = C_1 V_{ab} = 1 \times 10^{-6} \times 100$

$$\boxed{q_1' = 0.1 mC}$$

- $q_2' = C_2 V_{ab} = 3 \times 10^{-6} \times 100 = \boxed{0.3 mC = q_2'}$

25-46 Plot 1 in the below Figure gives the charge q that can be stored on Capacitor 1 versus the electric potential V setup across it. The vertical Scale is set by $q_s = 16.0\,\mu C$, and the horizontal scale is set by $V_s = 2.0\,V$. plot 2 and 3 are Similar plots for capacitors 2 and 3 respectively. What is the charge stored on capacitor 2 in the below circuit with those three capacitors and 10.0V battery?



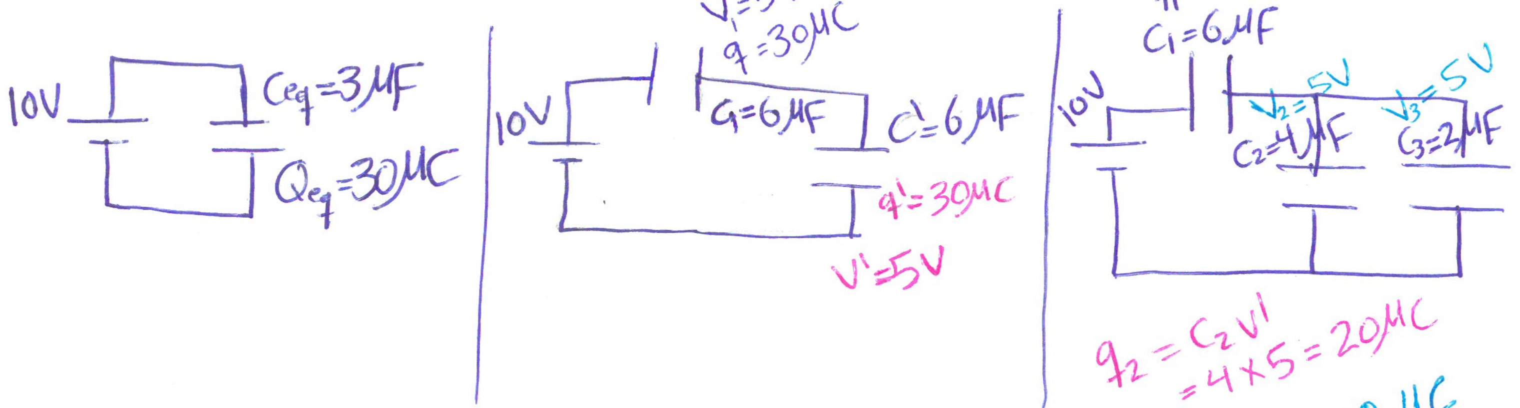
- Find each capacitance from the slope of q versus V curve

$$C_1 = \frac{12\,\mu C}{2.0V} = 6.0\,\mu F, \quad C_2 = \frac{8\,\mu C}{2.0} = 4\,\mu F, \quad C_3 = \frac{4\,\mu C}{2.0} = 2\,\mu F$$

- Equivalent Capacitance $\Rightarrow$ C_3 and C_2 in parallel and their combination in Series with C_1

$$C_{eq} \Rightarrow \frac{1}{C_2+C_3} + \frac{1}{C_1} = \frac{1}{C_{eq}} = \frac{1}{6} + \frac{1}{6}$$

$$\boxed{C_{eq} = 3\,\mu F}$$



$$q_2 = C_2 V' = 4\times5 = 20\,\mu C$$

$$q_3 = 2\times5 = 10\,\mu C$$

25–45 What is the capacitance of a drop that results when two mercury spheres, each of radius $R = 3.00\ mm$, merge?

When the drops combine the volume of the drop is doubled

$V' =$ new volume

$$V' = 2V$$

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

$$C = 4\pi\epsilon_0 R' = 4\pi\epsilon_0 2^{1/3} R = \frac{2^{1/3} \times (3\times10^{-3})}{9\times10^{9}}$$

$$C = 0.42\ pF$$