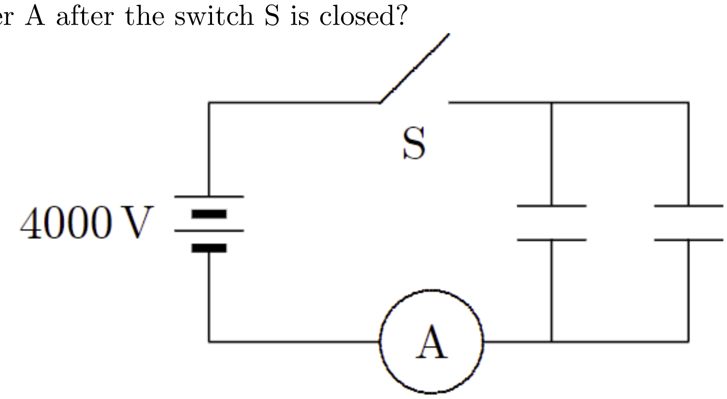
Physics 158 Circuits Problem Bank

Time Independent Circuits

Time Dependent Circuits

Problem 1

Each of the two 25 μF capacitors shown is initially uncharged. How many coulombs of charge pass through the ammeter A after the switch S is closed?



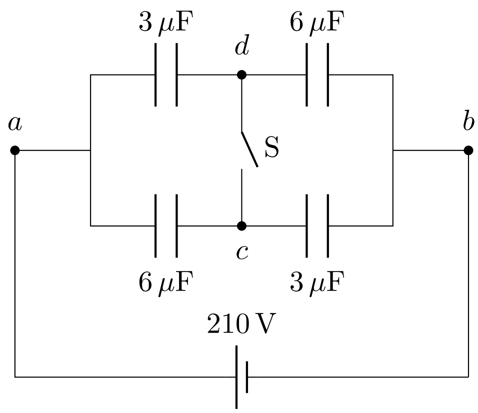
Solution:
When the switch is closed the two capacitors and power supply are all at 4000V.
The charge on each capacitor is $q = CV$ which in this case is

$$q = (25\,\mu\text{F})(4000\,\text{V}) = 0.1\,\text{C}$$

for each capacitor so a total of $\boxed{0.2\,\text{C}}$ flows through the ammeter

Problem 2

The capacitors in the figure are initially uncharged and are connected, as in the diagram, with the switch S open. The applied potential difference is $V_{ab} = 210\,\text{V}$



a) What is the potential difference V_{cd}

b) What is the potential difference across each capacitor after the switch S is closed?

c) How much charge flowed through the switch when it was closed?

Solution:
With the switch open each pair of $3.00\,\mu$F and $6\,\mu$F capacitors are in series with each other and each pair is in parallel with the other pair. When the switch is closed each pair of $3\,\mu$F and $6\,\mu$F capacitors are in parallel with each other and the two pairs are in series.

a) With the switch open

$$C_{\text{eq}} = \frac{1}{\frac{1}{3\,\mu\text{F}} + \frac{1}{6\,\mu\text{F}}} + \frac{1}{\frac{1}{3\,\mu\text{F}} + \frac{1}{6\,\mu\text{F}}} = 4\,\mu\text{F}$$
$$Q_{\text{total}} = C_{\text{eq}}V = (4\,\mu\text{F})(210\,\text{V}) = 8.40 \cdot 10^{-4}\,\text{C}$$

By symmetry, each capacitor carries $4.20 \cdot 10^{-4}$ C. The voltages are then calculated via $V = \frac{Q}{C}$. This gives $V_{ad} = \frac{Q}{C_3} = 140\,\text{V}$ and $V_{ac} = \frac{Q}{C_6} = 70\,\text{V}$. We then get V_{cd} as

$$V_{cd} = V_{ad} - V_{ac} = \boxed{70\,\text{V}}$$

b) When the switch is closed, the points c and d must be at the same potential, so the equivalent capacitance is

$$C_{\text{eq}} = \frac{1}{\frac{1}{(3+6)\,\mu\text{F}} + \frac{1}{(3+6)\,\mu\text{F}}} = 4.5\,\mu\text{F}$$
$$Q_{\text{total}} = C_{\text{eq}}V = (4.5\,\mu\text{F})(210\,\text{V}) = 9.5 \cdot 10^{-4}\,\text{C}$$

and each capacitor has the same potential difference of $\boxed{105\,\text{V}}$ (again, by symmetry).

c) The only way for the sum of the positive charge on one plate of C_2 and the negative charge on one plate of C_1 to change is for charge to flow through the switch. That is, the quantity of charge that flows through the switch is equal to the change in $Q_2 - Q_1$. With the switch open, $Q_1 = Q_2$ and $Q_2 - Q_1 = 0$. After the switch is closed, $Q_2 - Q_1 = 315\,\mu$C, so $\boxed{315\,\mu\text{C}}$ of charge flowed through the switch.
Note: It is better to compute the absolute charges on each plate before and after the switch is closed and then to follow the flow of the electrons through the switch.

RLC Circuits

AC Circuits