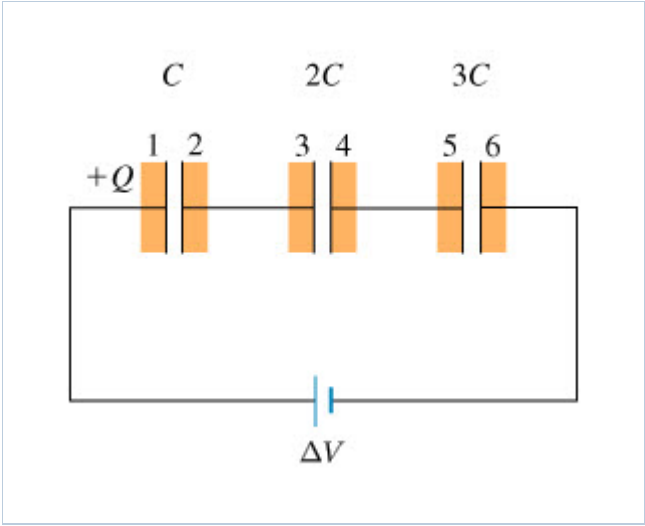
Description: Contains several questions that help practice basic calculations for capacitors connected in series; there is a similar skill-builder ("Capacitors in Parallel") about capacitors connected in parallel.

Learning Goal:
To understand how to calculate capacitance, voltage, and charge for a combination of capacitors connected in series.

Consider the combination of capacitors shown in the figure. Three capacitors are connected to each other in series, and then to the battery. The values of the capacitances are C, $2C$, and $3C$, and the applied voltage is ΔV. Initially, all of the capacitors are completely discharged; after the battery is connected, the charge on plate 1 is Q.



Part A

What are the charges on plates 3 and 6?

View Available Hint(s) (2)

Hint 1. Charges on capacitors connected in series

When the plates of two adjacent capacitors are connected, the sum of the charges on the two plates must remain zero, since the pair is isolated from the rest of the circuit; that is, $Q_2 + Q_3 = 0$ and $Q_4 + Q_5 = 0$, where Q_i is the charge on plate i.

Hint 2. The charges on a capacitor's plates

When electrostatic equilibrium is reached, the charges on the two plates of a capacitor must have equal magnitude and opposite sign.

ANSWER:

- ○ $+Q$ and $+Q$
- ○ $-Q$ and $-Q$
- ◉ $+Q$ and $-Q$
- ○ $-Q$ and $+Q$
- ○ 0 and $+Q$
- ○ 0 and $-Q$

Part B

If the voltage across the first capacitor (the one with capacitance C) is ΔV_1, then what are the voltages across the second and third capacitors?

▼ **View Available Hint(s)** (2)

Hint 1. Definition of capacitance

The capacitance C is given by $\frac{Q}{\Delta V}$, where Q is the charge of the capacitor and $\Delta\ V$ is the voltage across it.

Hint 2. Charges on the capacitors

As established earlier, the absolute value of the charge on each plate is Q: It is the same for all three capacitors and thus for all six plates.

ANSWER:

- ○ $2\Delta V_1$ and $3\Delta V_1$
- ◉ $\frac{1}{2}\Delta V_1$ and $\frac{1}{3}\Delta V_1$
- ○ ΔV_1 and ΔV_1
- ○ 0 and ΔV_1

Part C

Find the voltage ΔV_1 across the first capacitor.

Express your answer in terms of ΔV.

▼ **View Available Hint(s)** (1)

Hint 1. How to analyze voltages

According to the law of conservation of energy, the sum of the voltages across the capacitors must equal the

voltage of the battery.

ANSWER:

$\Delta V_1 = \frac{6\Delta V}{11}$

Part D

Find the charge Q on the first capacitor.

Express your answer in terms of C and ΔV_1.

ANSWER:

$Q = C\Delta V_1$

Part E

Using the value of Q just calculated, find the equivalent capacitance C_{eq} for this combination of capacitors in series.

Express your answer in terms of C.

▶ **View Available Hint(s)** (1)

ANSWER:

$C_{\text{eq}} = \frac{6C}{11}$

The formula for combining three capacitors in series is

$$\frac{1}{C_{\text{series}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

How do you think this formula may be generalized to n capacitors?