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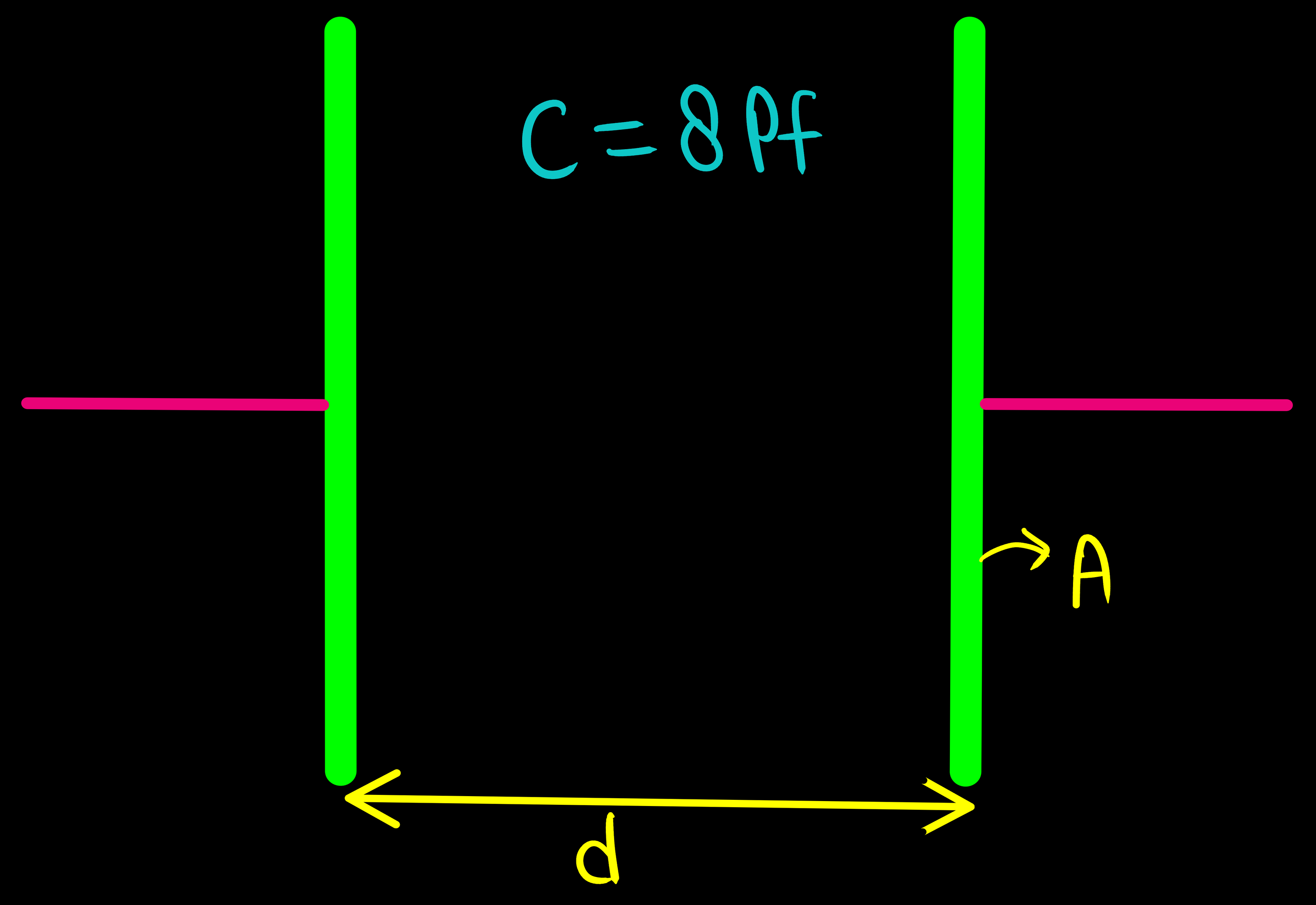

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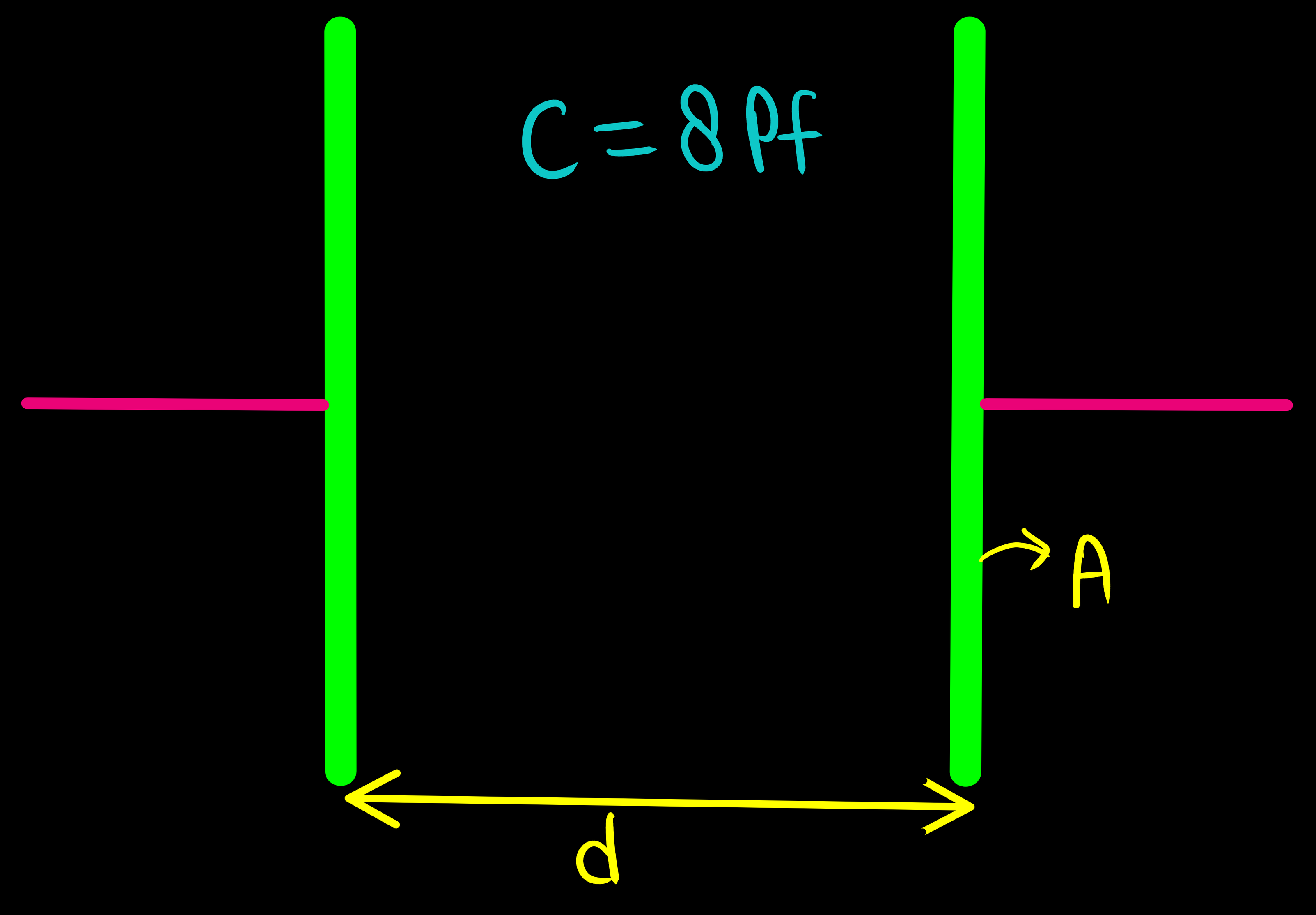

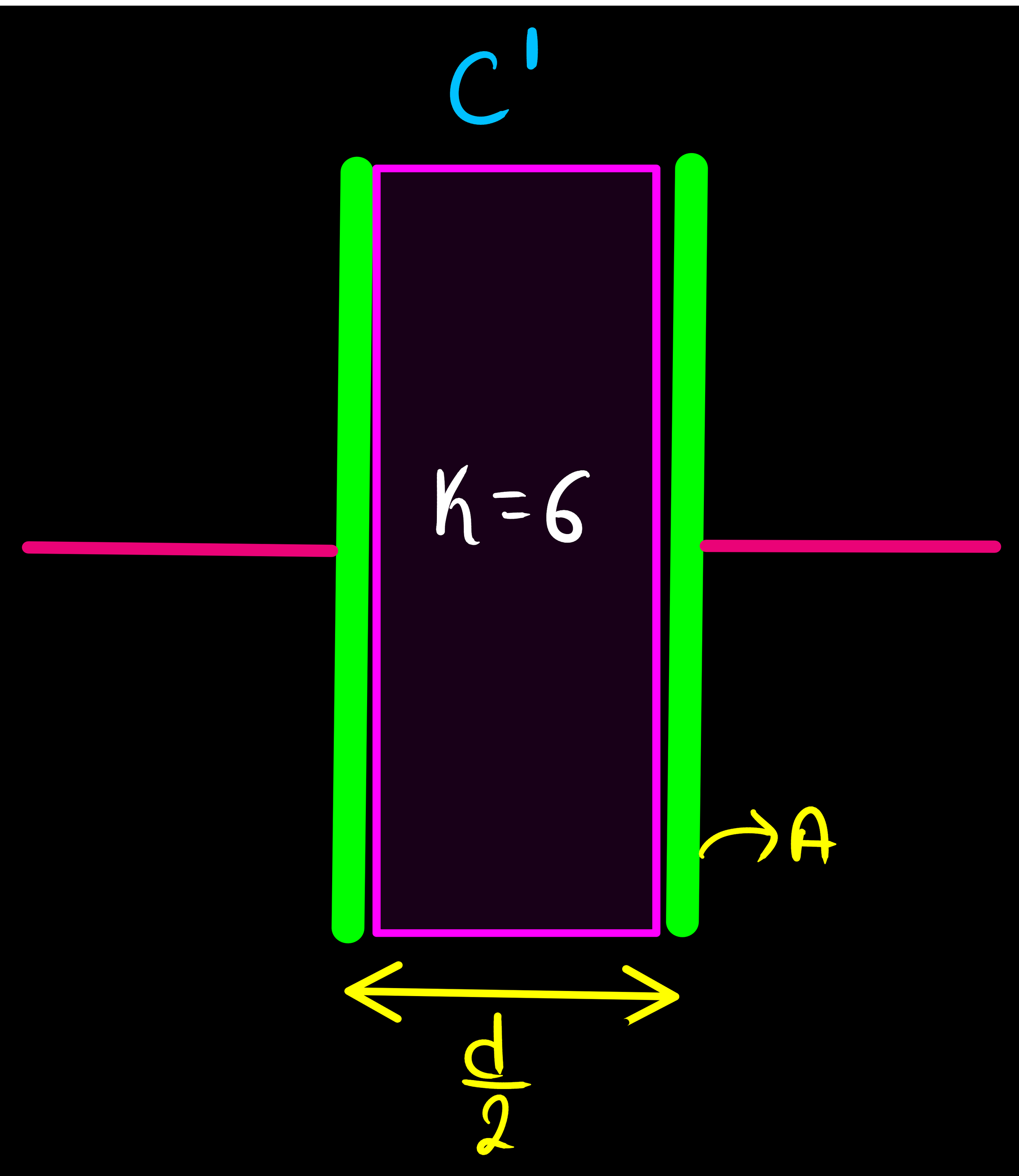

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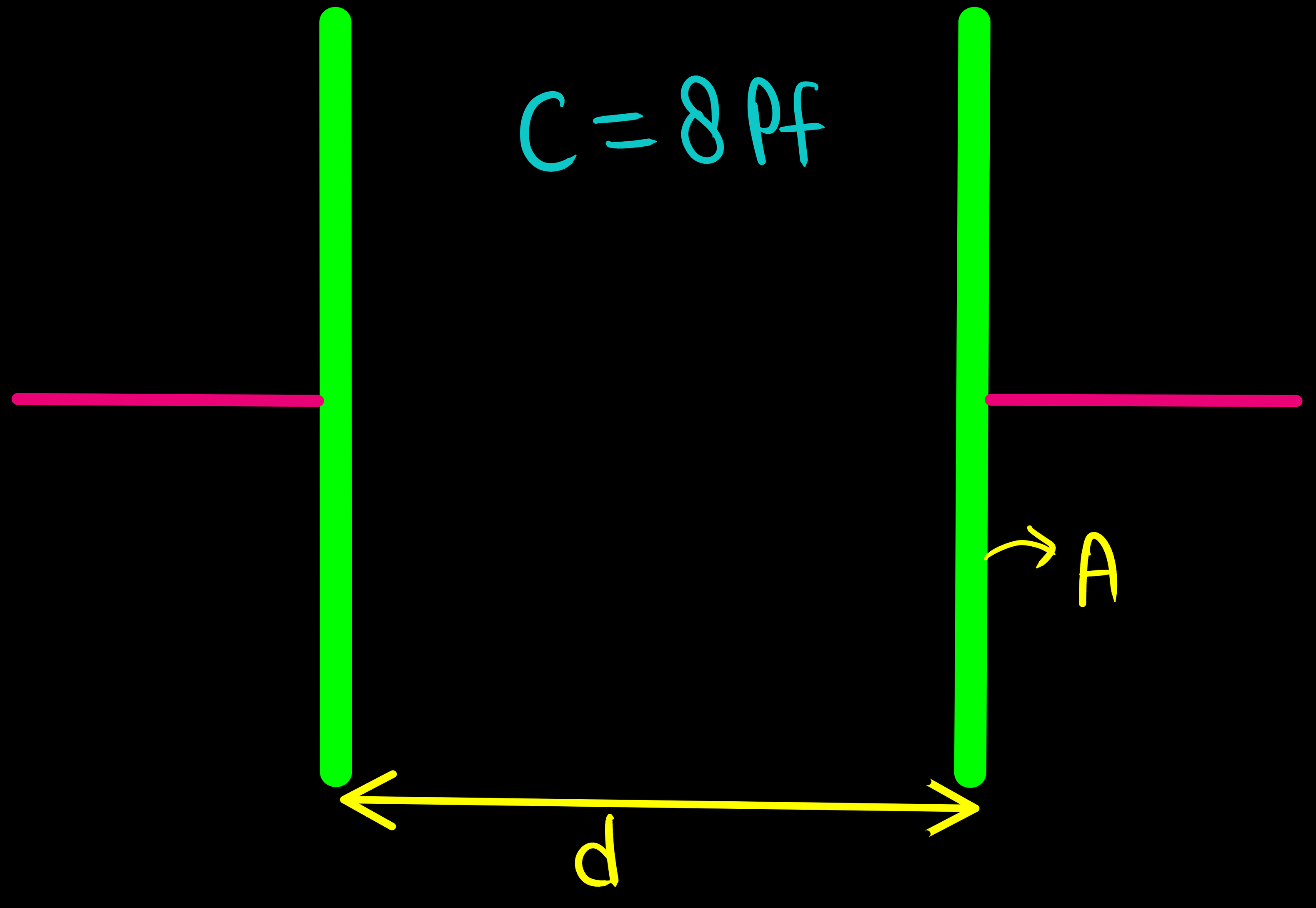

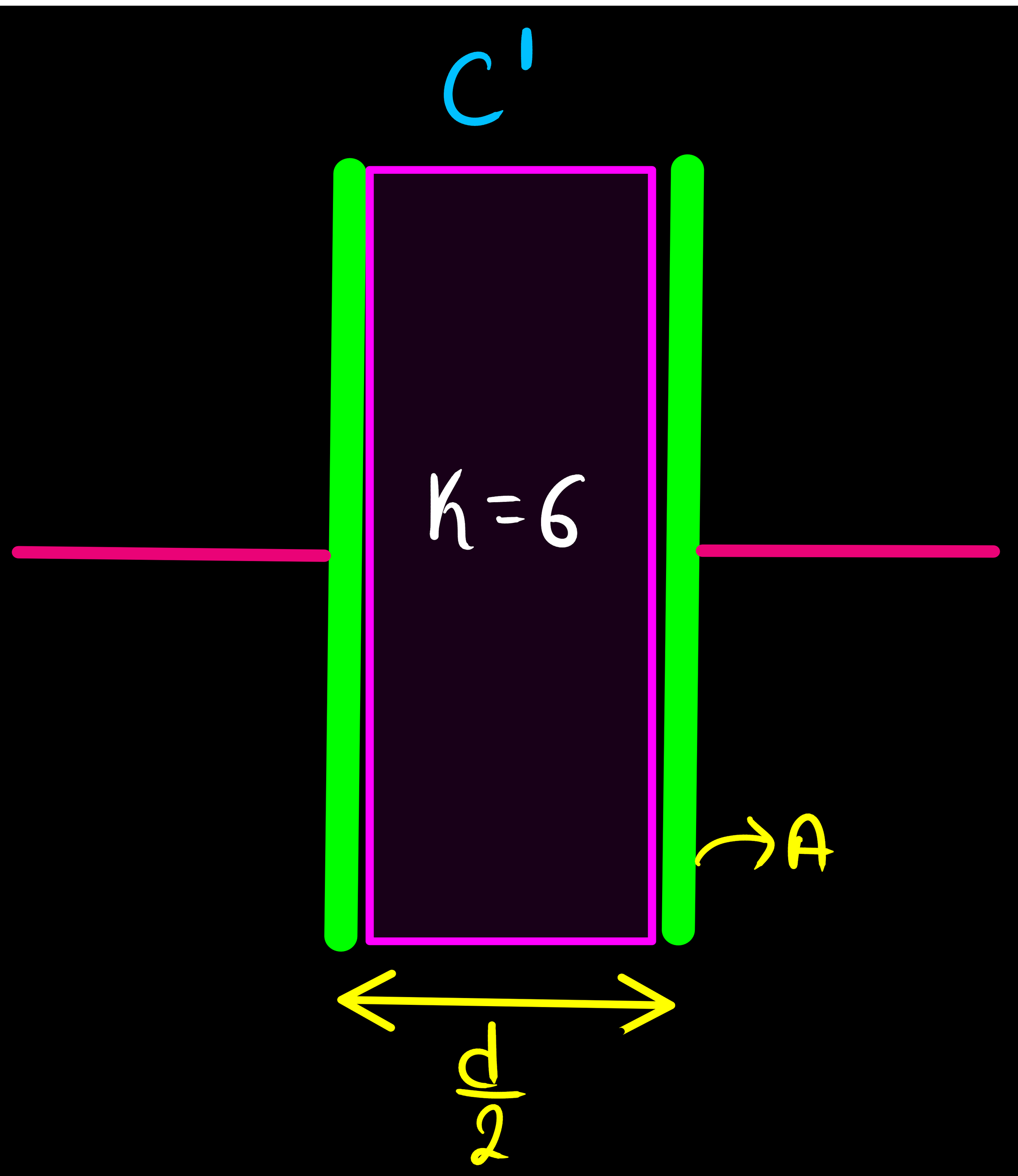

$$C = \frac{\varepsilon_0 A}{d} = 8 pF$$

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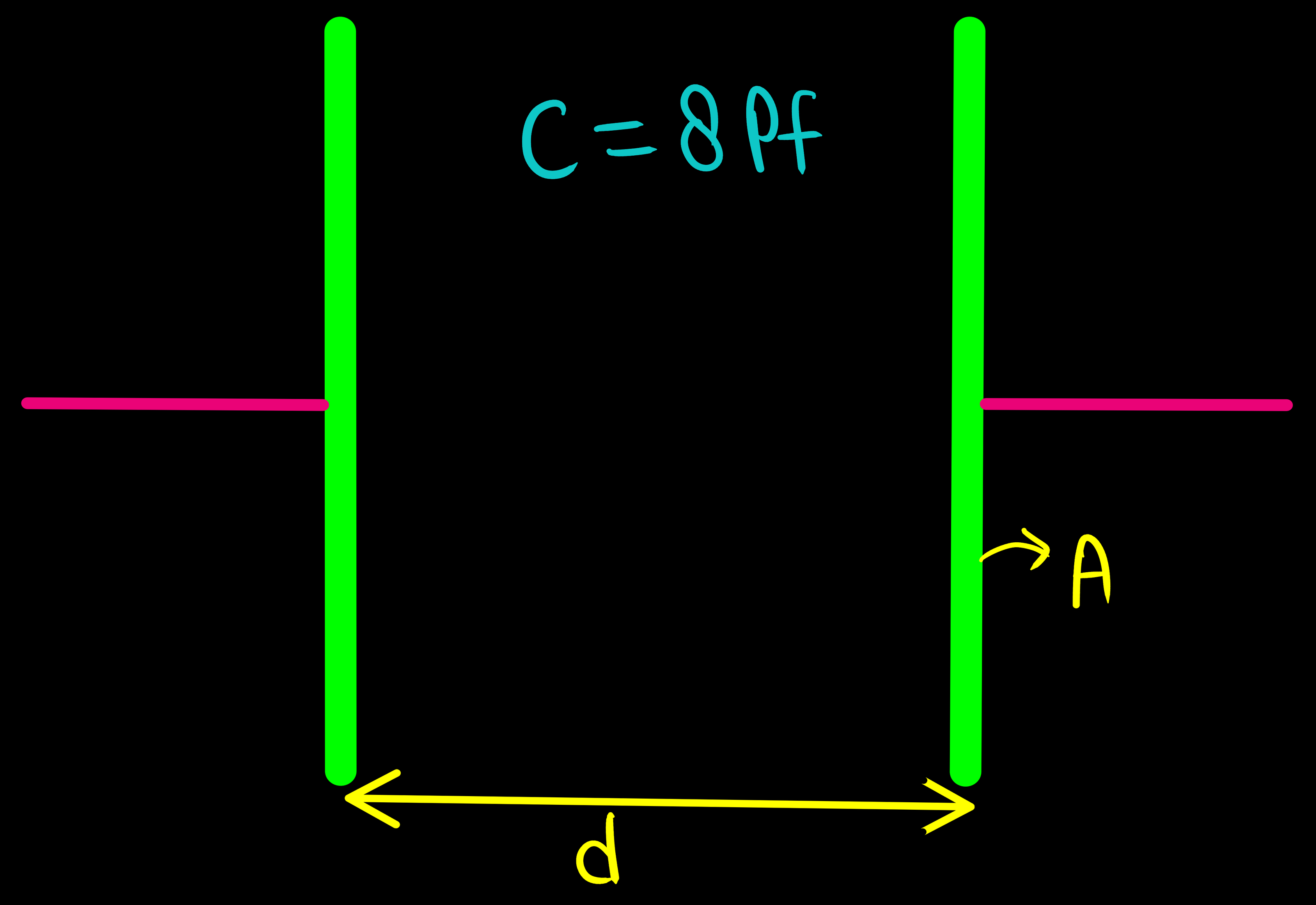

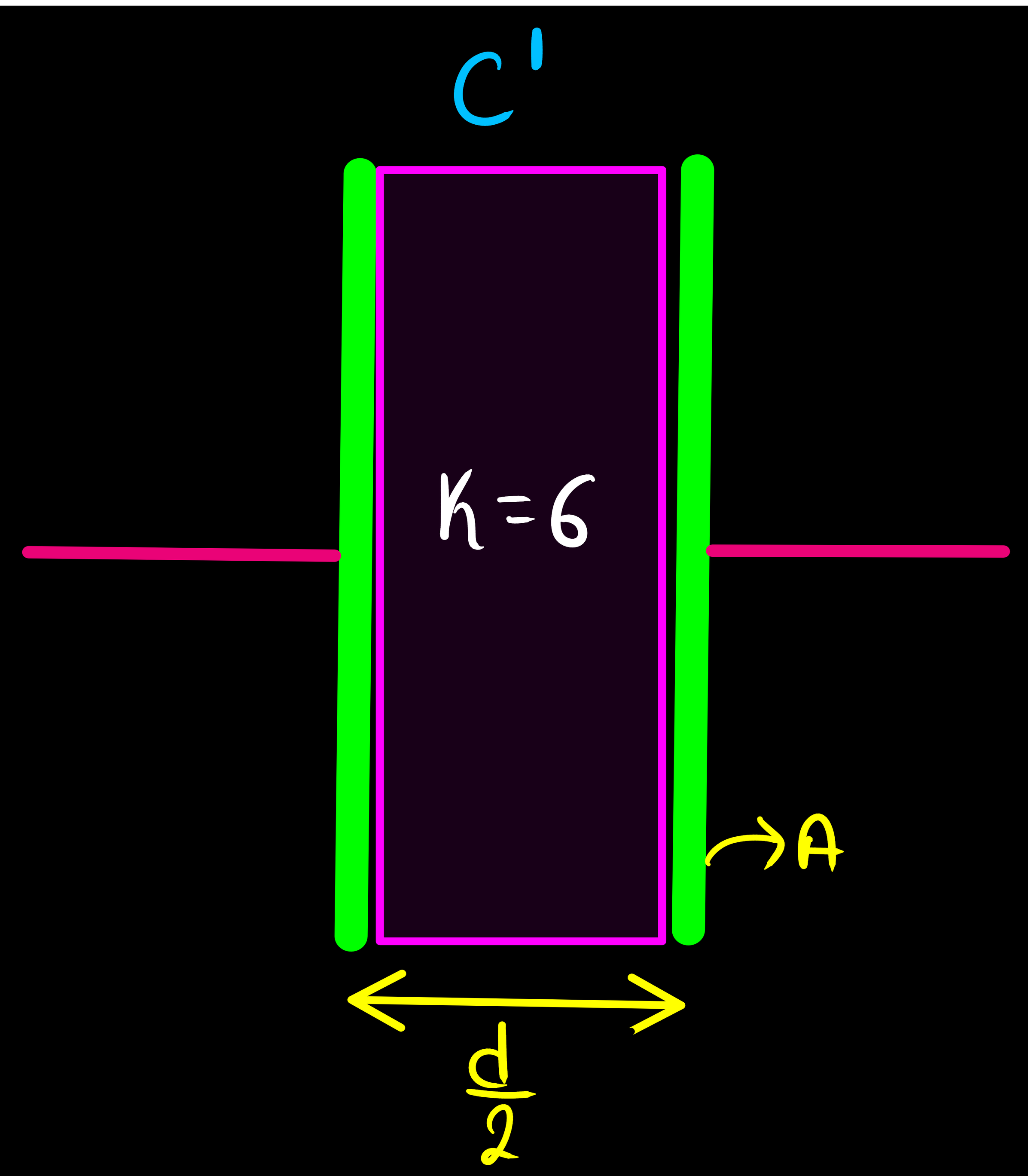

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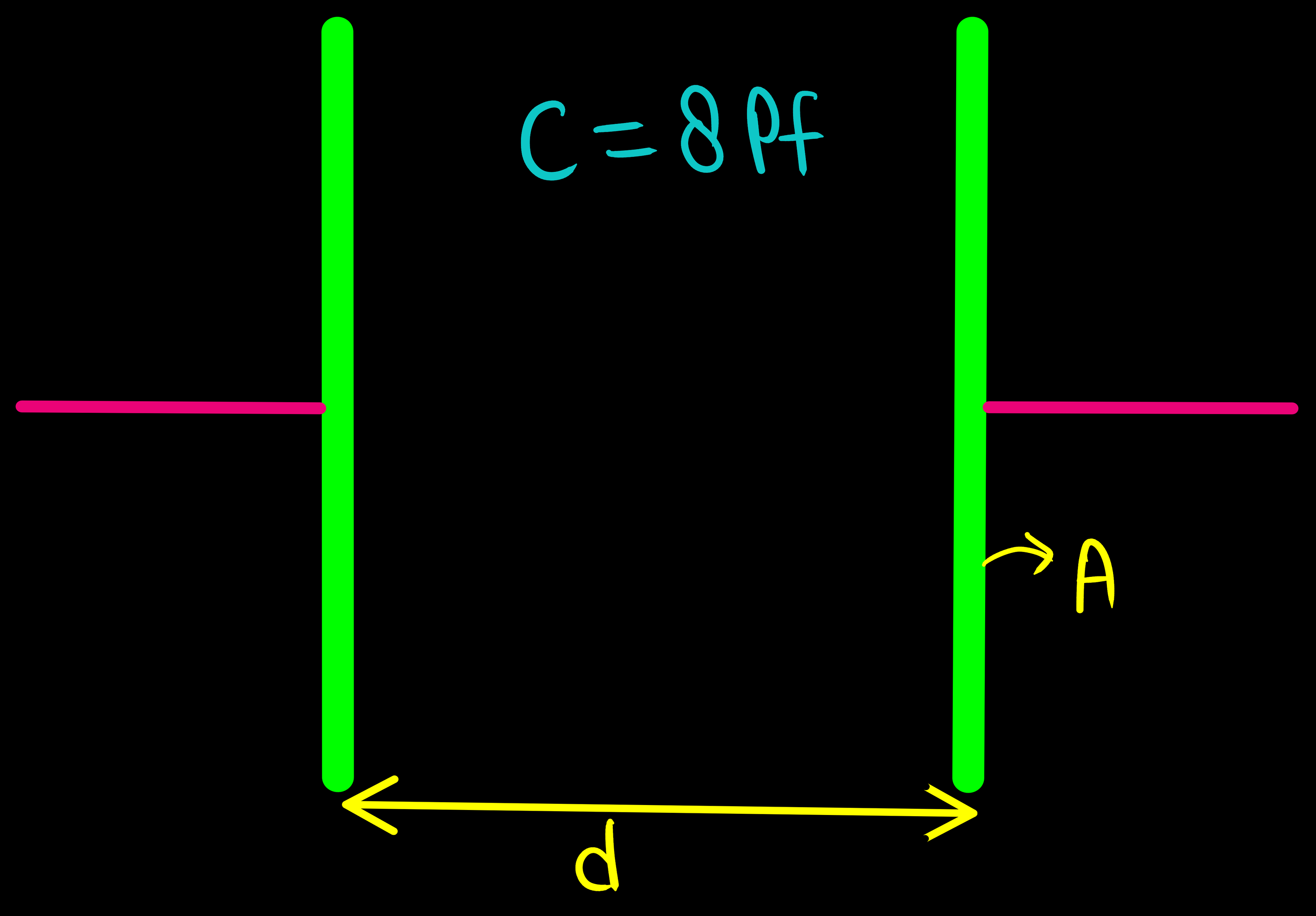

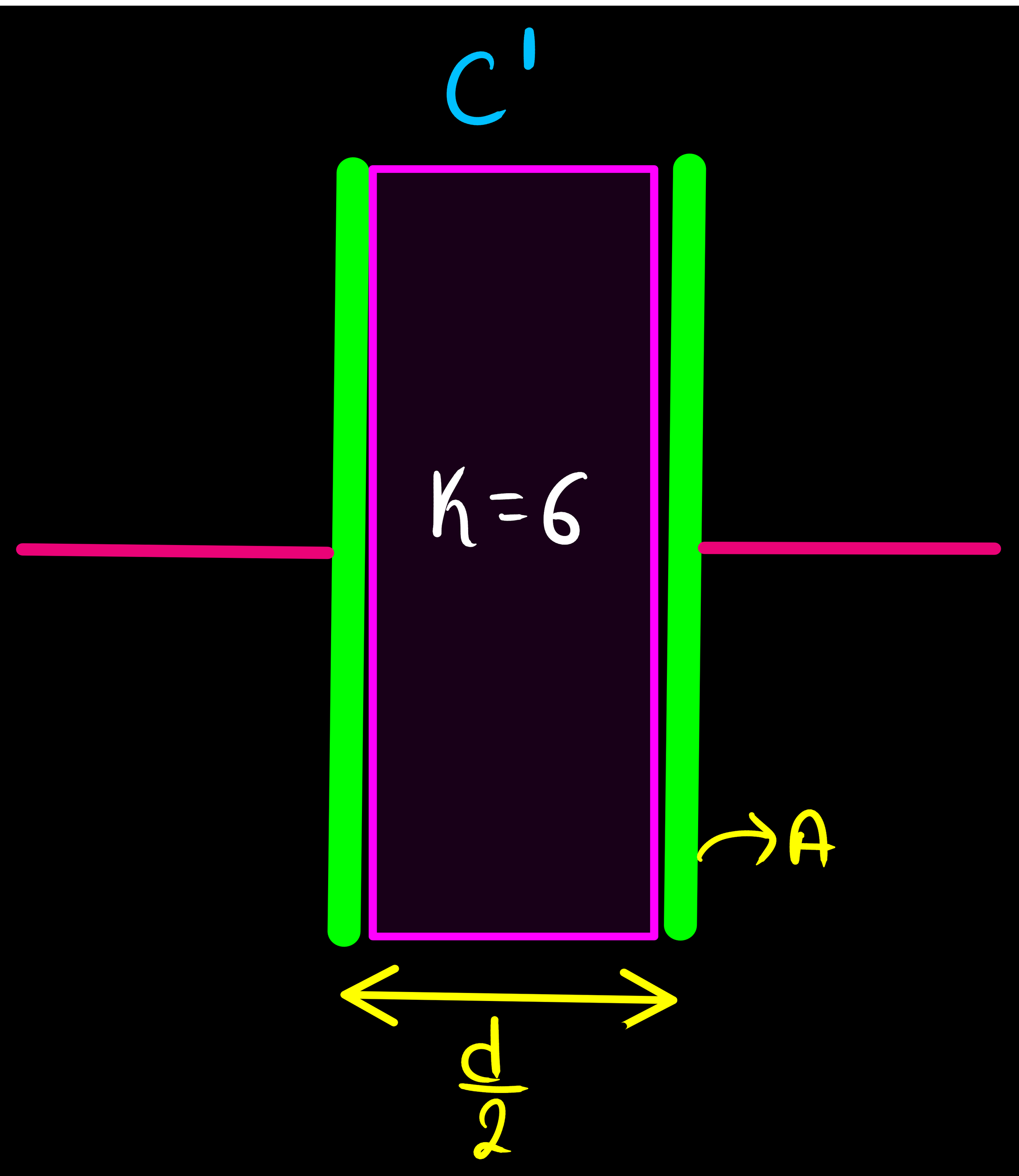

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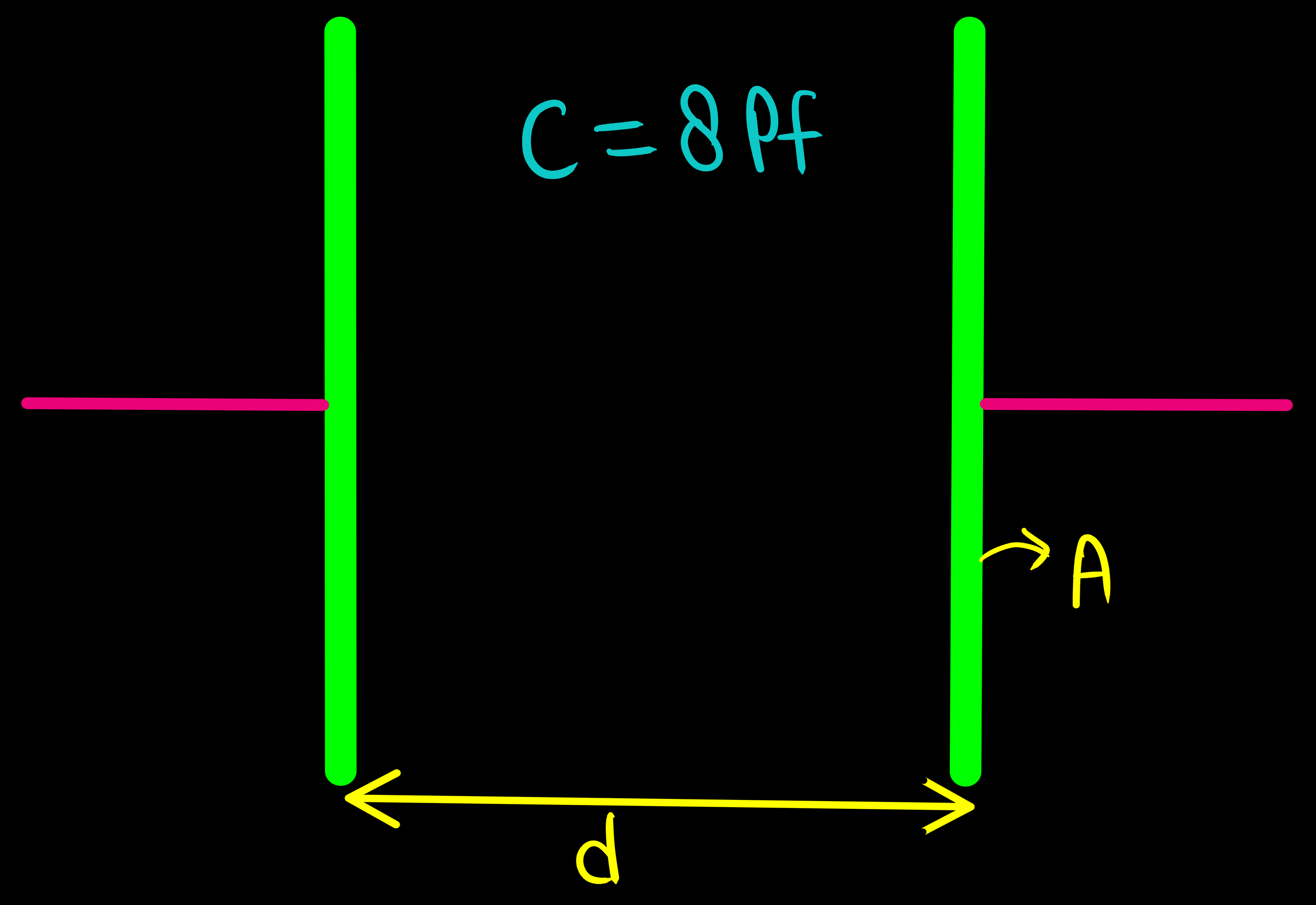

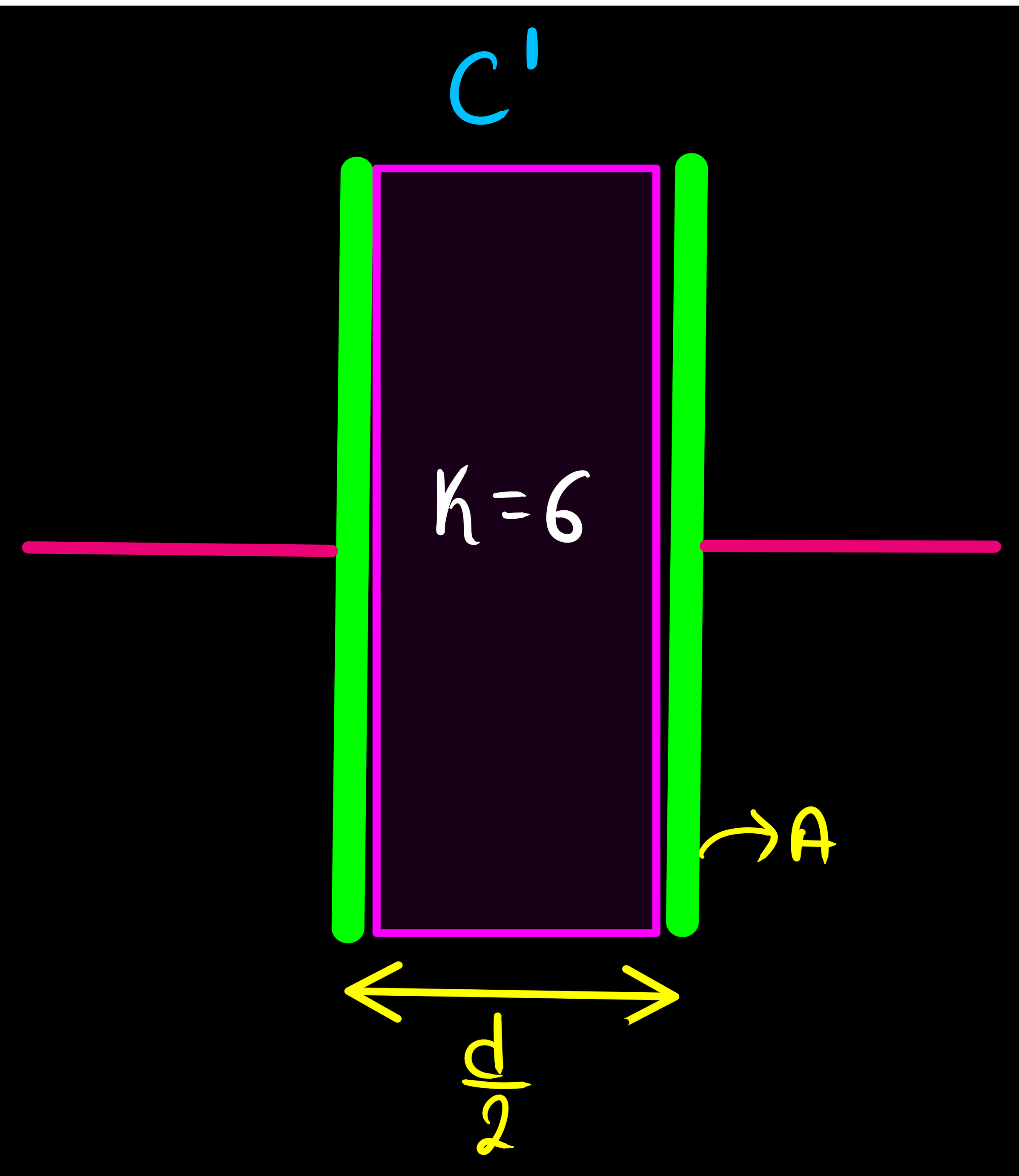

$$C = \frac{\varepsilon_0 A}{d} = 8 \text{ Pf}$$

$$C' = \frac{K \varepsilon_0 A}{\frac{d}{2}}$$

$$C' = 2K \frac{\varepsilon_0 A}{d}$$

$$\boxed{C' = 2 \times 6 \times 8 \text{ Pf} = 96 \text{ Pf}}$$

2.8 In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the distance between the plates is 3 mm. Calculate the capacitance of the capacitor. If this capacitor is connected to a 100 V supply, what is the charge on each plate of the capacitor?

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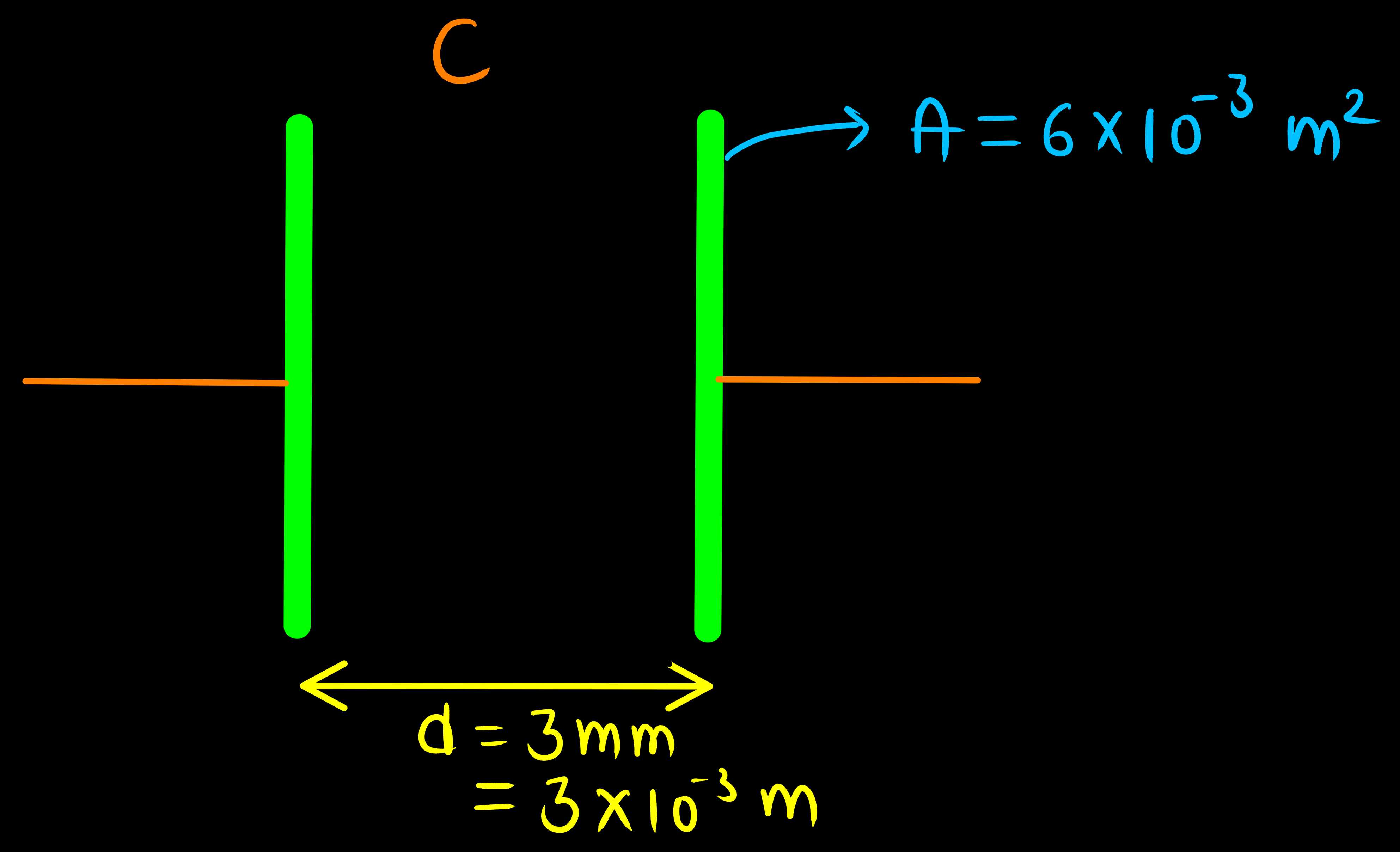

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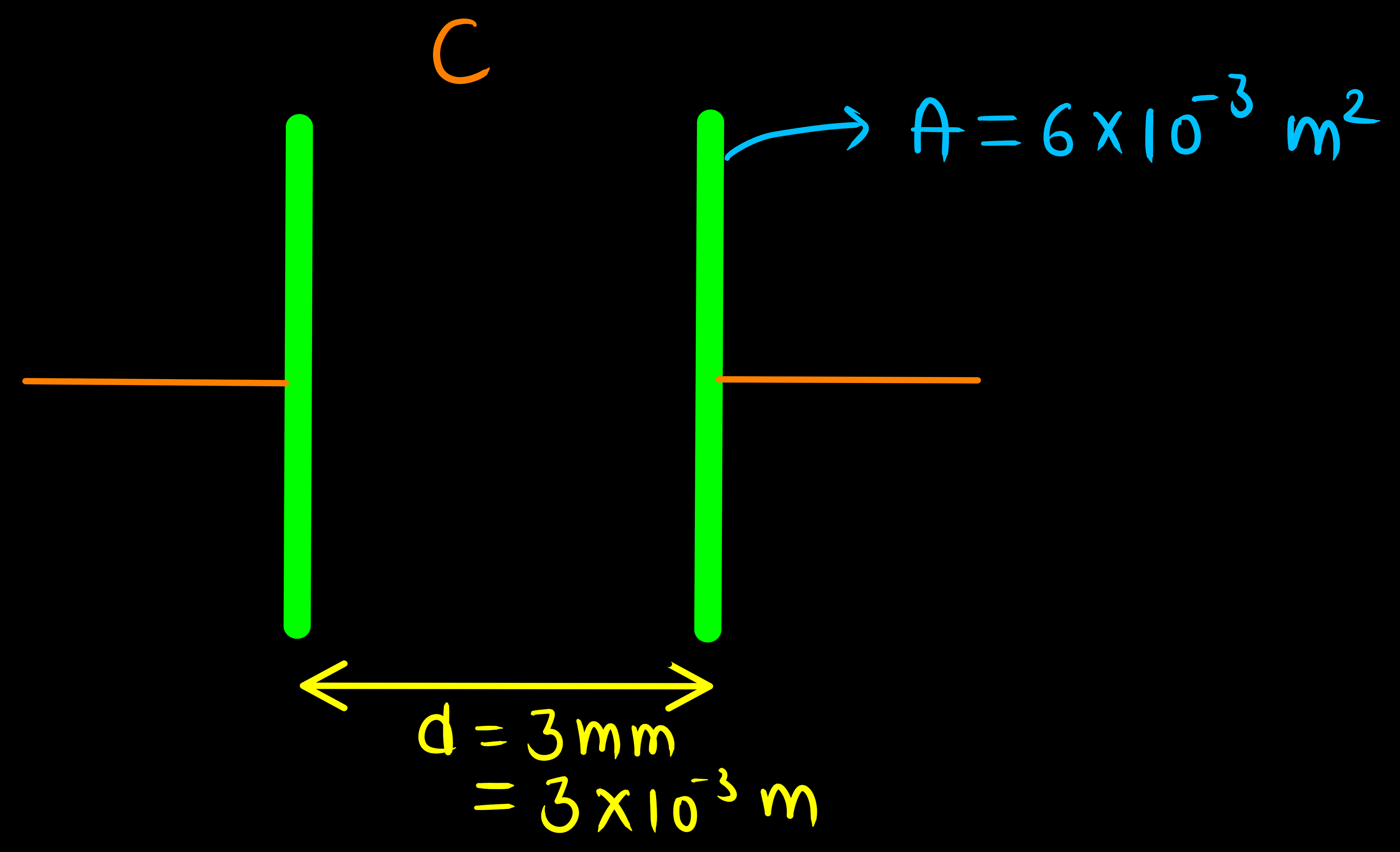

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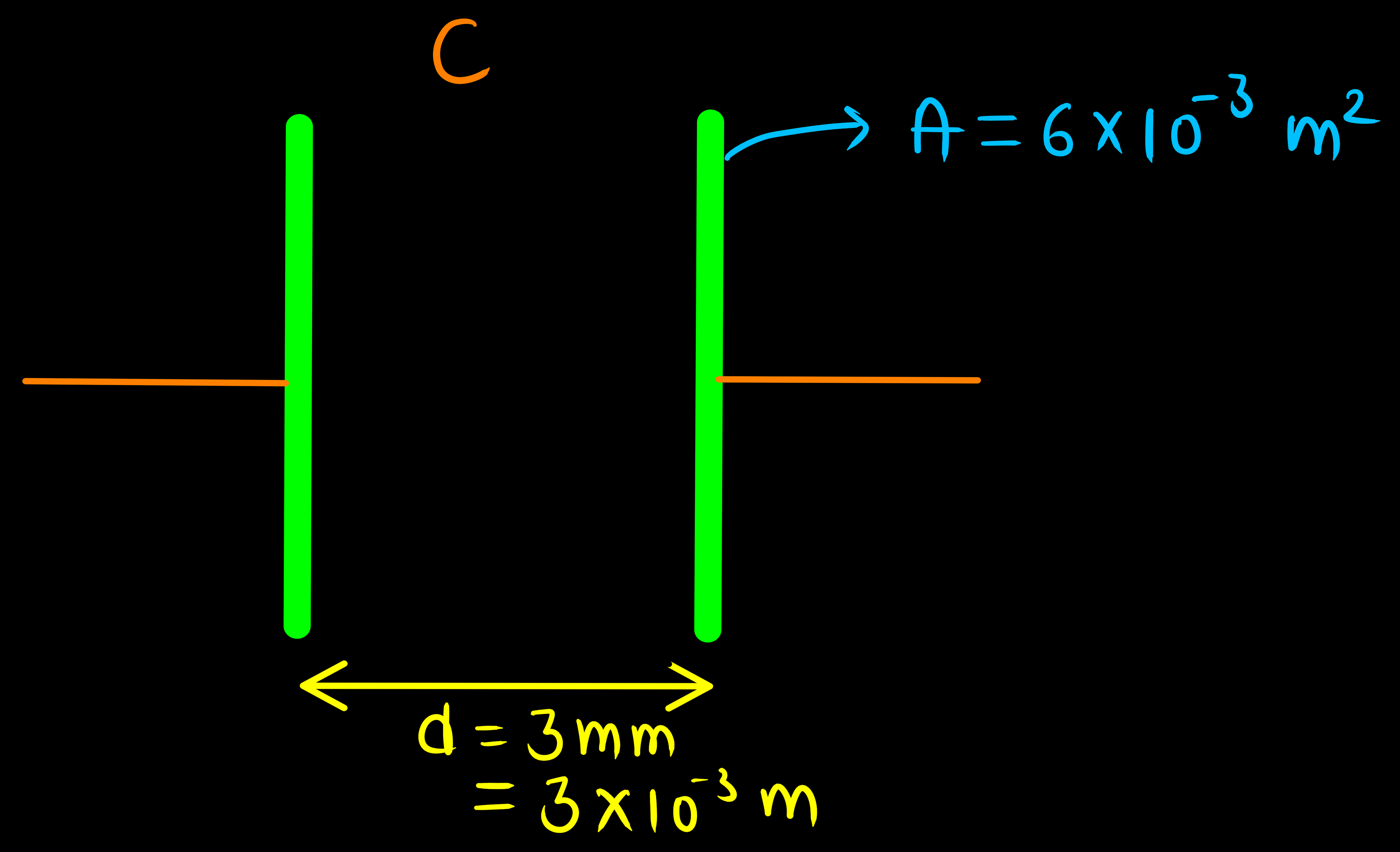
i) $$C = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{8.854 \times 10^{-12} \times 6 \times 10^{-3}}{3 \times 10^{-3}}$$



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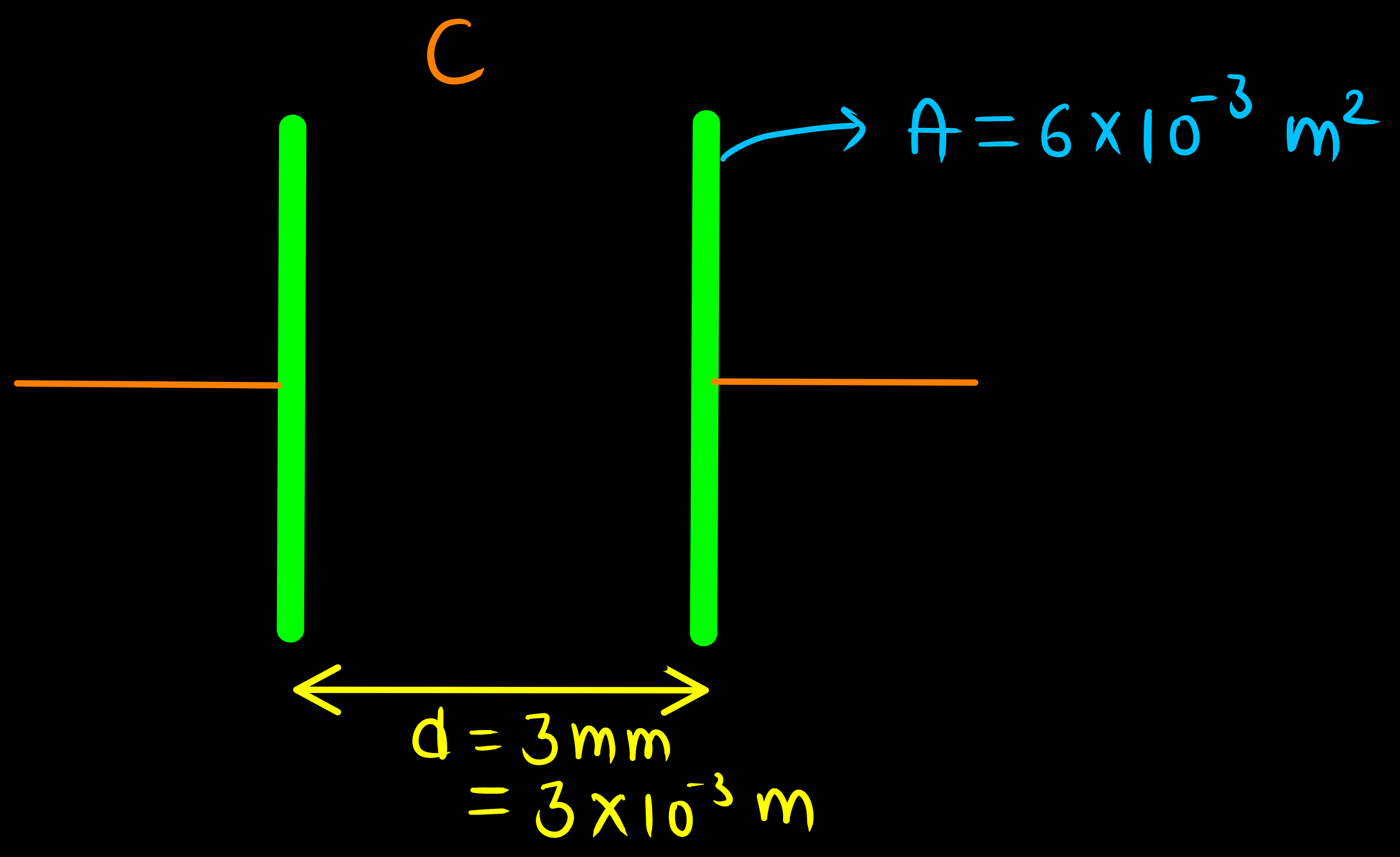
$$C = \frac{8.854 \times 10^{-12} \times \overset{2}{\cancel{6}} \times \cancel{10^{-3}}}{\cancel{3} \times \cancel{10^{-3}}}$$

$$\boxed{C = 17.708 \times 10^{-12}\ F}$$



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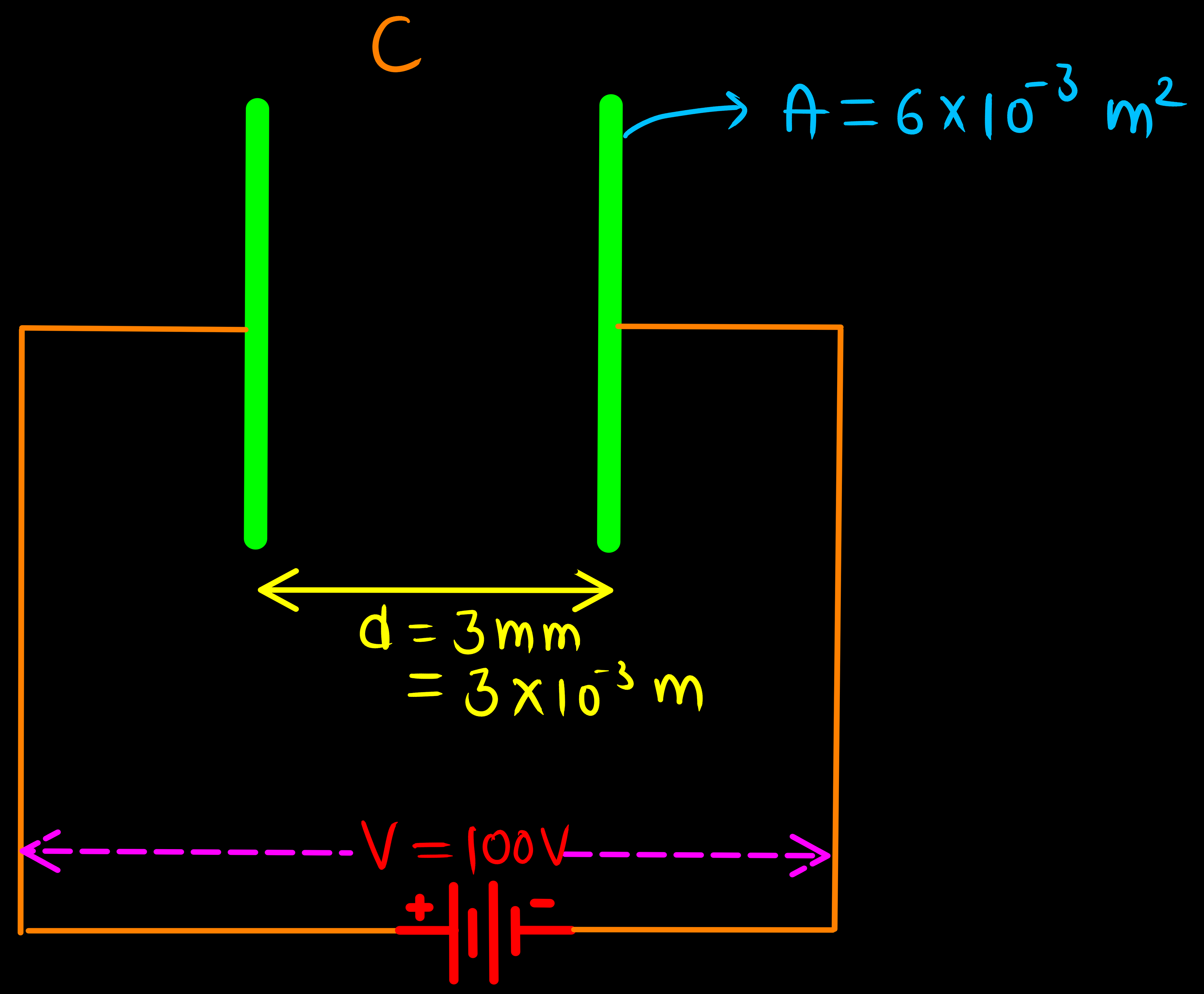

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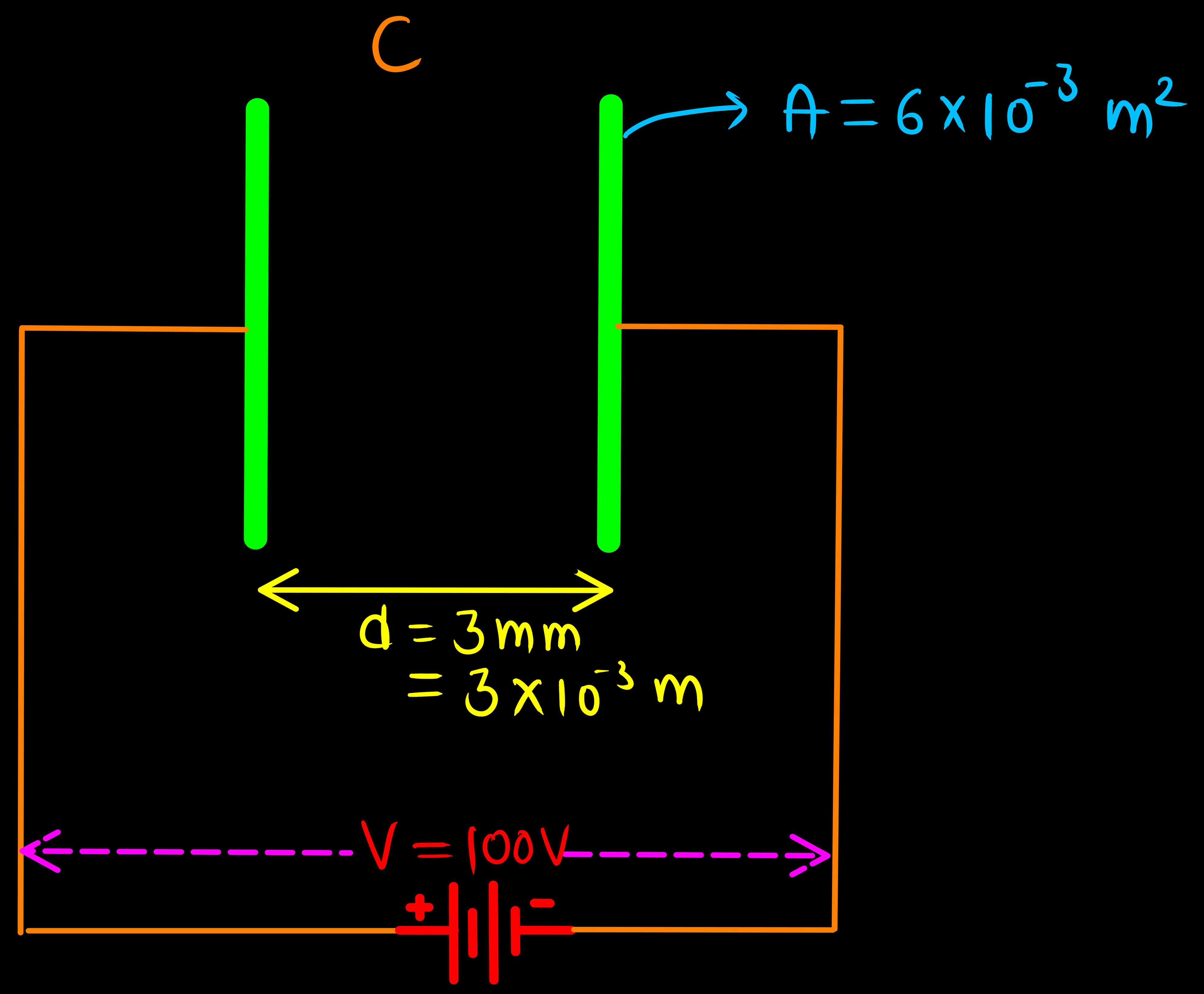

ii) $Q = CV$

$$Q = 17.708 \times 10^{-12} \times 100\ C$$

$$\boxed{Q = 17.708 \times 10^{-10}\ C}$$

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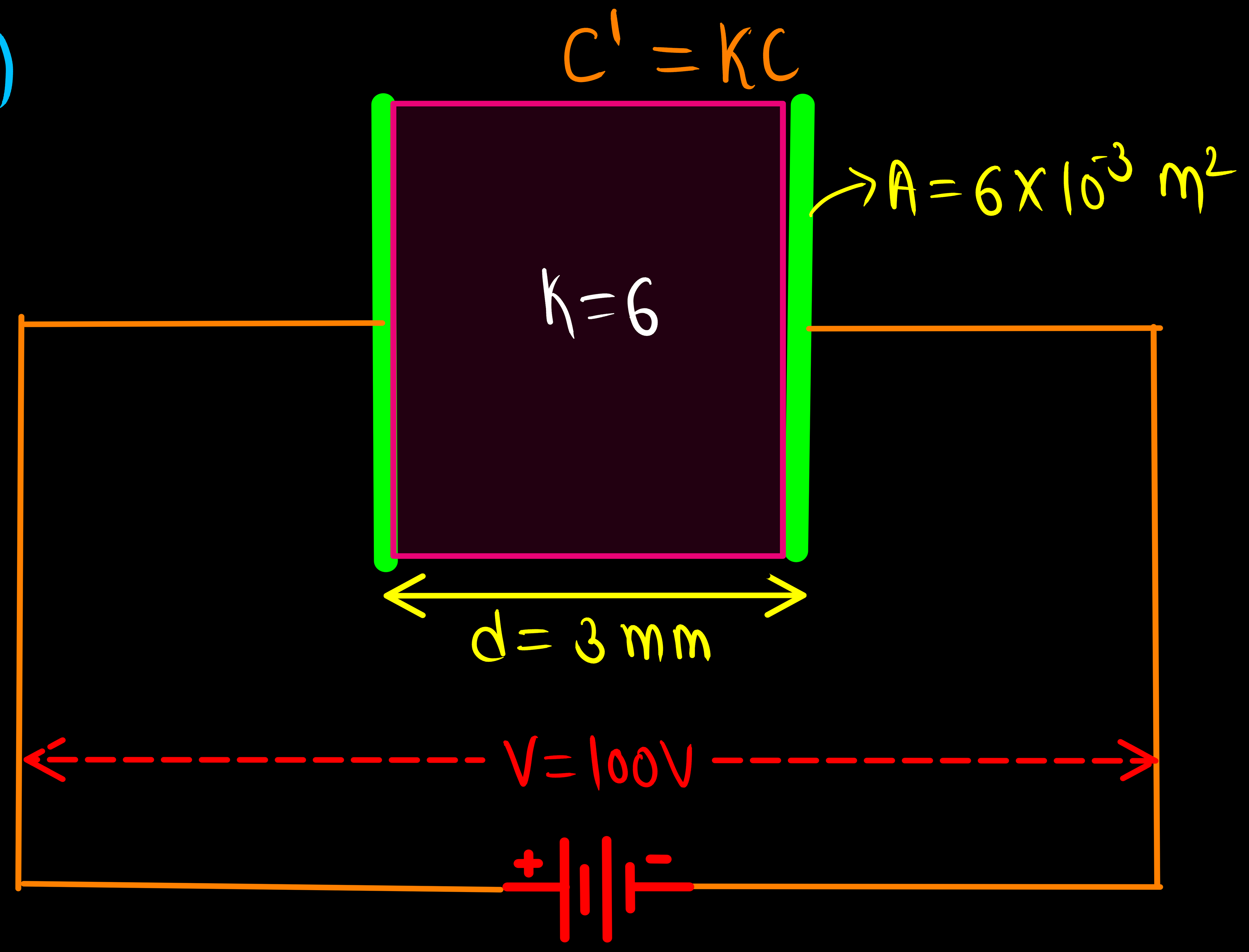

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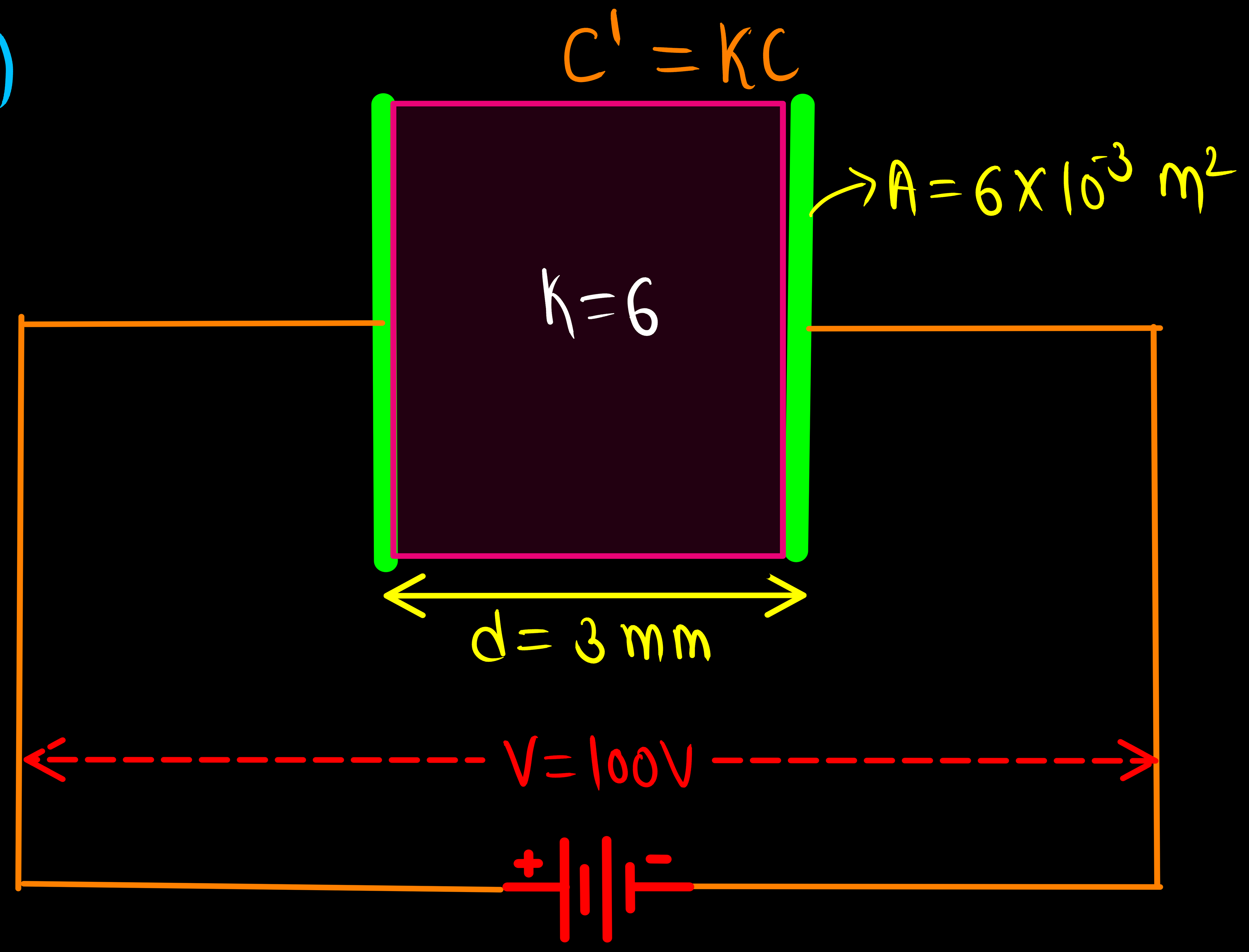

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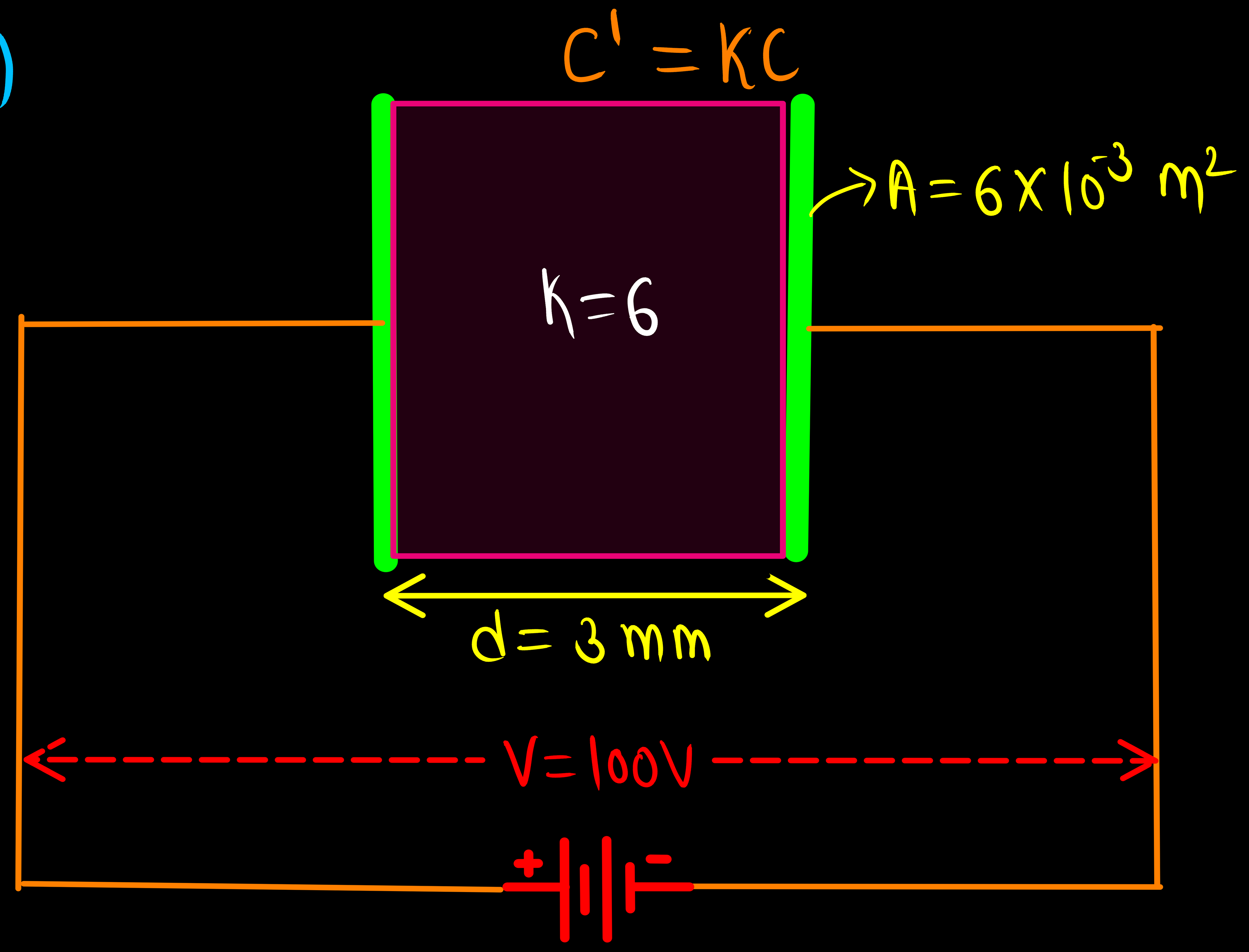

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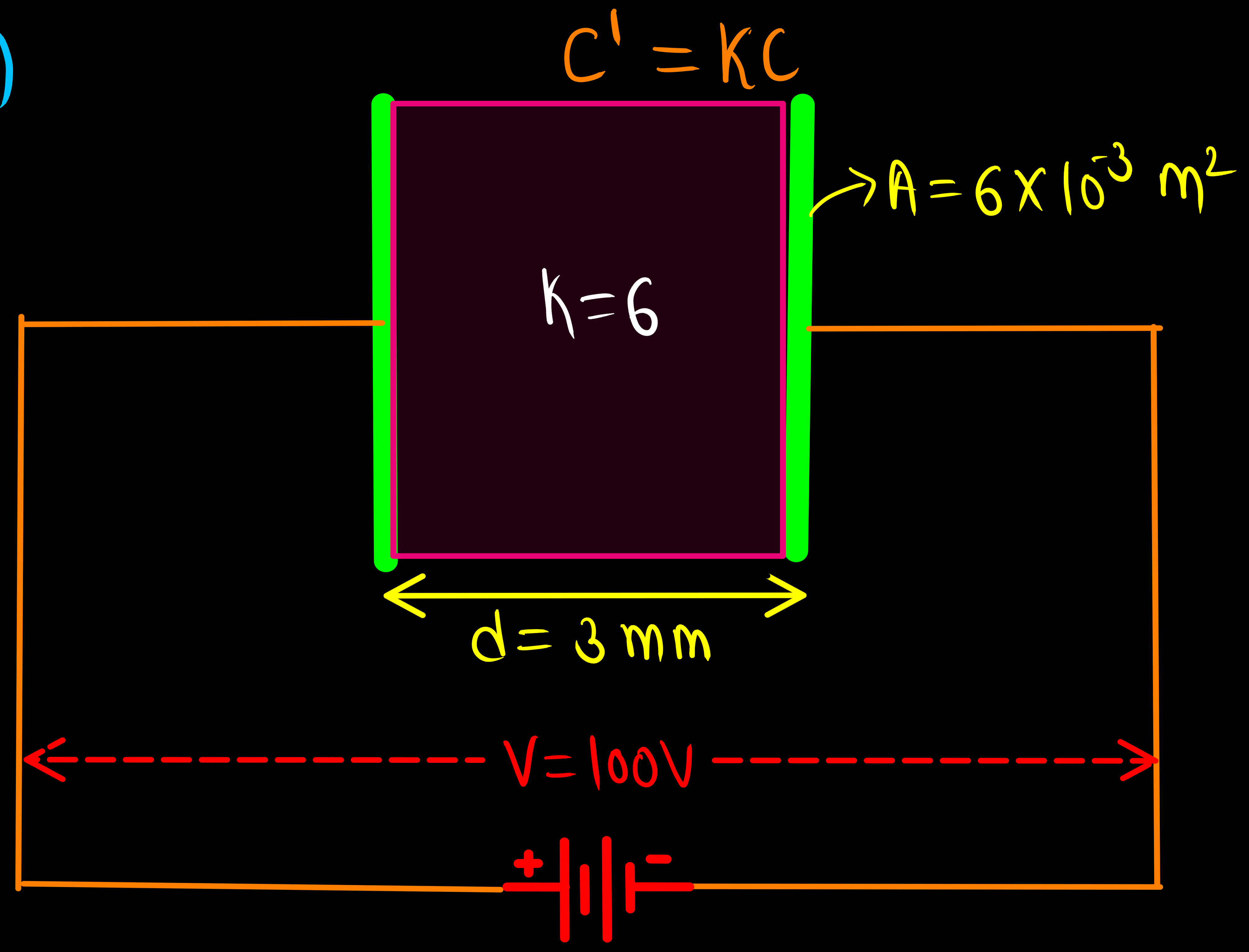

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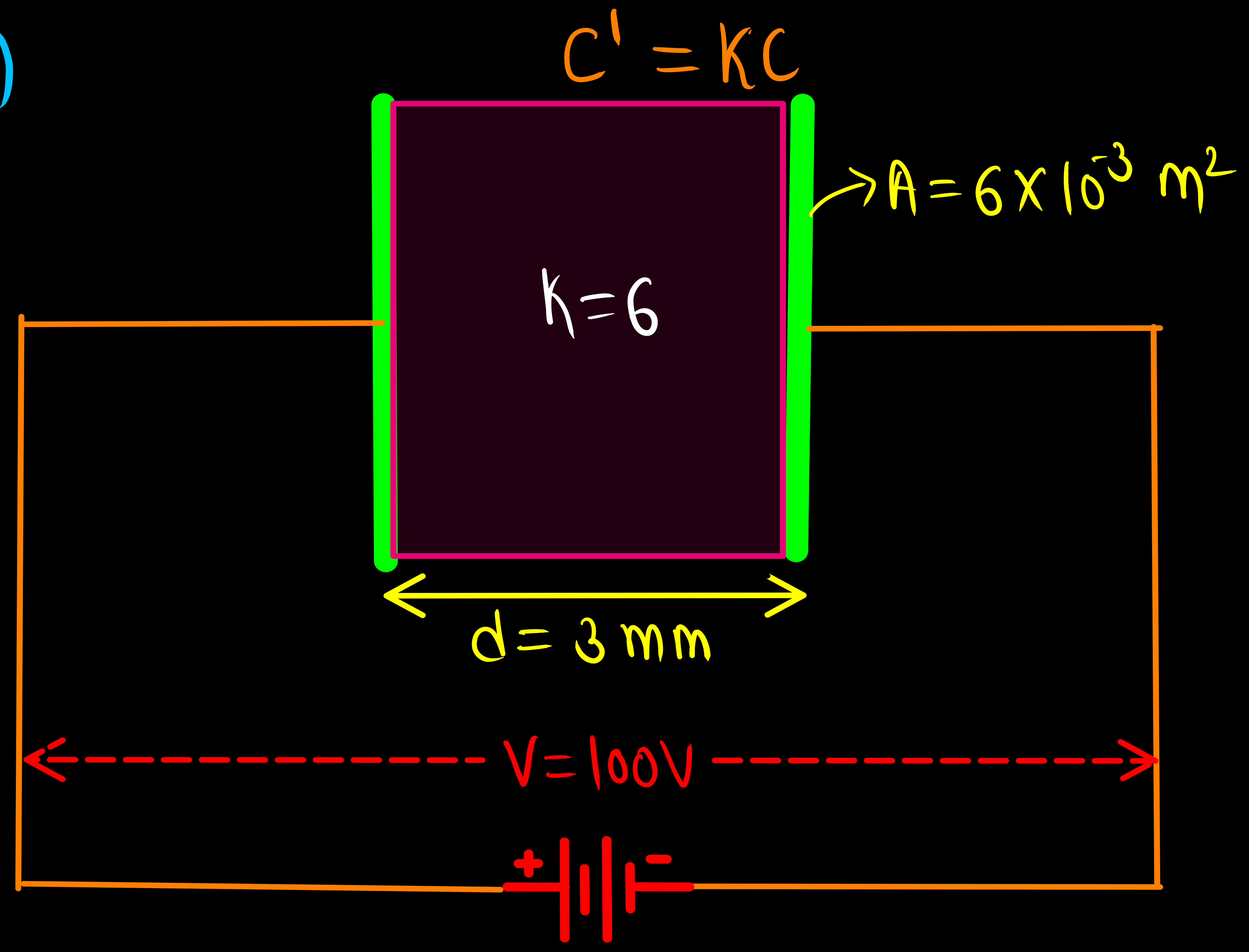

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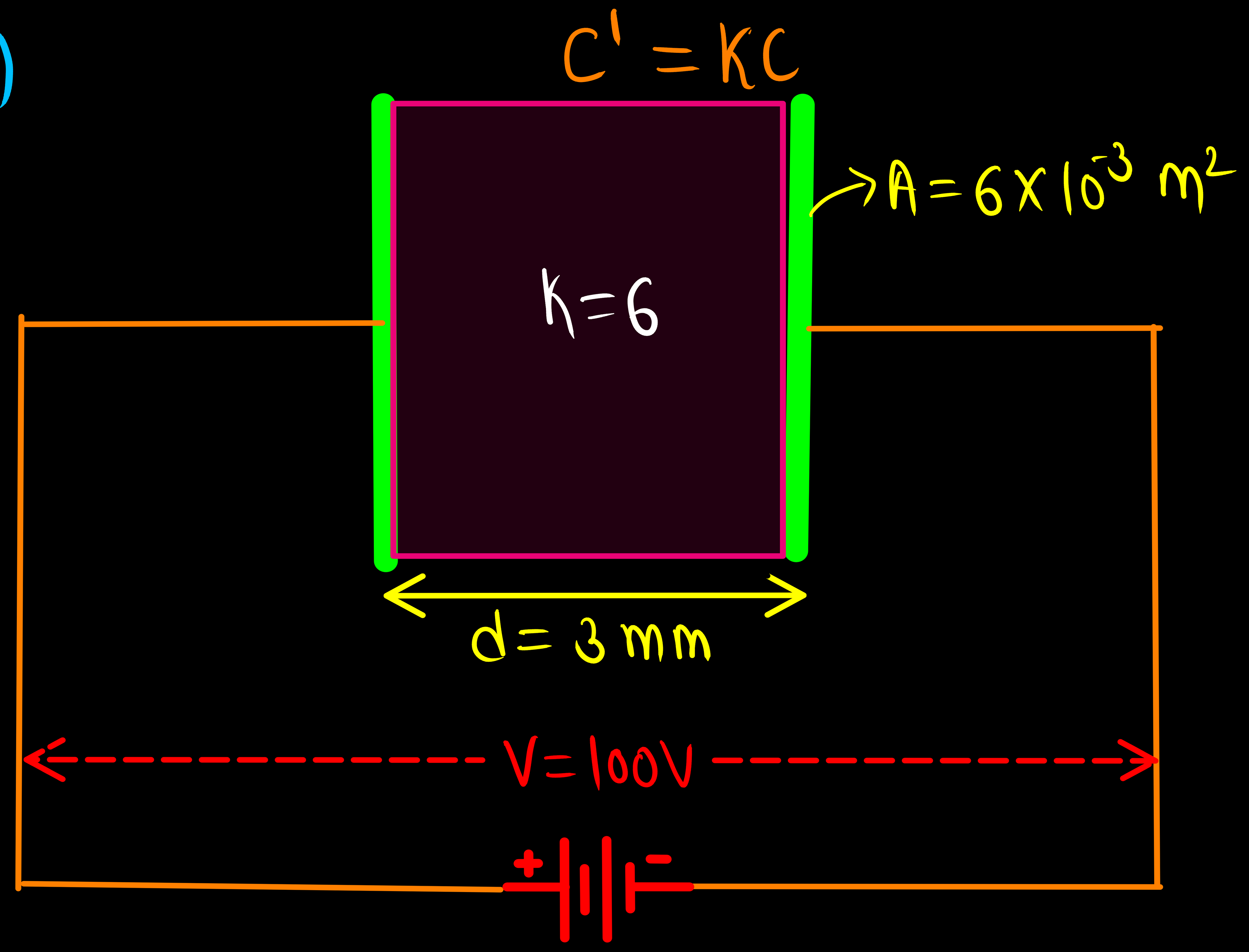

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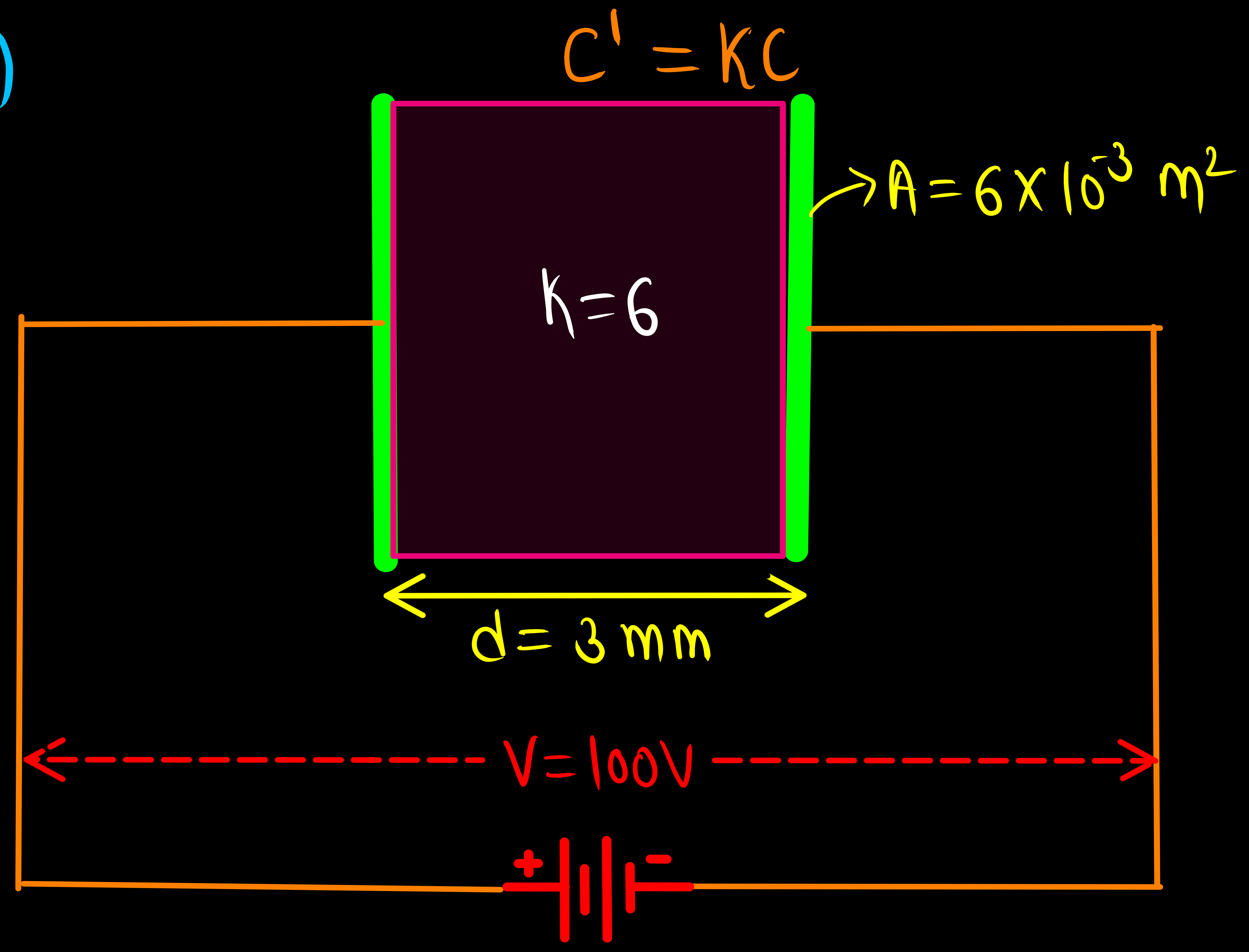

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from previous question $Q = 17.708 \times 10^{-10}$ C

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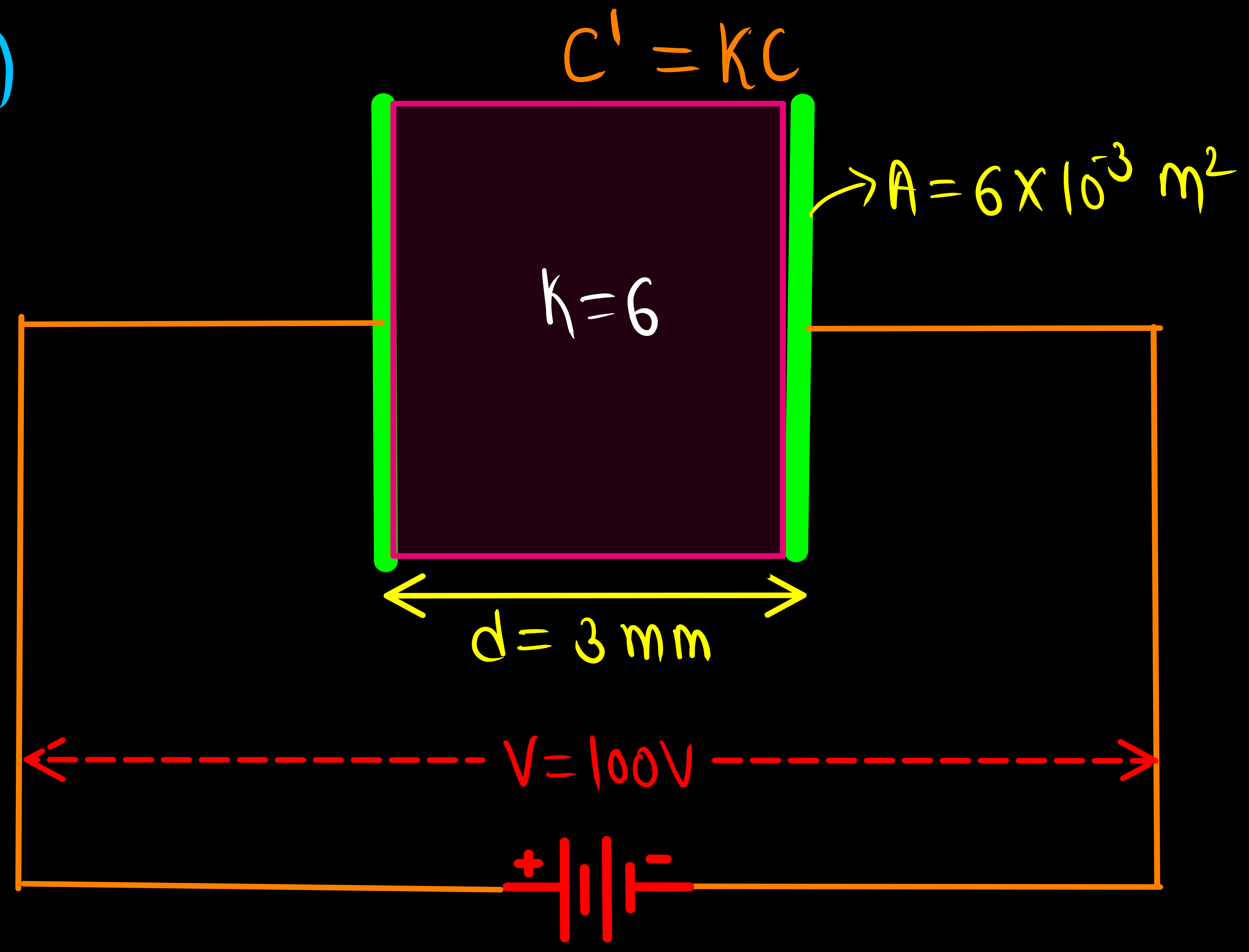

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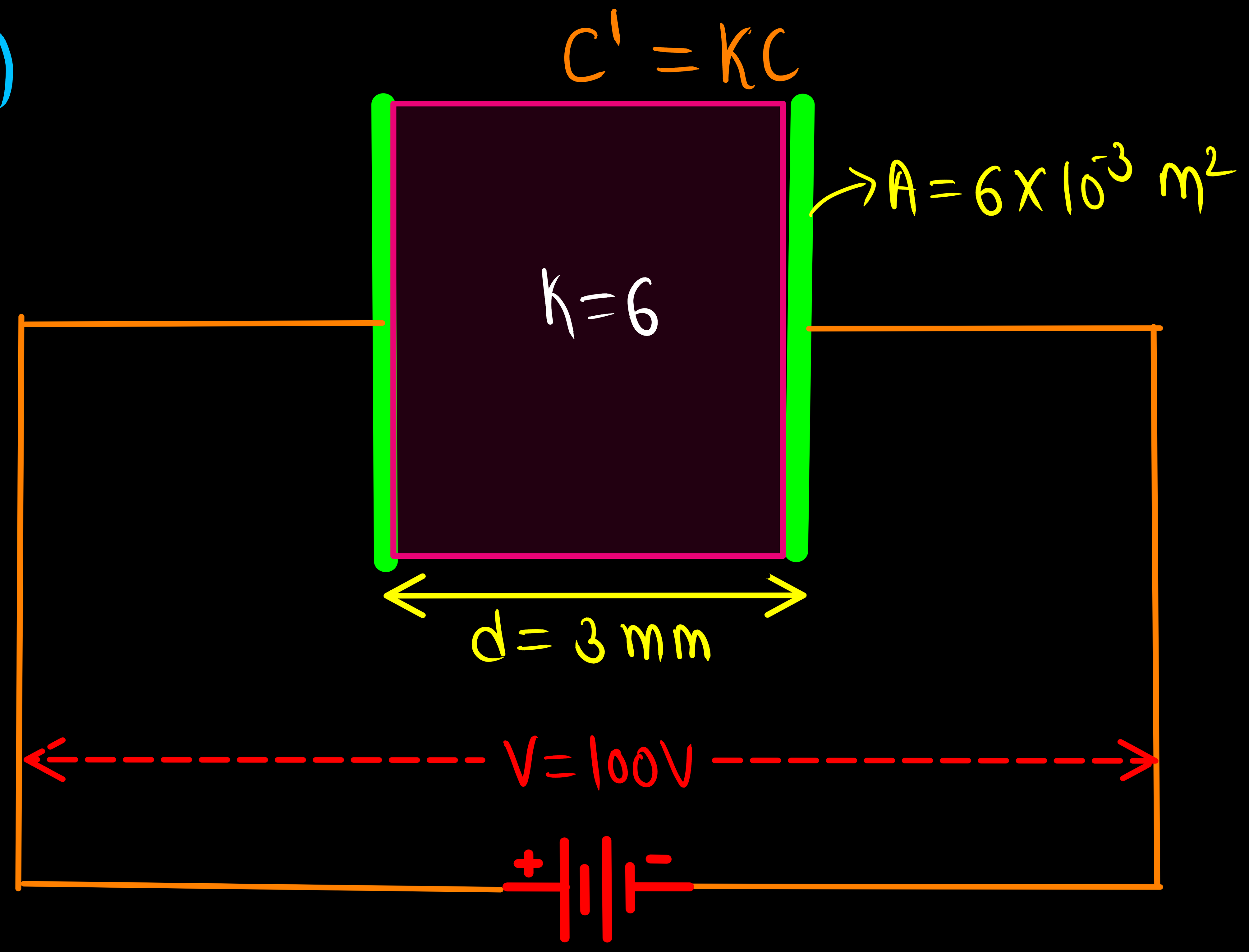

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from previous question $Q = 17.708 \times 10^{-10}\ C$

$Q' = 6 \times 17.708 \times 10^{-10}\ C$

$\boxed{Q' = 106.248 \times 10^{-10}\ C}$

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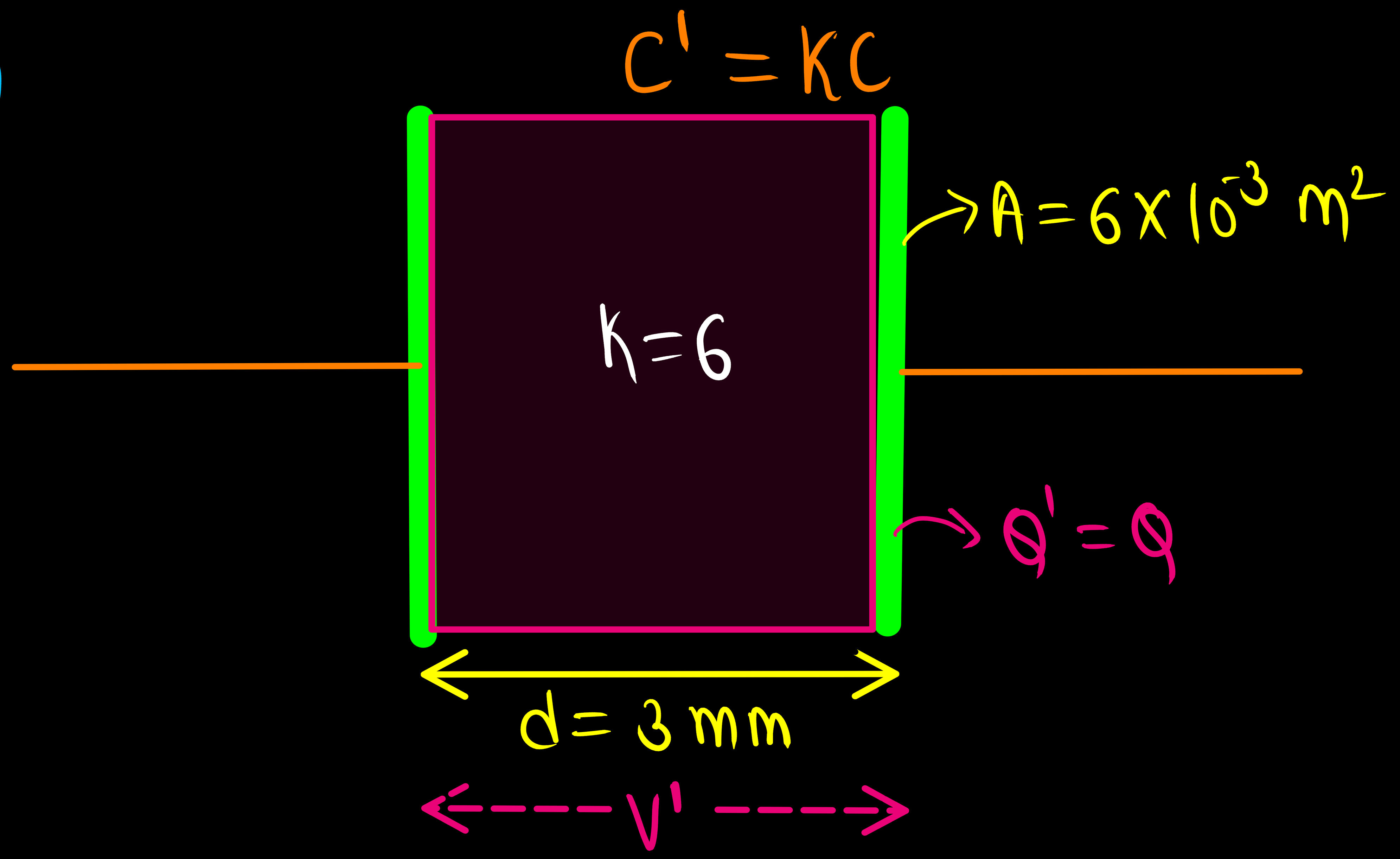

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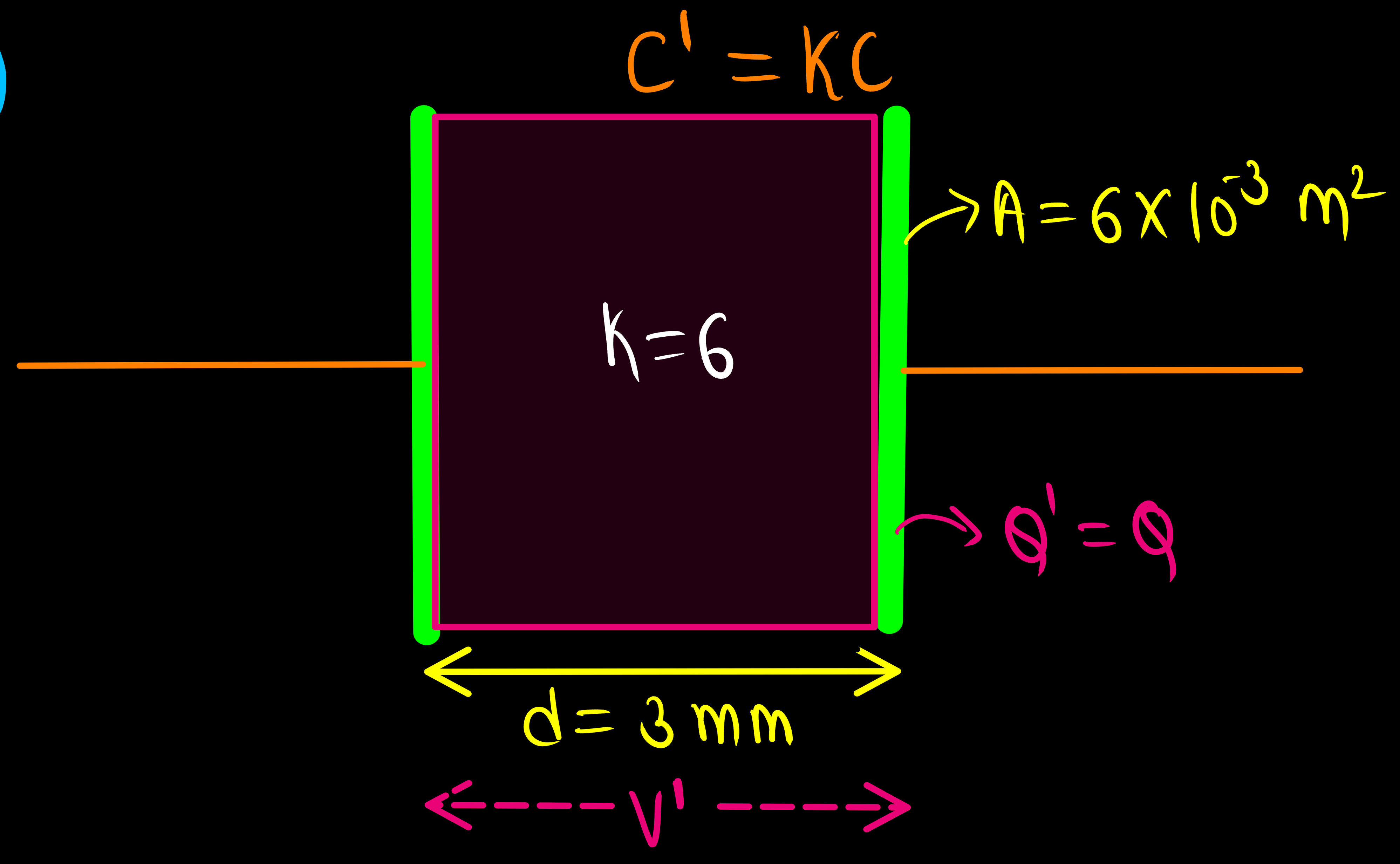

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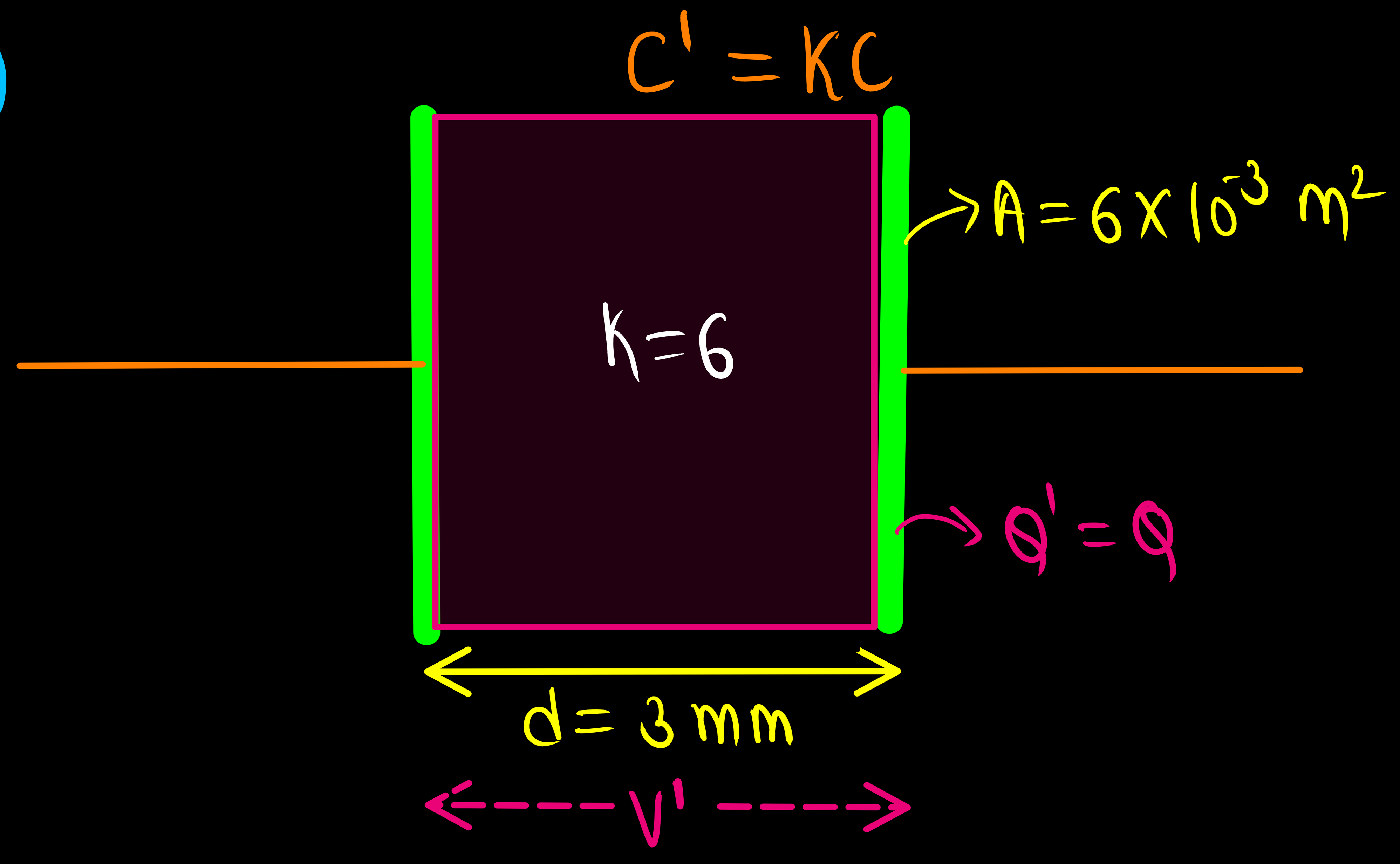

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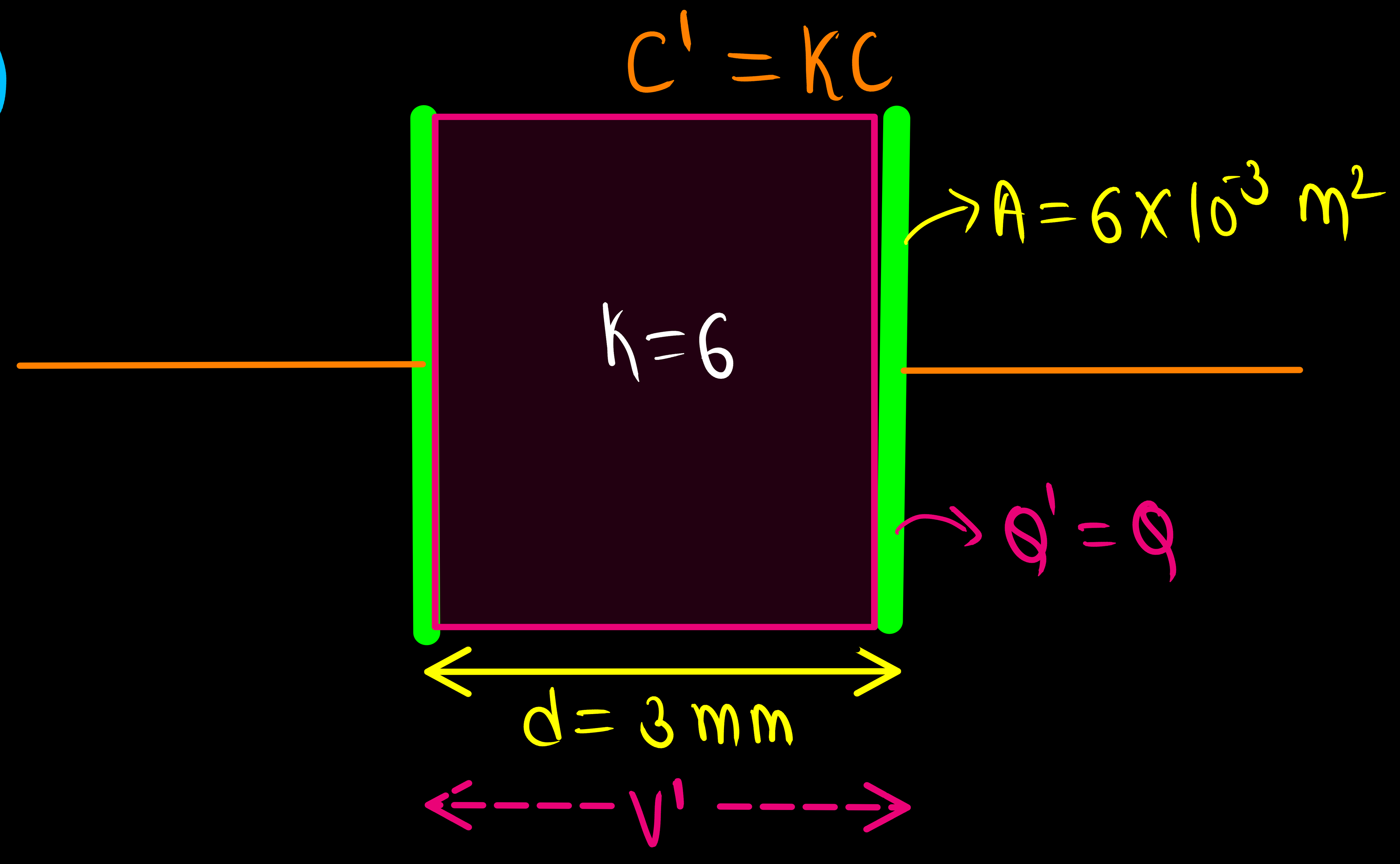

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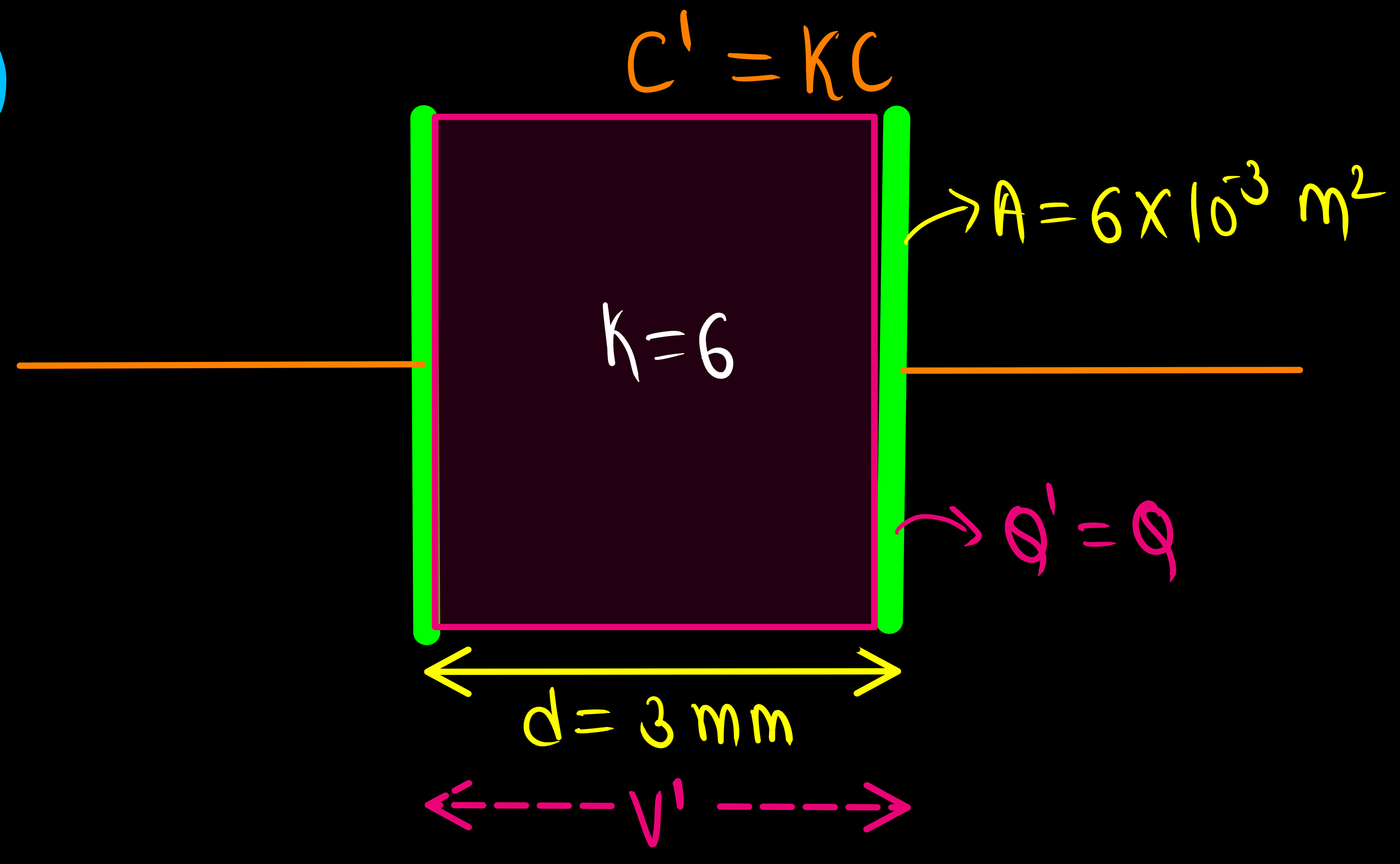

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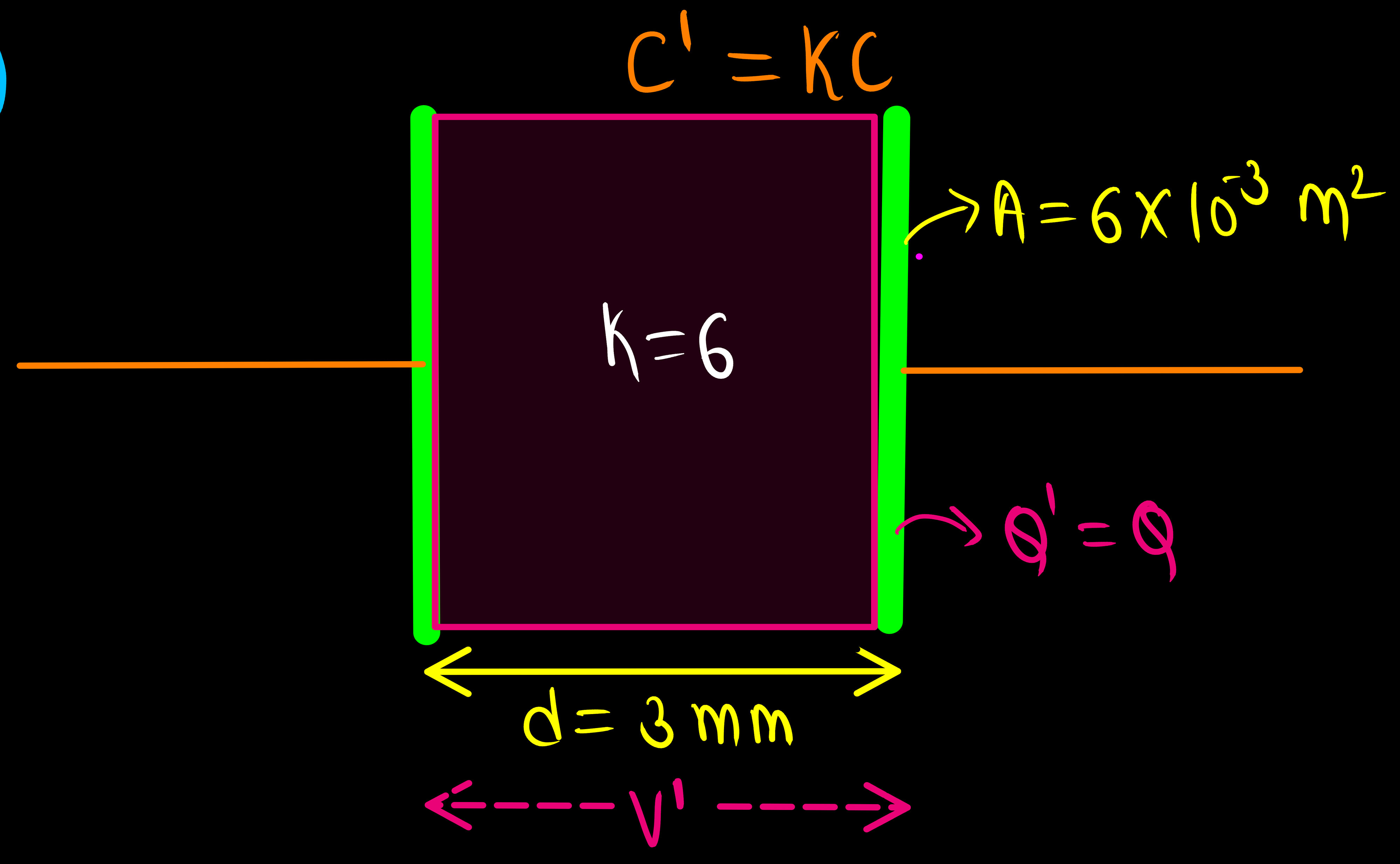

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$$V' = \frac{Q'}{C'}$$

$$V' = \frac{Q}{KC}$$

$$V' = \frac{V}{K} \qquad \left(\because \frac{Q}{C} = V\right)$$

→ Voltage decreases $\frac{1}{K}$ times.

Example 2.8 A slab of material of dielectric constant K has the same area as the plates of a parallel-plate capacitor but has a thickness $(3/4)d$, where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates?

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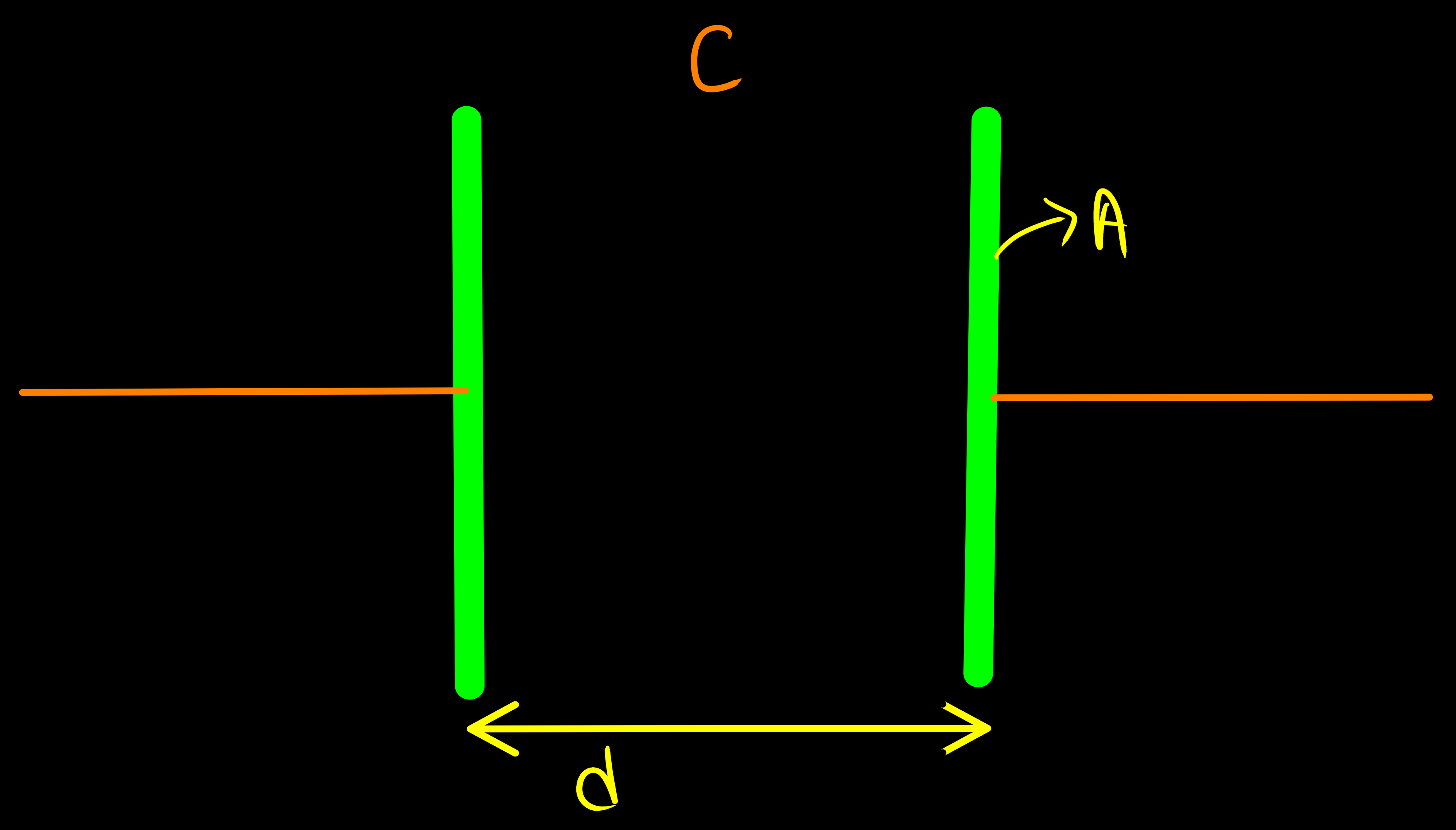

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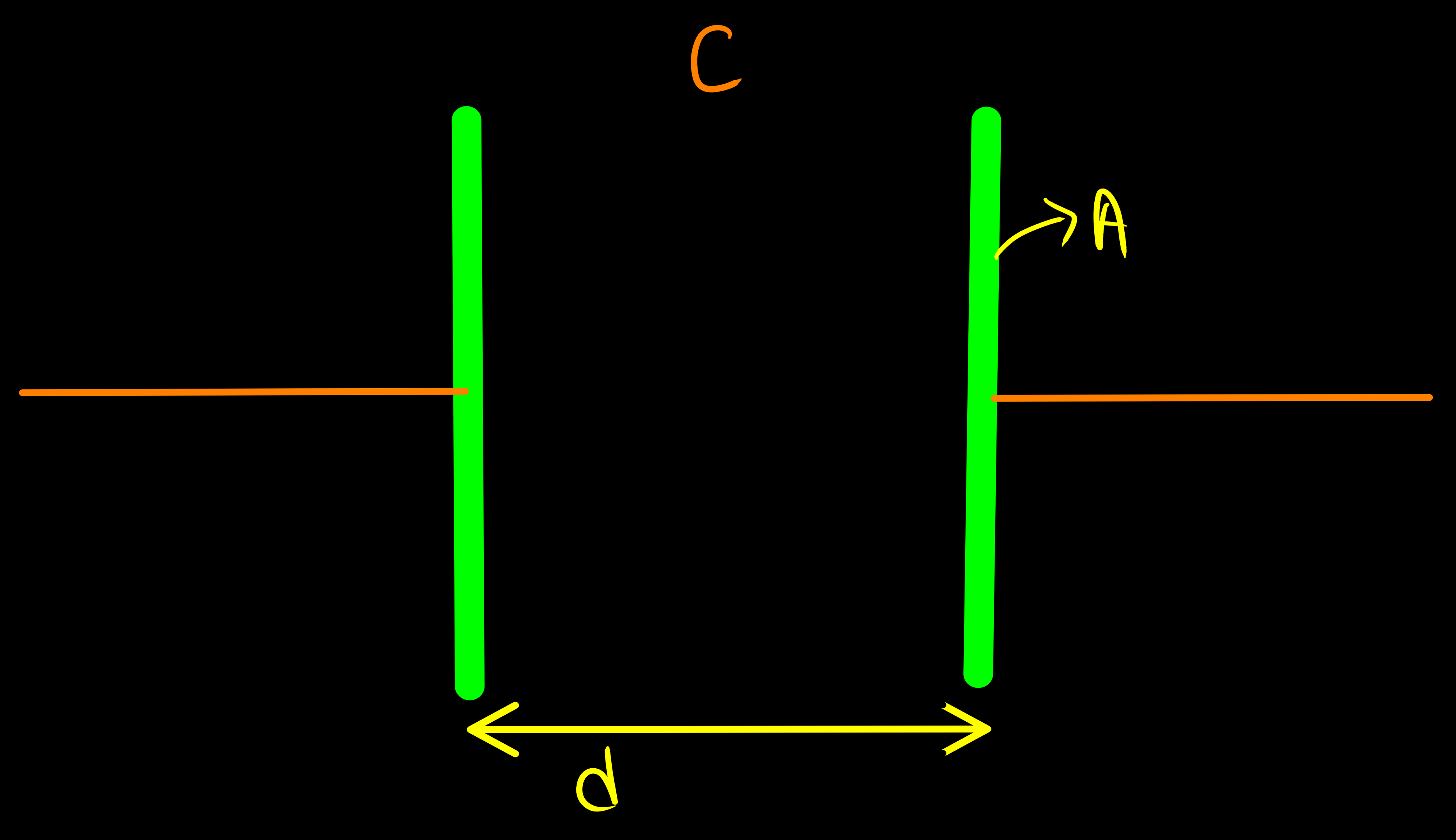

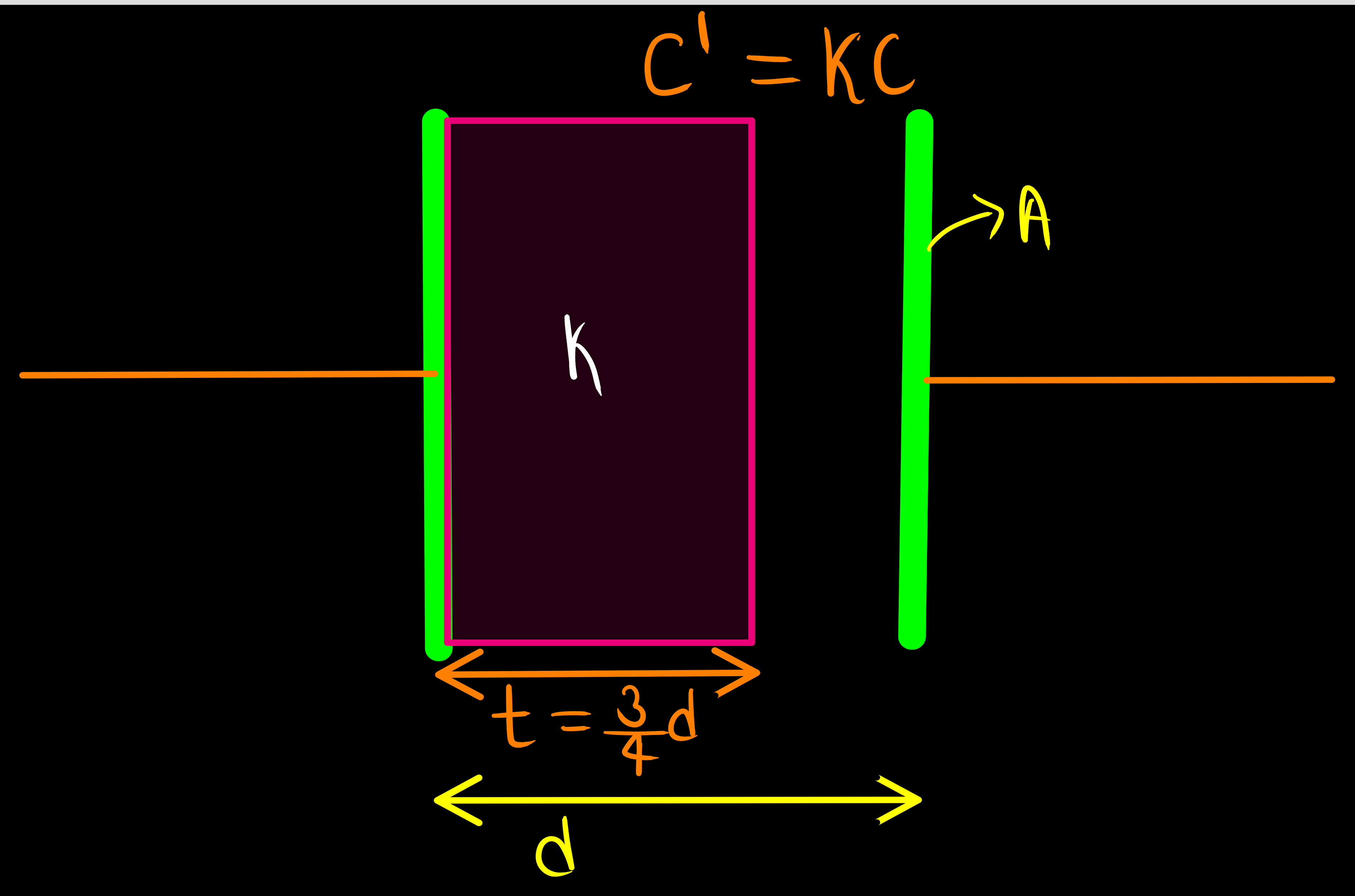

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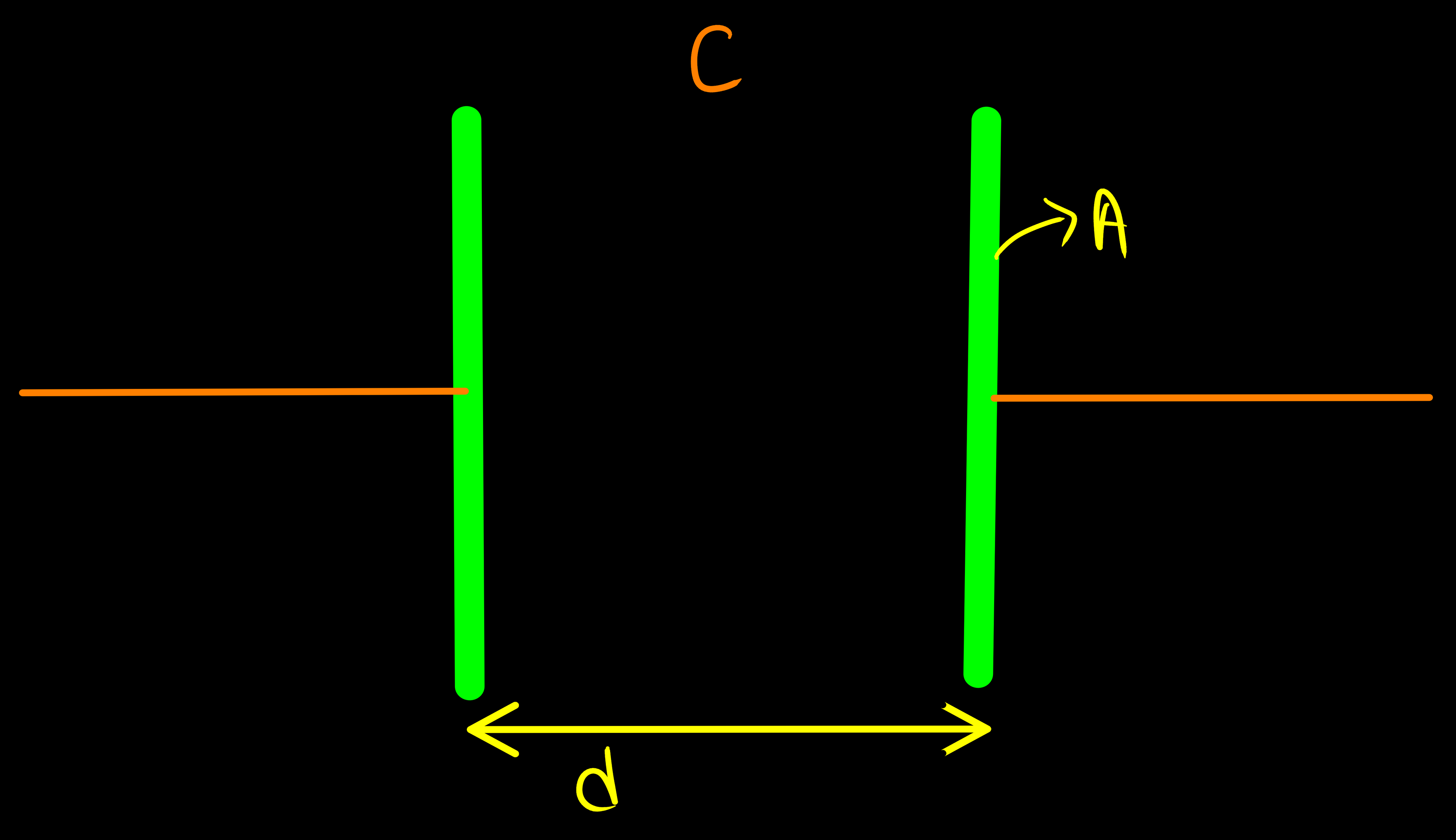

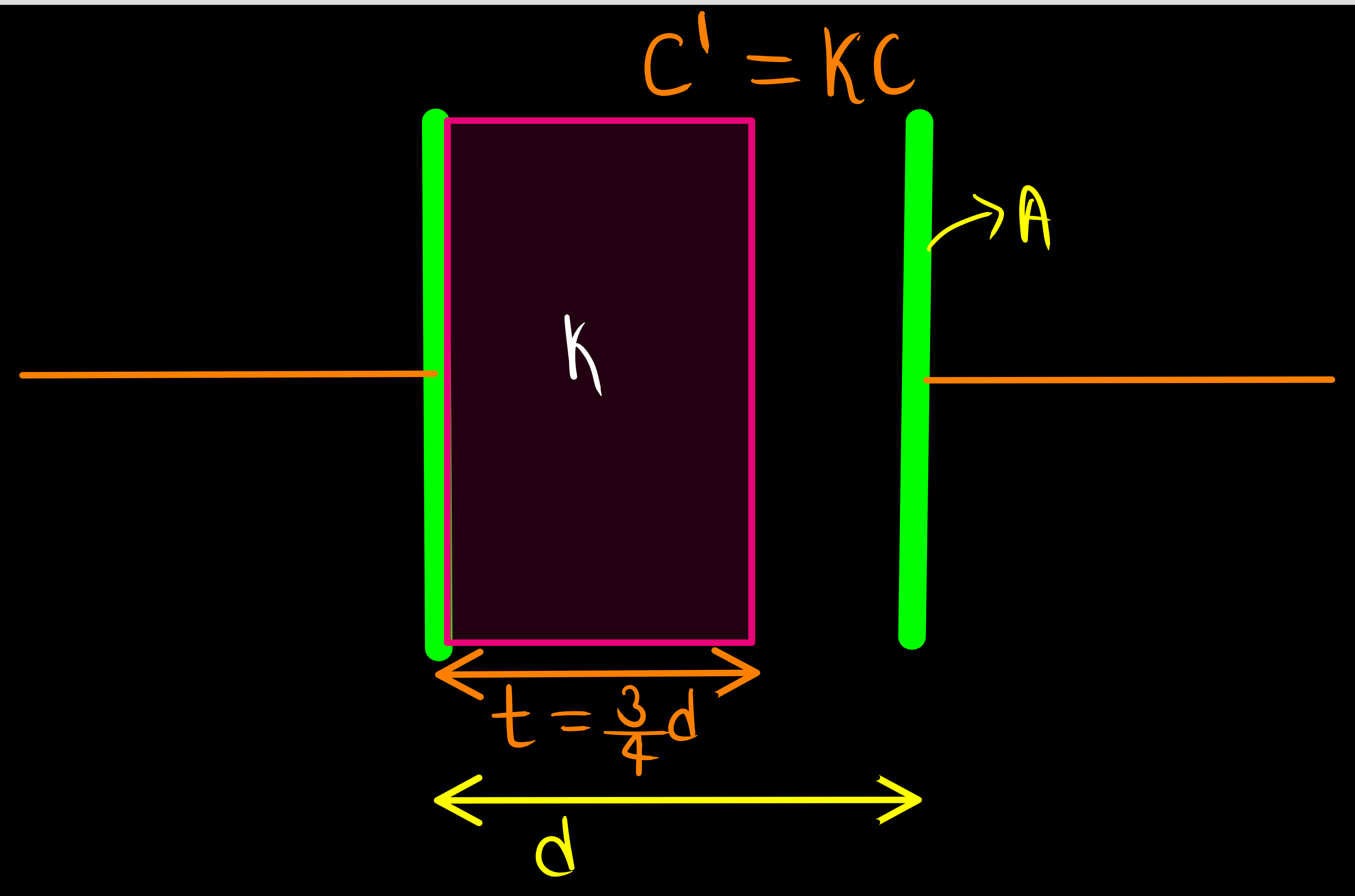

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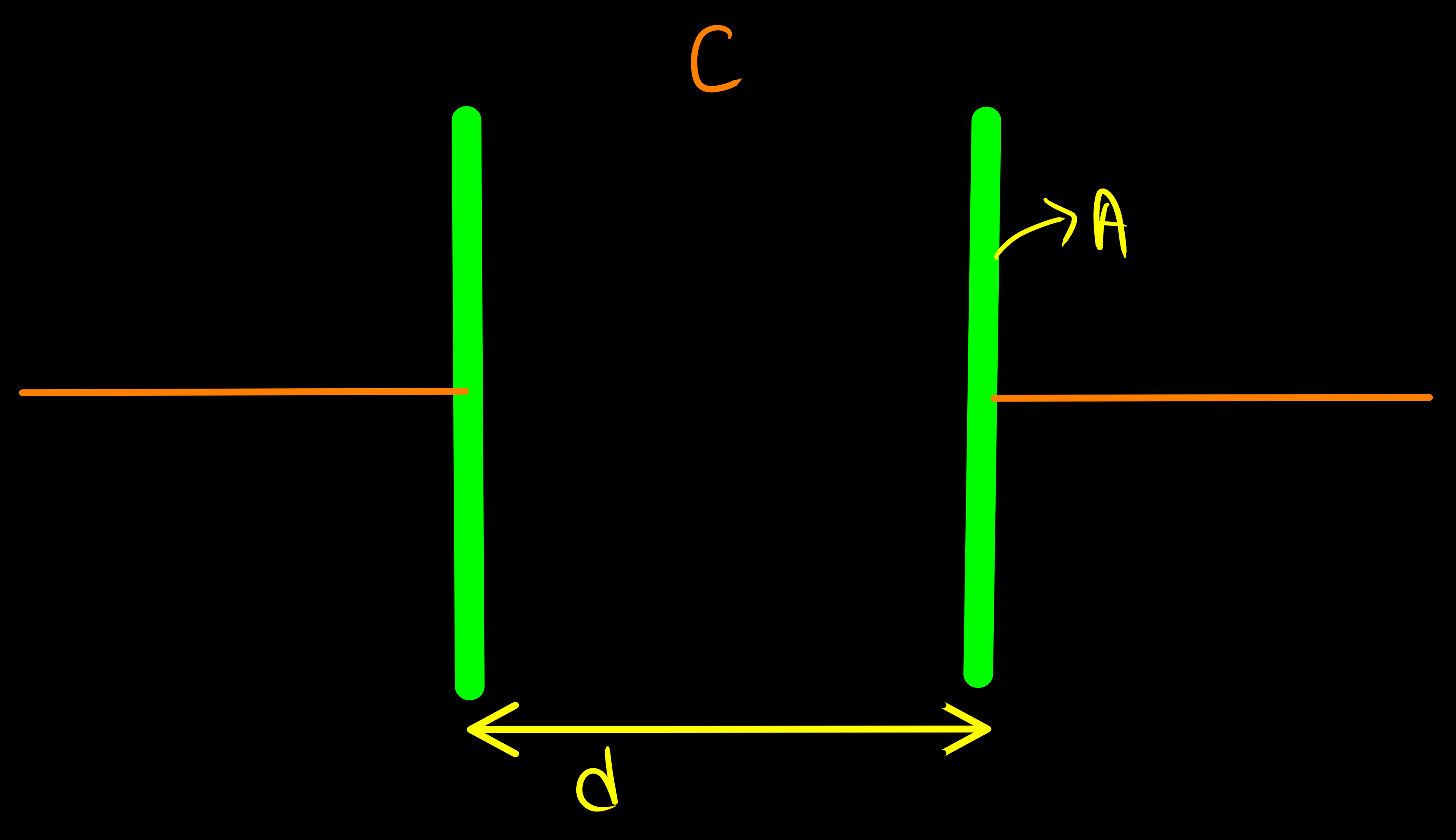

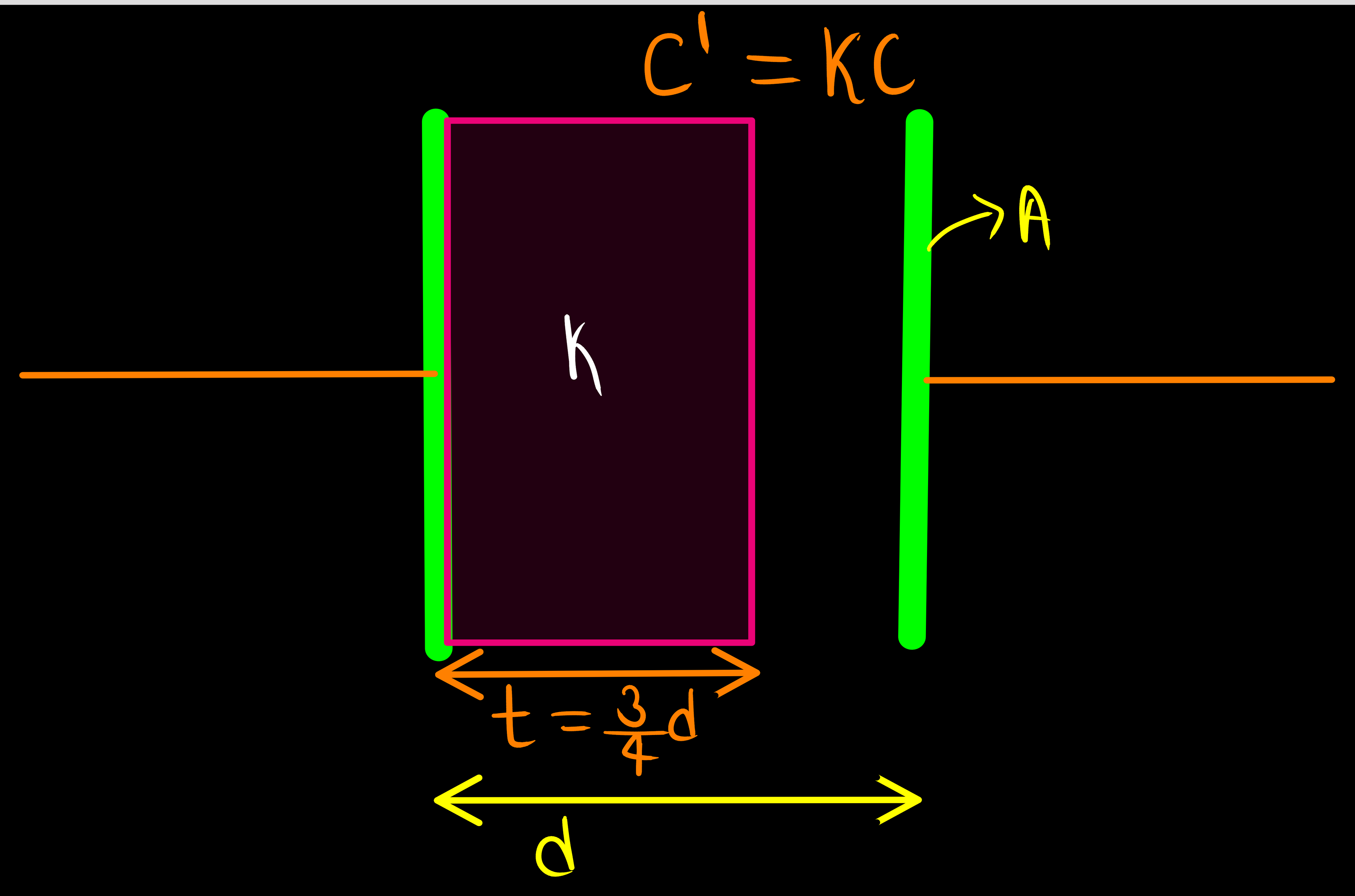

$$C = \frac{\varepsilon_0 A}{d}$$

$$C' = \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$$

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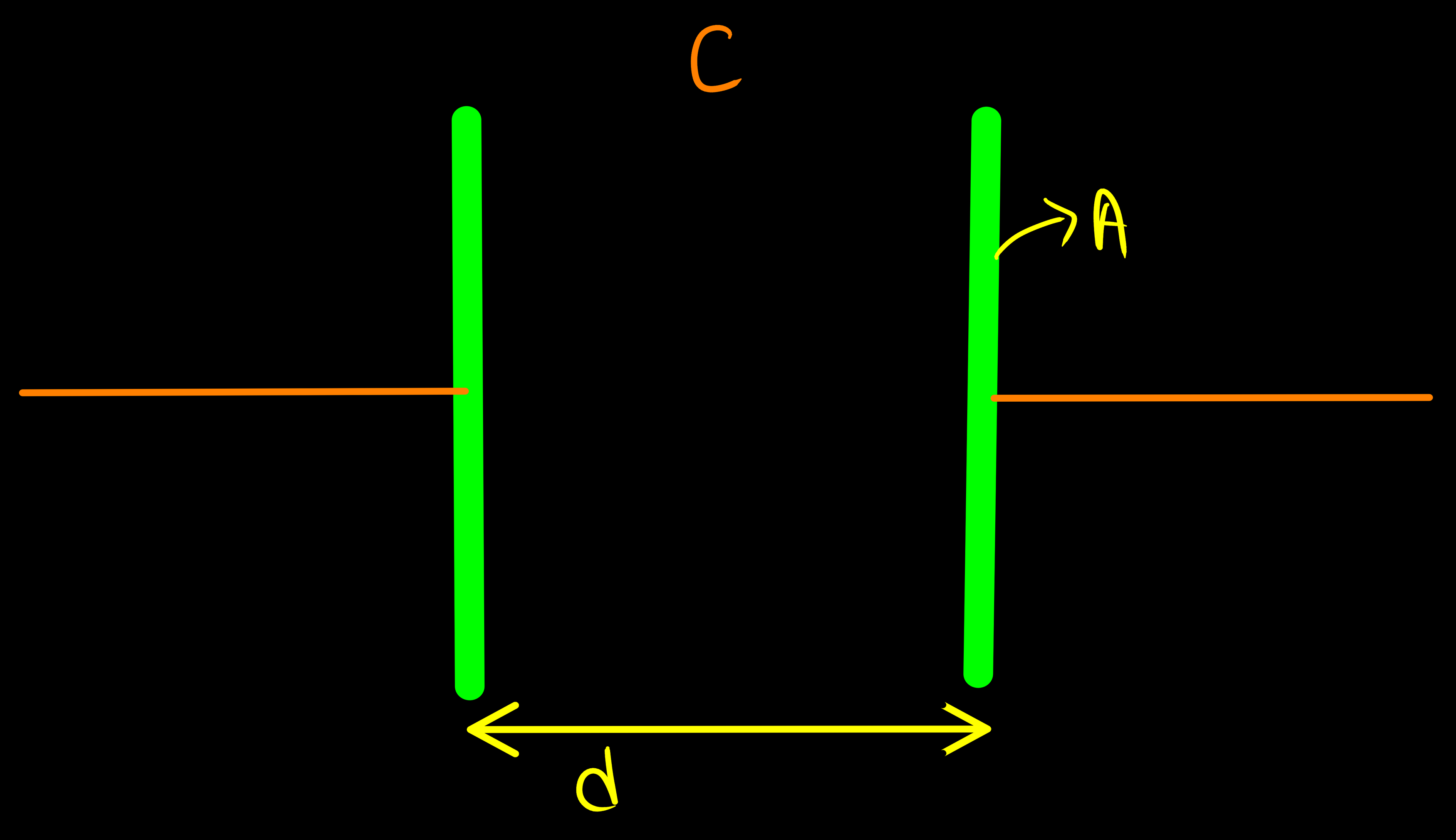

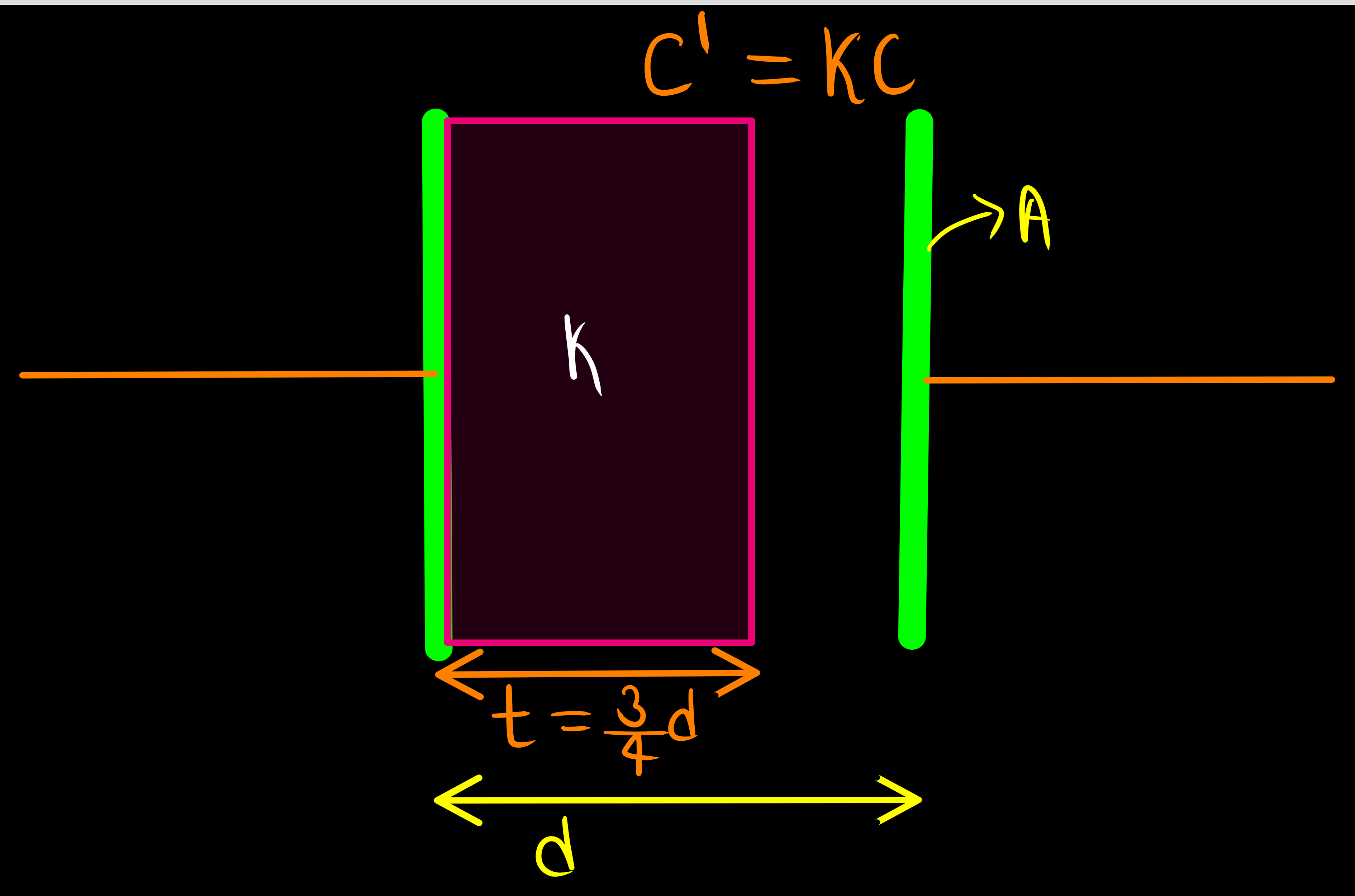

$$C = \frac{\varepsilon_0 A}{d}$$

$$C' = \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$$

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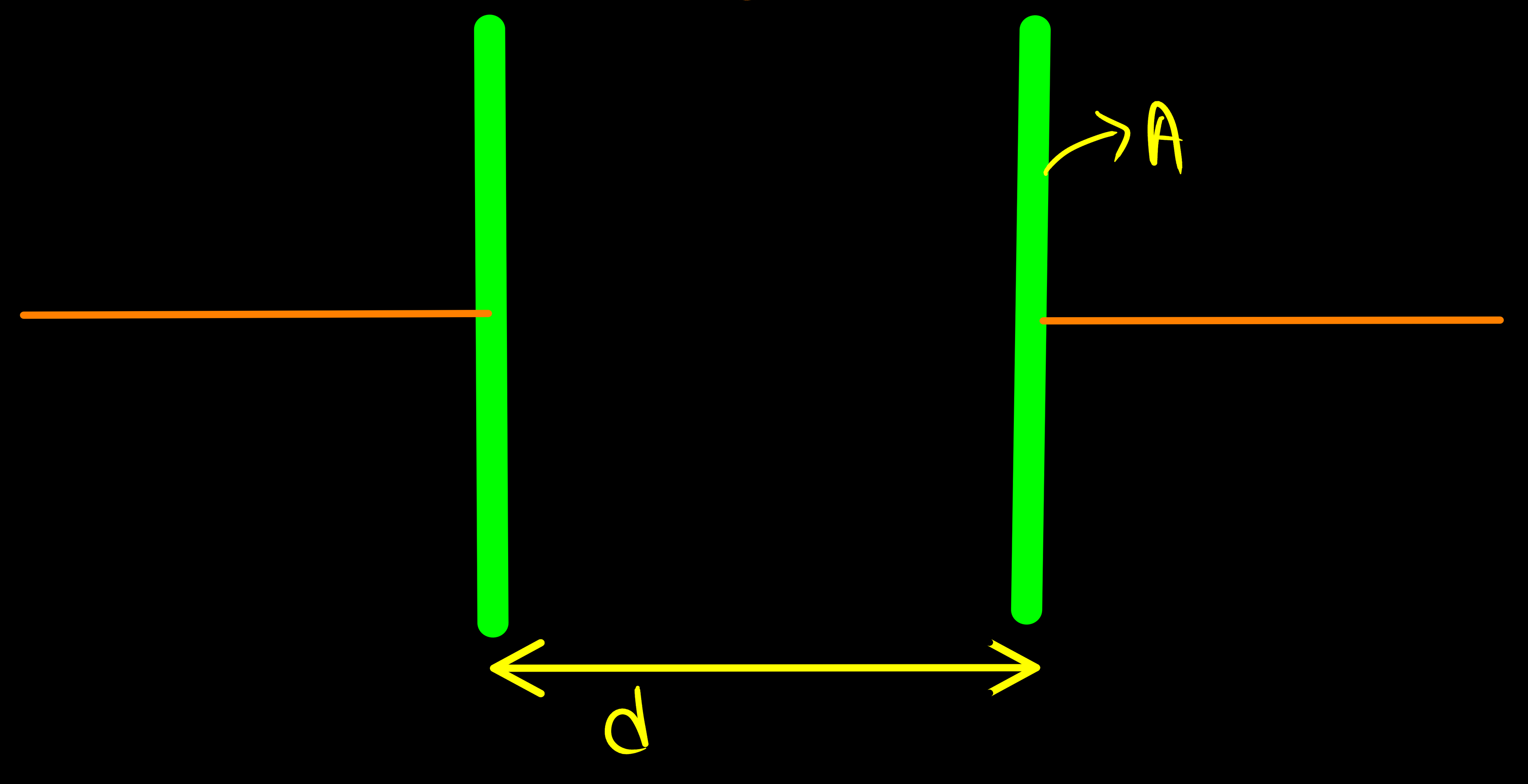
Example 2.8 A slab of material of dielectric constant K has the same area as the plates of a parallel-plate capacitor but has a thickness $(3/4)d$, where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates?



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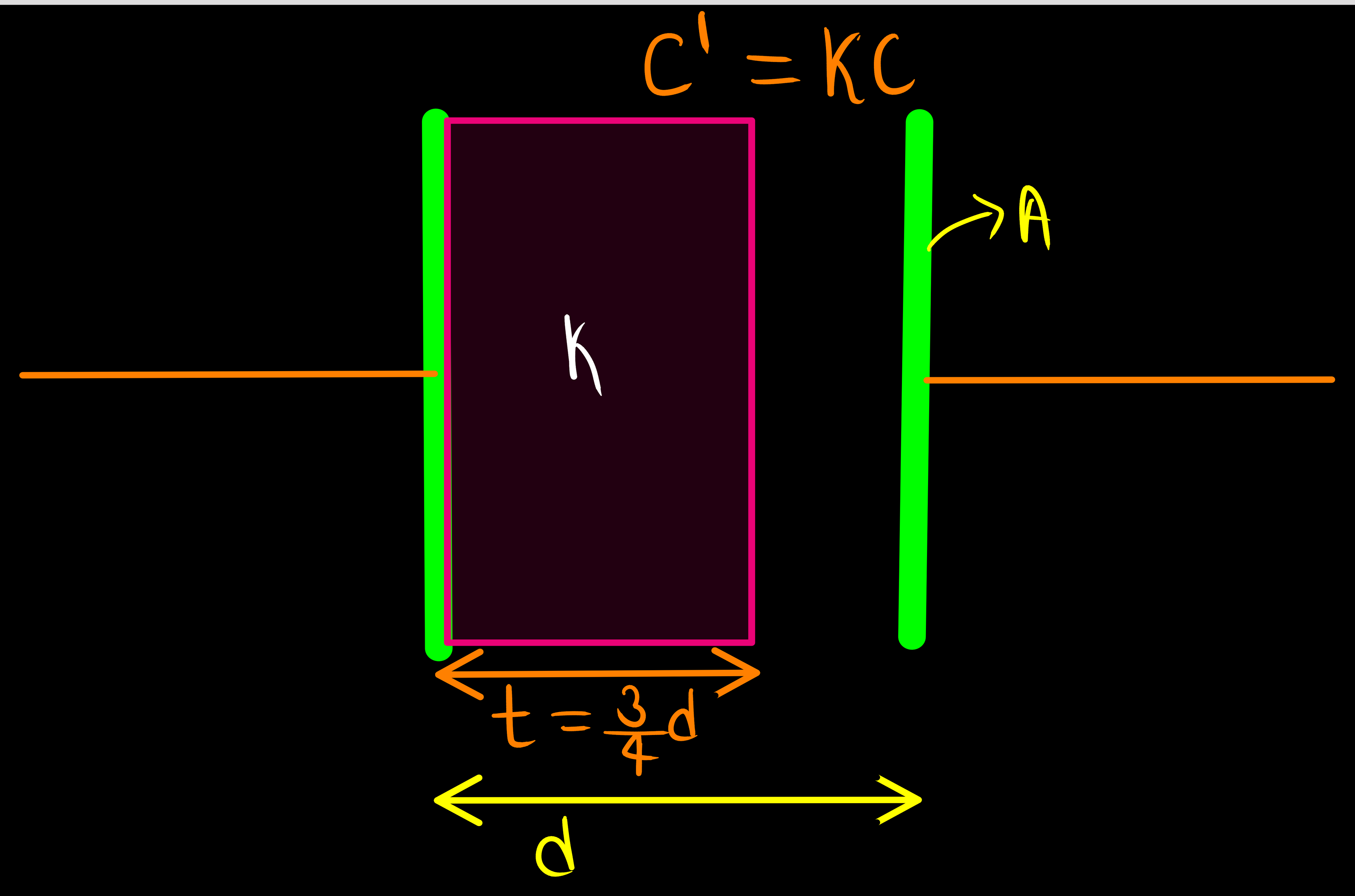

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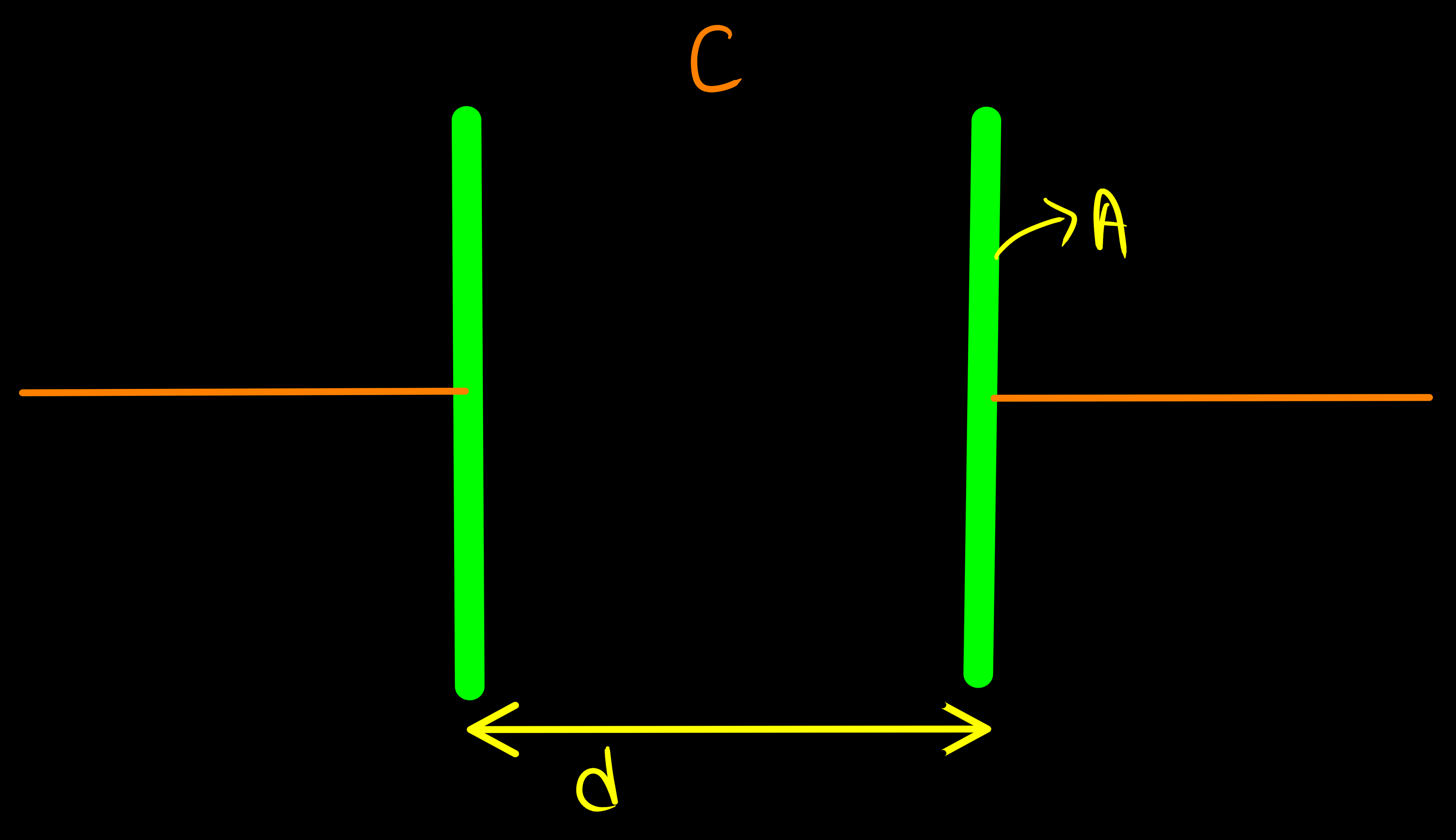

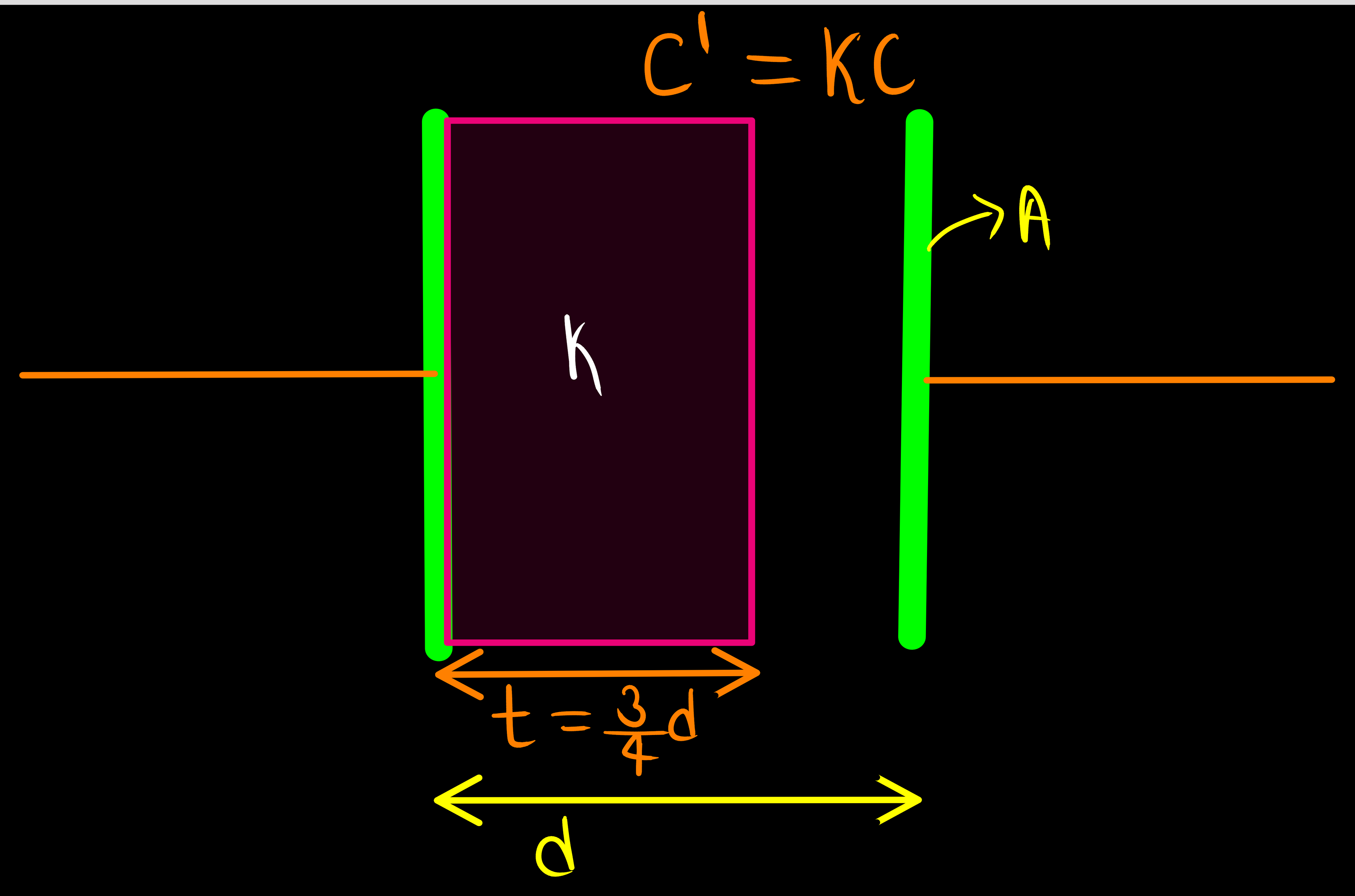

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(a) What is the total capacitance of the combination?

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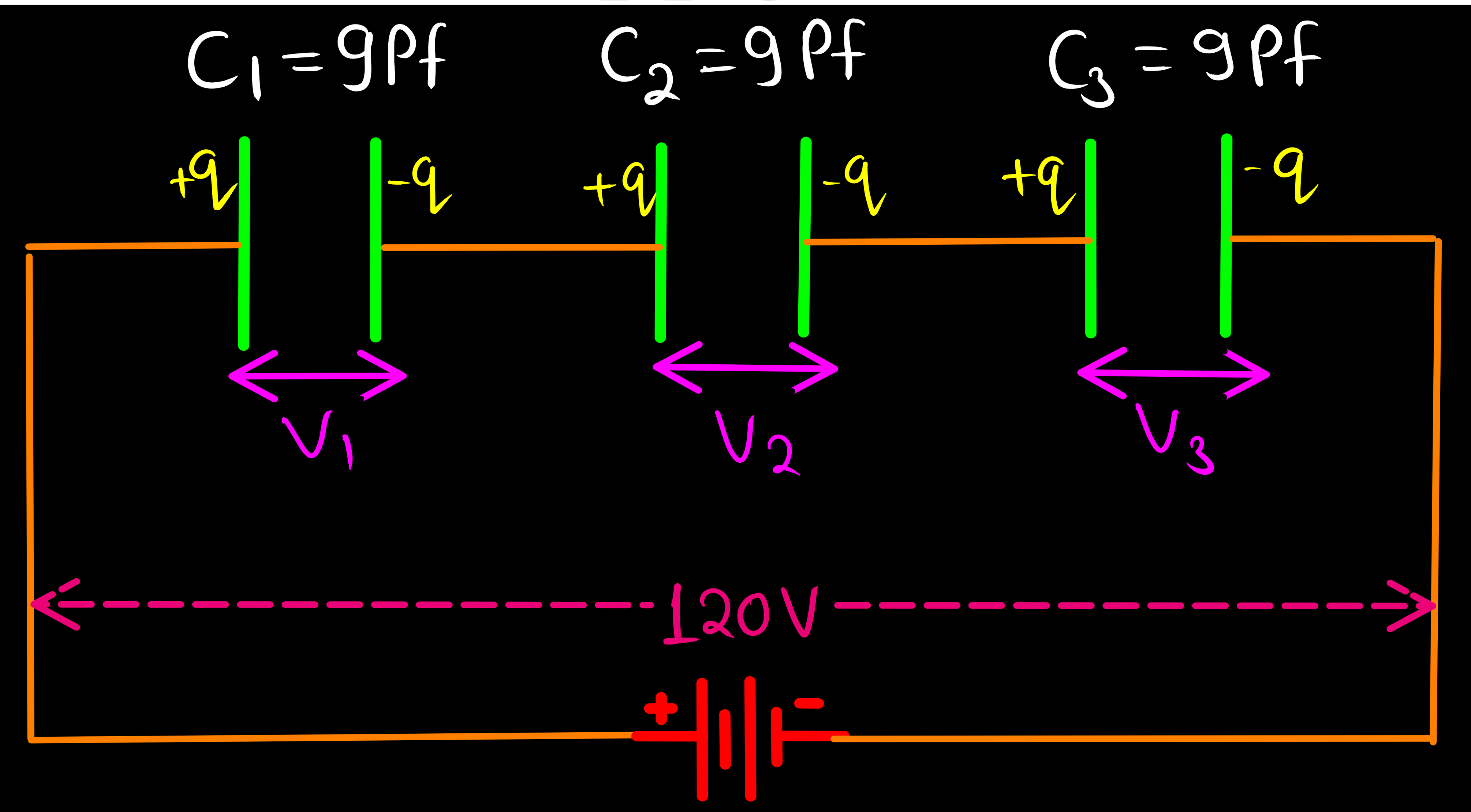

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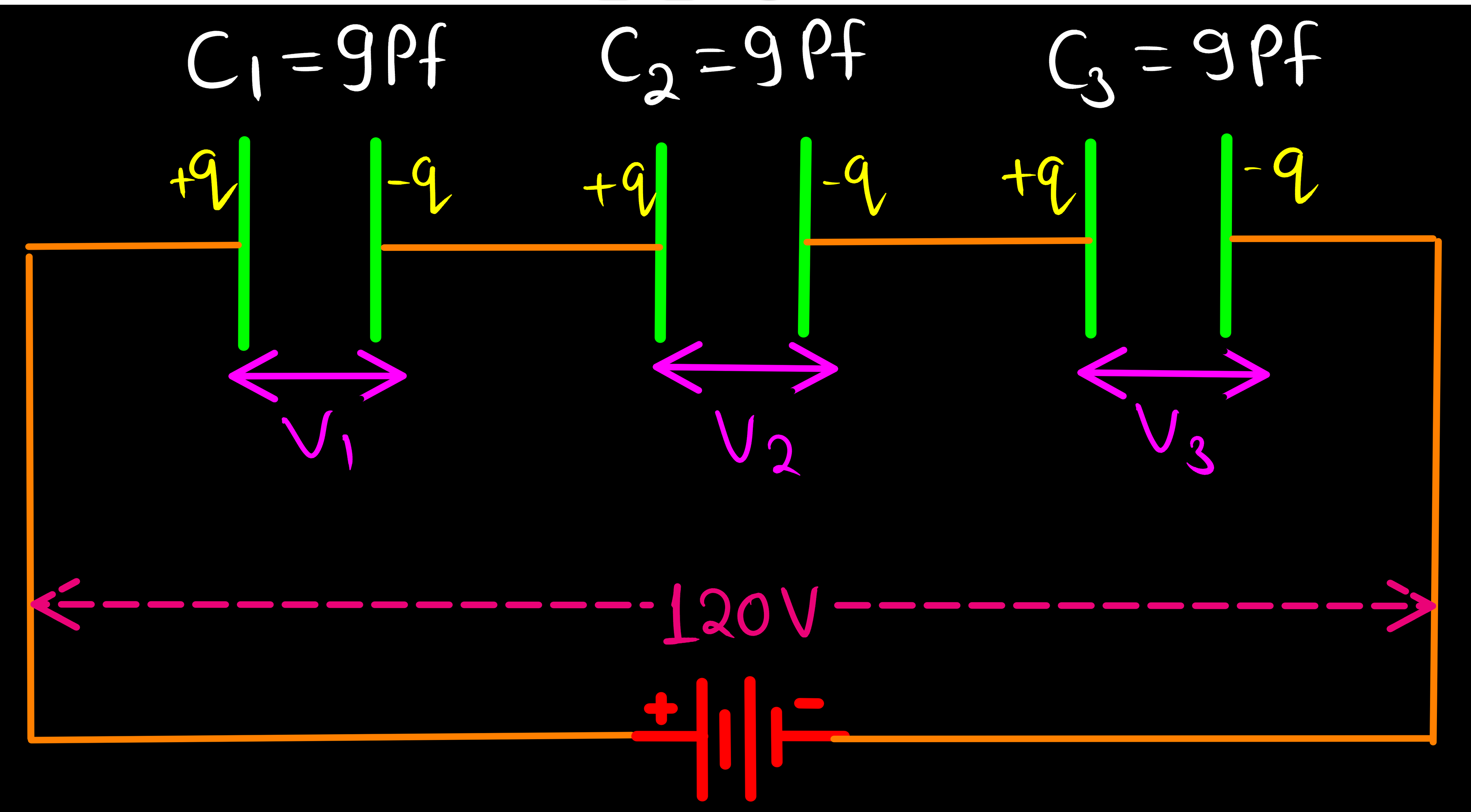

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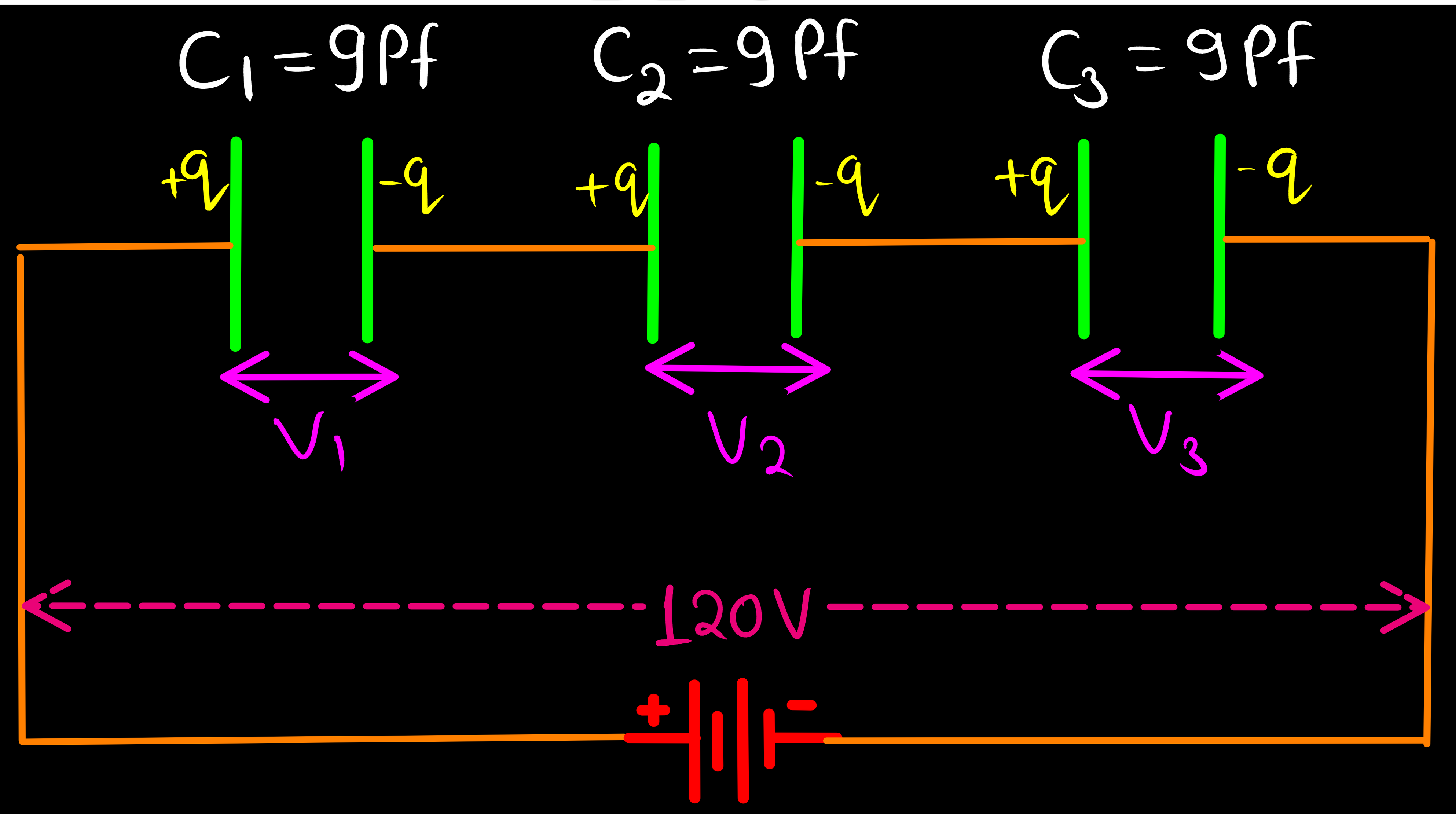

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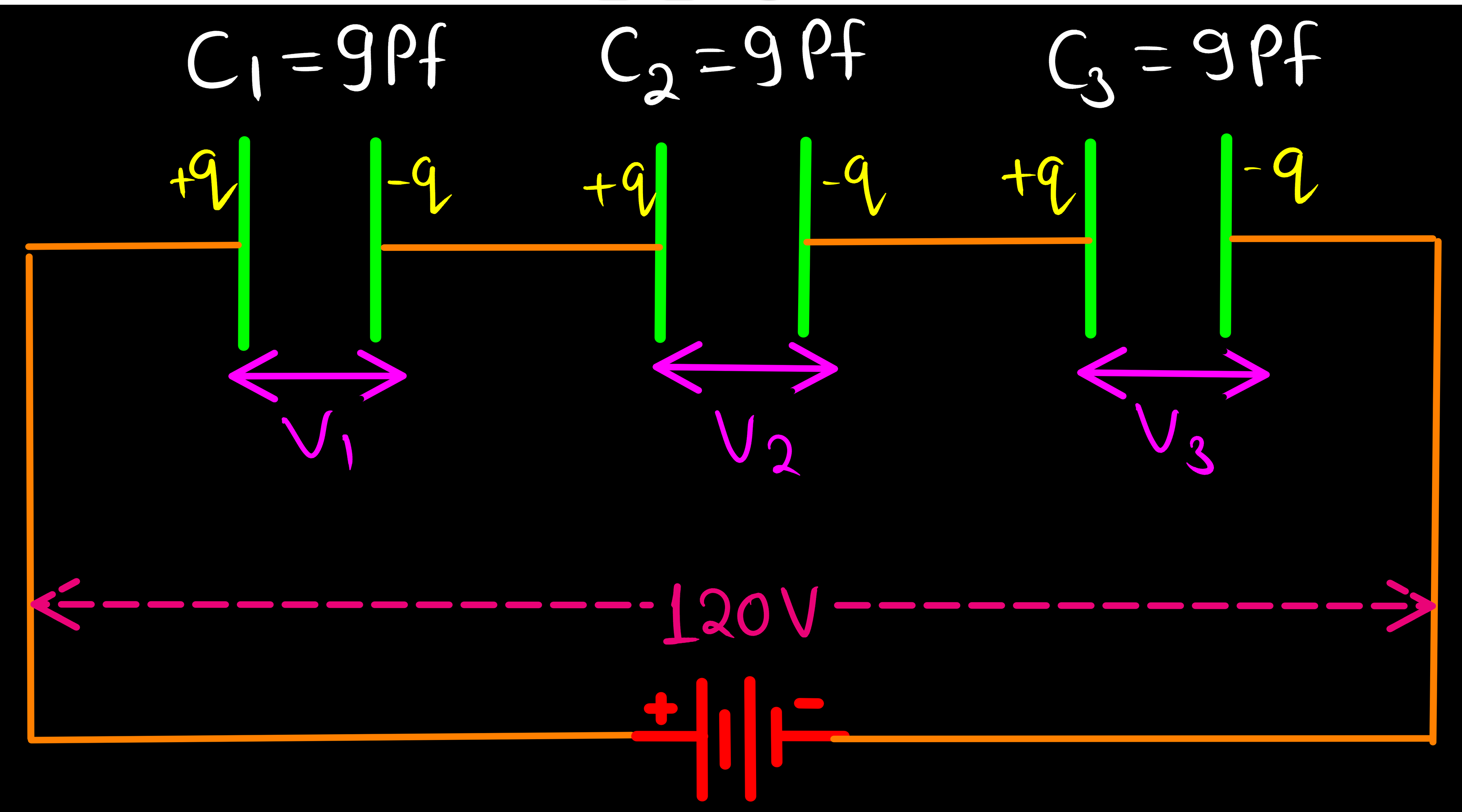

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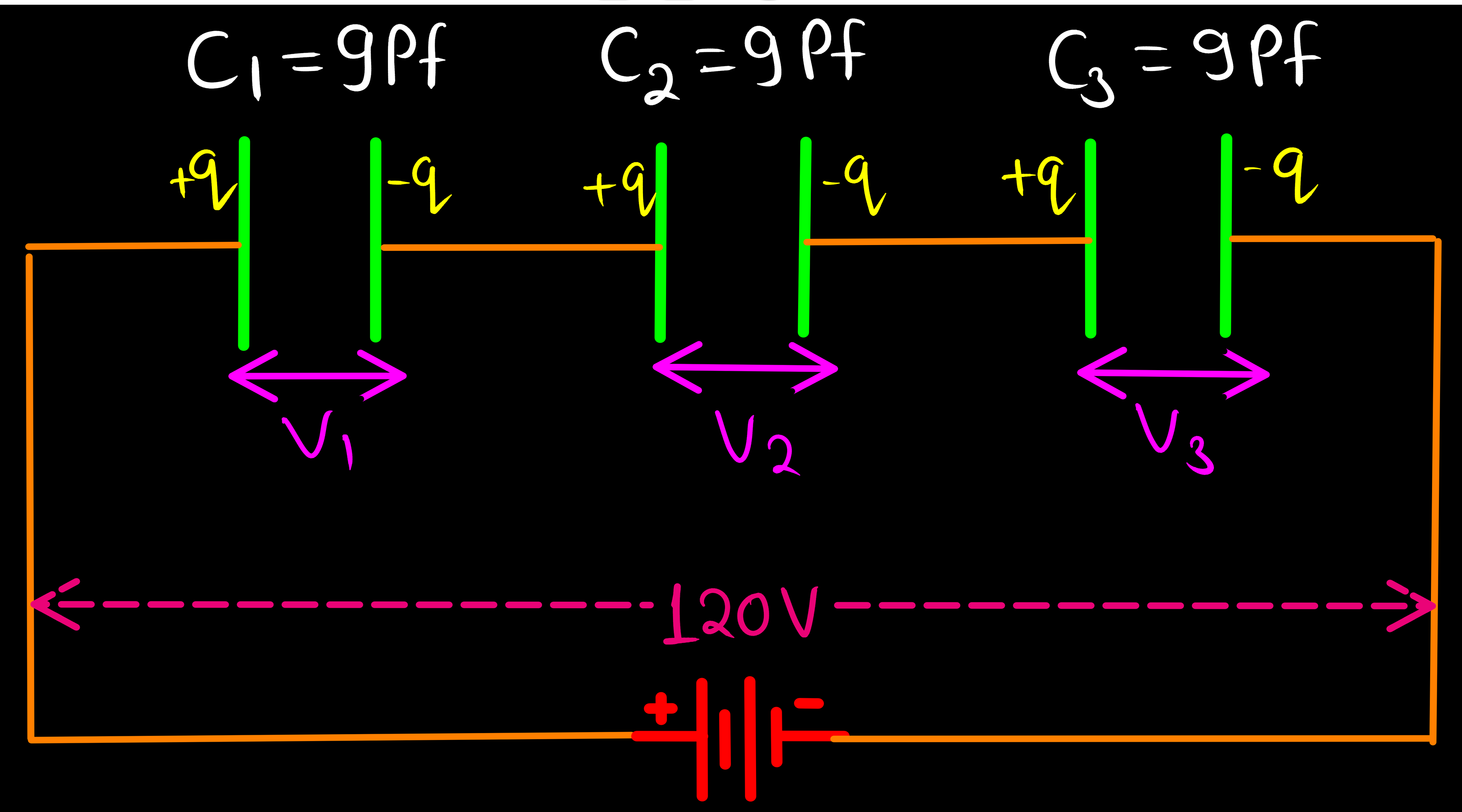

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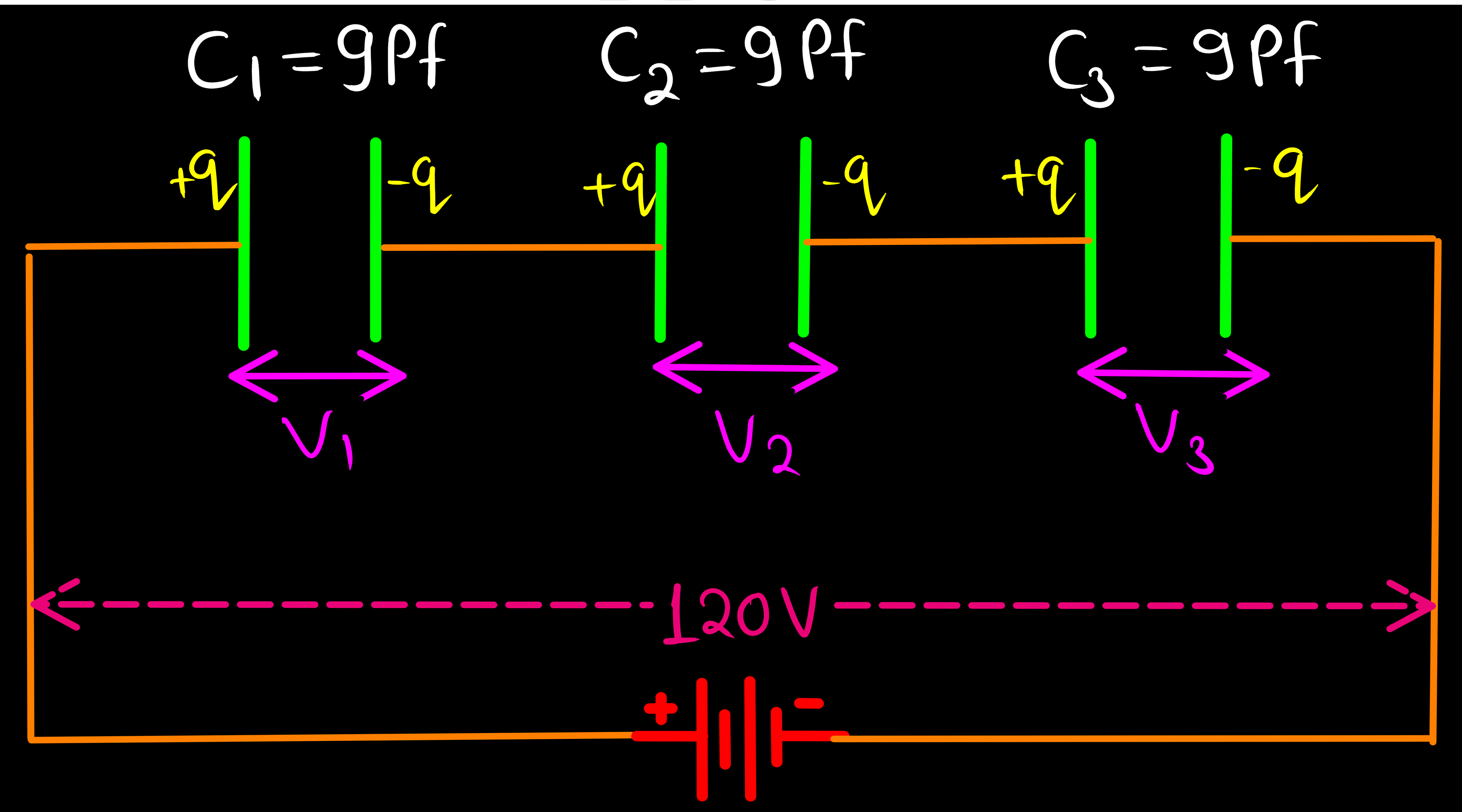

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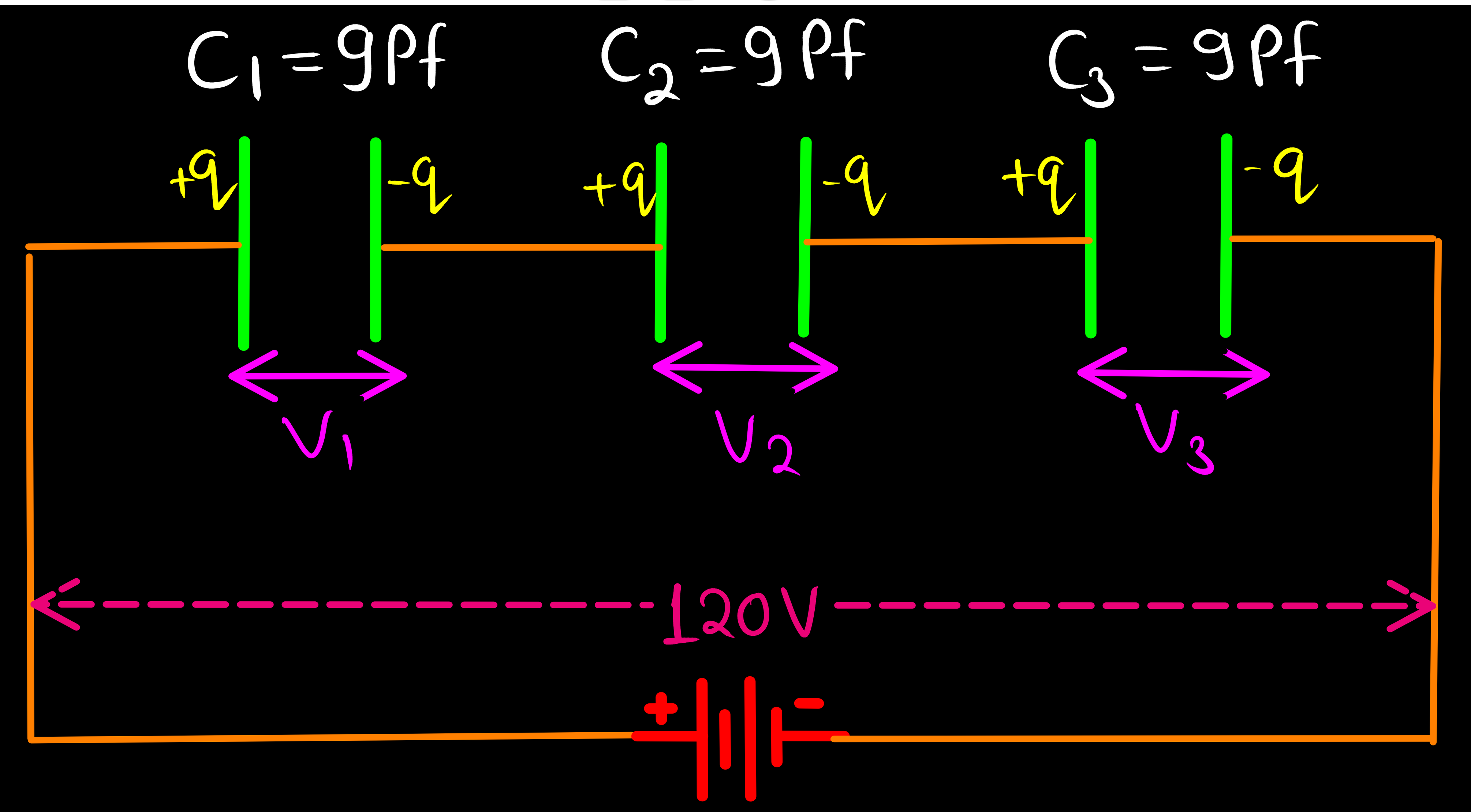

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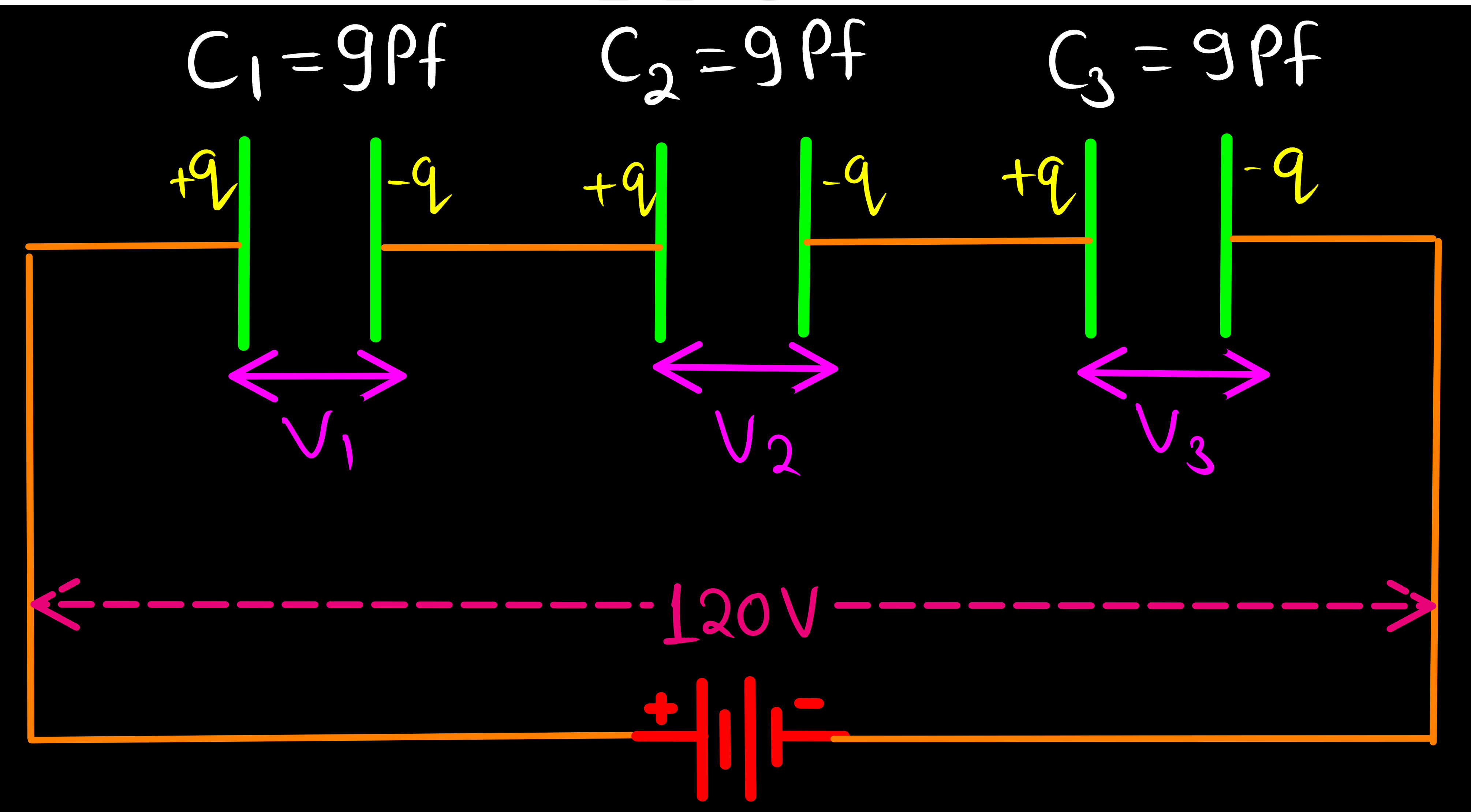

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$$\boxed{C = 3\,pF}$$

* b) Charge stored by all Capacitors –

$q_1 = q_2 = q_3 = q$ → (In series q → same)

$q = CV = 3 \times 10^{-12} \times 120$

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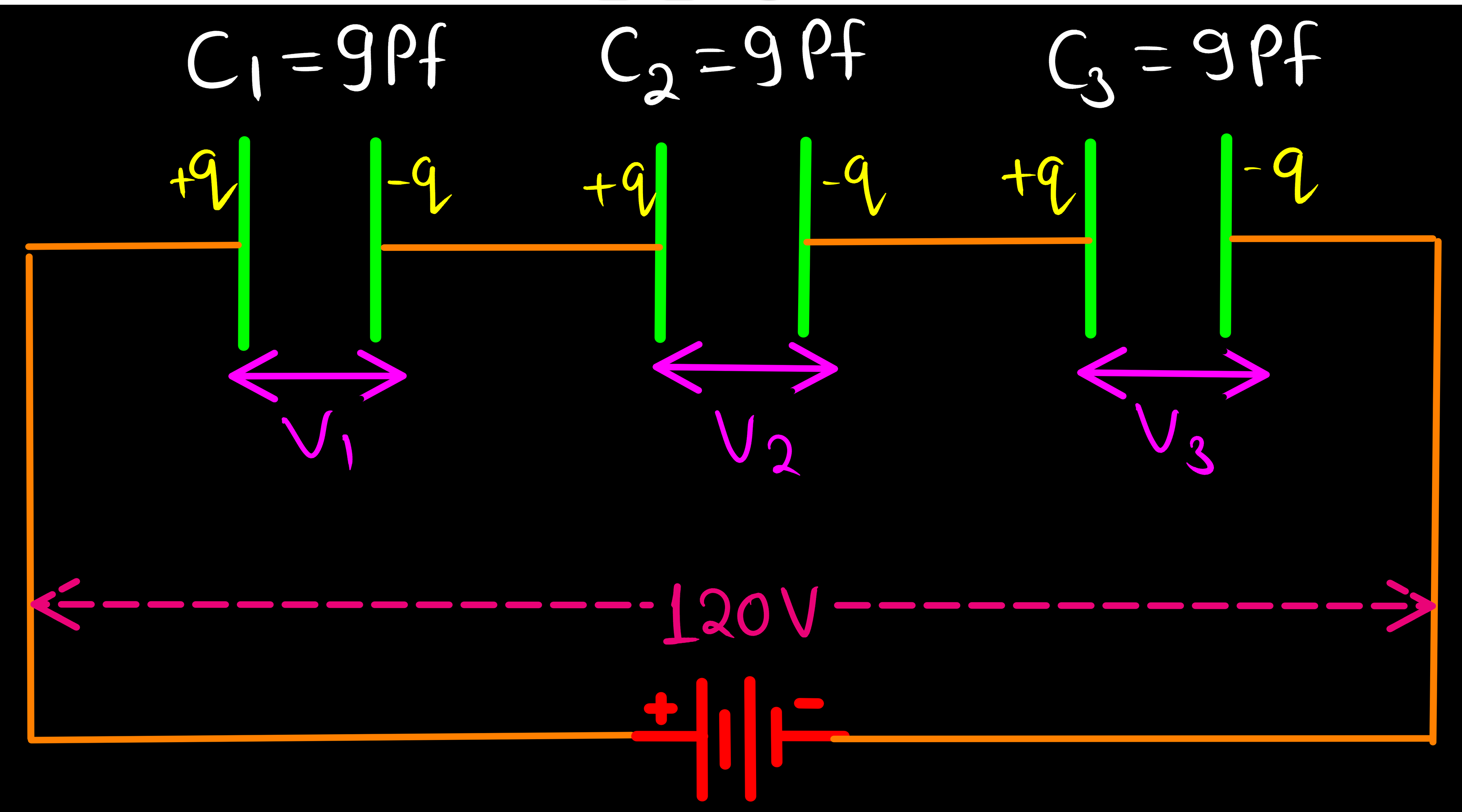

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$$\boxed{q = 360 \times 10^{-12}\,C}$$

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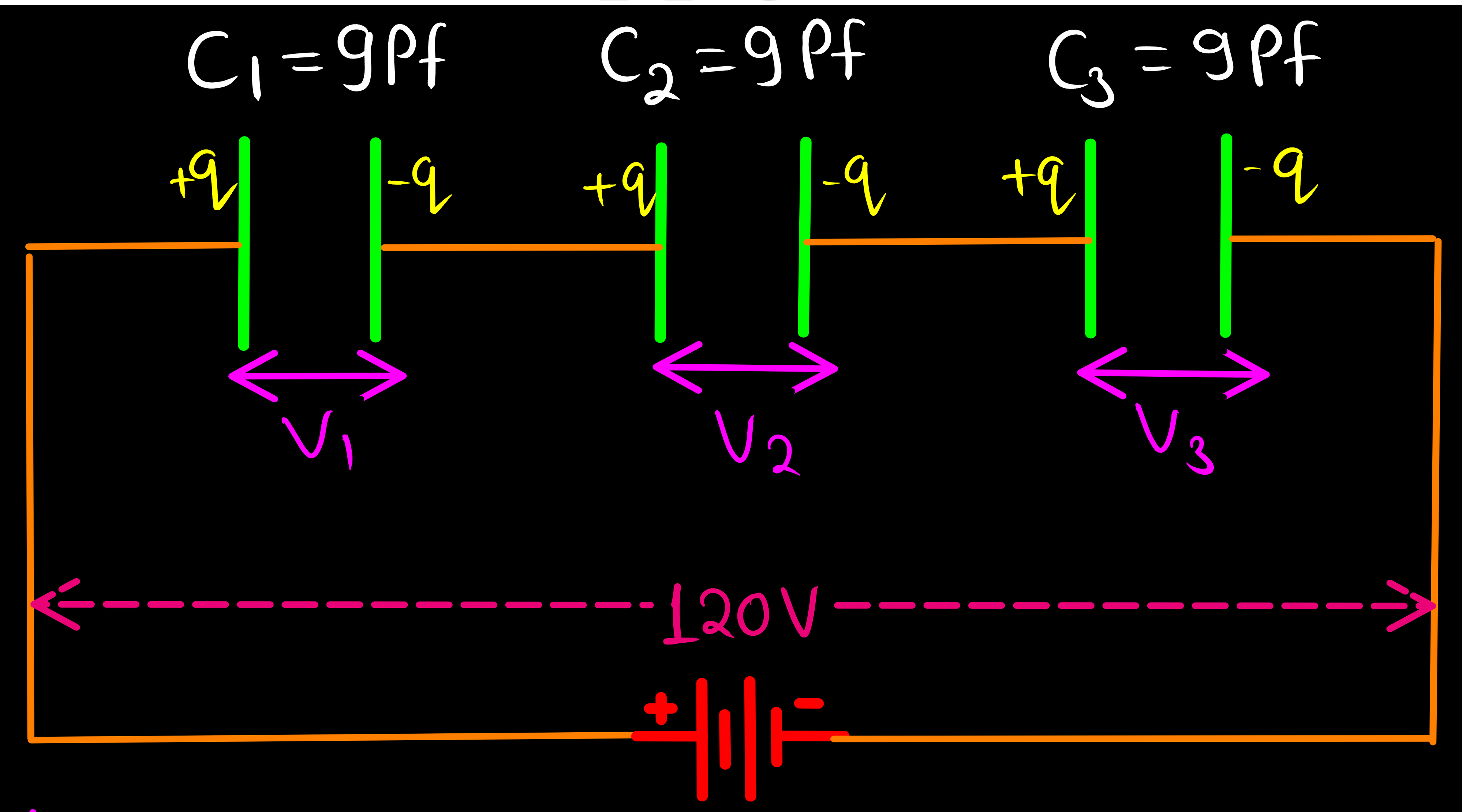

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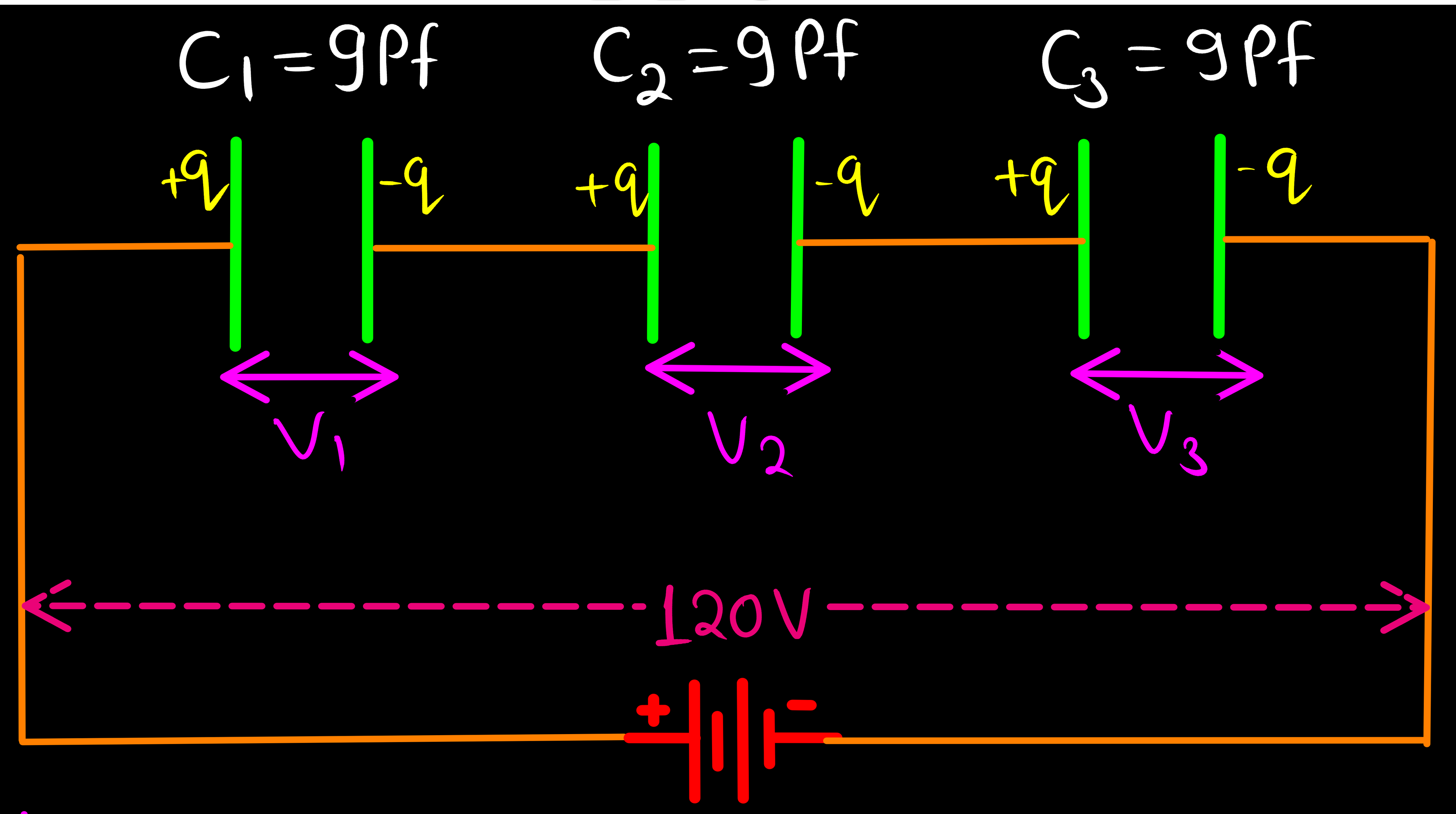

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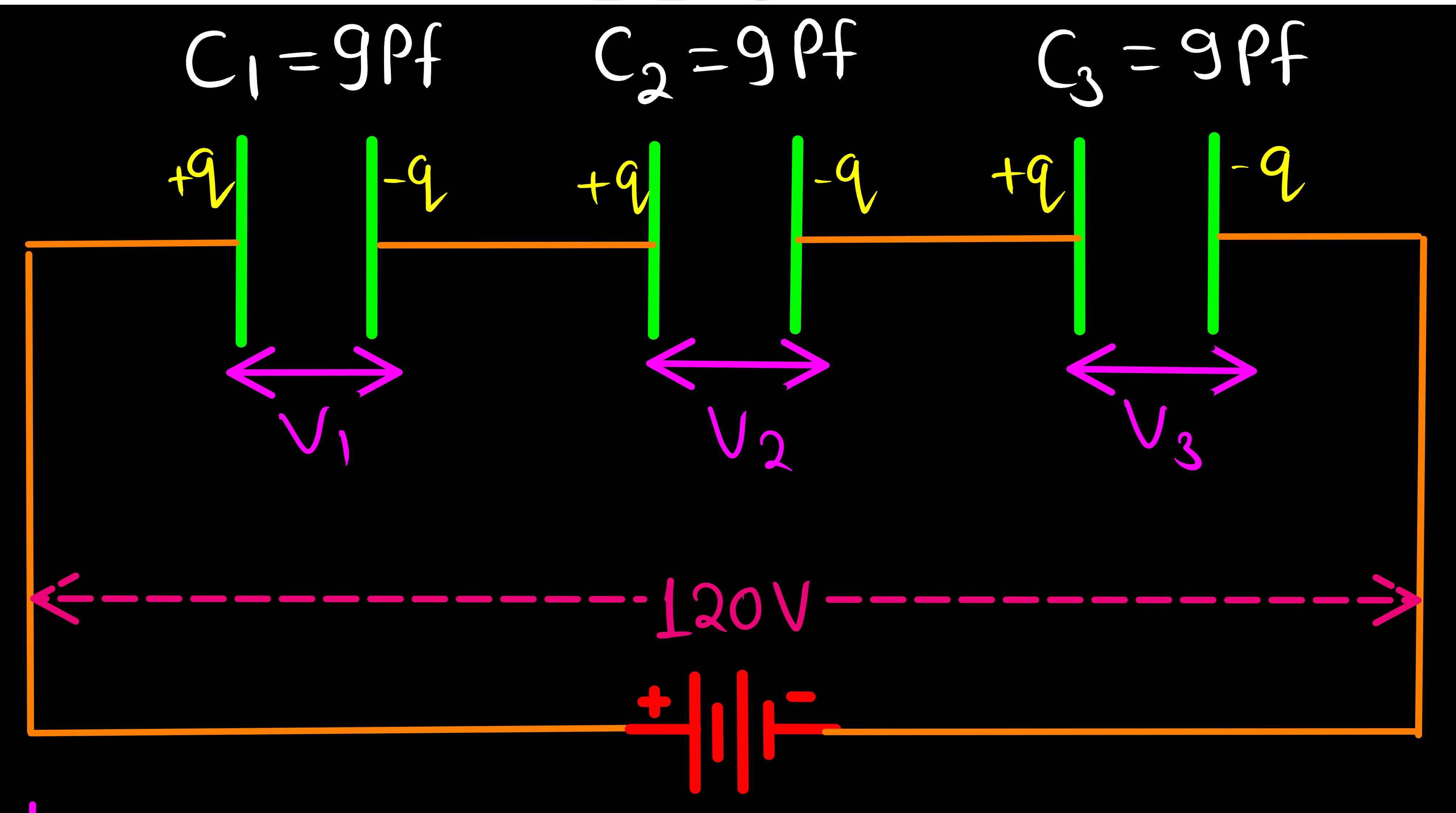

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$$\boxed{V_1 = 40\,V}$$

$V_2 = V_3 = V_1 = 40\,V$

2.7 Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel.

(a) What is the total capacitance of the combination?

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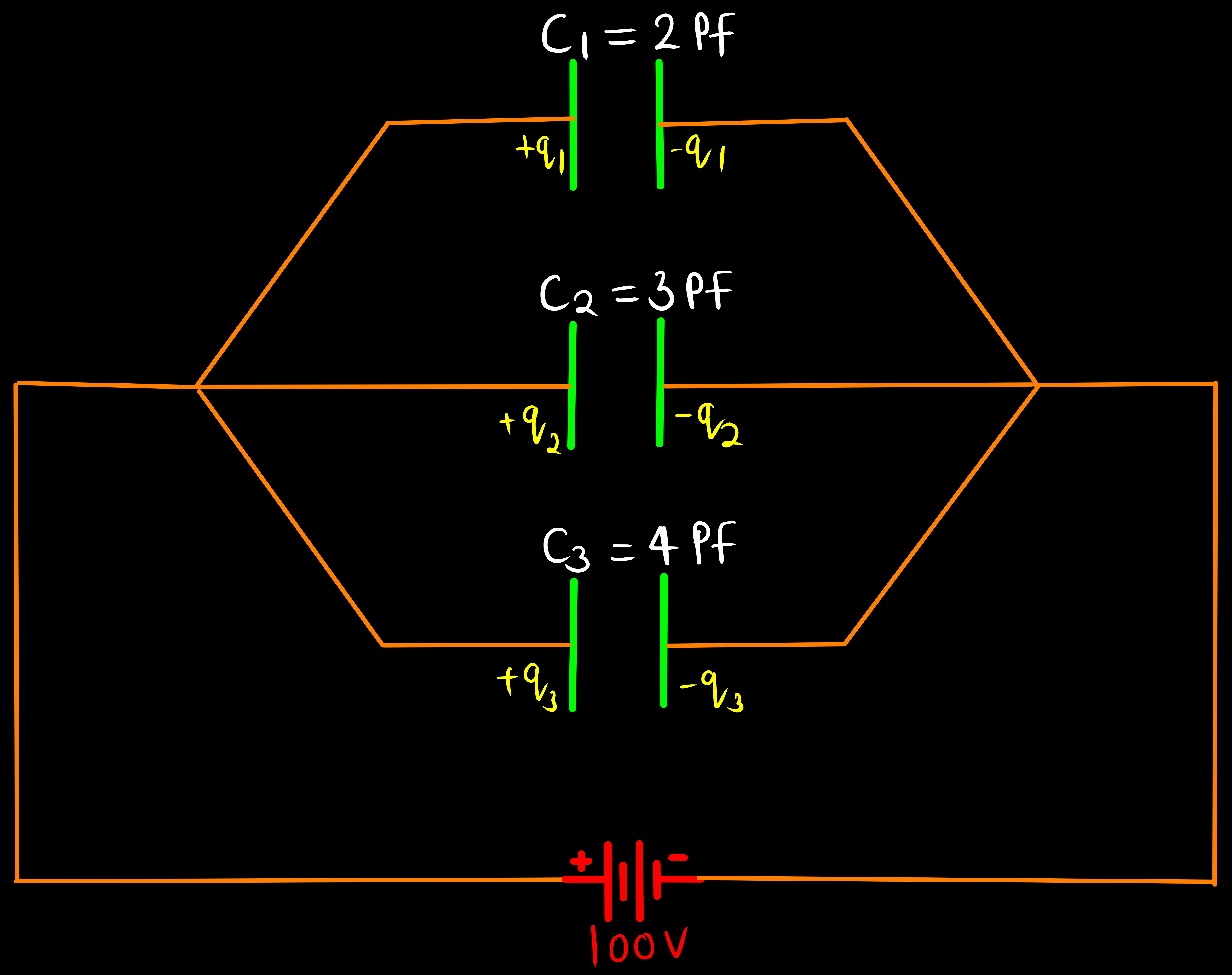

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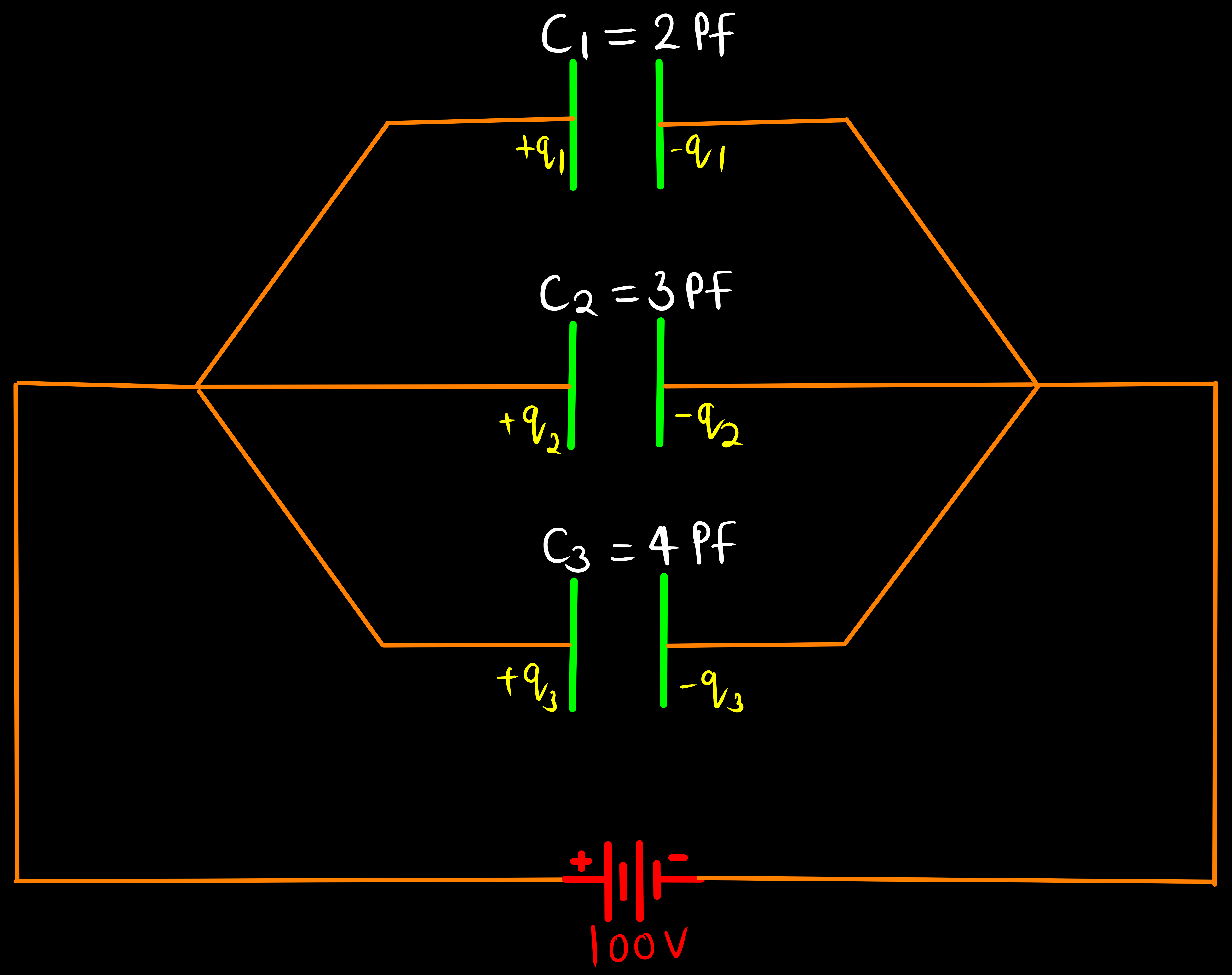

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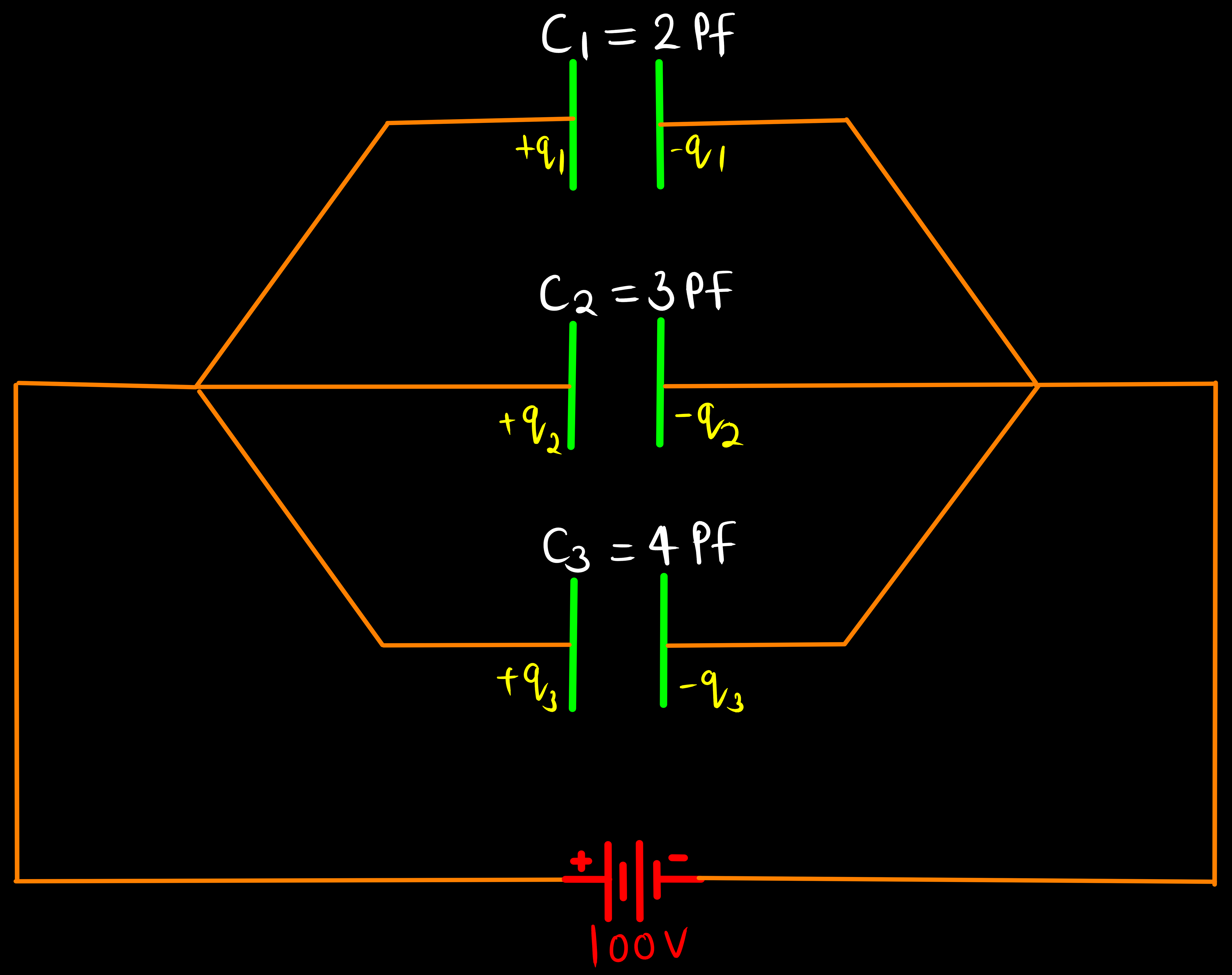

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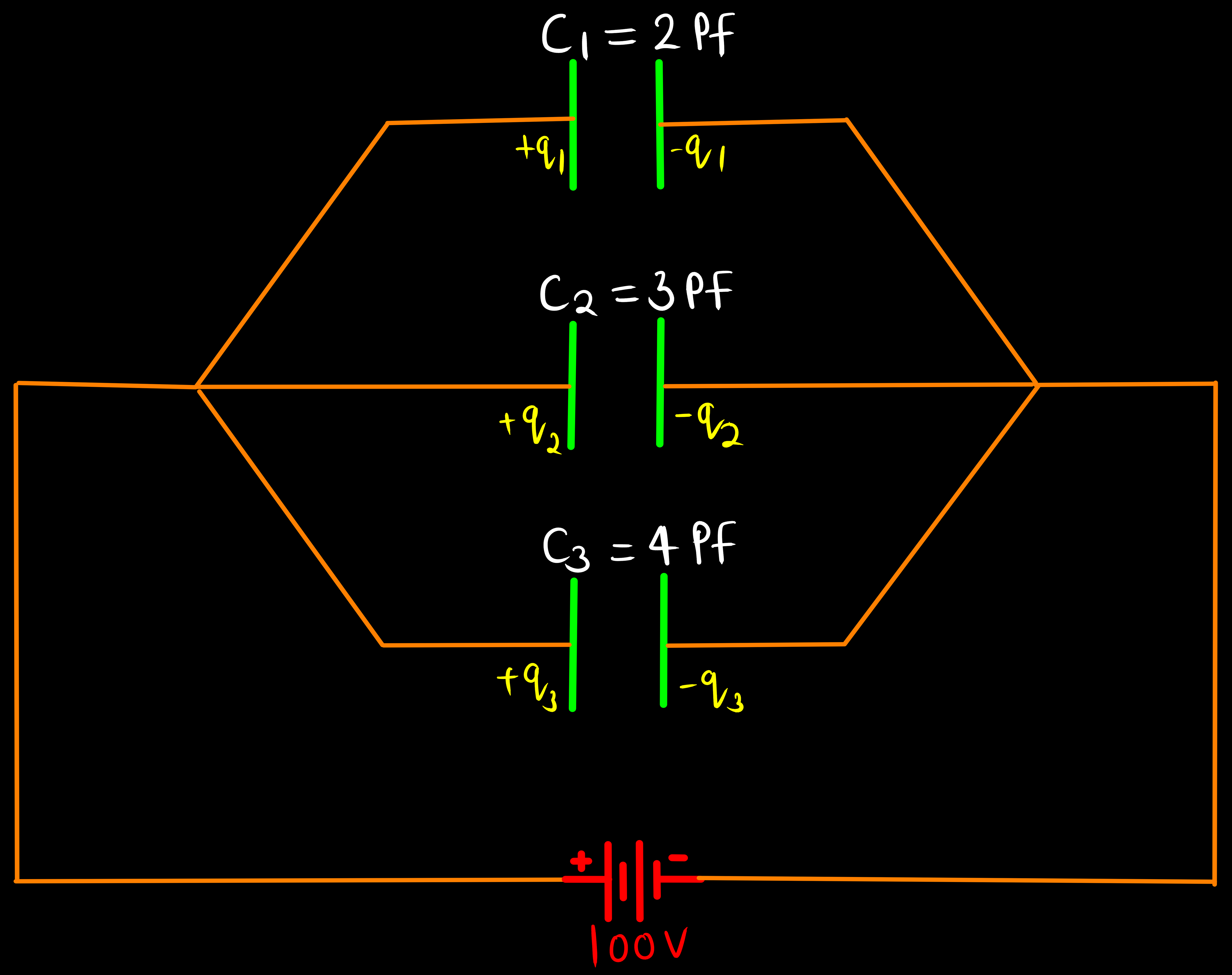
b) $q_1 = C_1 V$



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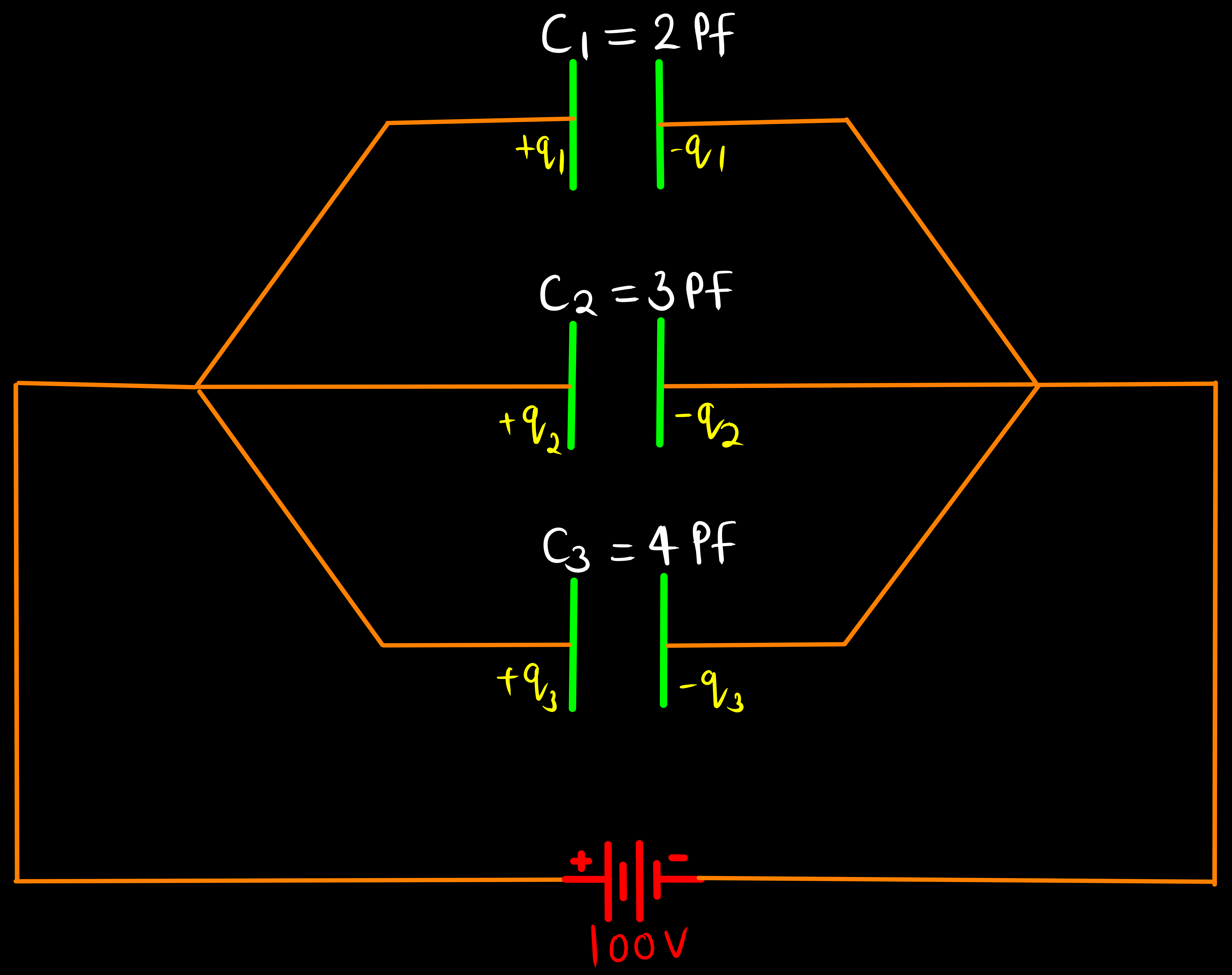

b) $q_1 = C_1 V$

$q_1 = 2 \times 10^{-12} \times 100$

$q_1 = 2 \times 10^{-10}\,C$

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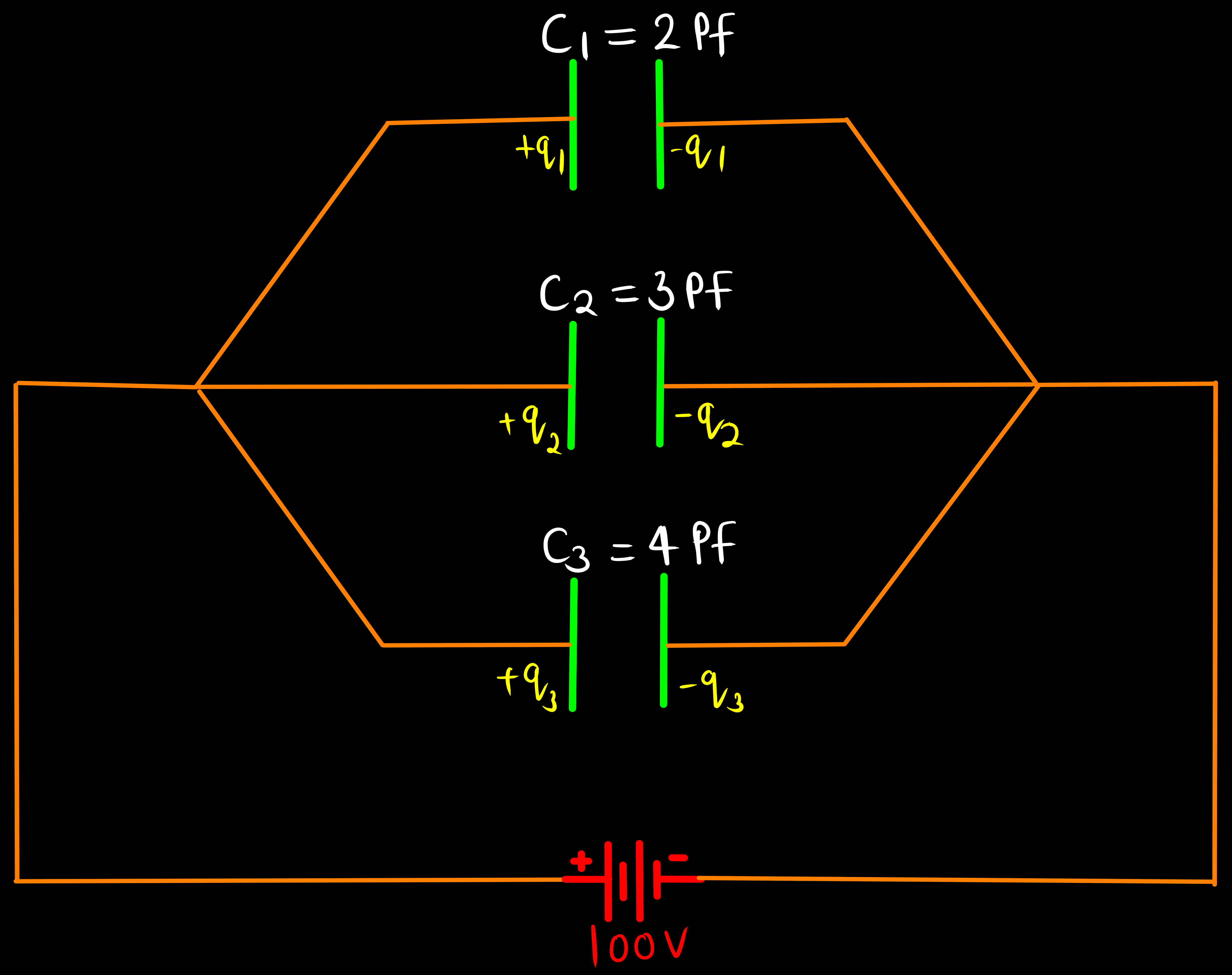
$q_2 = C_2 V$

$q_2 = 3 \times 10^{-12} \times 100 = 3 \times 10^{-10}\,C$



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$q_2 = C_2 V$

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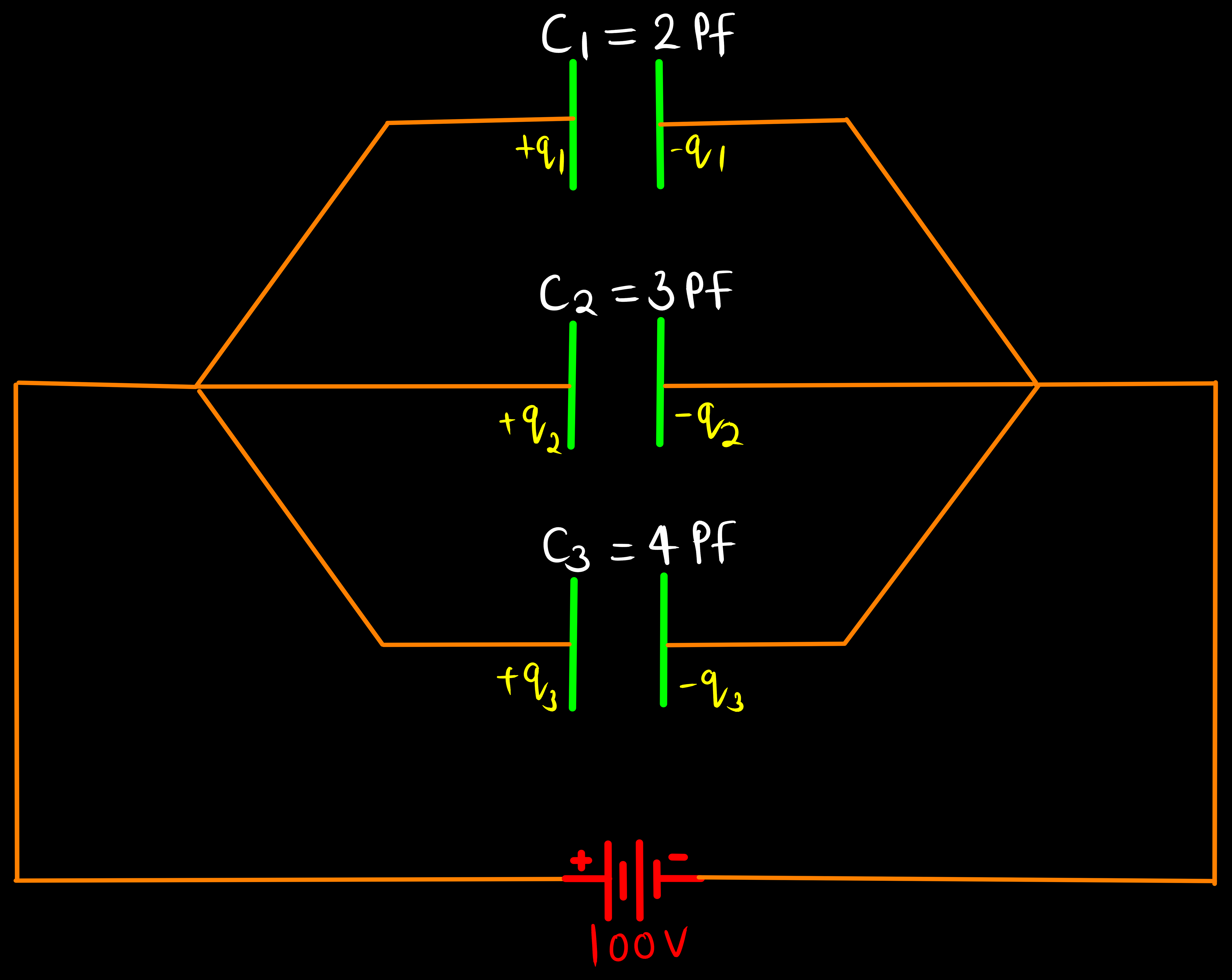
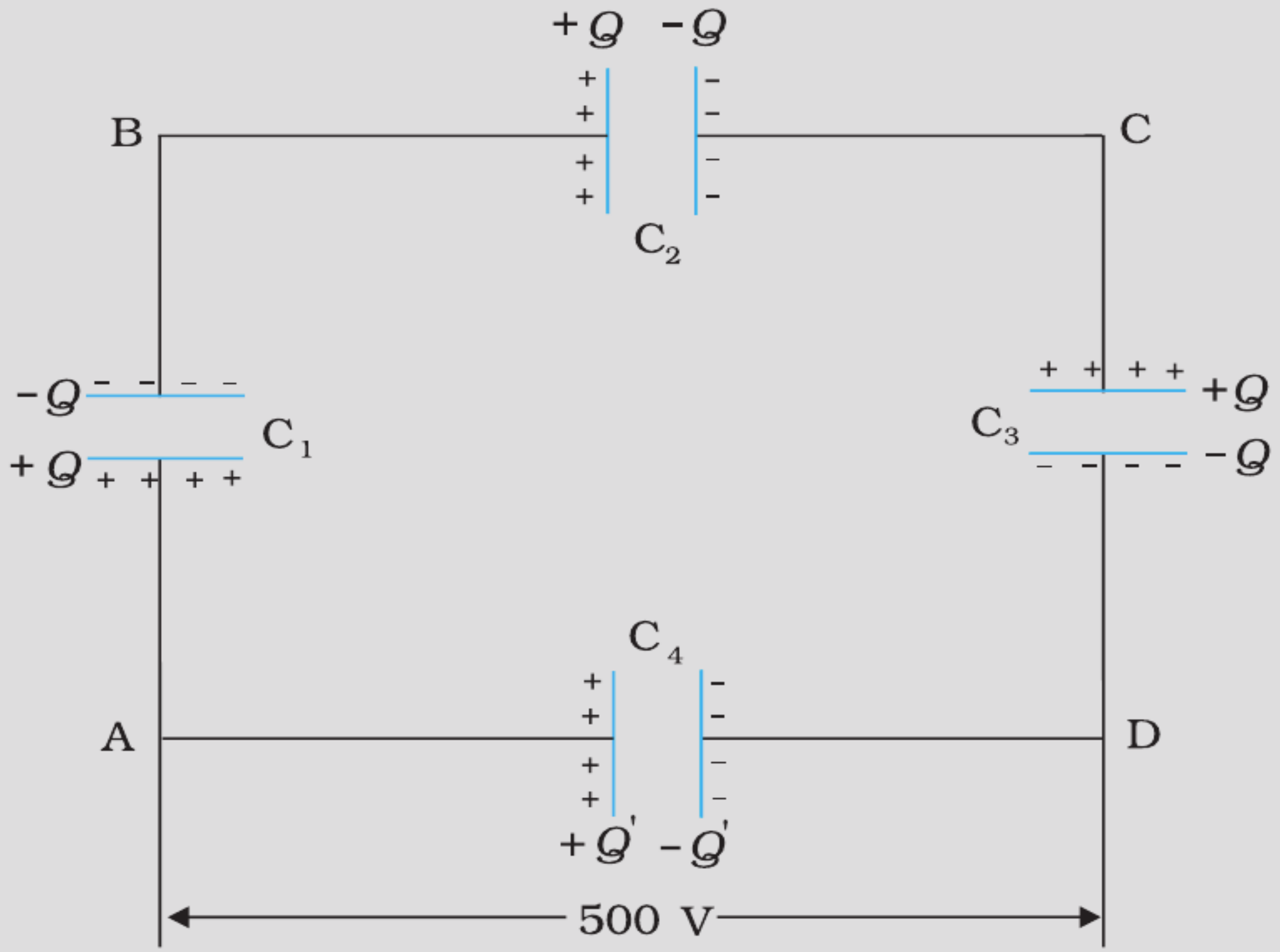
$q_3 = C_3 V$

$\boxed{q_3 = 4 \times 10^{-12} \times 100 = 4 \times 10^{-10}\,C}$



Example 2.9 A network of four 10 μF capacitors is connected to a 500 V supply, as shown in Fig. 2.29. Determine (a) the equivalent capacitance of the network and (b) the charge on each capacitor. (Note, the *charge on a capacitor* is the charge on the plate with higher potential, equal and opposite to the charge on the plate with lower potential.)



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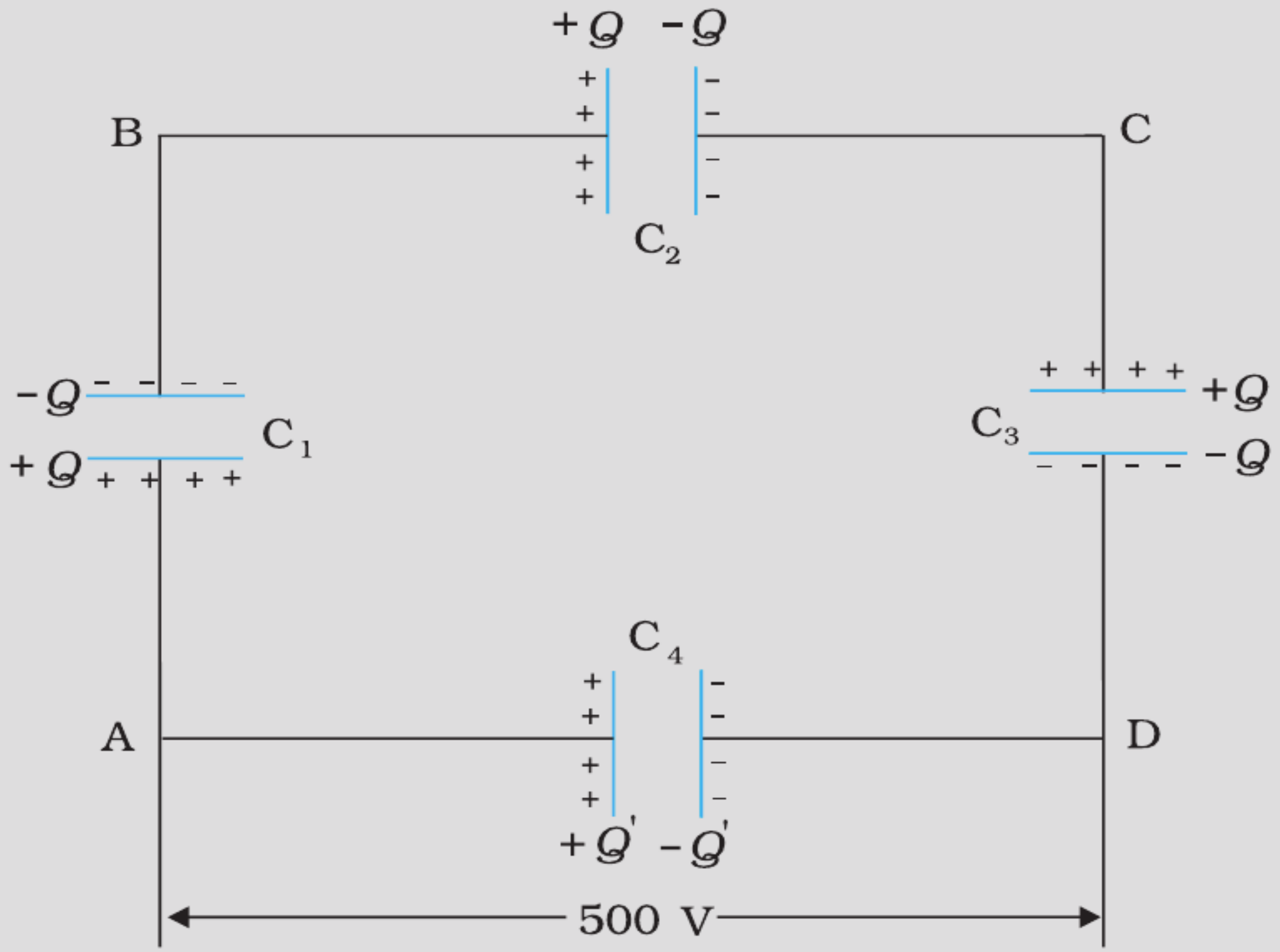

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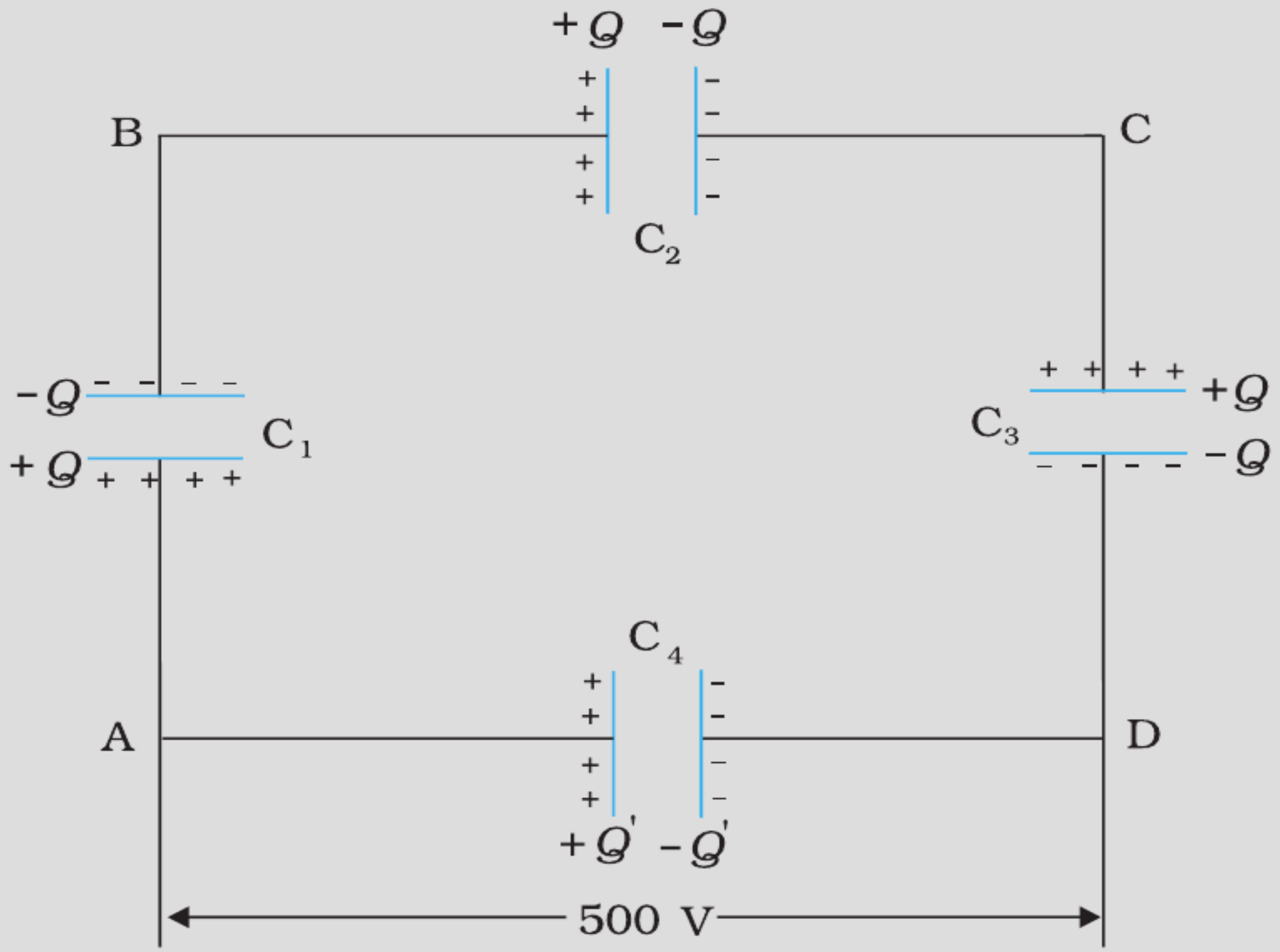

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$$C' = \frac{10}{3}\ \mu F$$

Now, C' and C_4 are in parallel

$$C = C' + C_4$$

$$C = \left(\frac{10}{3} + 10\right) \mu F$$

$$\boxed{C = \frac{40}{3}\ \mu F}$$

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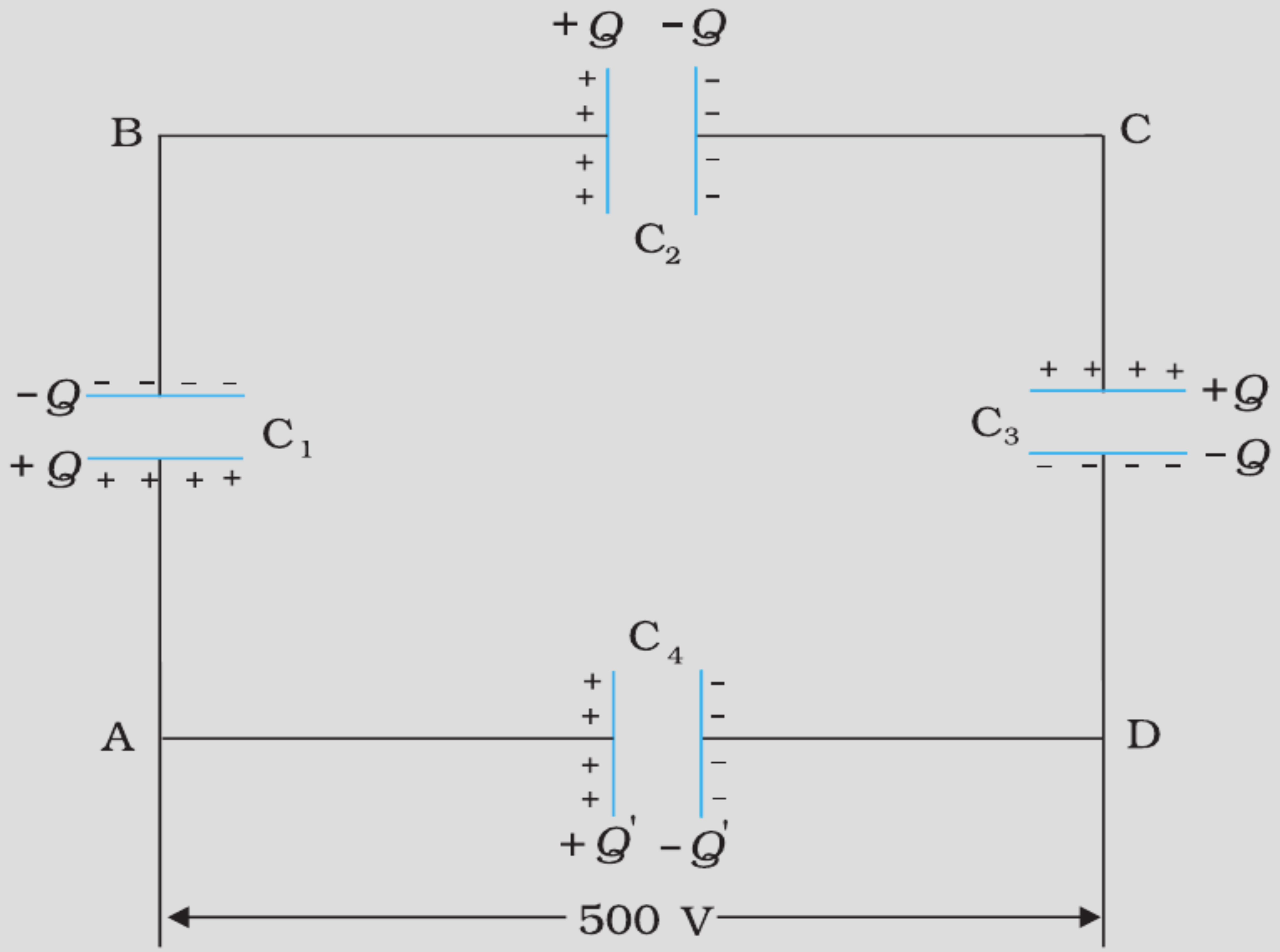

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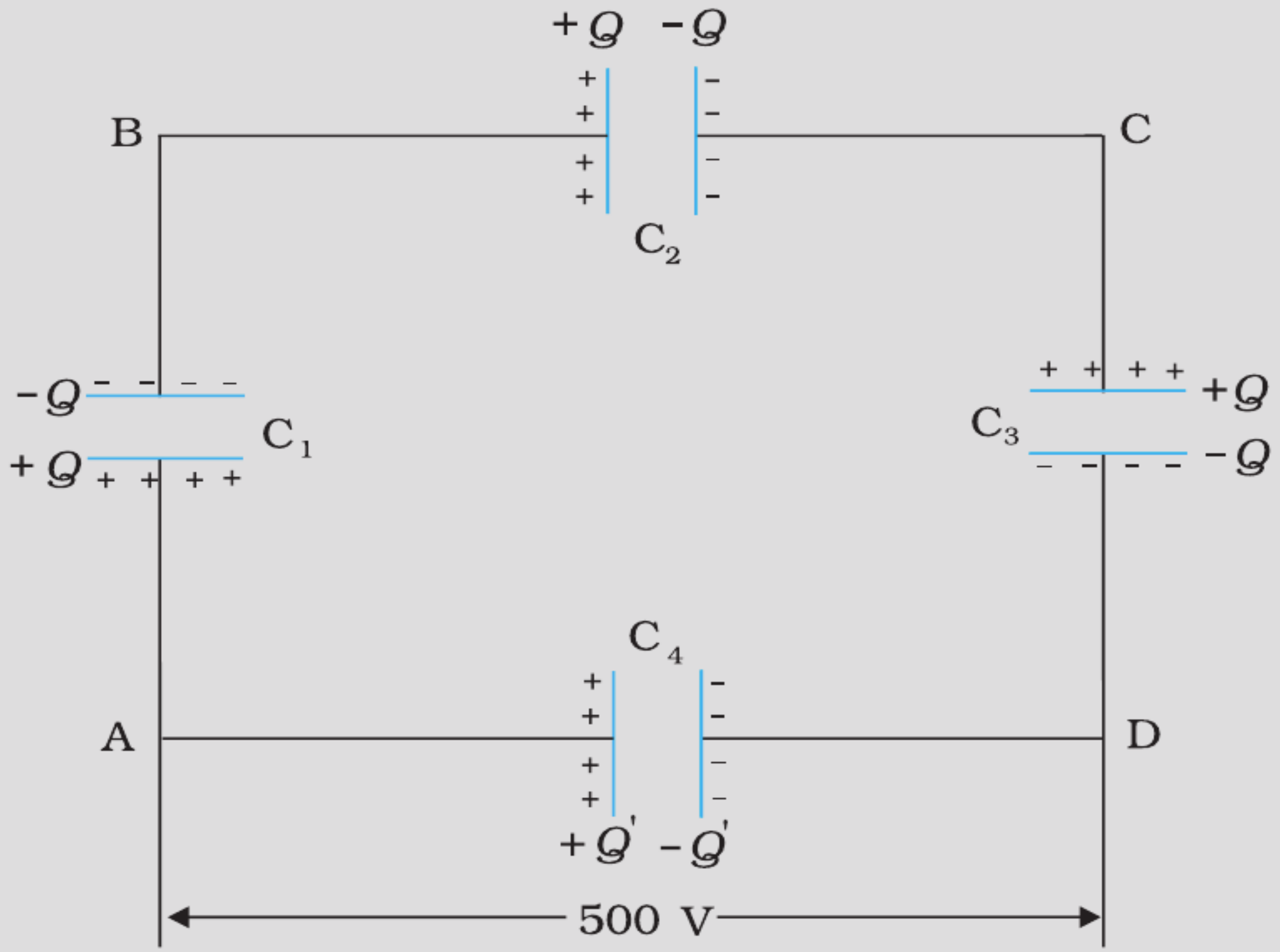

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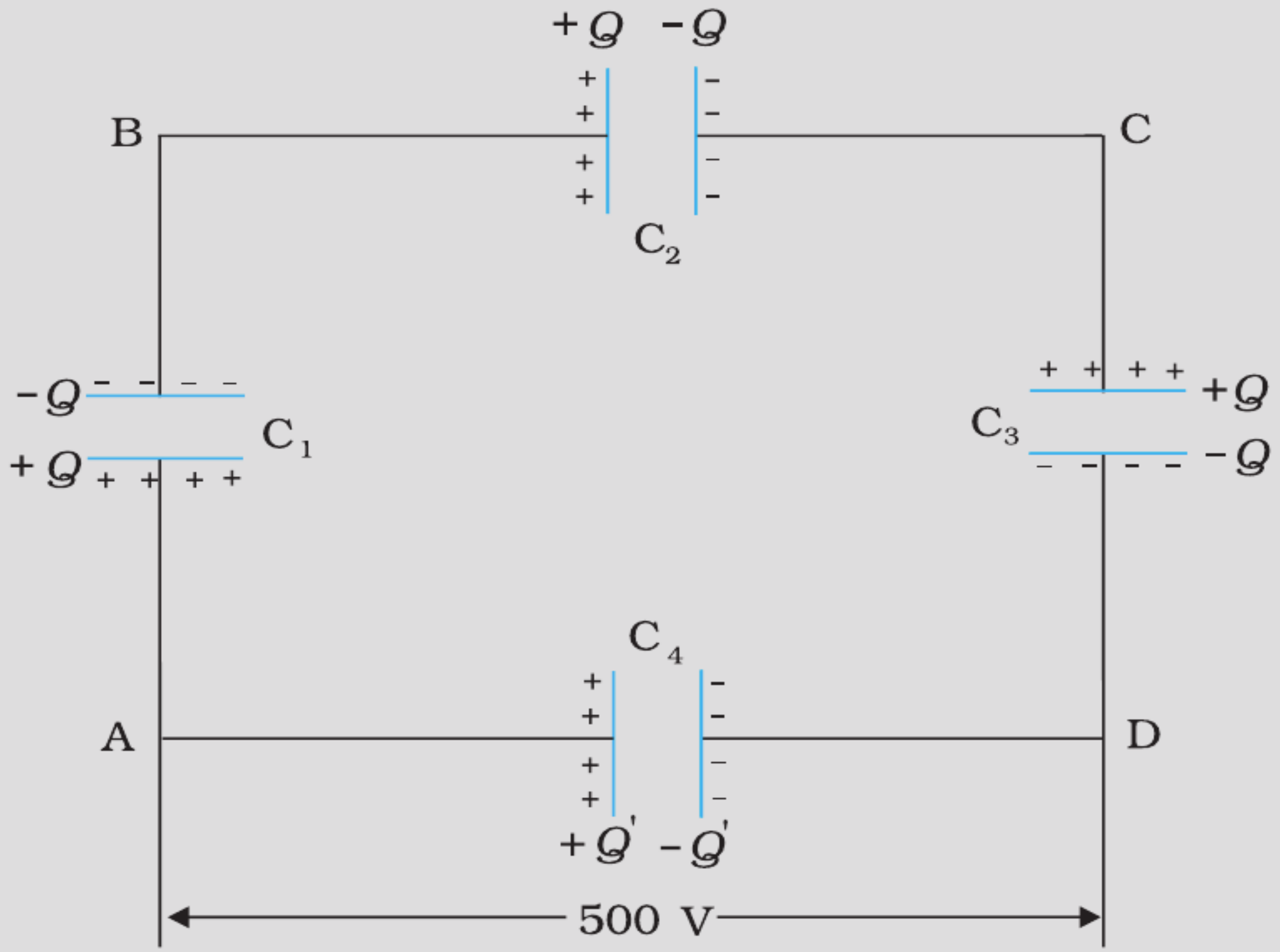

a) C_1, C_2, and C_3 are in series-

$$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C'} = \frac{1}{10} + \frac{1}{10} + \frac{1}{10} = \frac{3}{10}$$

$$C' = \frac{10}{3}\ \mu F$$

Now, C' and C_4 are in parallel

$$C = C' + C_4$$

$$C = \left(\frac{10}{3} + 10\right)\mu F$$

$$\boxed{C = \frac{40}{3}\ \mu F}$$

b) $q_4 = C_4 V$

$$q_4 = 10 \times 10^{-6} \times 500$$

$$\boxed{q_4 = 5 \times 10^{-3}\ C}$$

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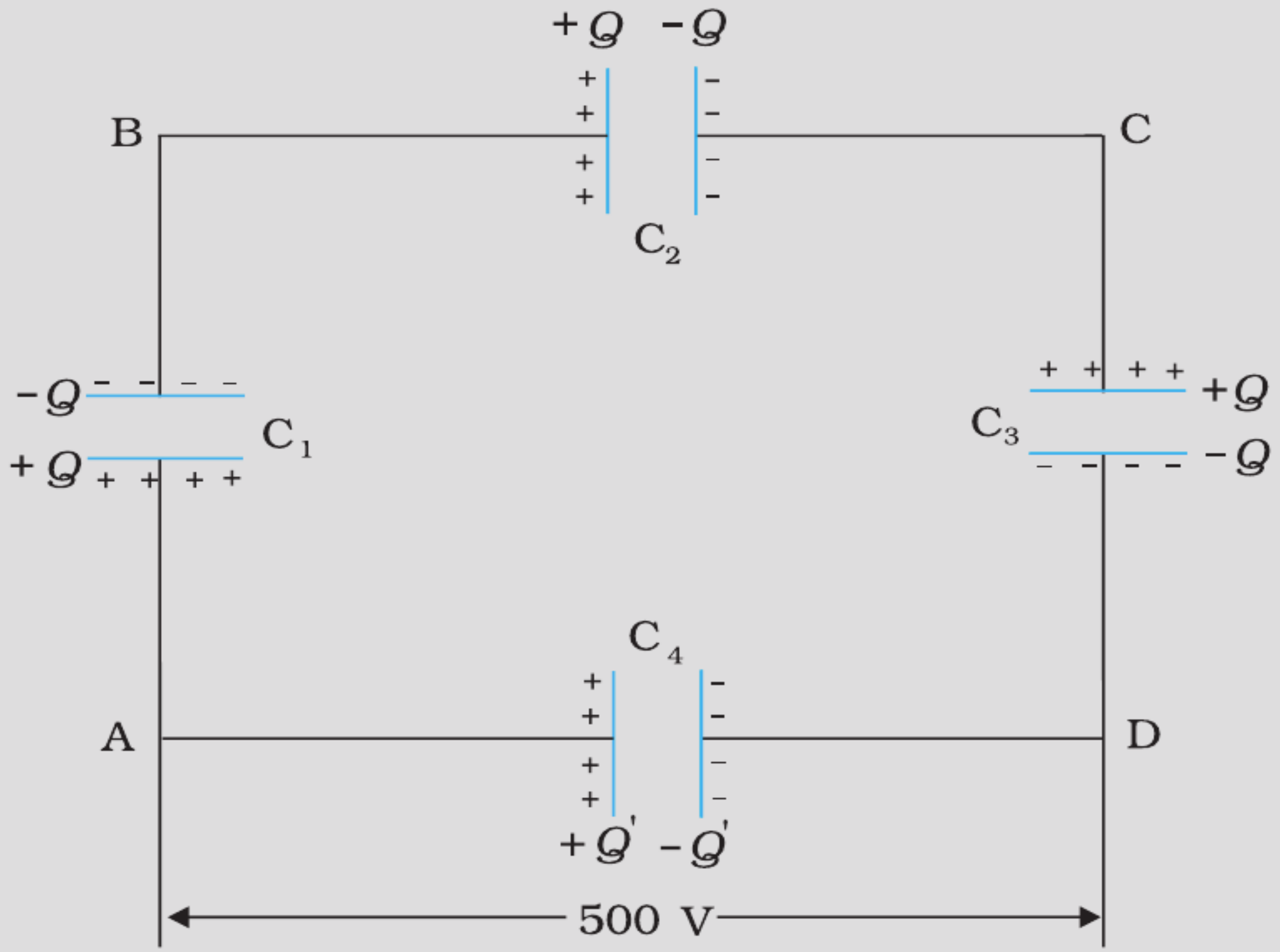

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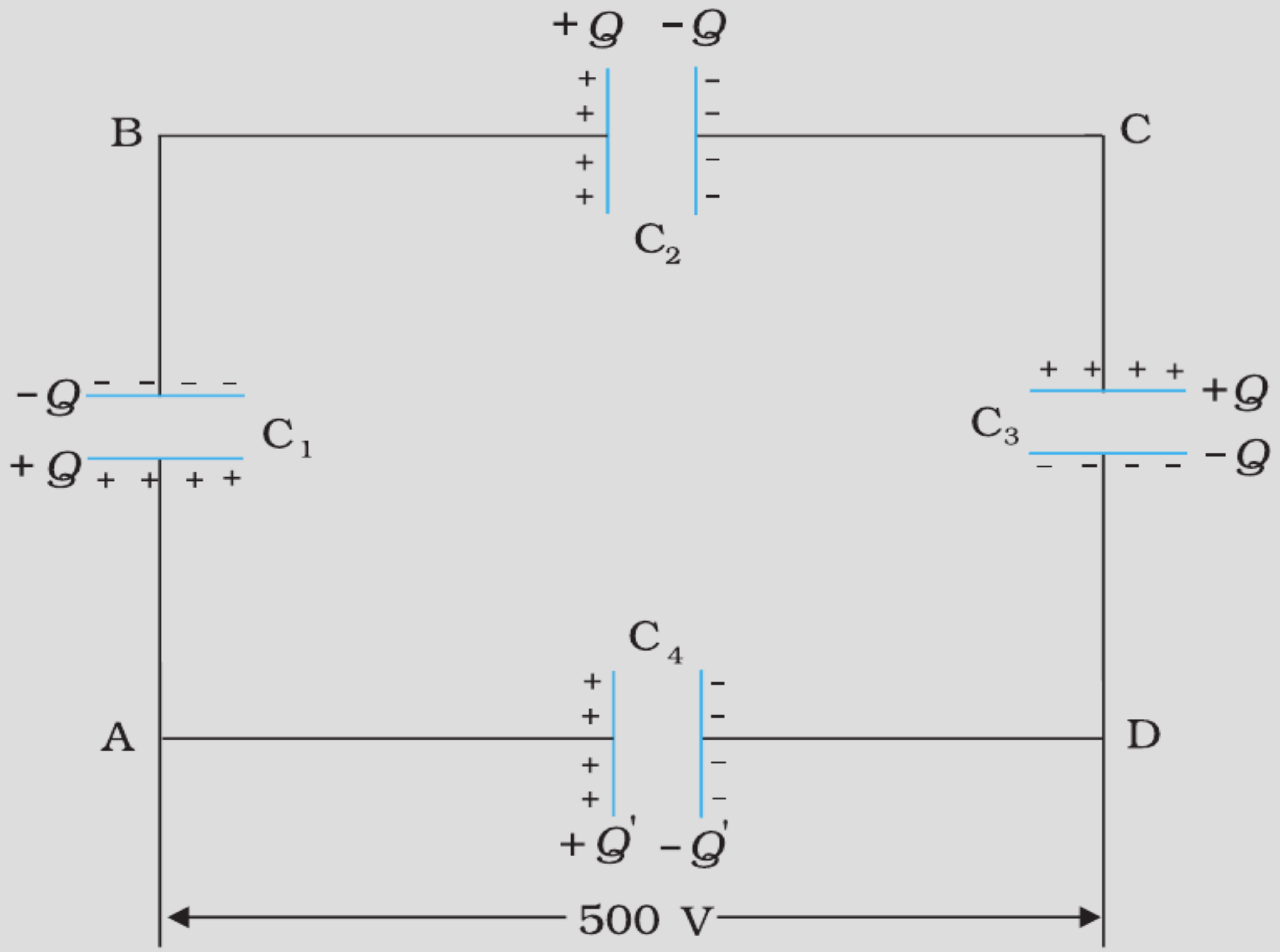

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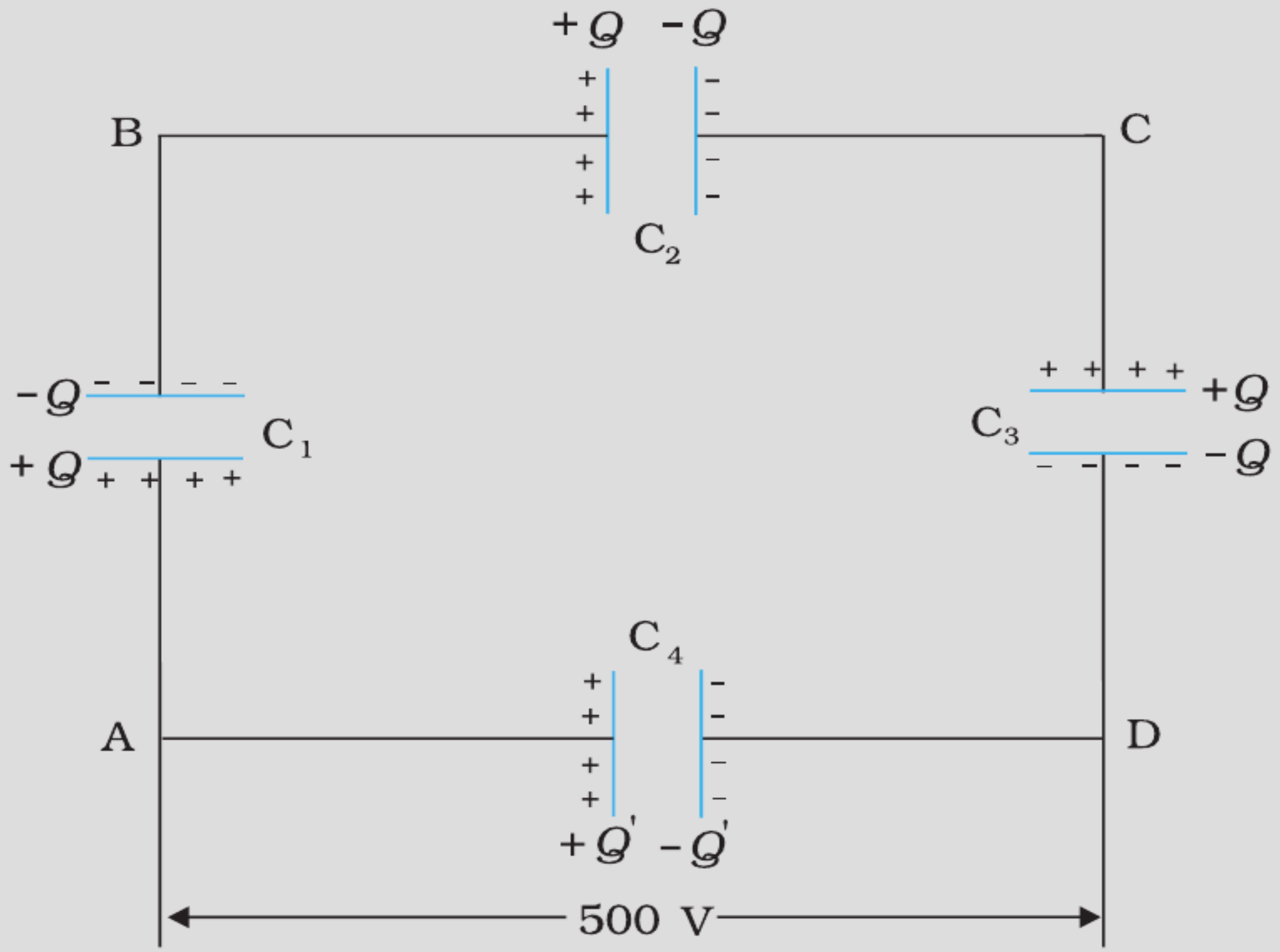

$$\frac{3q}{C} = 500$$

$$q = \frac{500 \times C}{3} = \frac{500 \times 10 \times 10^{-6}}{3}$$

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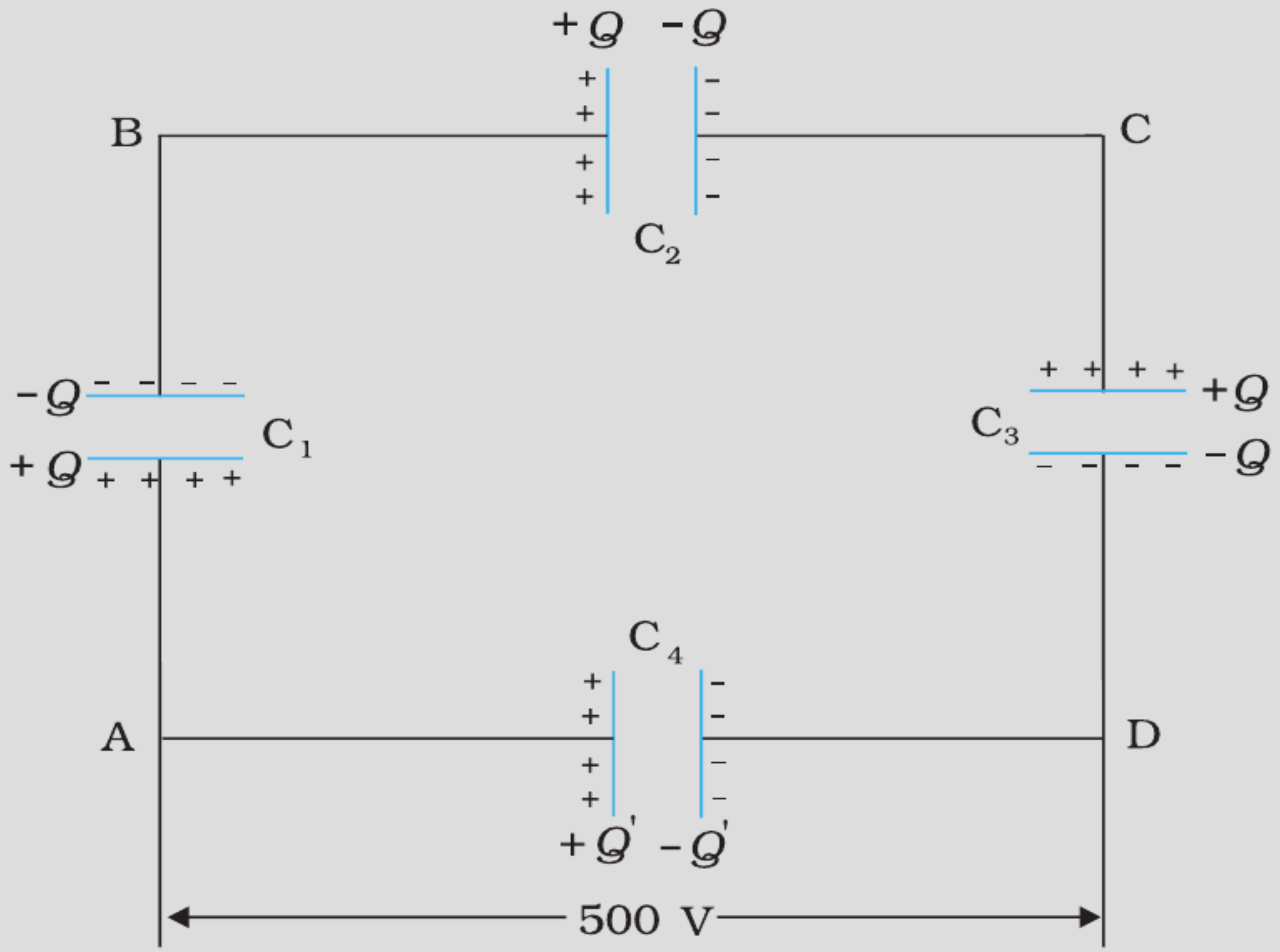

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$U = \frac{1}{2} C V^2$ → Energy stored in the capacitor

$U = \frac{1}{2} \times 120 \times 10^{-6} \times 50$

$\boxed{U = 3 \times 10^{-3}\ J}$

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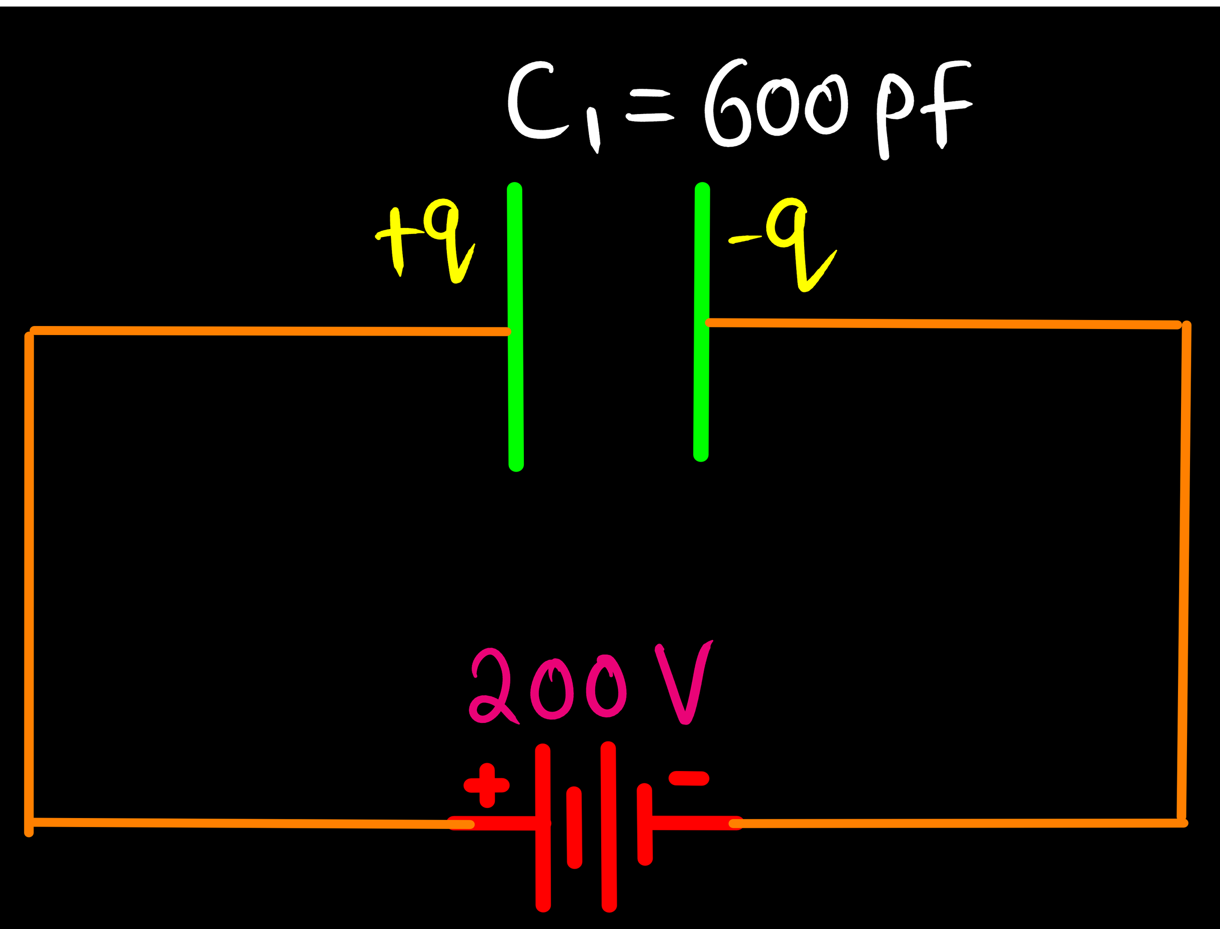

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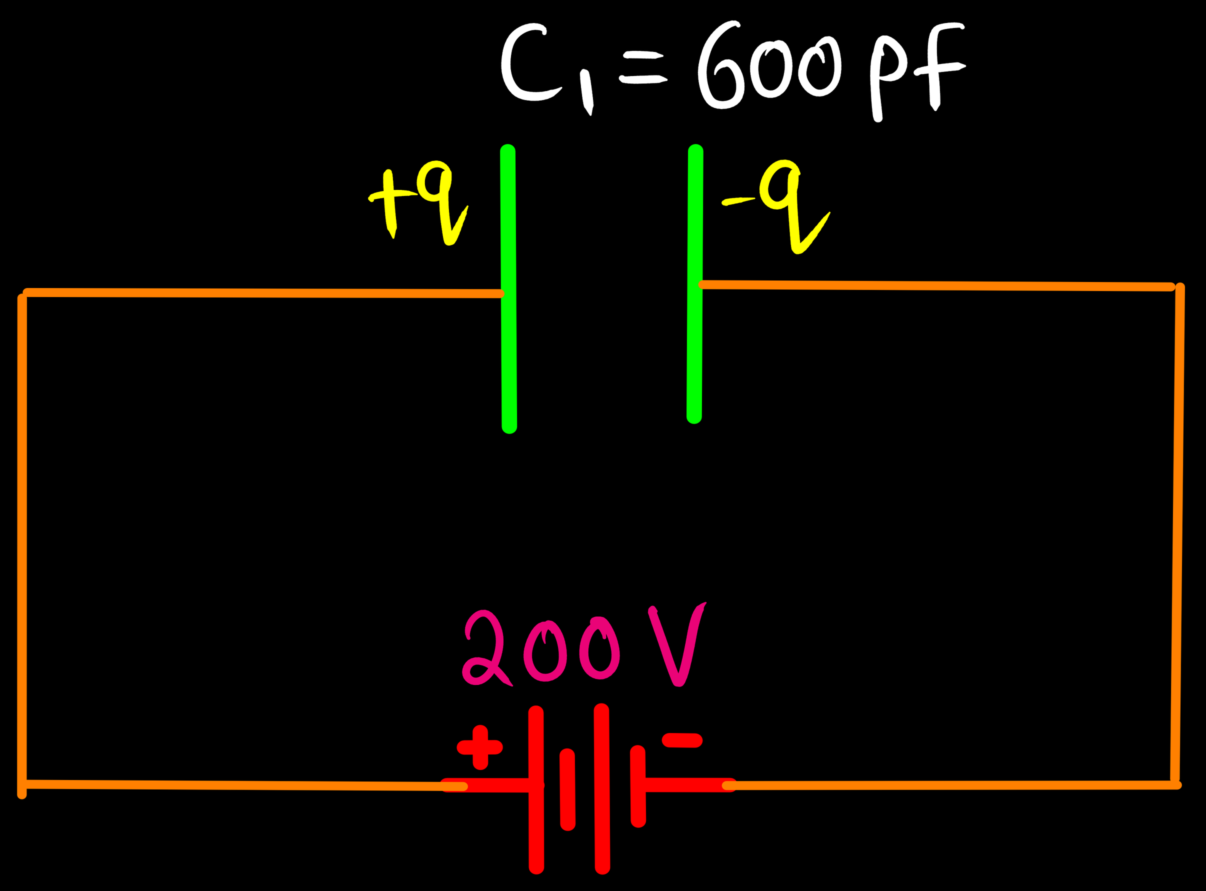

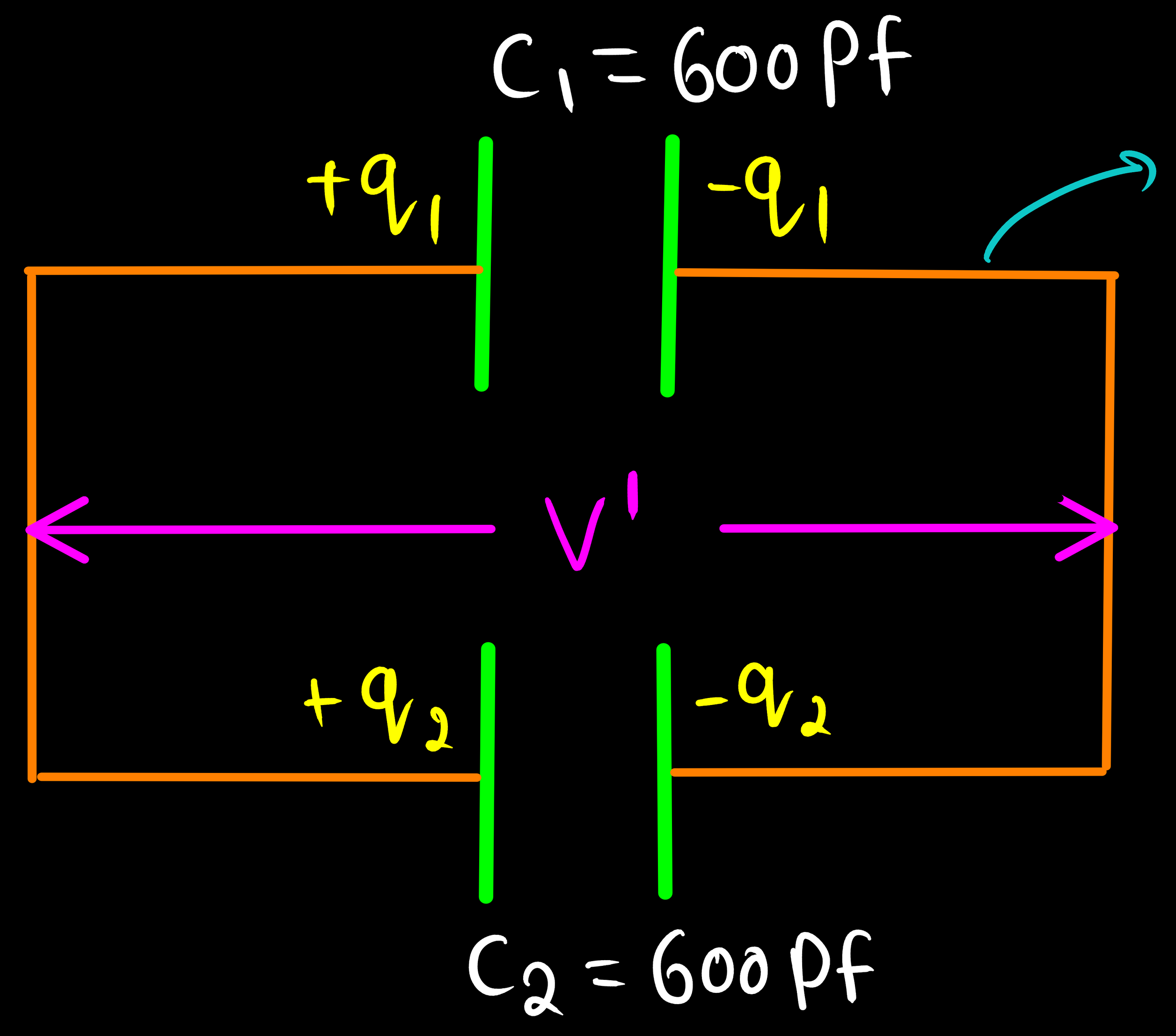

Charge will flow from C_1 to C_2 untill both Capacitor have Common potential.

$$q_1 + q_2 = q$$

↳ Conservation of Charge.

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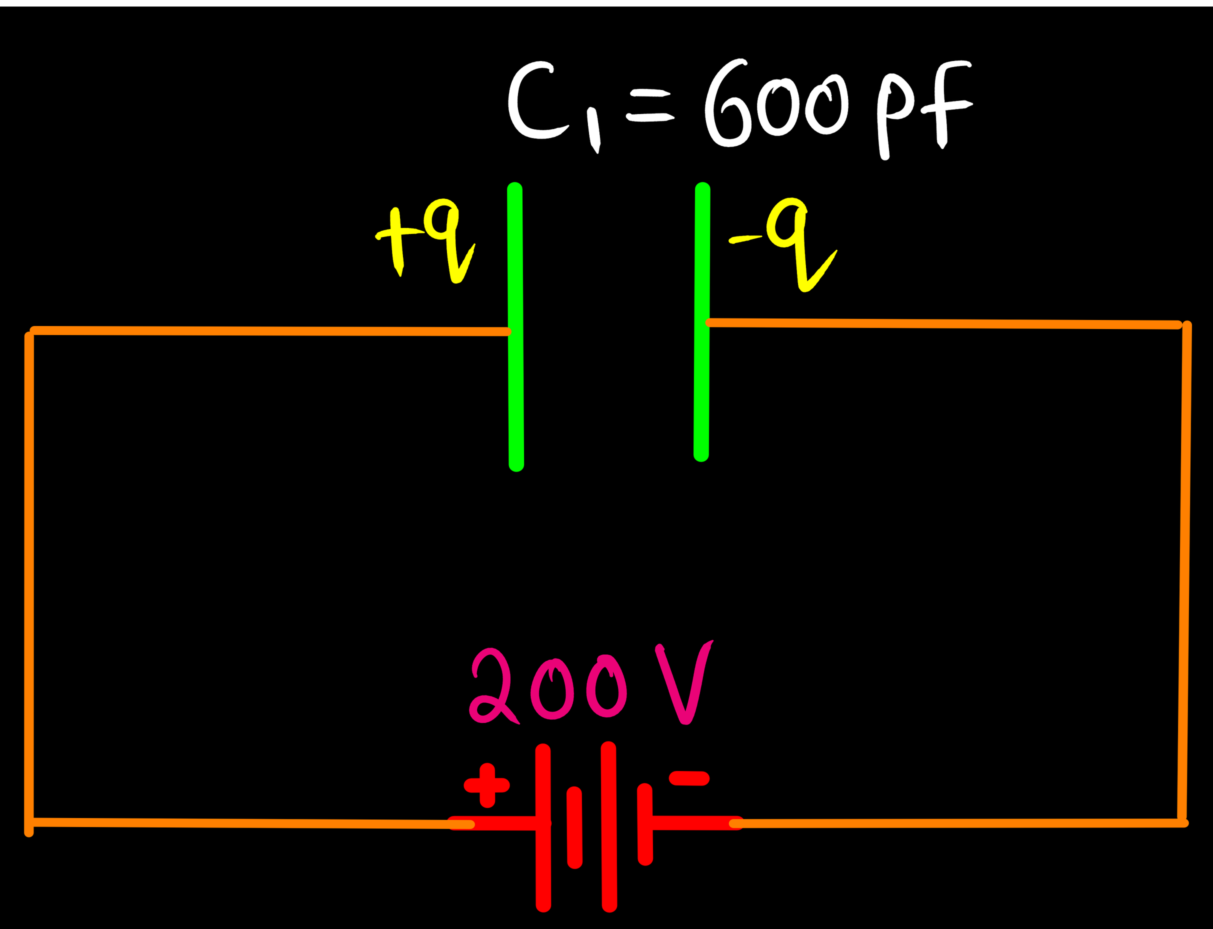
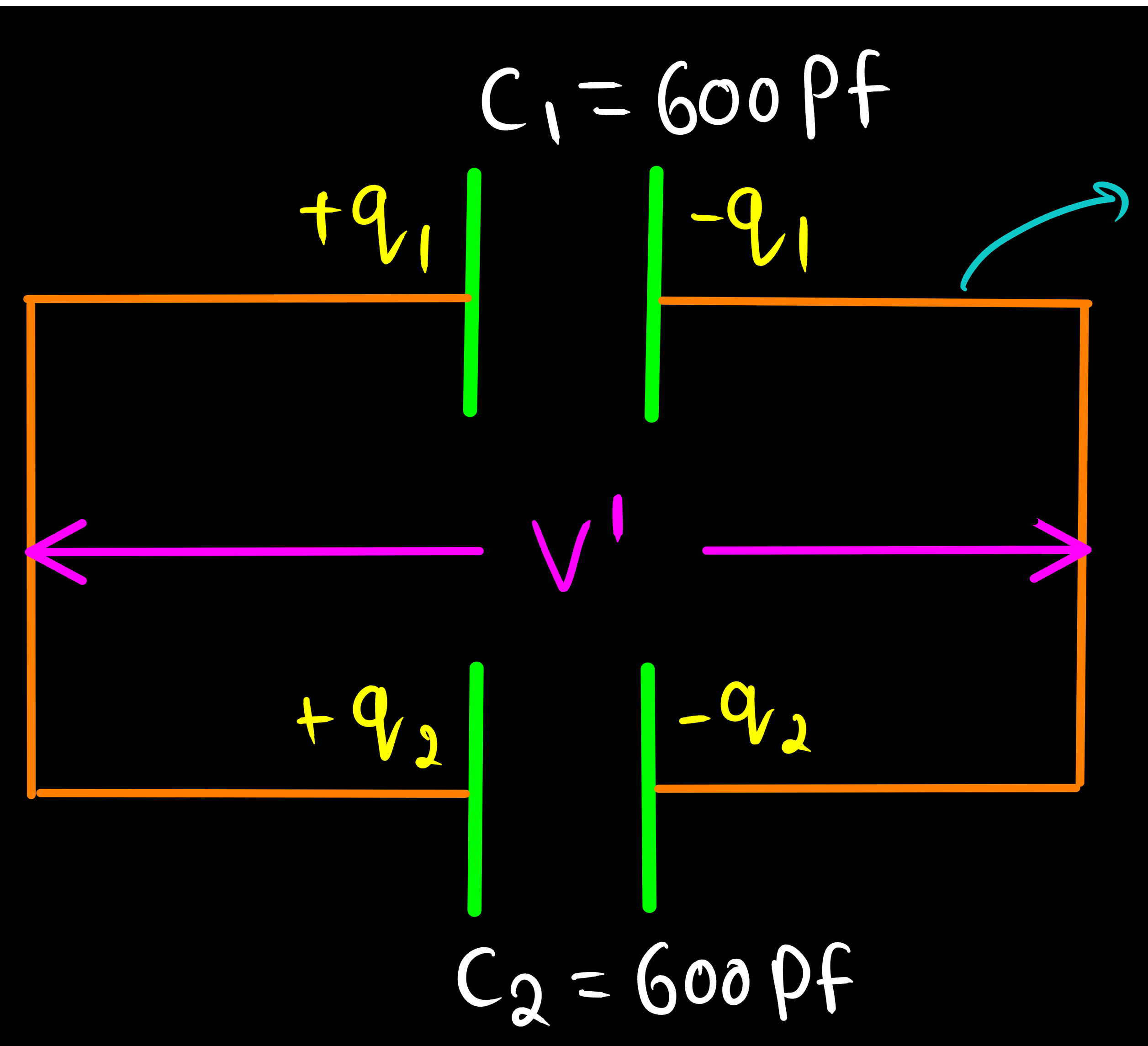


* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{2} \times 600 \times 10^{-12} \times 4 \times 10^{4}$$



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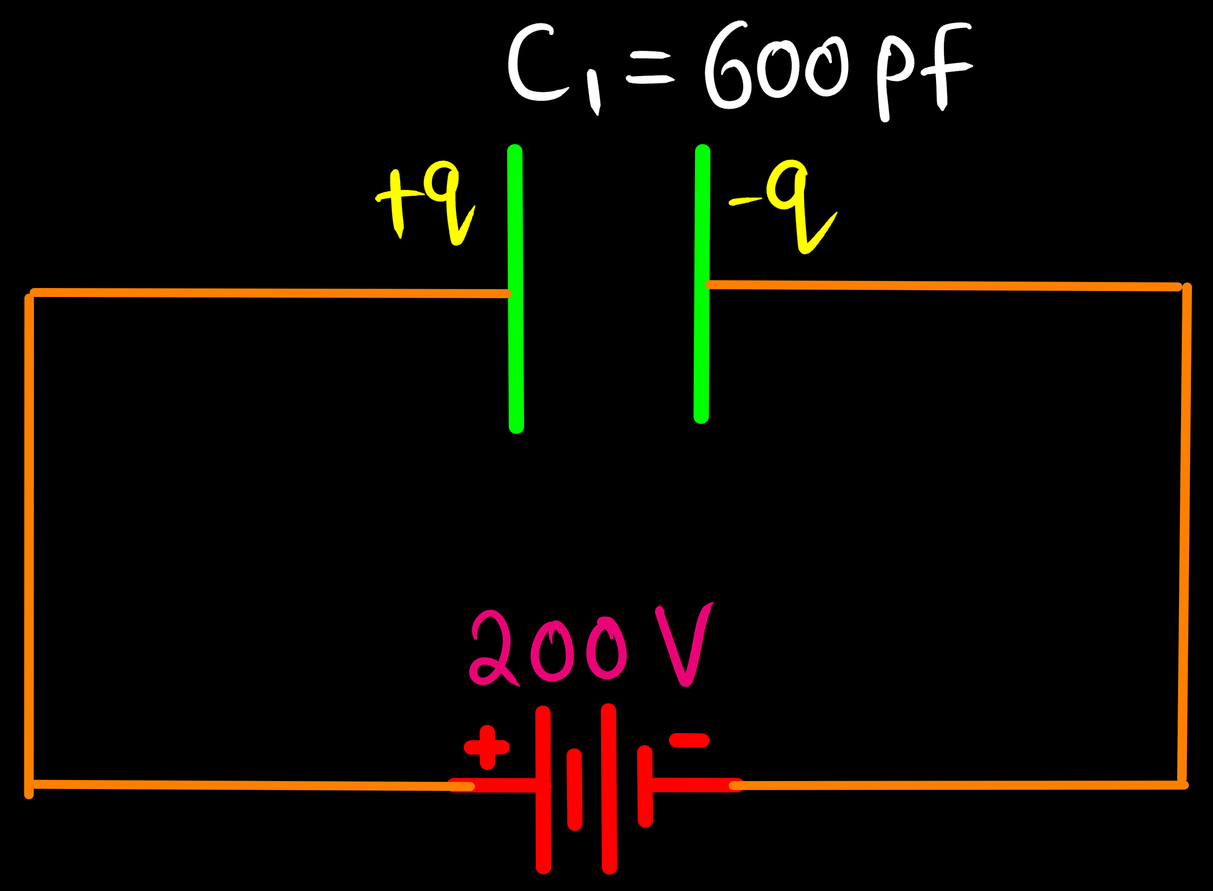

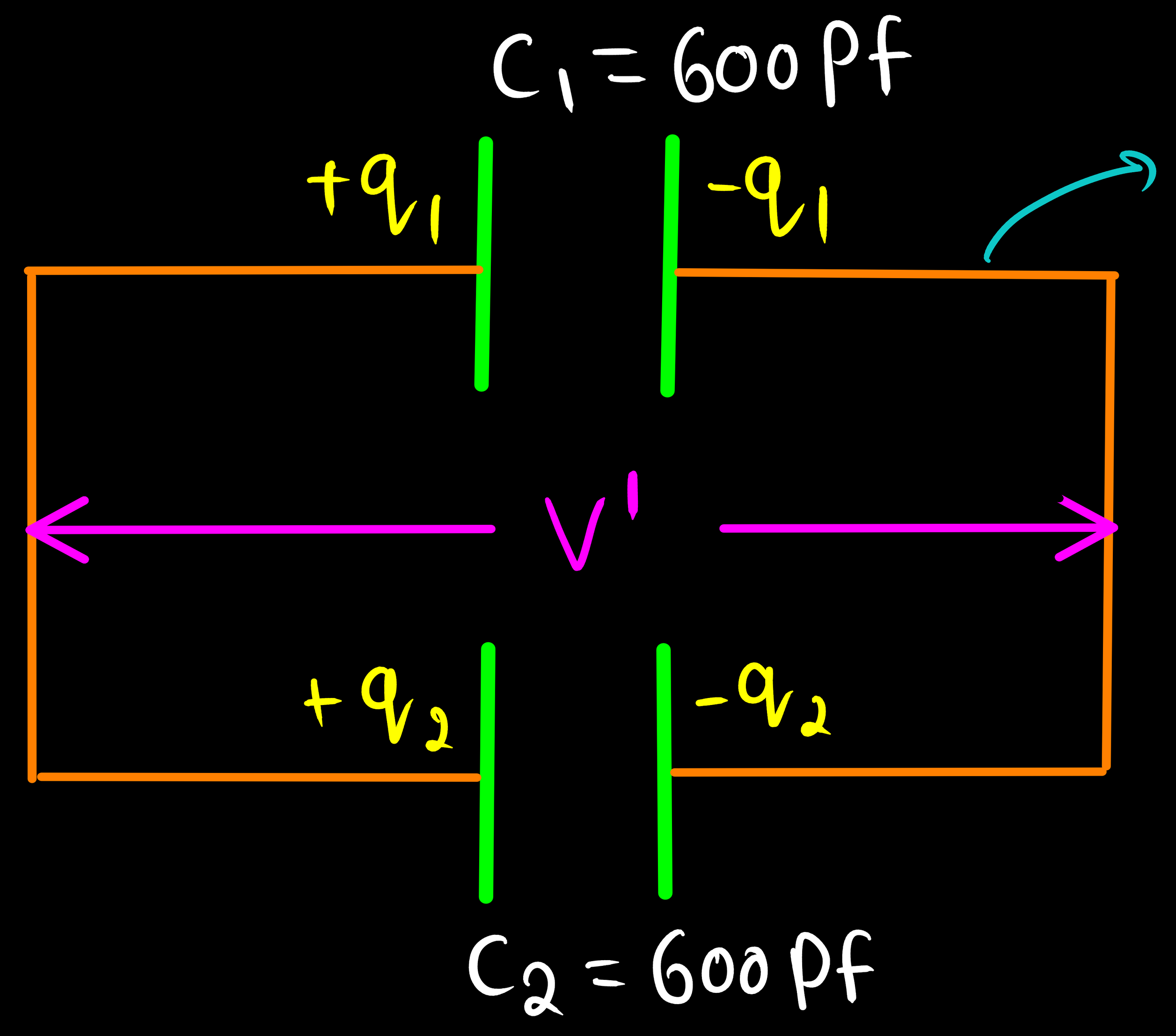

Charge will flow from C_1 to C_2 untill both capacitor have common potential.

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* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{\,2} \times 10^{4}$$

$$U_i = 12 \times 10^{-6} \text{ J}$$

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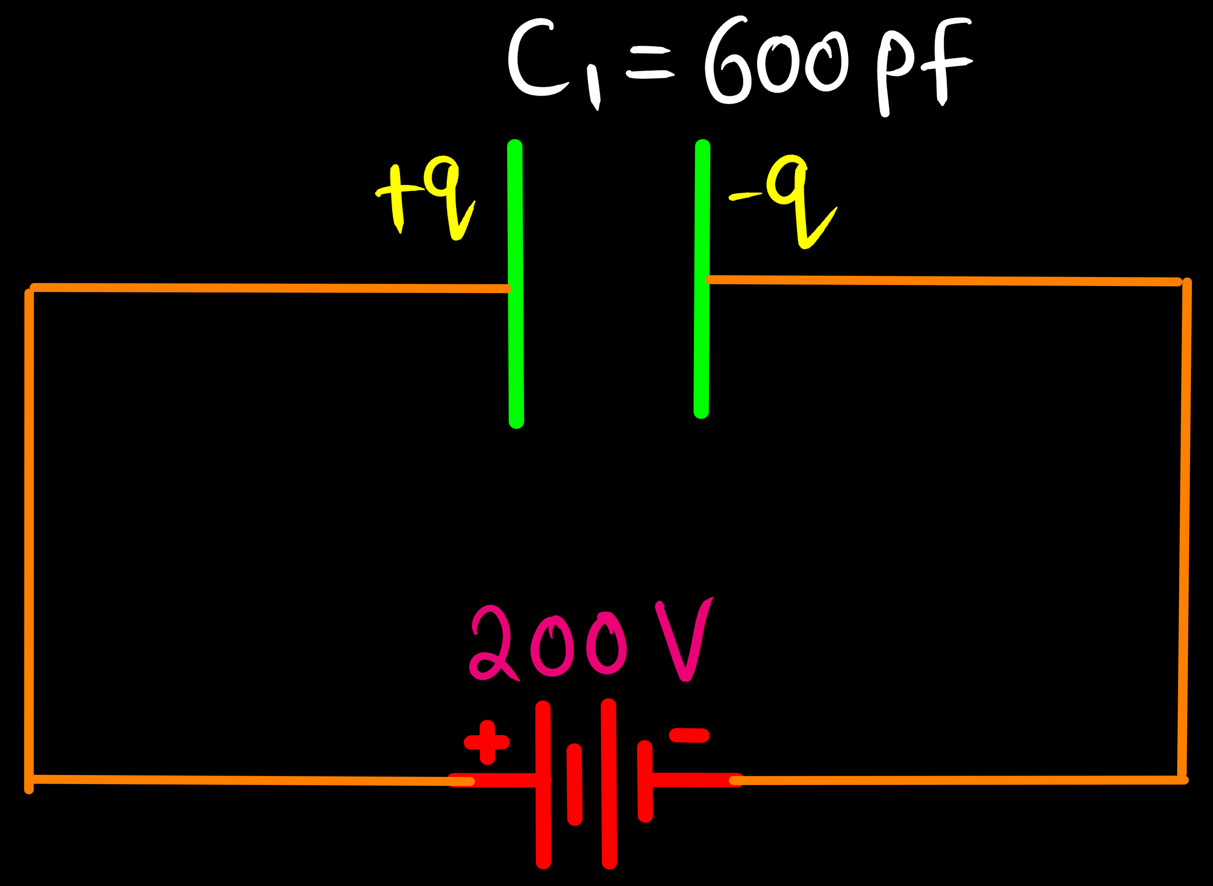

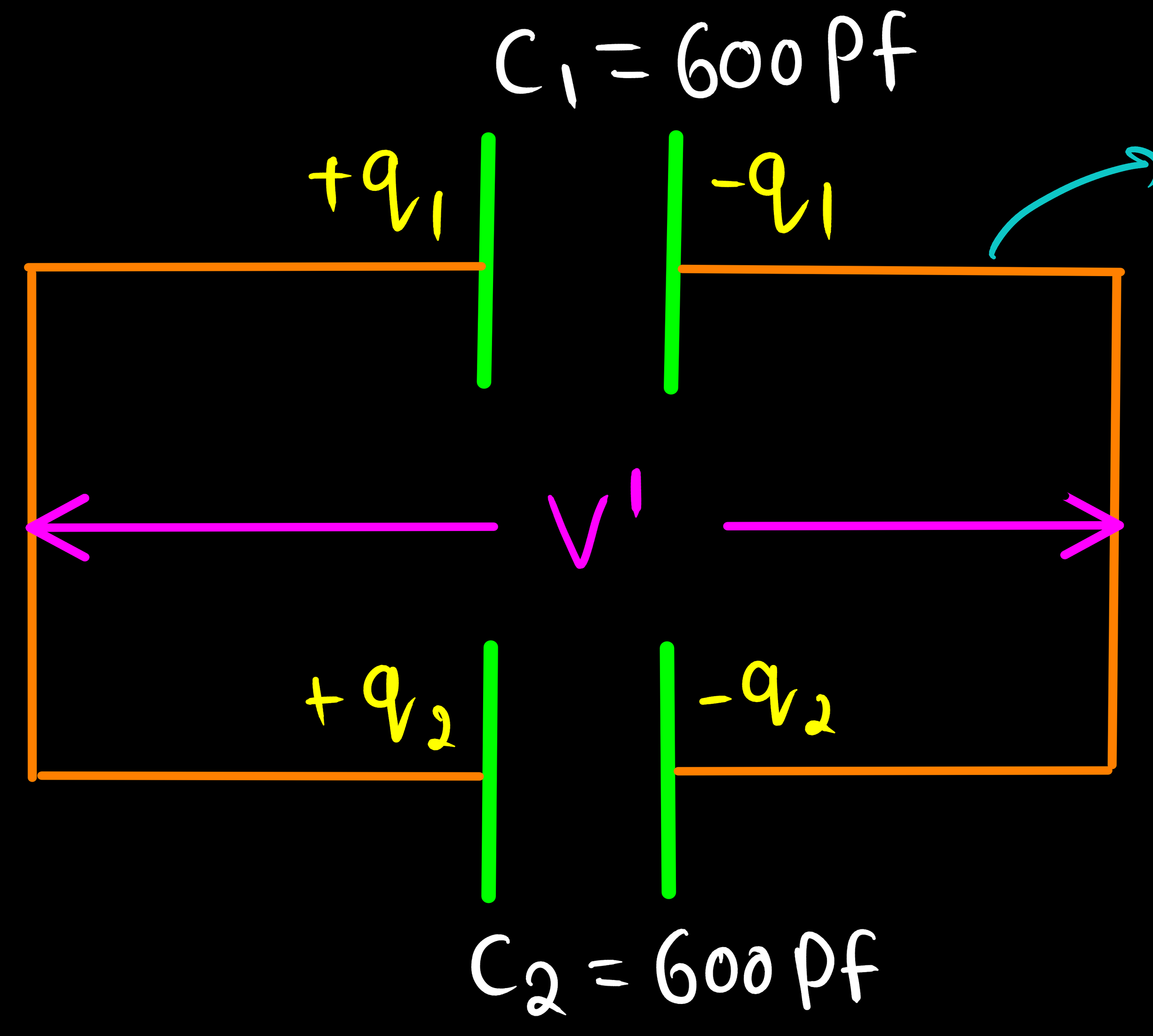

Charge will flow from C_1 to C_2 untill both Capacitor have Common potential.

$q_1 + q_2 = q$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

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$$\frac{C}{V'} + \frac{C}{V'} = q$$

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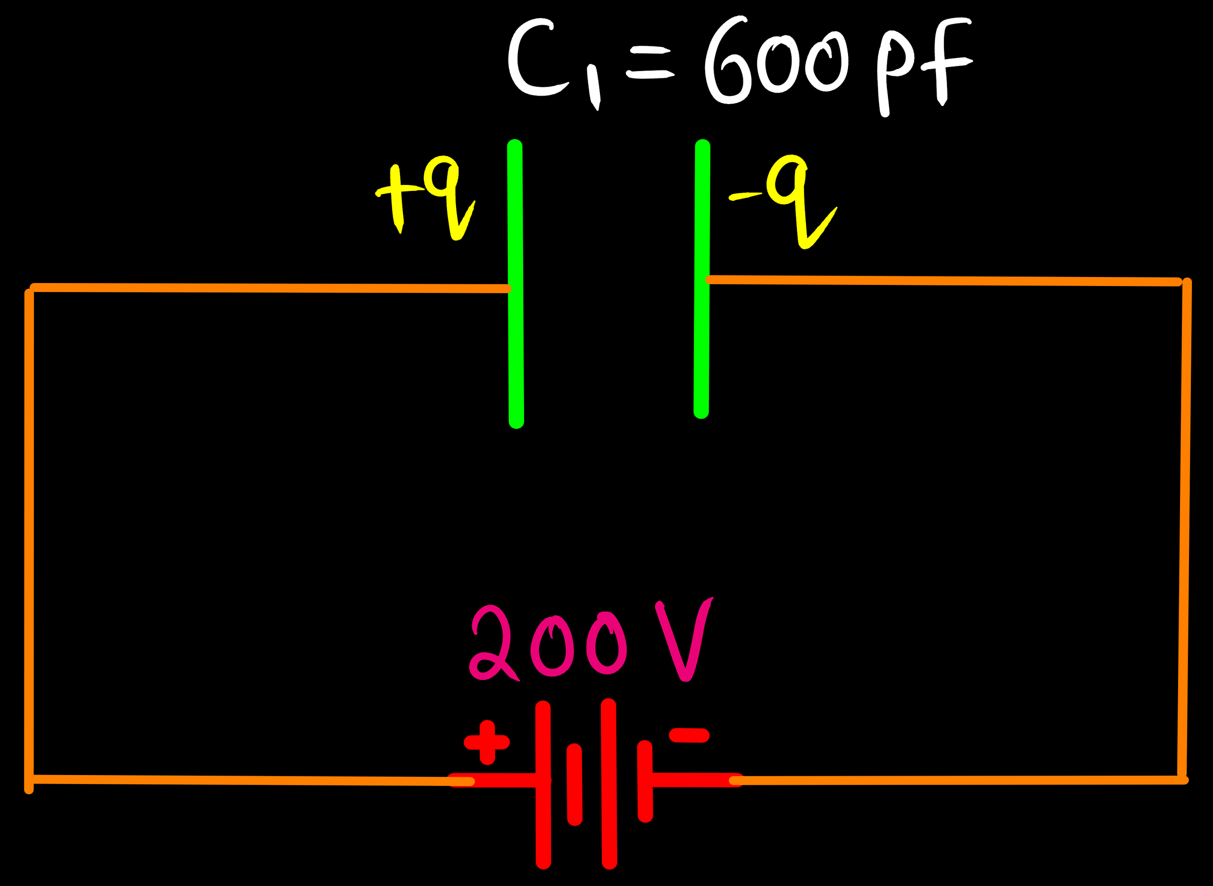

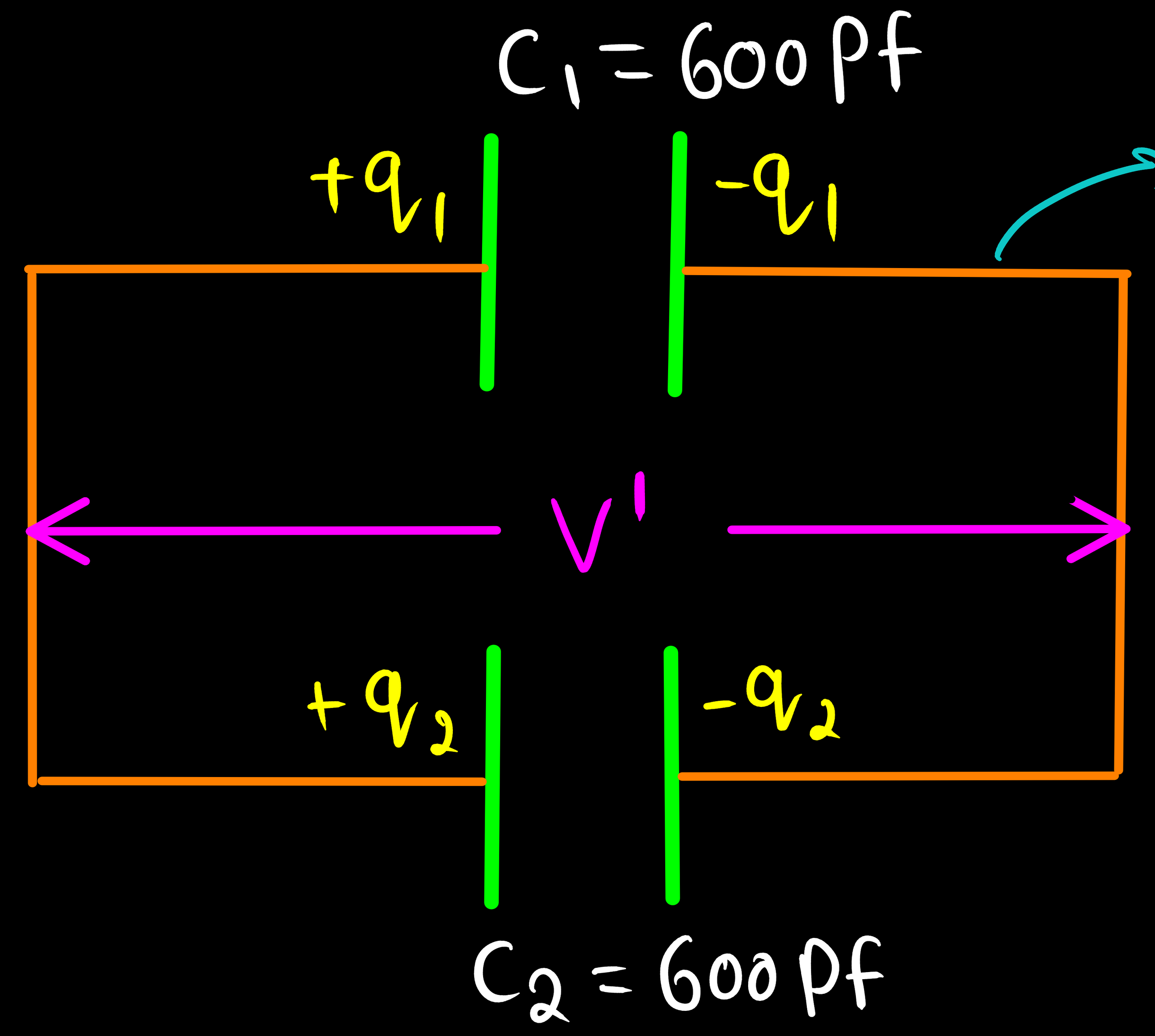

Charge will flow from C_1 to C_2 untill both capacitor have common potential.

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$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C}$$

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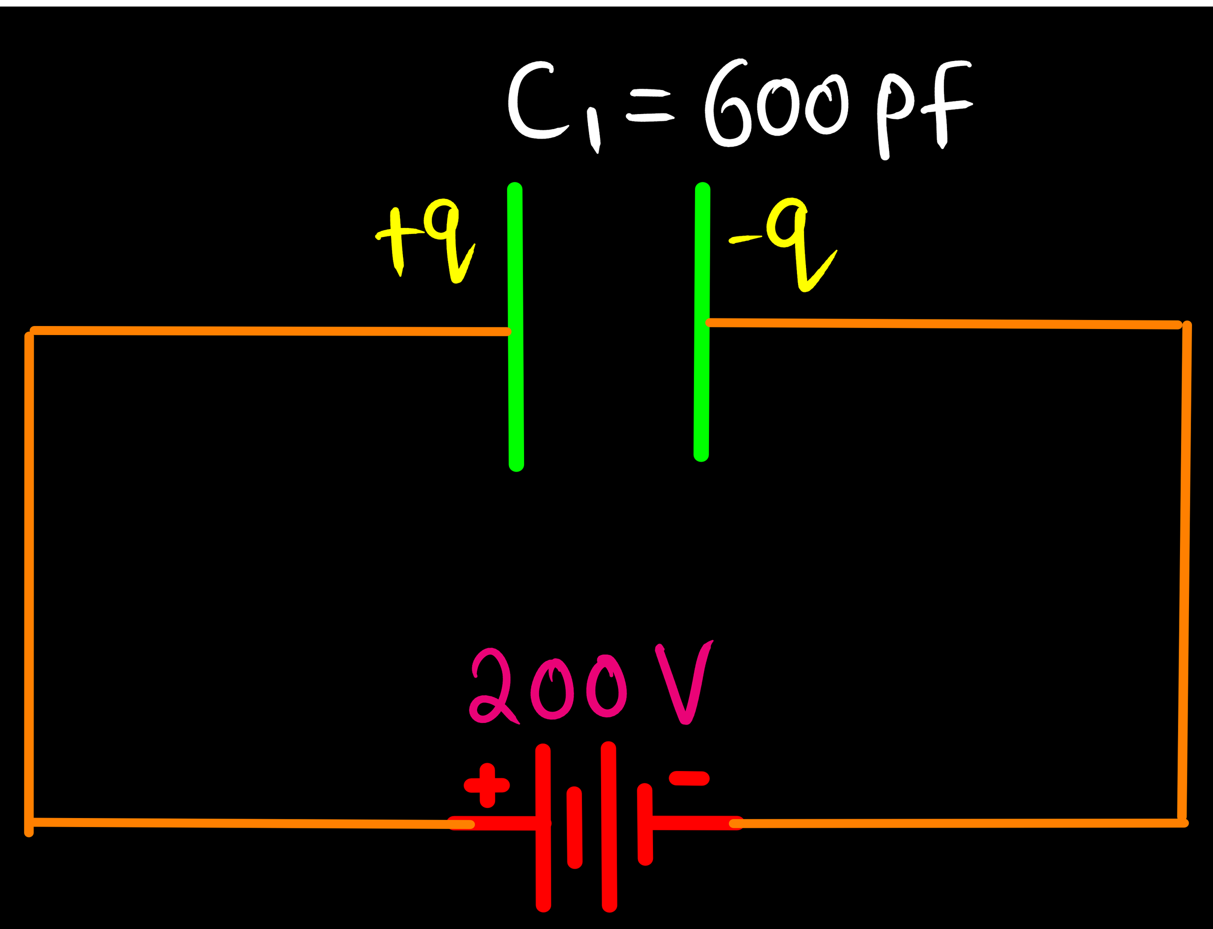

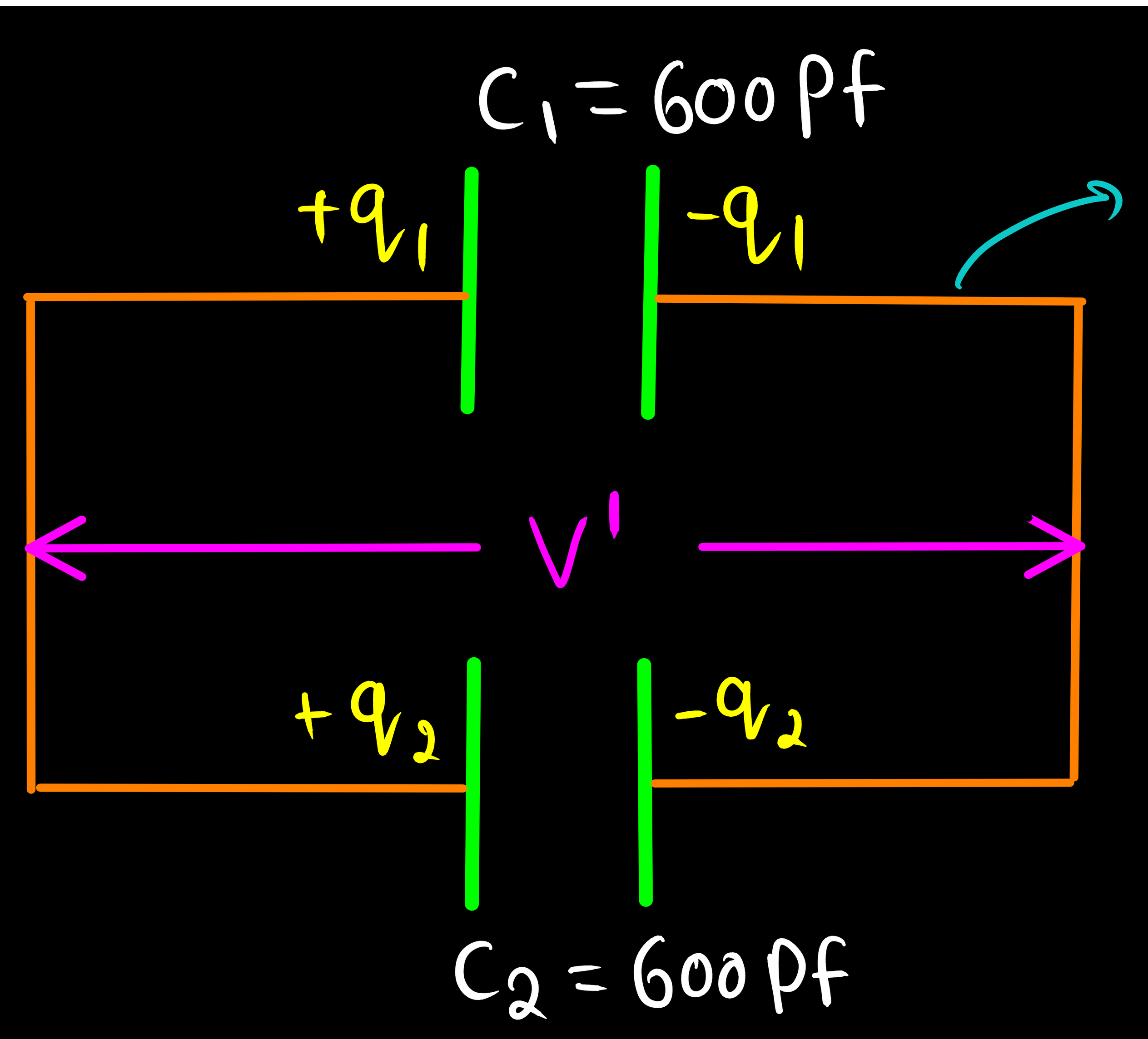

Charge will flow from C_1 to C_2 untill both Capacitor have Common potential.

$q_1 + q_2 = q$

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* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{2} \times 10^{4}$$

$$U_i = 12 \times 10^{-6}\ J$$

* $q_1 + q_2 = q$

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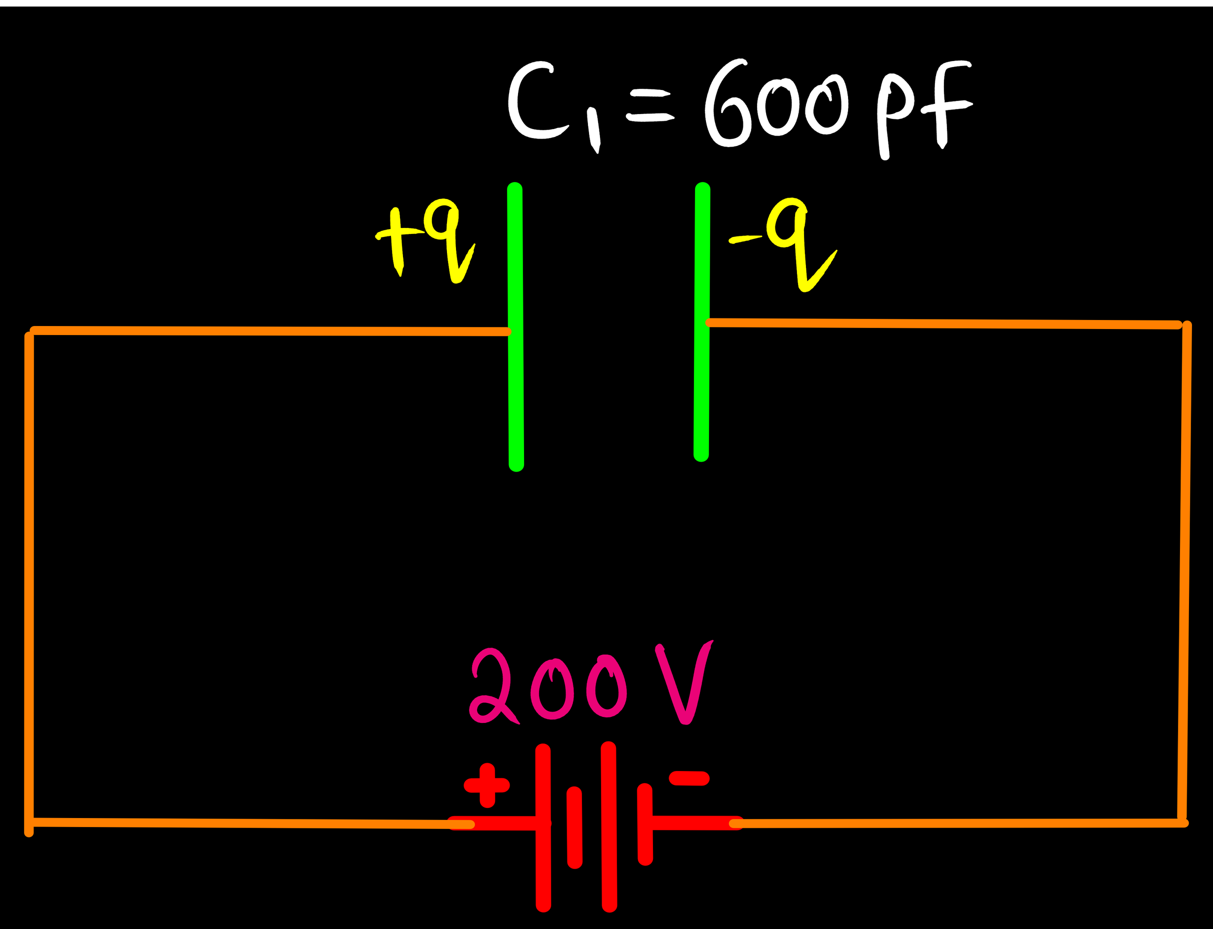

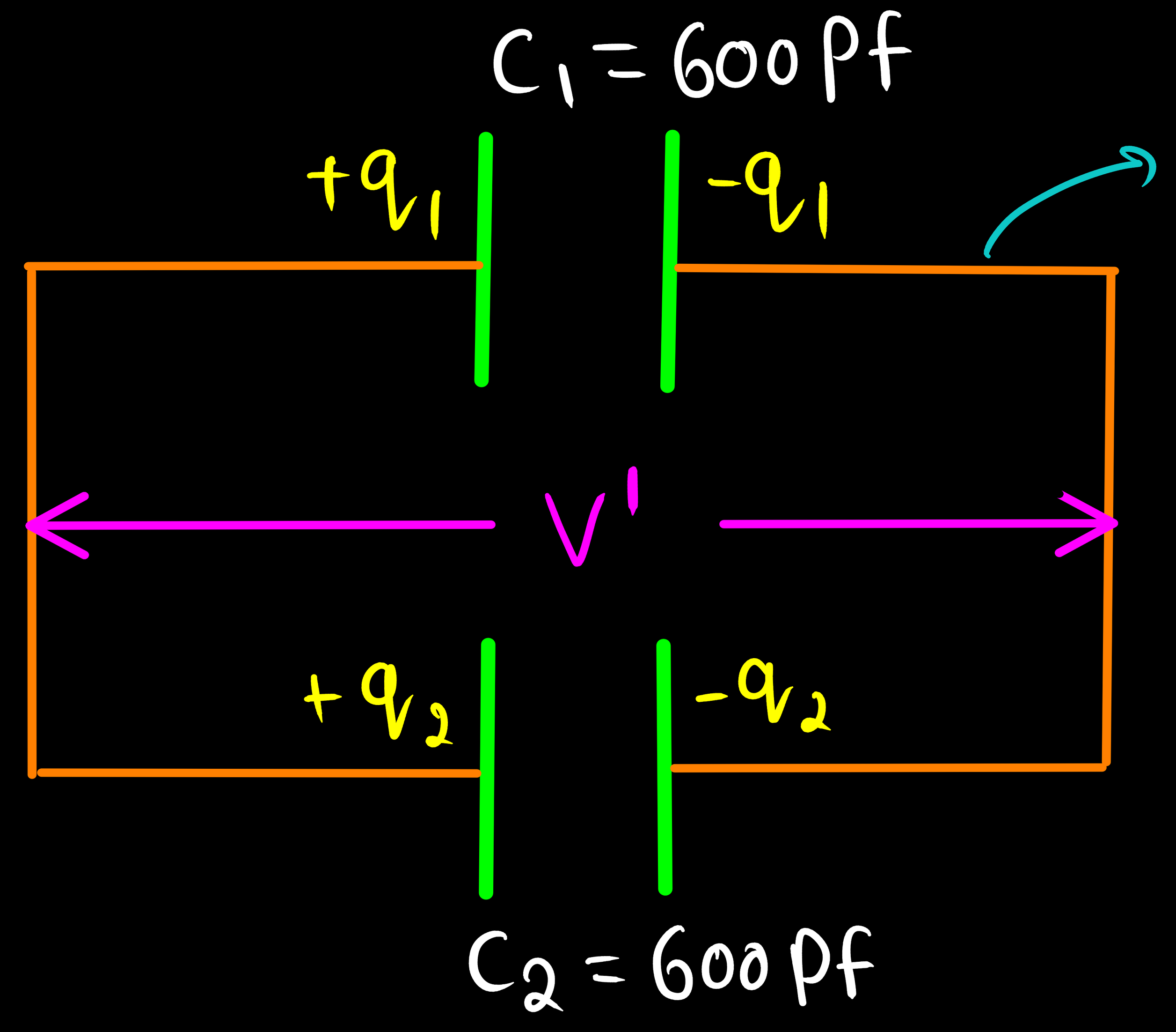

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$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \overset{2}{\cancel{4}} \times 10^4$$

$$U_i = 12 \times 10^{-6}\ J$$

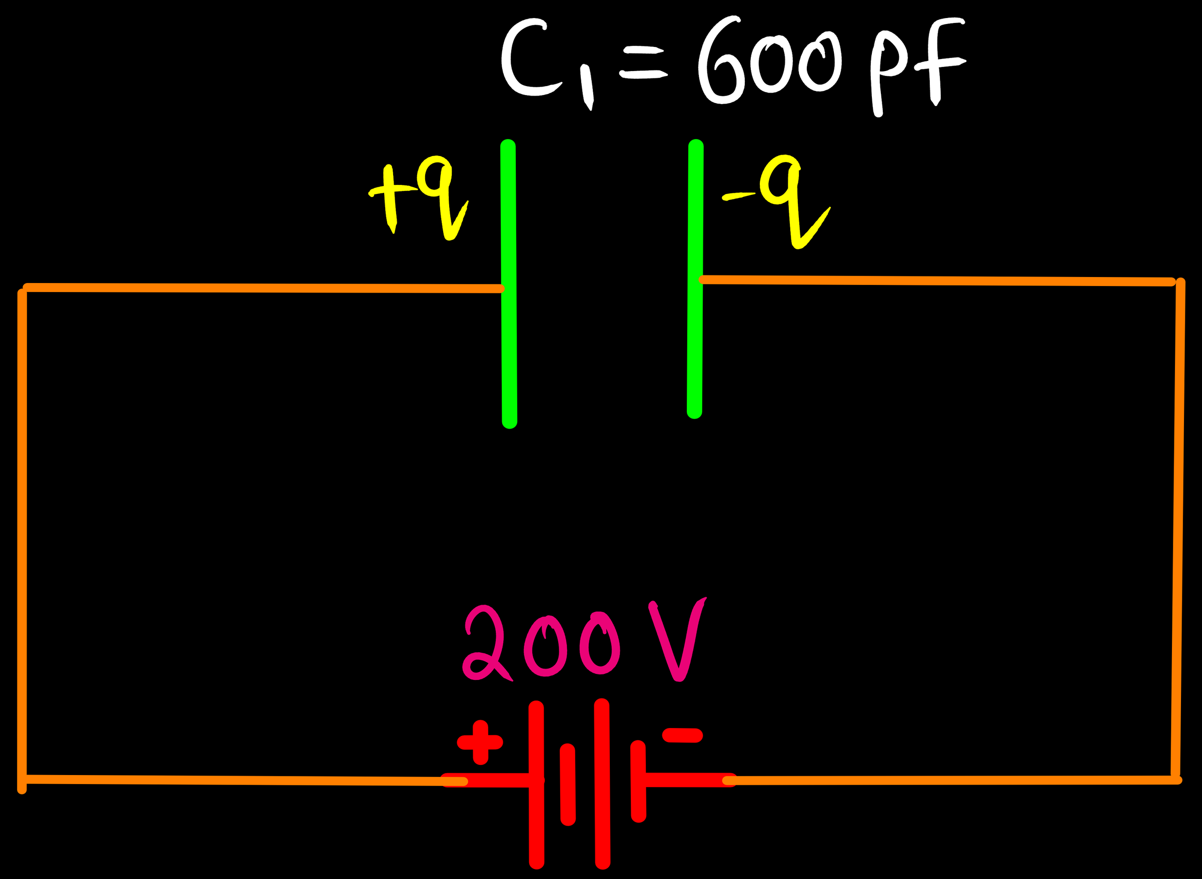
* $q_1 + q_2 = q$

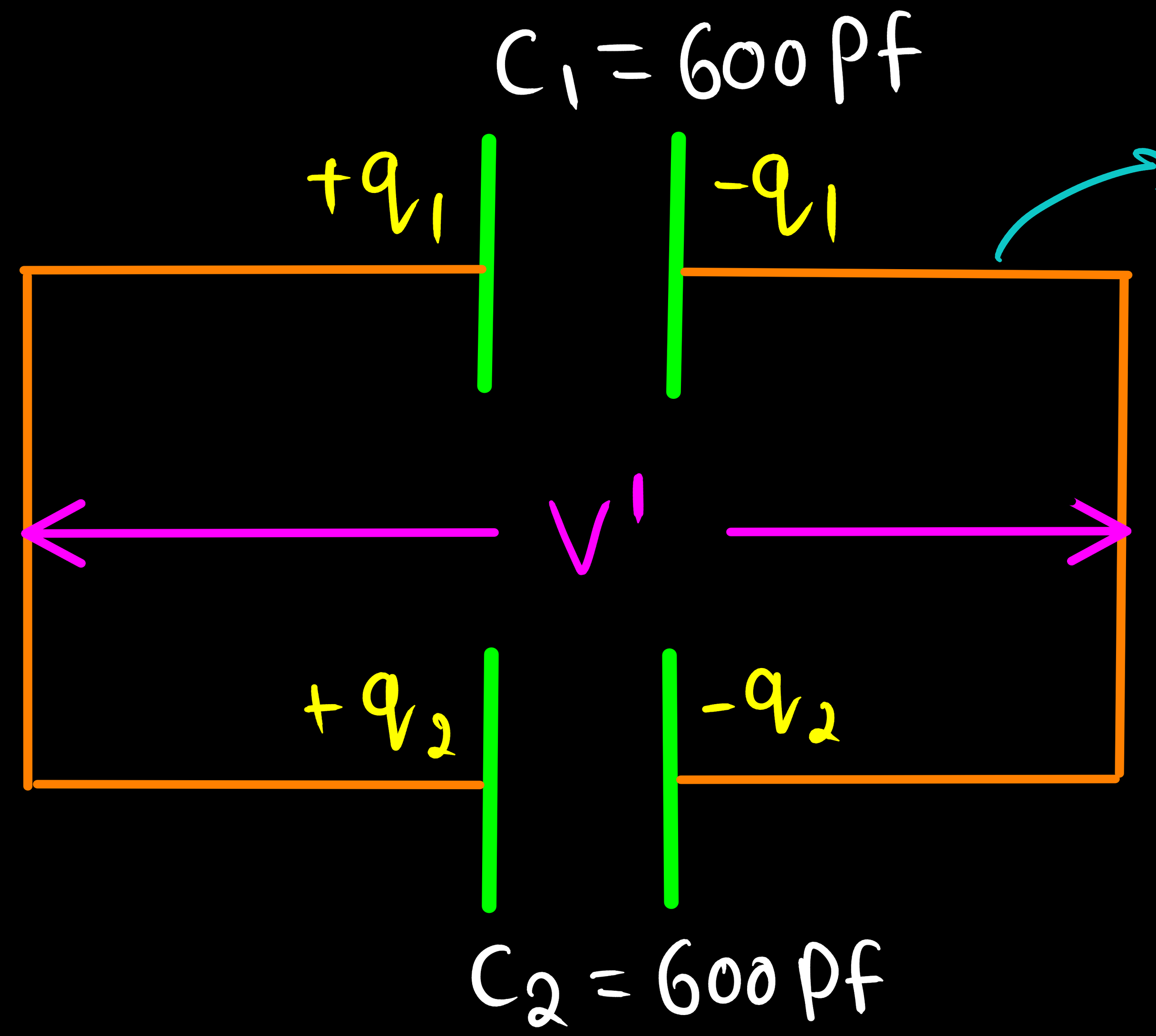
$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100V$$

2.11 A 600pF capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?





Charge will flow from C_1 to C_2 untill both capacitor have common potential.

$$q_1 + q_2 = q$$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \overset{2}{\cancel{4}} \times 10^4$$

$$U_i = 12 \times 10^{-6}\ J$$

* $q_1 + q_2 = q$

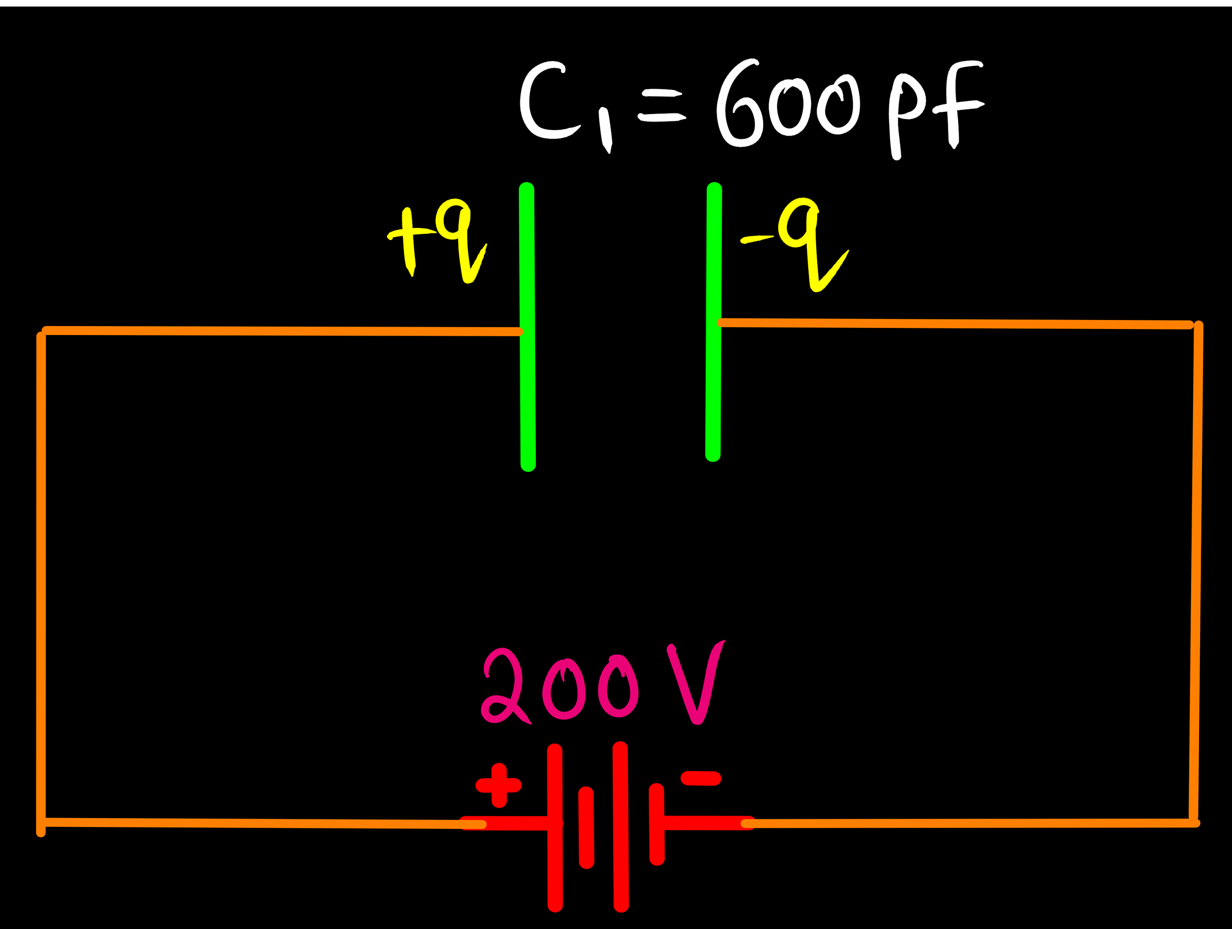
$$\frac{c}{V'} + \frac{c}{V'} = q$$

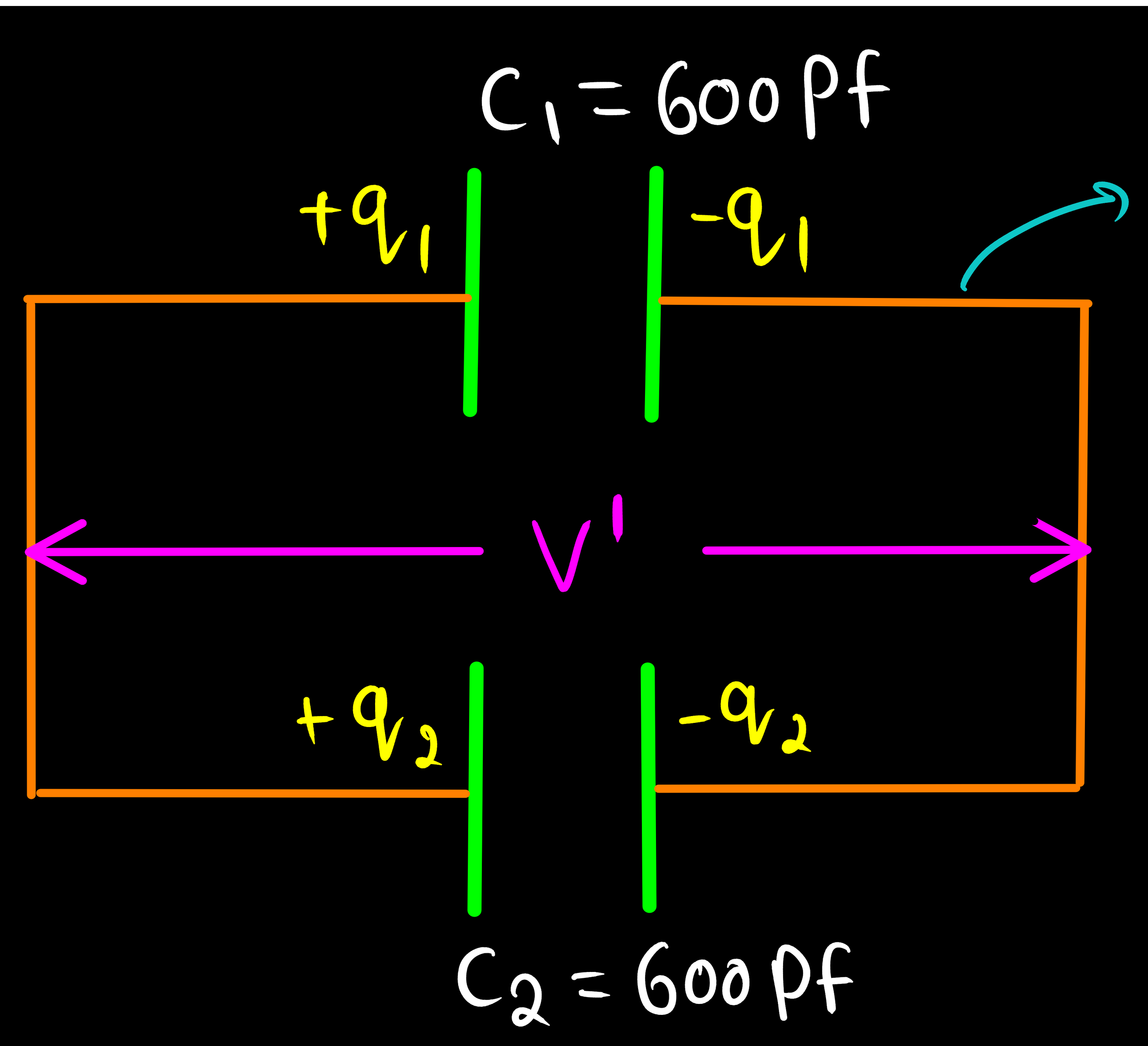
$$\frac{2c}{V'} = q$$

$$V' = \frac{q}{2c} = \frac{V}{2} = \frac{200}{2} = 100\,V$$

$$C' = C_1 + C_2 = 1200\ pF$$

2.11 A 600pF capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?





Charge will flow from C_1 to C_2 untill both capacitor have common potential.

$q_1 + q_2 = q$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{2} \times 10^4$$

$$U_i = 12 \times 10^{-6}\ J$$

* $q_1 + q_2 = q$

$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100V$$

$C' = C_1 + C_2 = 1200\ pF$

Final Potential Energy –

$$U_f = \frac{1}{2} C' V'^2$$

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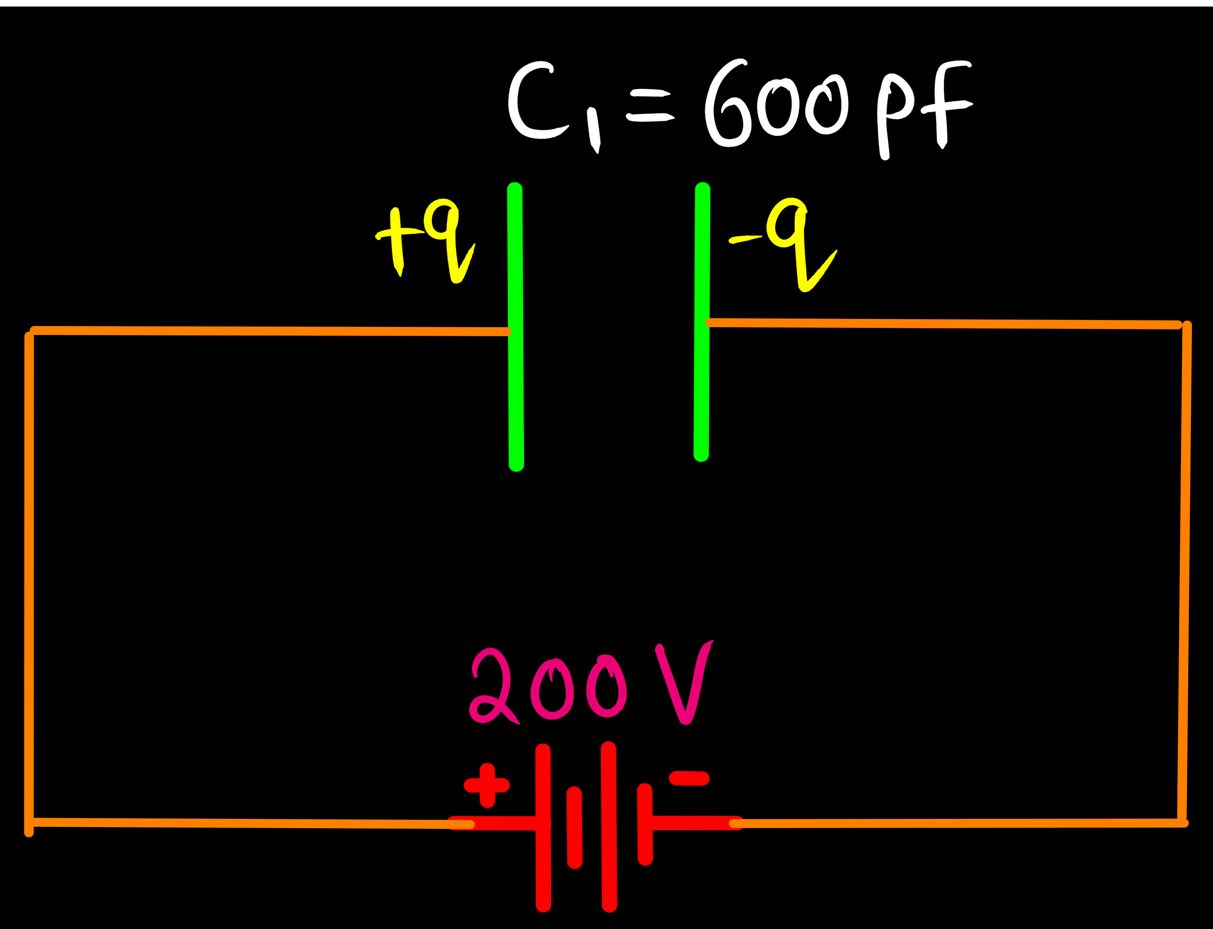

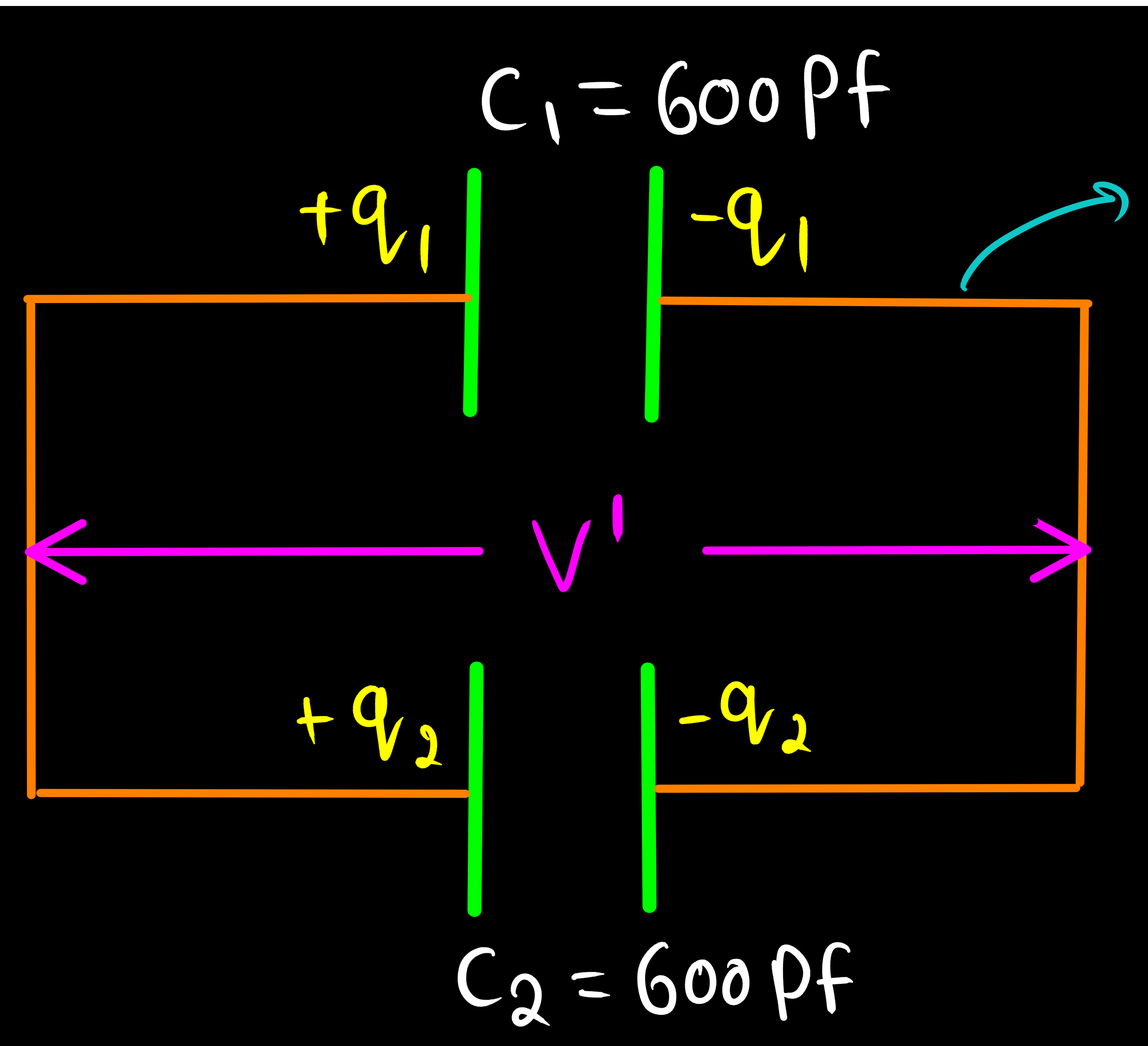

Charge will flow from C_1 to C_2 untill both capacitor have common potential.

$q_1 + q_2 = q$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{\,2} \times 10^4$$

$$U_i = 12 \times 10^{-6} \text{ J}$$

* $q_1 + q_2 = q$

$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100\text{V}$$

$C' = C_1 + C_2 = 1200$ pF

Final Potential Energy -

$$U_f = \frac{1}{2} C' V'^2$$

$$U_f = \frac{1}{2} \times 1200 \times 10^{-12} \times 100 \times 100$$

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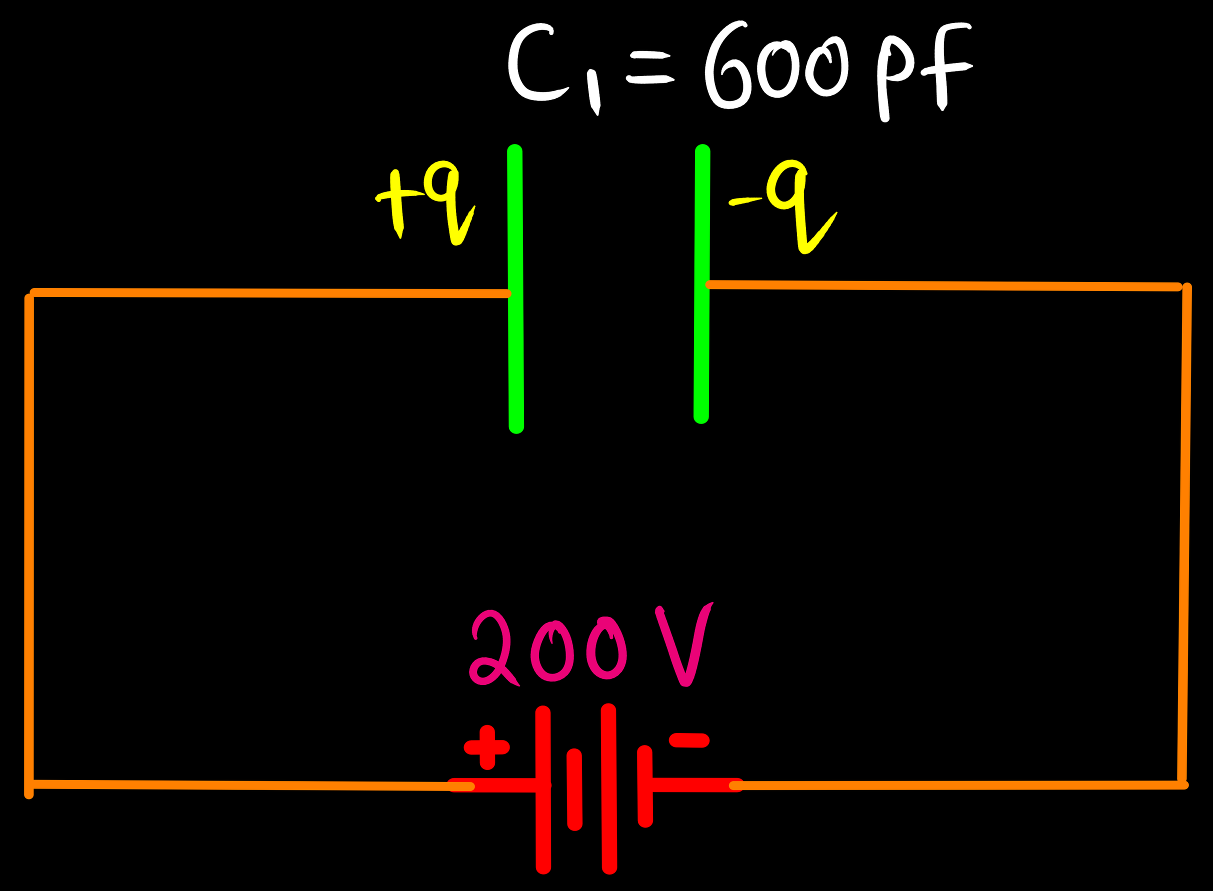

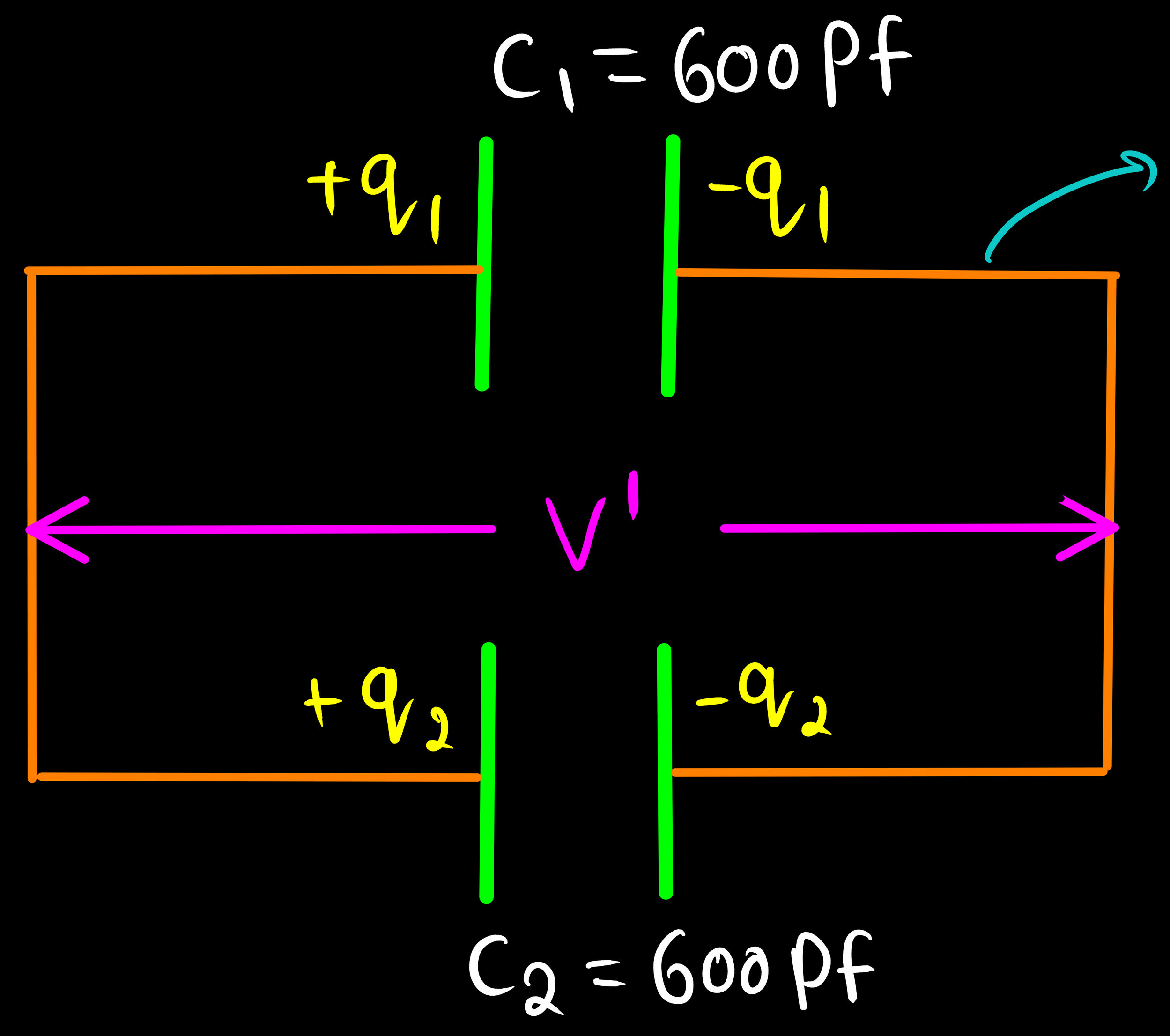

Charge will flow from C_1 to C_2 untill both capacitor have common potential.

$q_1 + q_2 = q$

↳ Conservation of Charge.

* Initial potential energy

$U_i = \frac{1}{2} C_1 V^2$

$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{2} \times 10^4$

$\boxed{U_i = 12 \times 10^{-6} \text{ J}}$

* $q_1 + q_2 = q$

$\frac{c}{V'} + \frac{c}{V'} = q$

$\frac{2c}{V'} = q$

$V' = \frac{q}{2c} = \frac{V}{2} = \frac{200}{2} = 100V$

$C' = C_1 + C_2 = 1200 \text{ pF}$

Final Potential Energy –

$U_f = \frac{1}{2} C' V'^2$

$U_f = \frac{1}{\cancel{2}} \times \cancel{1200}^{600} \times 10^{-12} \times 100 \times 100$

$\boxed{U_f = 6 \times 10^{-6} \text{ J}}$

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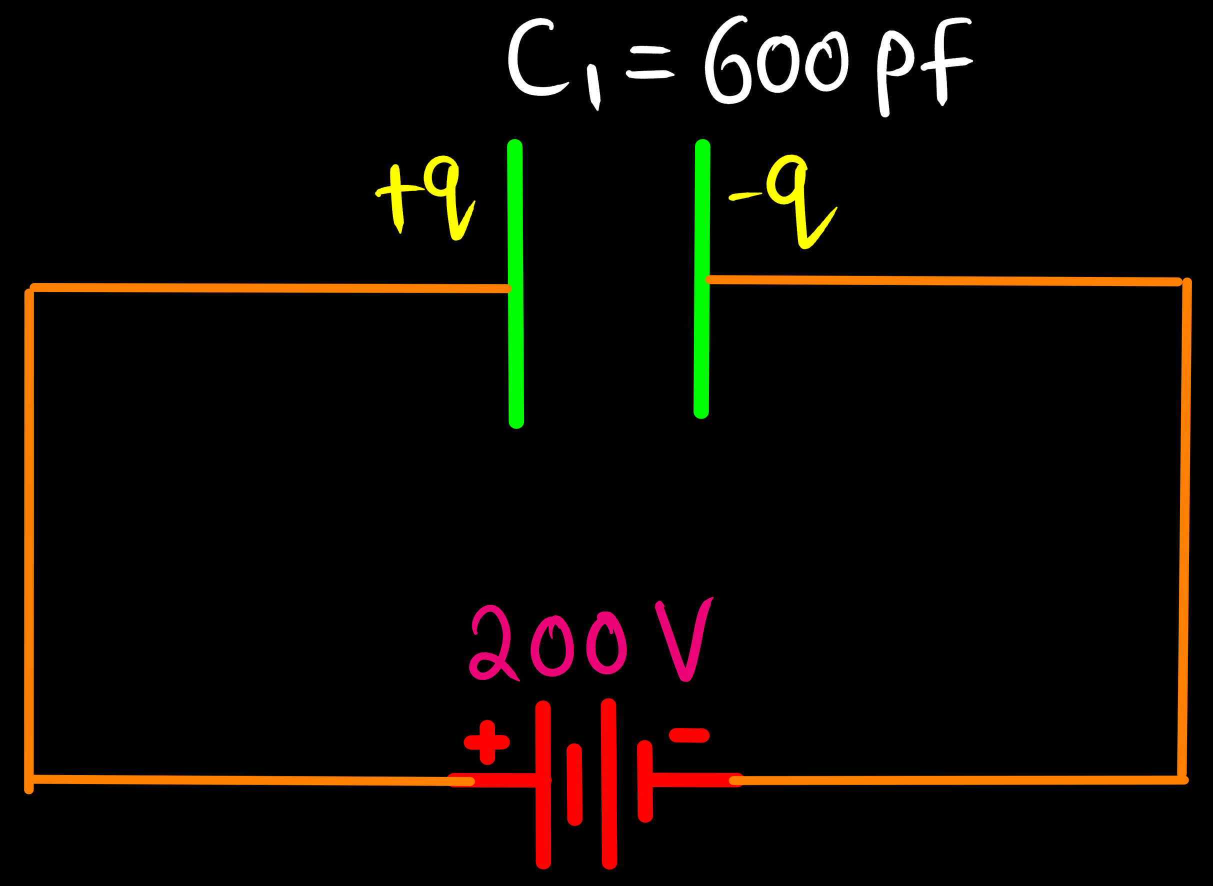

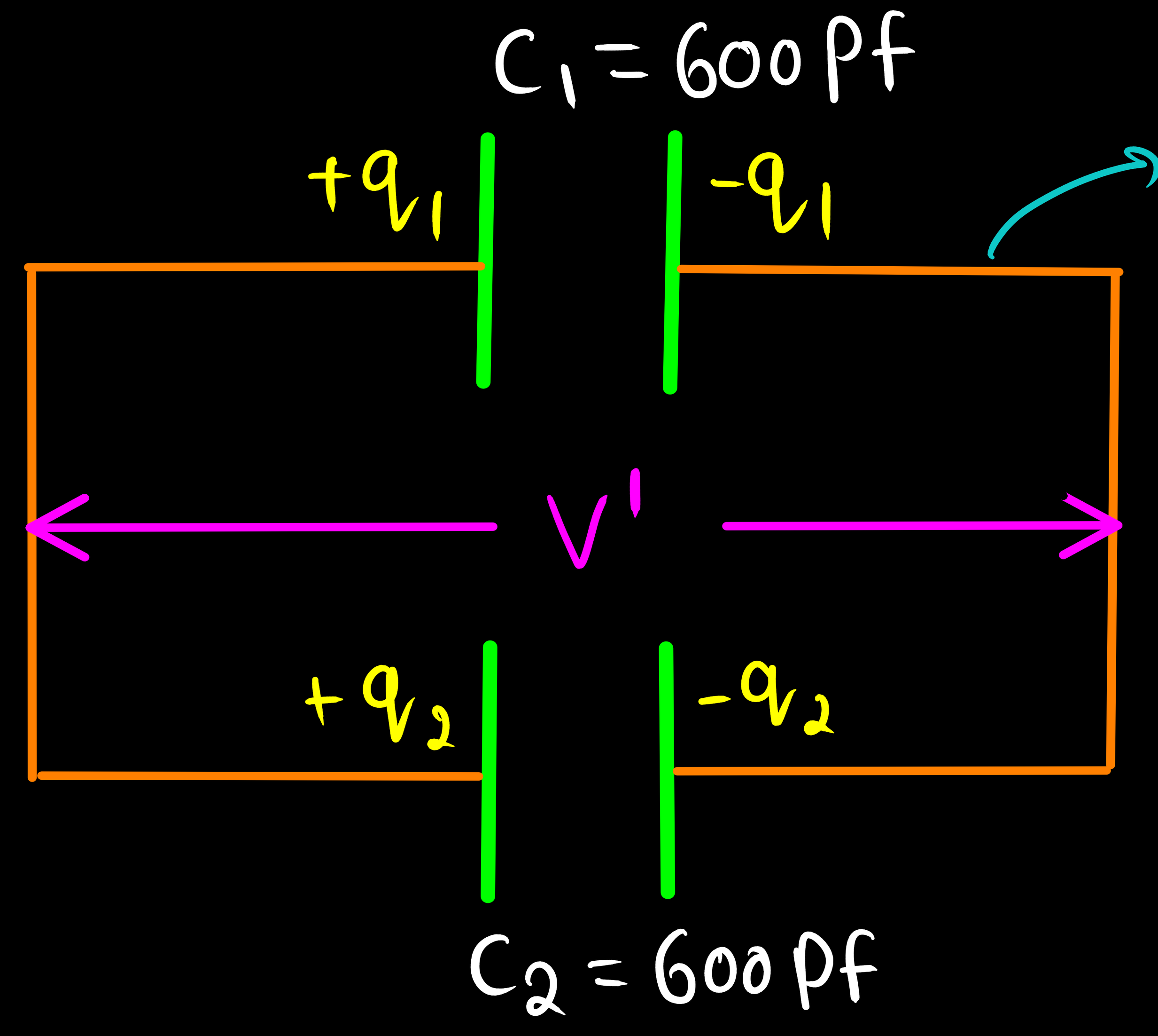

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* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{2} \times 10^4$$

$$\boxed{U_i = 12 \times 10^{-6}\ J}$$

* $q_1 + q_2 = q$

$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100V$$

$C' = C_1 + C_2 = 1200\ pF$

Final Potential Energy –

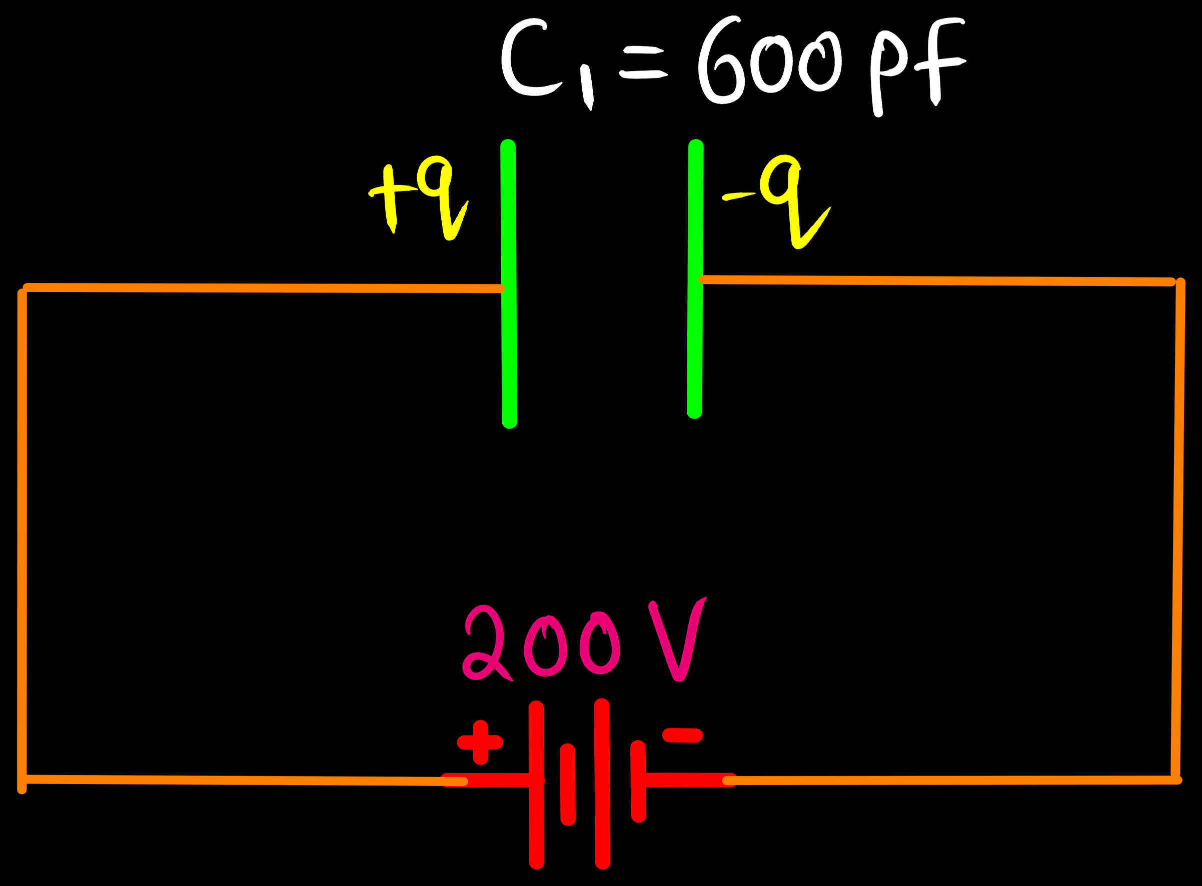
$$U_f = \frac{1}{2} C' V'^2$$

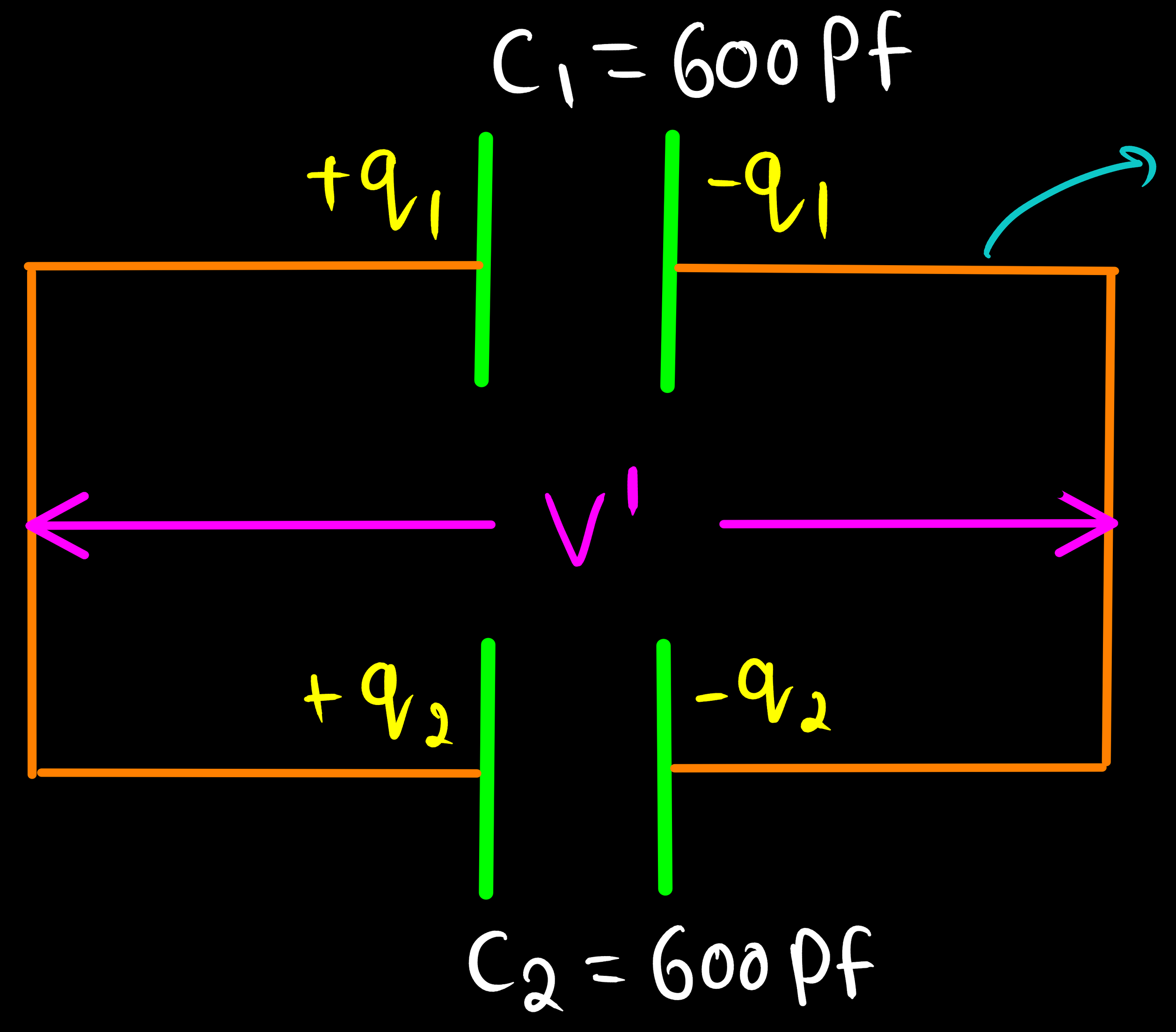
$$U_f = \frac{1}{\cancel{2}} \times \cancel{1200}^{600} \times 10^{-12} \times 100 \times 100$$

$$\boxed{U_f = 6 \times 10^{-6}\ J}$$

Energy lost $= U_i - U_f$

2.11 A 600pF capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?





Charge will flow from C_1 to C_2 untill both Capacitor have Common potential.

$q_1 + q_2 = q$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \overset{2}{\cancel{4}} \times 10^4$$

$$\boxed{U_i = 12 \times 10^{-6}\ J}$$

* $q_1 + q_2 = q$

$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100\,V$$

$C' = C_1 + C_2 = 1200\ pF$

Final Potential Energy –

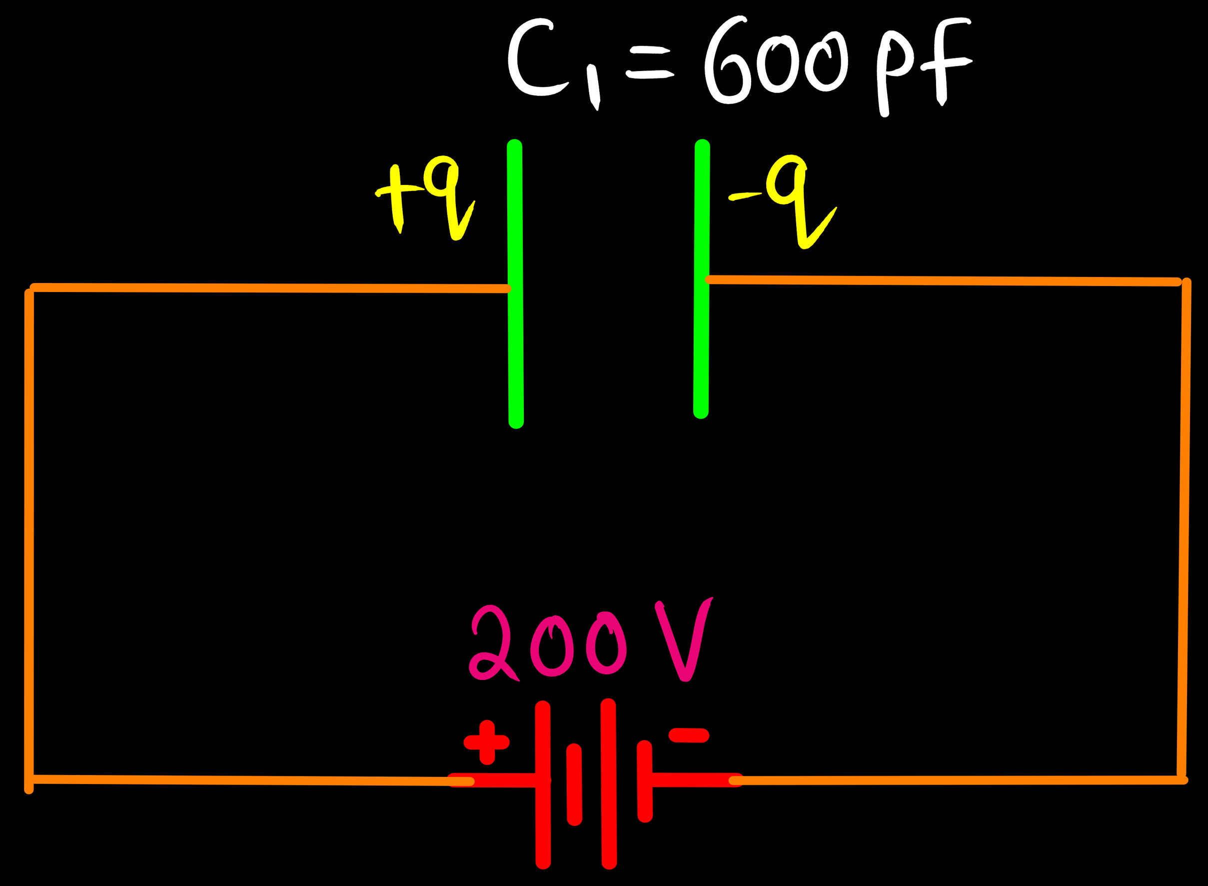
$$U_f = \frac{1}{2} C' V'^2$$

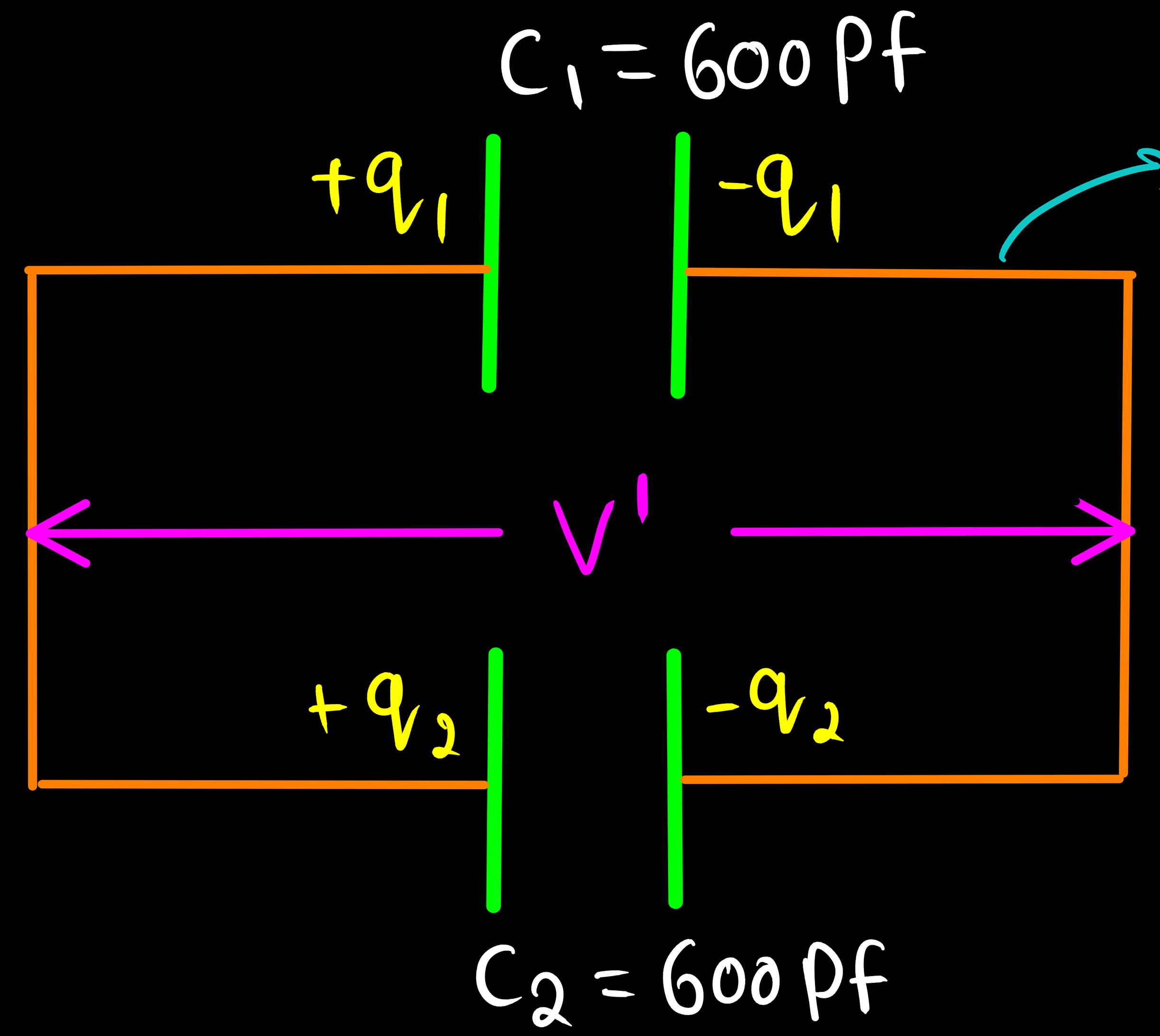
$$U_f = \frac{1}{\cancel{2}} \times \overset{600}{\cancel{1200}} \times 10^{-12} \times 100 \times 100$$

$$\boxed{U_f = 6 \times 10^{-6}\ J}$$

Energy lost $= U_i - U_f = 12 \times 10^{-6}\ J - 6 \times 10^{-6}\ J$

2.11 A 600pF capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?





Charge will flow from C_1 to C_2 untill both capacitor have Common potential.

$$q_1 + q_2 = q$$

↳ Conservation of Charge.

* Initial potential energy

$$U_i = \frac{1}{2} C_1 V^2$$

$$U_i = \frac{1}{\cancel{2}} \times 600 \times 10^{-12} \times \cancel{4}^{\,2} \times 10^4$$

$$\boxed{U_i = 12 \times 10^{-6}\ J}$$

*

$$q_1 + q_2 = q$$

$$\frac{C}{V'} + \frac{C}{V'} = q$$

$$\frac{2C}{V'} = q$$

$$V' = \frac{q}{2C} = \frac{V}{2} = \frac{200}{2} = 100\,V$$

$$C' = C_1 + C_2 = 1200\ pF$$

Final Potential Energy –

$$U_f = \frac{1}{2} C' V'^2$$

$$U_f = \frac{1}{\cancel{2}} \times \cancel{1200}^{\,600} \times 10^{-12} \times 100 \times 100$$

$$\boxed{U_f = 6 \times 10^{-6}\ J}$$

$$\text{Energy lost} = U_i - U_f = 12 \times 10^{-6}\ J - 6 \times 10^{-6}\ J$$

$$\boxed{\text{Energy lost} = 6 \times 10^{-6}\ J}$$