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Electric Potential & Capacitance

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Today's GOALS!

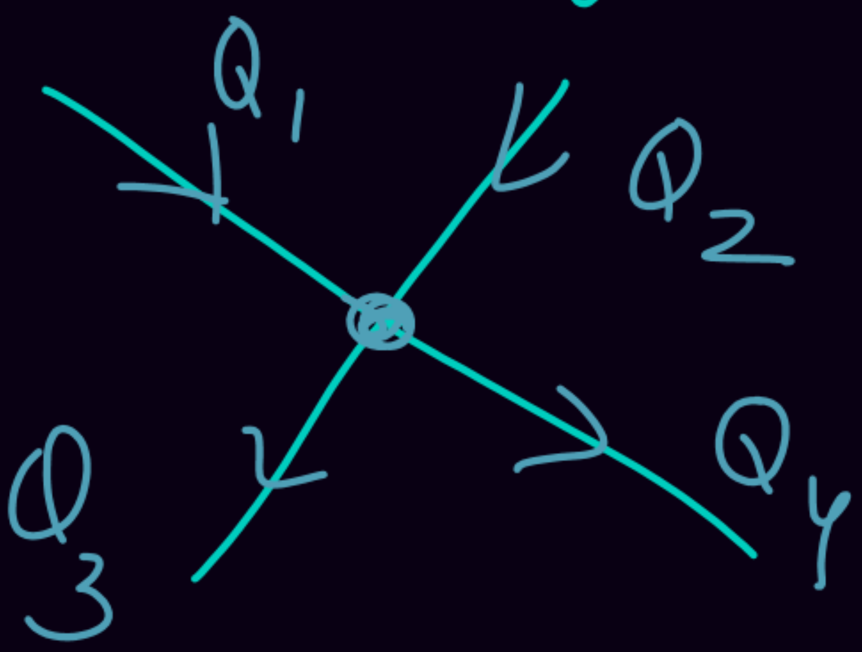
Capacitors

&

Dielectrics

Kirchhoff's rules

1. Kirchhoff's junction rule.



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$$\boxed{Q_1 + Q_2} = \boxed{Q_3 + Q_4}$$

→ Conservation of charge.

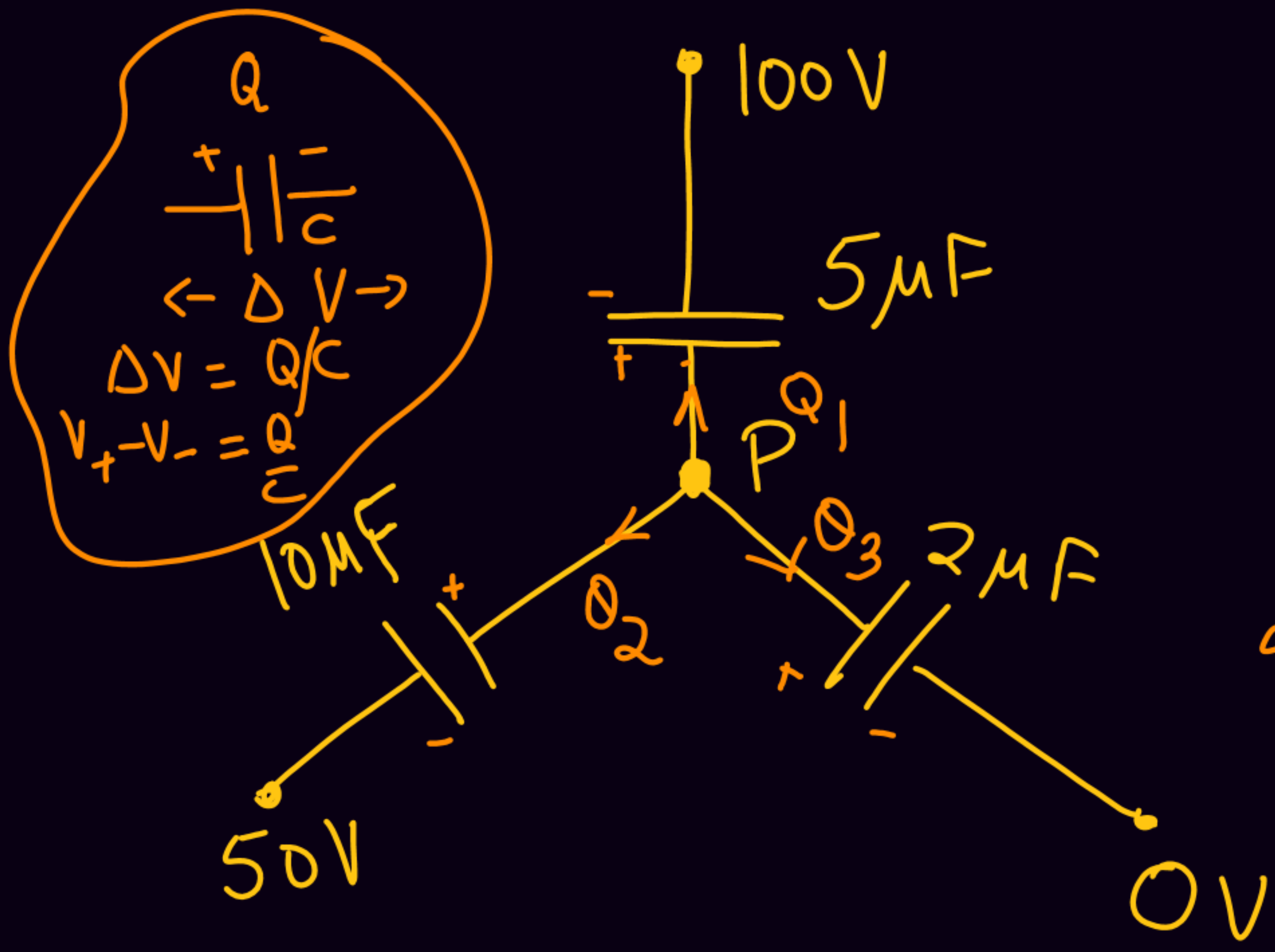
② <u>Kirchhoff's loop rule</u> (conservation of energy)

In a closed circuit net potential difference / drop is zero.

Electrostatic field is a conservative field.

This means the net work done in a closed loop is zero.

$$\Delta V = -\frac{W}{q} = 0$$



Find the potential of the junction.

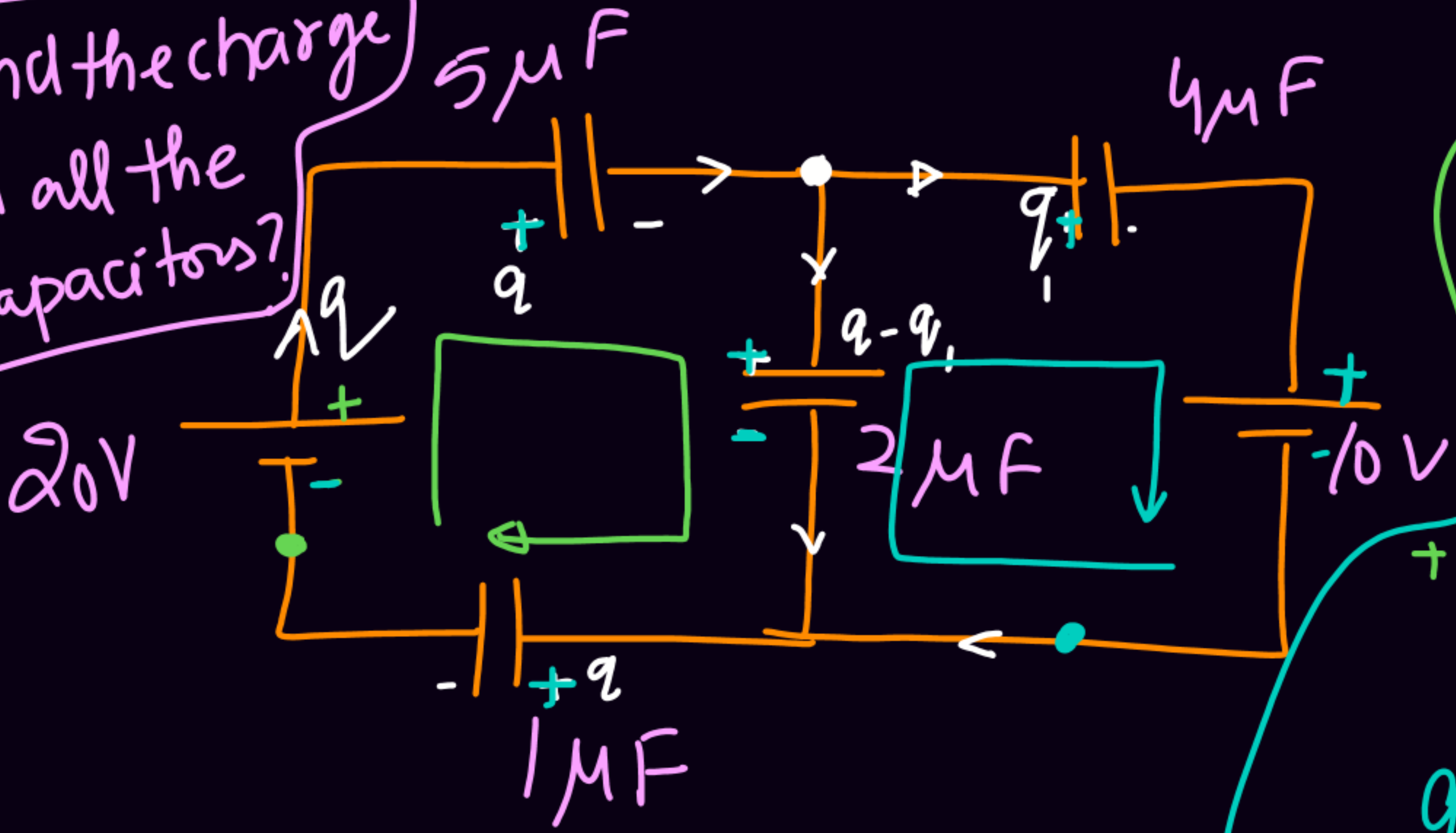
$$Q_1+Q_2+Q_3=0$$

$$5(V_p-100)+(V_p-50)10+(V_p-0)\times 2=0$$

$$17V_p-500-500=0$$

$$V_p=\frac{1000}{17}=58.82\ V.$$

Find the charge on all the capacitors?

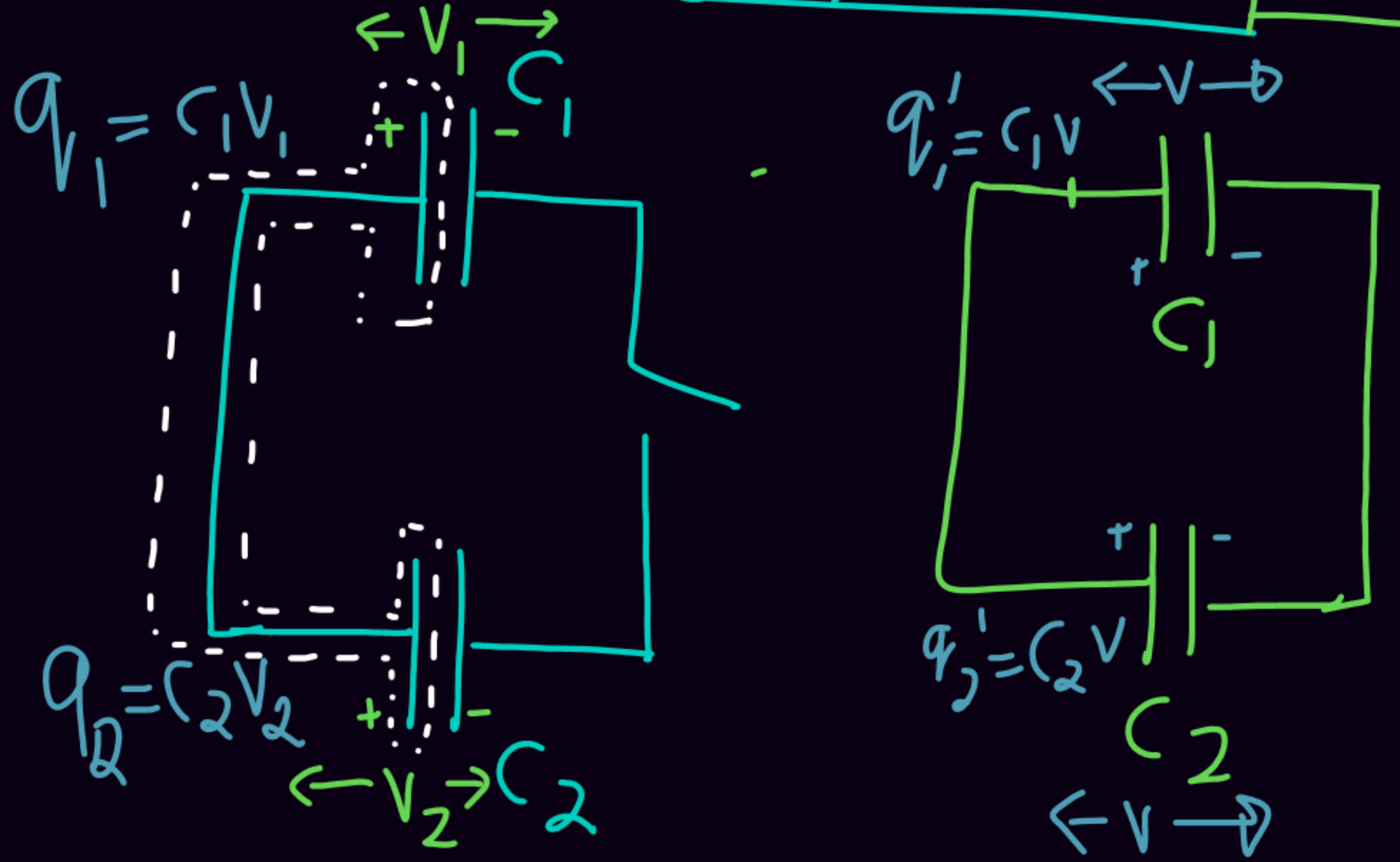


q, q_1

$$+20 - \frac{q}{5} - \frac{(q-q_1)}{2} - \frac{q}{1} = 0 \quad (1)$$

$$+\frac{q-q_1}{2} - \frac{q_1}{4} - 10 = 0 \quad (2)$$

Sharing of charge / Common pot.

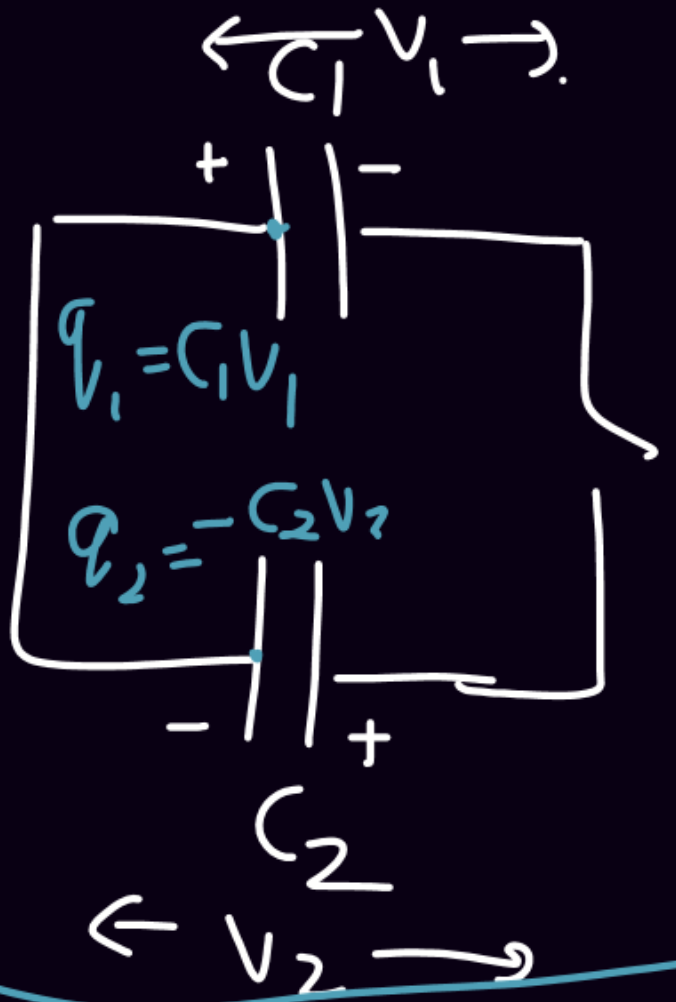


find the common potential after closing the switch?

$$q_1 + q_2 = q_1' + q_2'$$

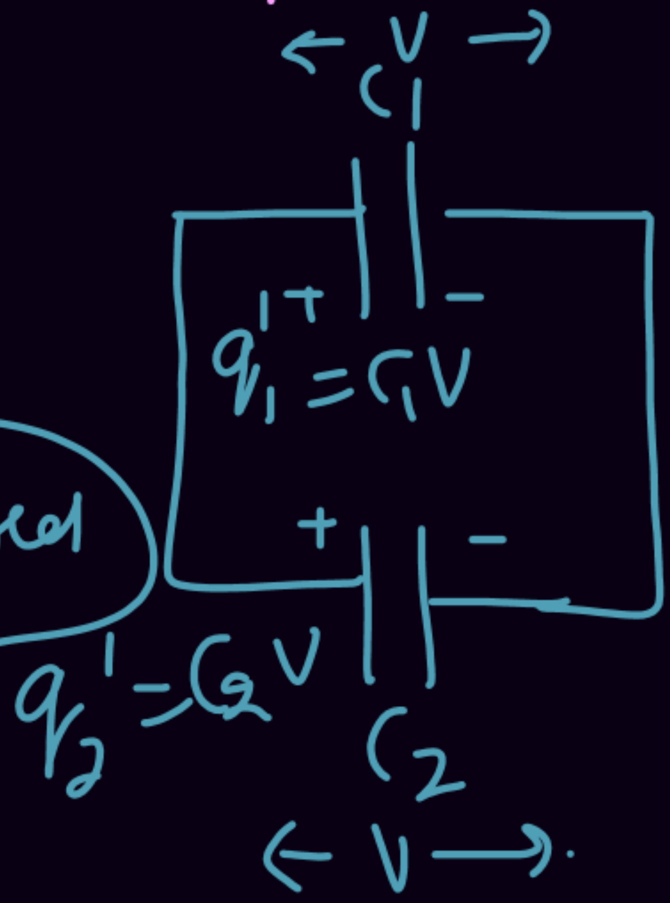
$$C_1V_1 + C_2V_2 = C_1V + C_2V$$

$$\boxed{V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$



Two capacitors are charged & connected as shown.

find common pot. after closing the switch.



$$q_1 + q_2 = q_1' + q_2'$$

$$C_1 V_1 - C_2 V_2 = C_1 V + C_2 V$$

$$V = \frac{C_1 V_1 - C_2 V_2}{C_1 + C_2}$$

Two condensers of capacities C_1 and C_2 are connected in parallel and charged. Then the ratio of charge on C_1 to charge on C_2 is

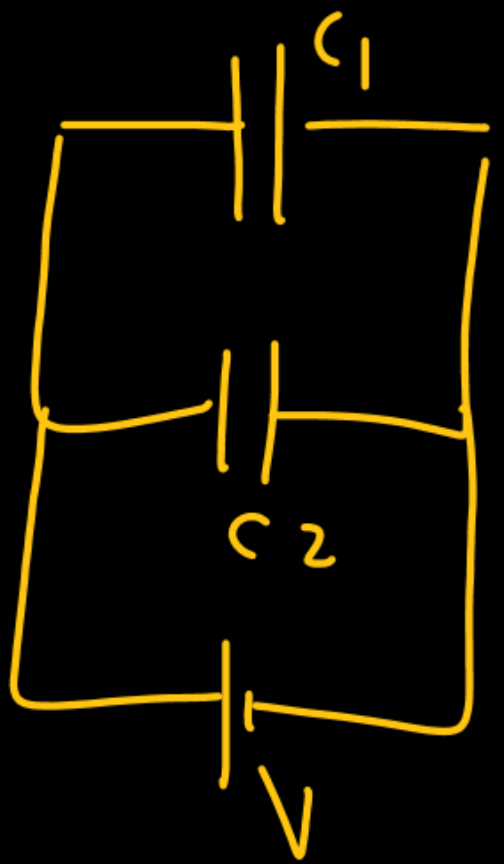
1) $\frac{C_2}{C_1}$

2) $\left(\frac{C_2}{C_1}\right)^2$

3) $\frac{C_1}{C_2}$ ✓

4) $\left(\frac{C_1}{C_2}\right)^2$

Condenser ≡ Capacitor.



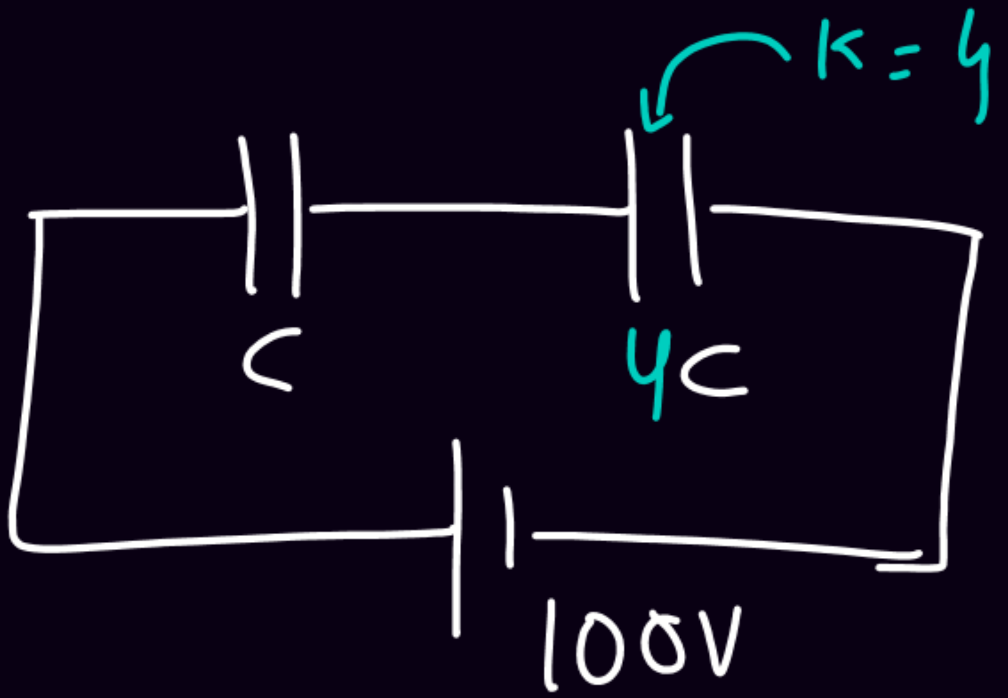
$q_1 = C_1 V$

$q_2 = C_2 V$

$$\frac{q_1}{q_2} = \frac{C_1}{C_2}$$

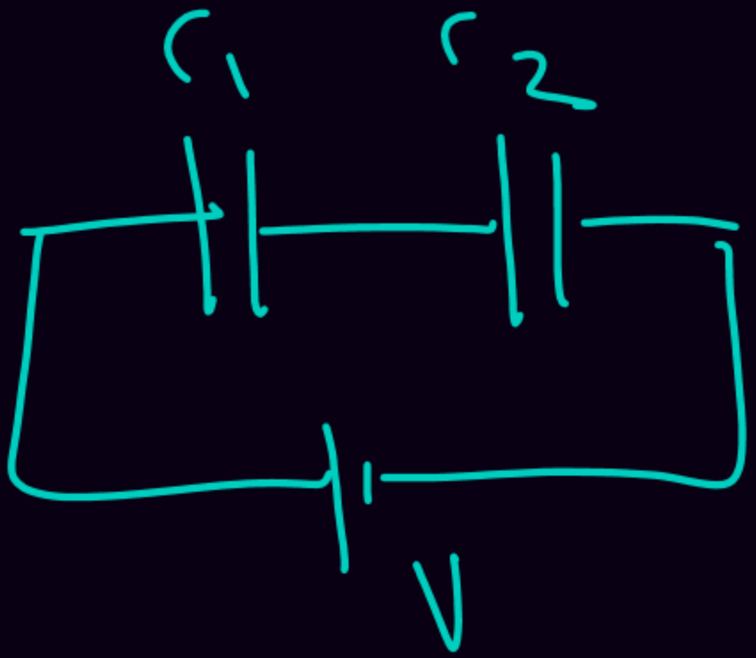
Two identical parallel plate capacitors are joined in series to 100 V battery. Now a dielectric constant (K = 4) is introduced between the plates of second capacitor. The potential differences on capacitors are

1) 60 V, 40 V   2) 70 V, 30 V   3) 75 V, 25 V   4) 80 V, 20 V ✓



$$V_C = \frac{4C \times 100}{4C + C}$$

$$= 80 V.$$



$$V_{C_1} = \frac{V C_2}{C_1 + C_2}$$

The work done in increasing the potential difference across the plates of a capacitor from 4 V to 6 V is W. The further work done in increasing the potential difference from 6 V to 8 V is

1) W 2) 5W/7 3) 7W/5 4) 2W/5

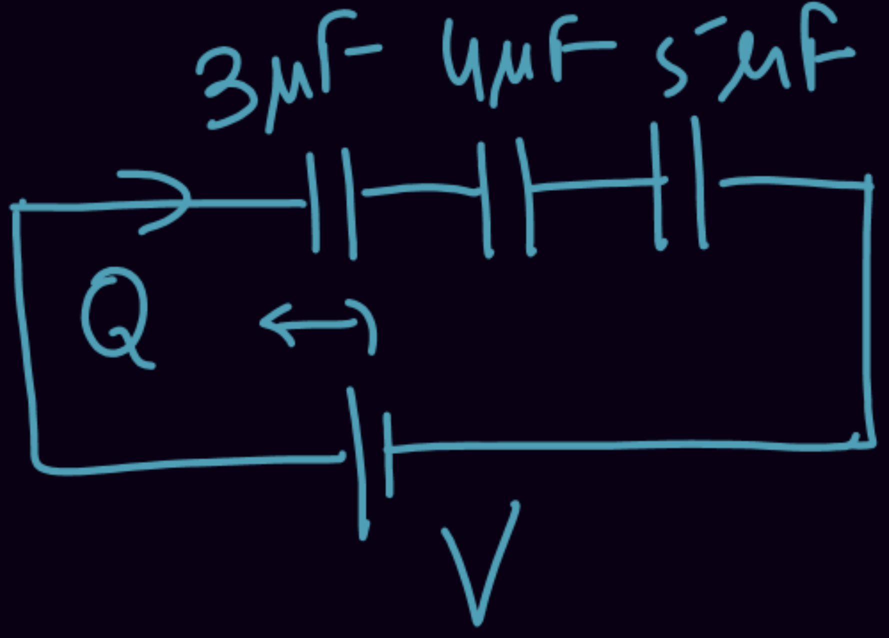
$$\Delta U = \frac{1}{2} C (V_2^2 - V_1^2) = W$$

$$\frac{W}{W'} = \frac{\frac{1}{2} C (6^2 - 4^2)}{\frac{1}{2} C (8^2 - 6^2)} = \frac{36-16}{64-36} = \frac{20}{28} = \frac{5}{7}$$

$$W' = \frac{7W}{5}$$

Three condensers of capacities 3 μF, 4 μF and 5 μF are connected in series and a constant potential is applied between the ends of the combination. Their potentials are in the ratio of

1) 5 : 4 : 3   2) 3 : 4 : 5   3) 4 : 5 : 3   4) 20 : 15 : 12



$$V_3 = \frac{Q}{3}$$

$$V_4 = \frac{Q}{4}$$

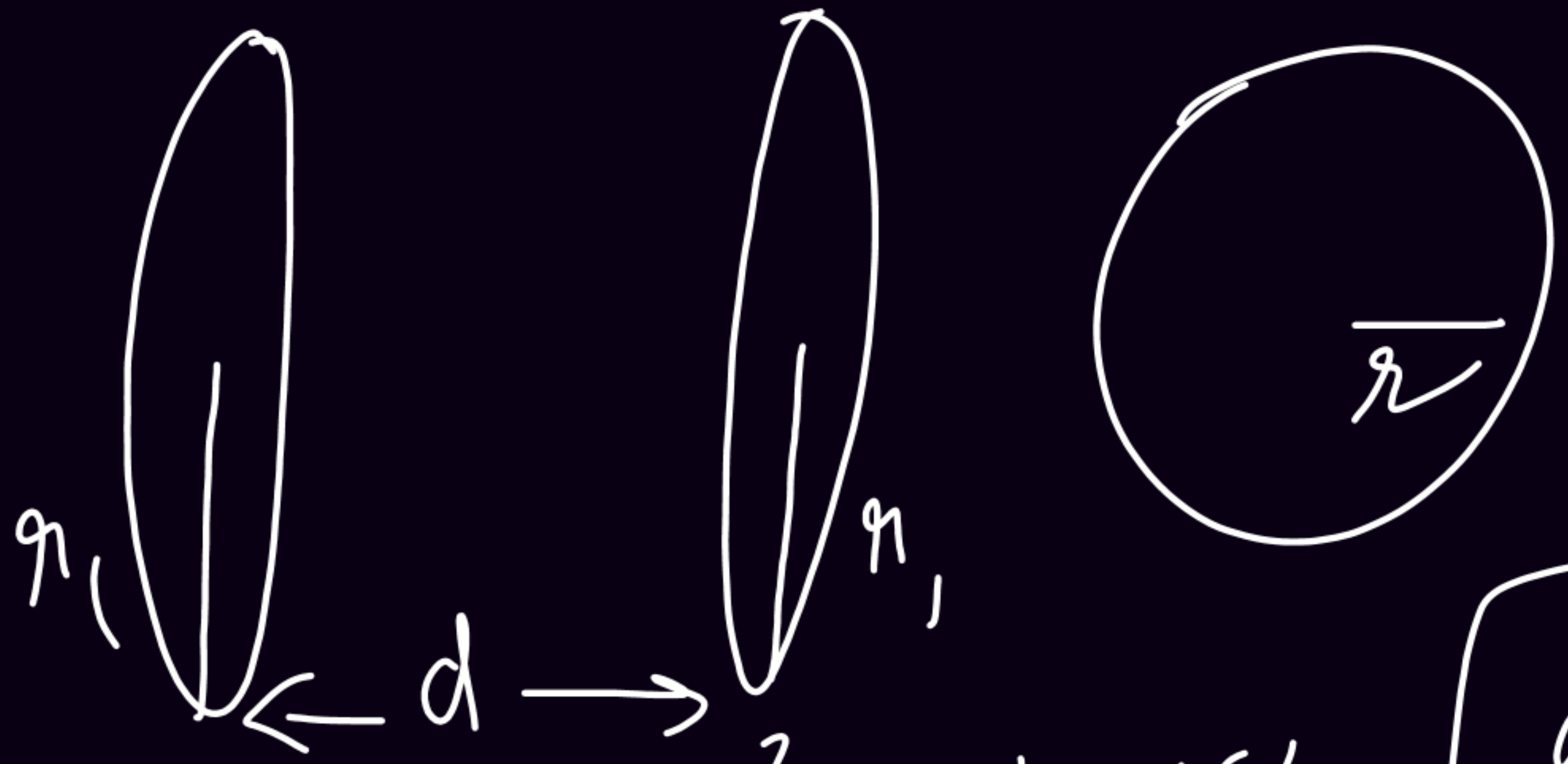
$$V_5 = \frac{Q}{5}$$

$$V_3 : V_4 : V_5 = \frac{Q}{3} : \frac{Q}{4} : \frac{Q}{5}$$

$$= 20 : 15 : 12$$

The radius of the circular plates of a parallel plate condenser is r_1. Air is there as dielectric. The distance between the plates if its capacitance is equal to that of an isolated sphere of radius r is

1) $r_1^2 / 4r$ 2) r^2 / r_1 3) r / r_1 4) $r^2 / 4$



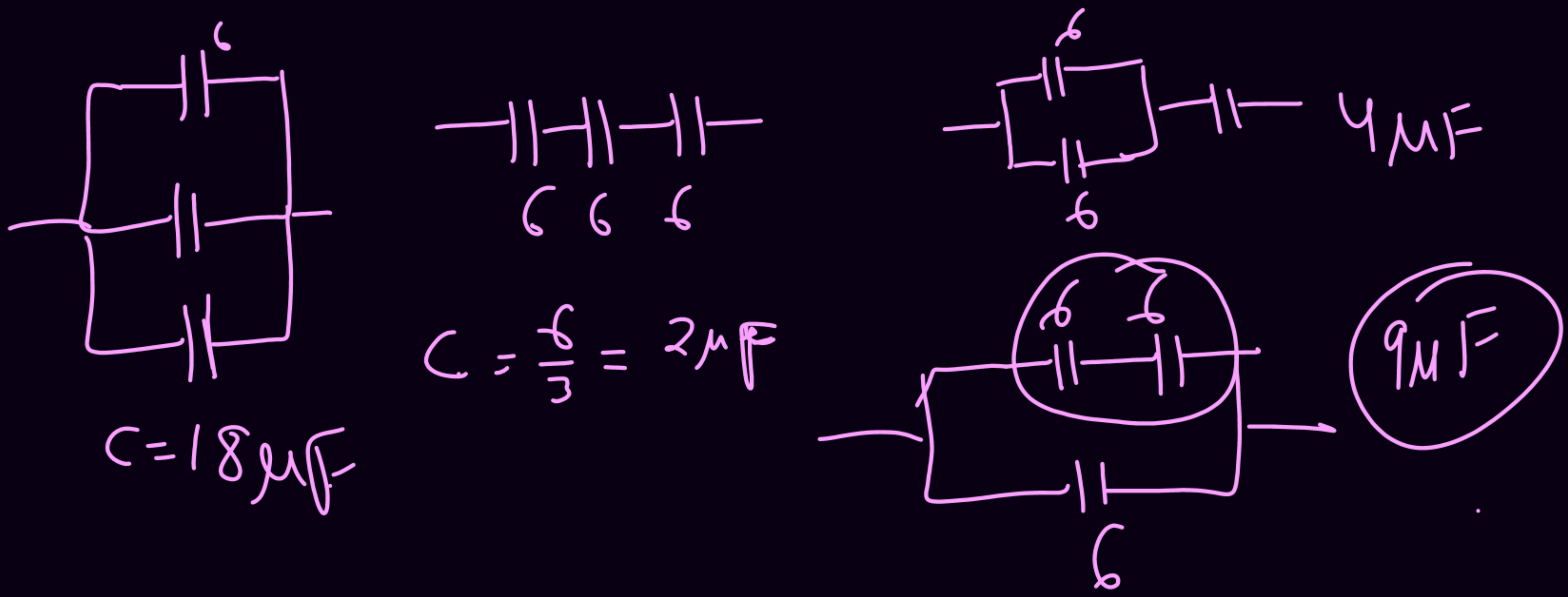
$C = 4\pi\varepsilon_0 r$.

$$\varepsilon_0 \frac{\pi r_1^2}{d} = 4\pi\varepsilon_0 r$$

$$d = \frac{r_1^2}{4r}$$

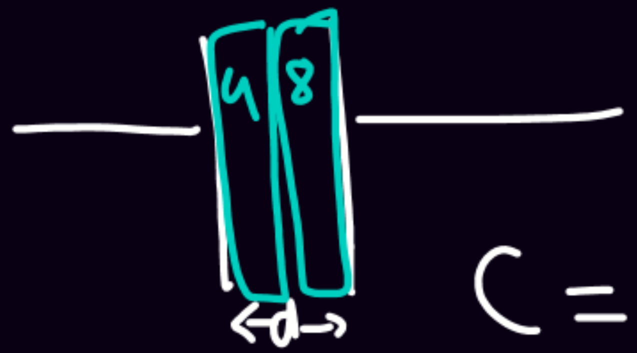
Three condensers each of capacity 6 μF are available. The effective capacity that cannot be obtained by combining them all is

1) 18 μF 2) 9 μF 3) 4 μF 4) 8 μF



The capacity of a parallel plate condenser with air medium is 60 μF having distance of separation d. If the space between the plates is filled with two slabs each of thickness d/2 and dielectric constants 4 and 8, the effective capacity becomes

1) 160 μF 2) 320 μF 3) 640 μF 4) 360 μF



$C = 60\,\mu F$

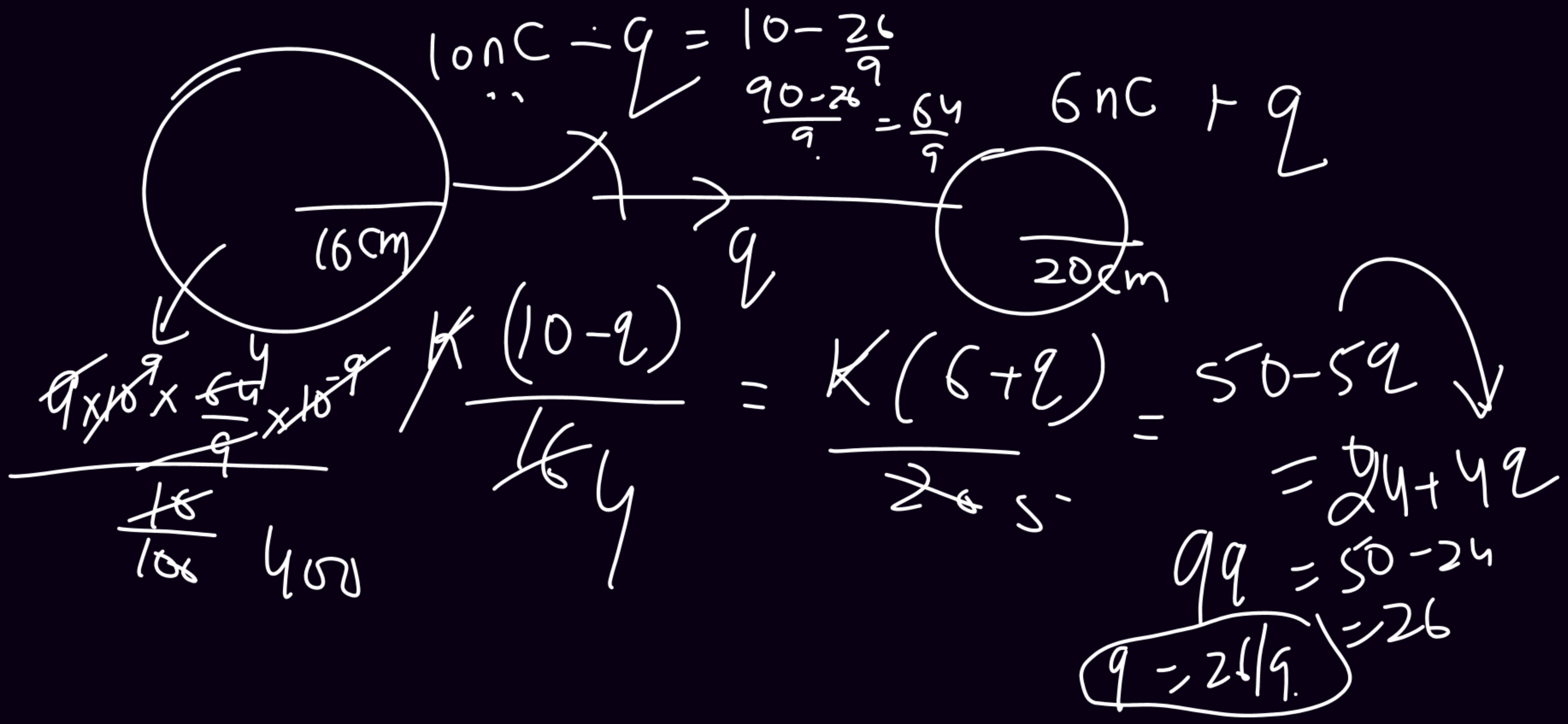
$$\frac{d-t}{1} + \frac{t}{k}$$

$$C = \frac{\varepsilon_0 A}{\frac{d}{2\times 4} + \frac{d}{2\times 8}} = \frac{\varepsilon_0 A}{\frac{d}{2\times 4}\left(1+\frac{1}{2}\right)}$$

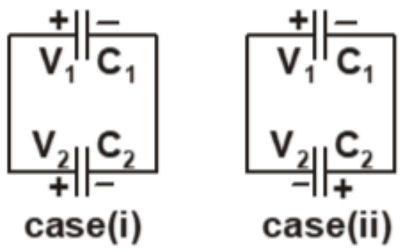
$$= \frac{16\varepsilon_0 A}{3d} = \frac{16\times 60}{3} = 320\,\mu F$$

Two metal spheres of radii 16 cm and 20 cm having charges 10 nC and 6 nC respectively are connected by a wire. Then the common potential is

1) 400 V 2) 200 V 3) 300 V 4) 100 V



Two condensers of capacities C_1 and C_2 charged to potentials V_1 and V_2 are connected in two ways as shown in the figure. The ratio of loss of energies in the case (i) to case (ii) is



1) $\frac{V_1 - V_2}{V_1 + V_2}$

2) $\frac{(V_1 - V_2)^2}{(V_1 + V_2)^2}$

3) $\frac{V_1^2 - V_2^2}{V_1^2 + V_2^2}$

4) $\frac{(V_1 + V_2)^2}{(V_1 - V_2)^2}$

A parallel plate capacitor with air as medium between the plates has a capacitance 10 μF. The area of the capacitor is divided into two equal halves and filled with two media having dielectric constants 2 and 4. The capacitance of the system will be

1) 10 μF 2) 20 μF 3) 30 μF 4) 40 μF

Thank You Lakshyians