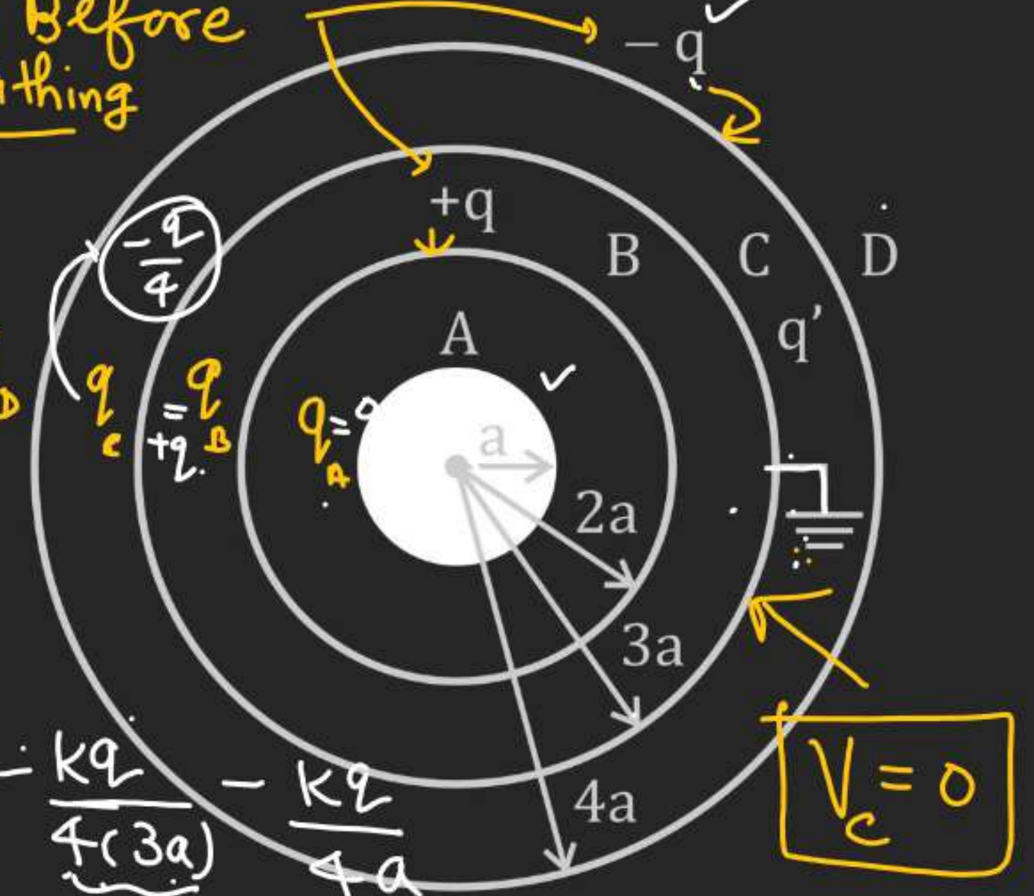
# Conductor

H.W.

There are 4 concentric shells A, B, C and D of radius a, 2 a, 3 a, 4 a respectively. Shells B and D are given charges +9 and -9 respectively. Shell C is now earthed. Find the potential difference $V_A - V_C$.

$+q$ $-q$.

Before earthing




Let, after earthing let, charges on Shell A, B, C & D be $q_A$, $q_B$, $q_c$ & $q_D$.

Charge Conservation

$q_D = -q$, $q_B = +q$, $q_A = 0$. $\boxed{V_c = 0}$

$V_c = 0$.

$$\frac{Kq}{3a} + \frac{Kq_c}{3a} - \frac{Kq}{4a} = 0$$

$$\frac{Kq_c}{3a} = \frac{Kq}{4a} - \frac{Kq}{3a} = \frac{3Kq - 4Kq}{12a} = \frac{-Kq}{12a}$$

$$\boxed{q_c = \left(-\frac{q}{4}\right)}$$

$-q = q_D$

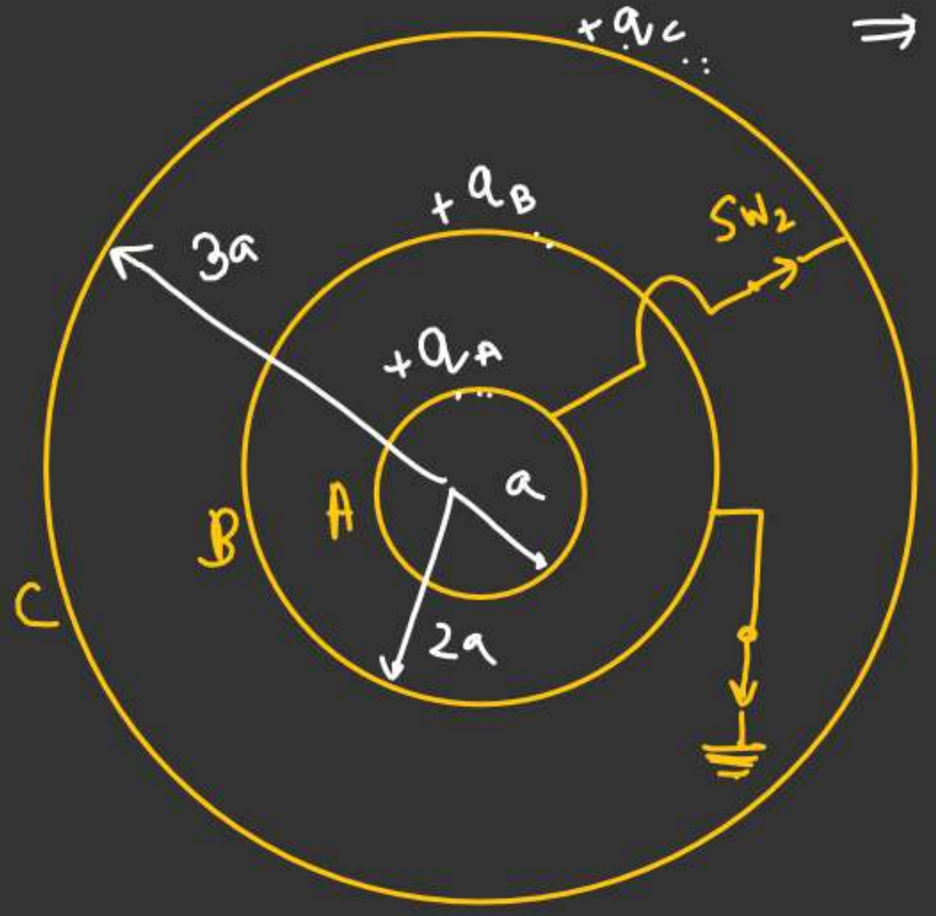
$V_A - V_c = V_A$.

$$V_A = \underbrace{\frac{Kq}{2a}}_{B} - \underbrace{\frac{Kq}{4(3a)}}_{C} - \underbrace{\frac{Kq}{4a}}_{D}$$

$$V_A = \left(\frac{Kq}{2a} - \frac{Kq}{12a} - \frac{Kq}{4a}\right) = \frac{Kq}{6a}$$

# Before $Sw_1$ and $Sw_2$ is Closed.

Charges on Shell A, B & C be $2q$, $q$, & $-q$.
Both the Switch Closed Simultaniously.
Find new charges on Shell A, B & C.




⇒ For A and C Shell.

Charge Conservation (Shell A + Shell C)

$q_A + q_c = 2q - q$

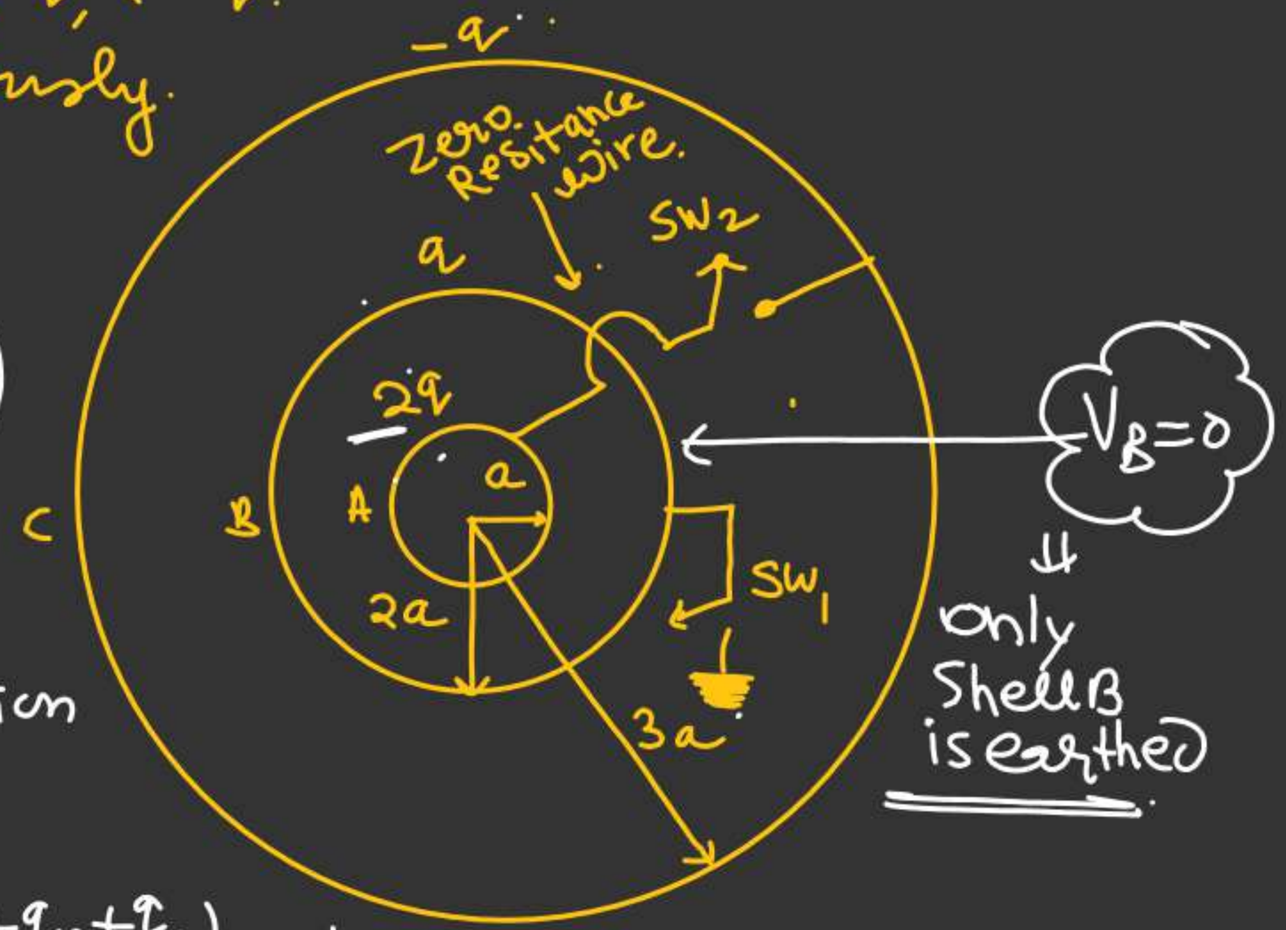
$q_A + q_c = q$ — (1)

$V_A = V_c$ ⇒ [After Conduction process]

$$\frac{Kq_A}{a} + \frac{Kq_B}{2a} + \frac{Kq_c}{3a} = \frac{K(q_A+q_B+q_c)}{3a}$$

$$q_A + \frac{q_B}{2} + \frac{q_c}{3} = \frac{q_A+q_B+q_c}{3} \quad \text{— (2)}$$

$\boxed{q_A = ?,\ q_B = ?,\ q_c = ?}$ ⇐




⇓

only Shell B is earthed

$V_B = 0$.

$$\frac{Kq_A}{2a} + \frac{Kq_B}{2a} + \frac{Kq_c}{3a} = 0$$

$$\frac{q_A}{2} + \frac{q_B}{2} + \frac{q_c}{3} = 0 \quad \text{— (3)}$$

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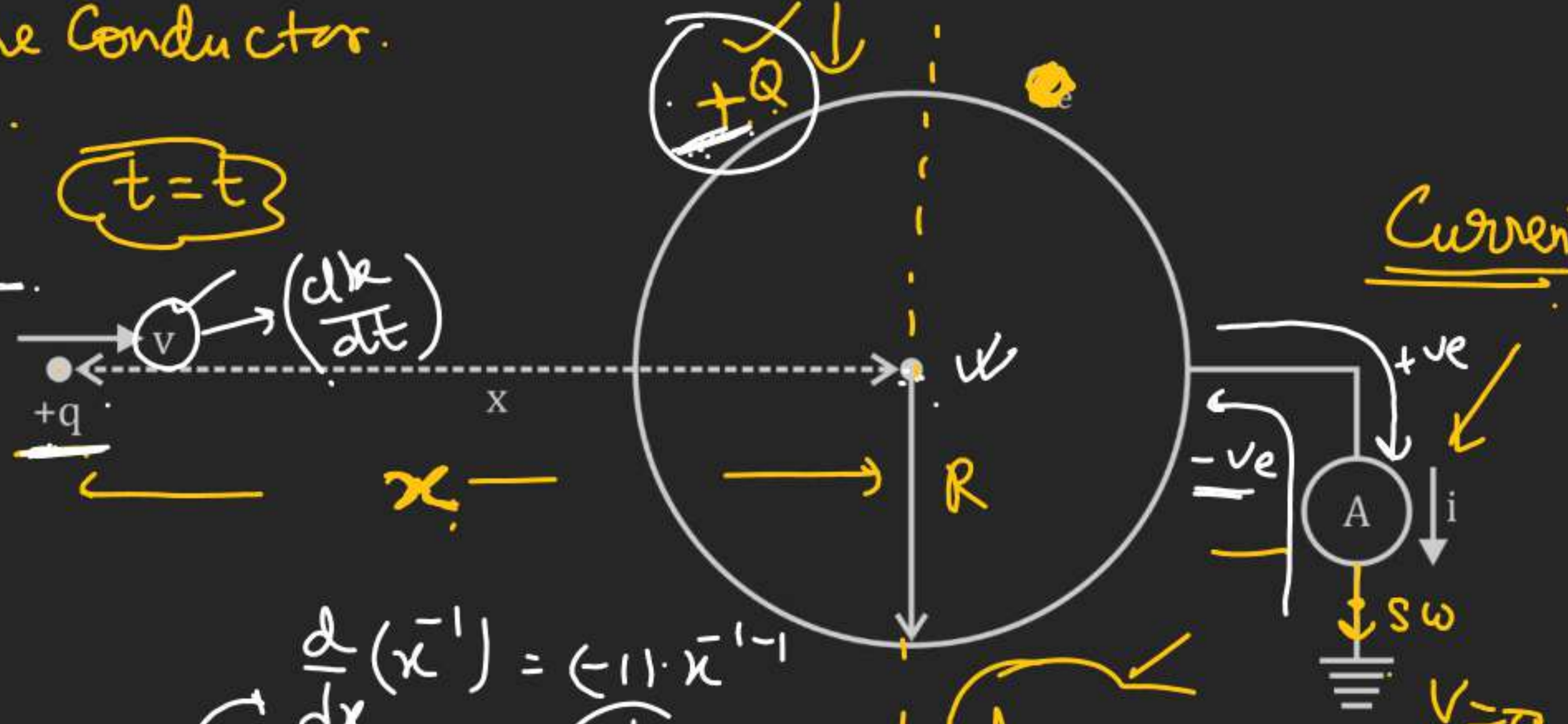
## ❖ Current due to Movement of Charges Through Earth:

Initially no charge on the Conductor.
Switch is closed at t = 0.

$V_{net} = 0$




$$\boxed{V_{conductor} = 0}$$

$$\frac{Kq}{x} + \frac{KQ}{R} = 0$$

$$\frac{\cancel{K}Q}{R} = -\frac{\cancel{K}q}{x}$$

$$\boxed{Q = (-)\frac{qR}{x}}$$

$$\frac{d}{dx}(x^{-1}) = (-1)\cdot x^{-1-1} = \frac{-1}{x^2}$$

$$\frac{dQ}{dt} = -qR\,\boxed{\frac{d}{dx}\left(\frac{1}{x}\right)} \times \left(\frac{dx}{dt}\right) = \left(+\frac{qR}{x^2}\right)v \Rightarrow \boxed{i = \frac{qRv}{x^2}}$$

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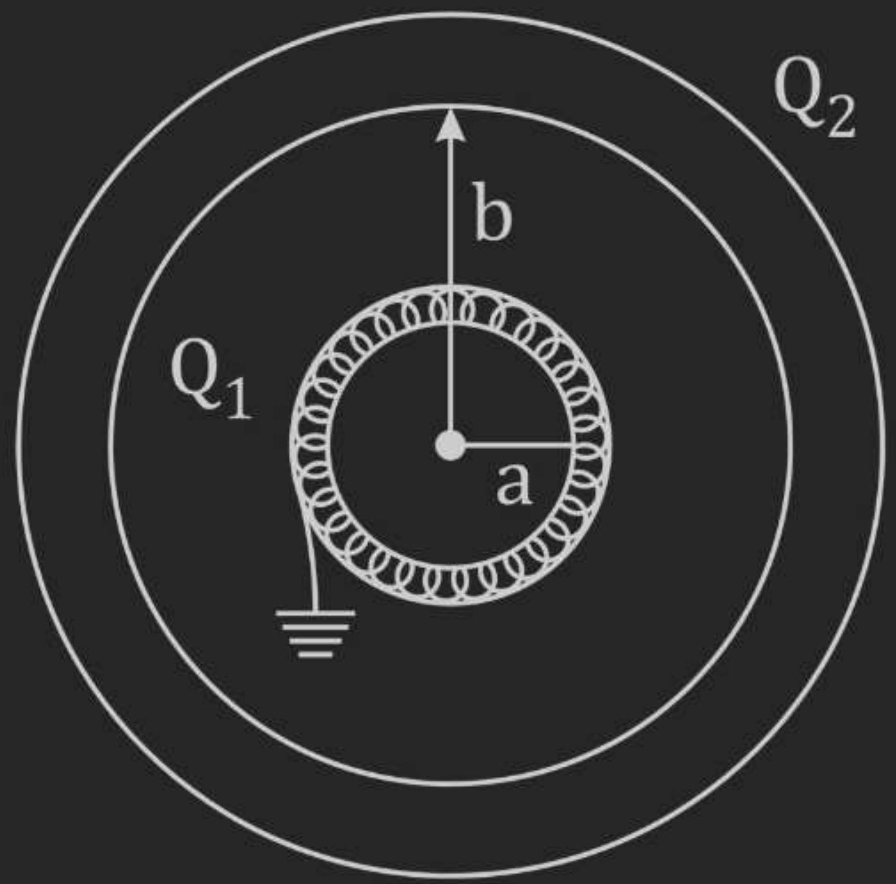
# Conductor

Consider concentric spherical shells of negligible thickness. Initial charges on these shells are $Q_1$ and $Q_2$. Now inner shell is earthed.



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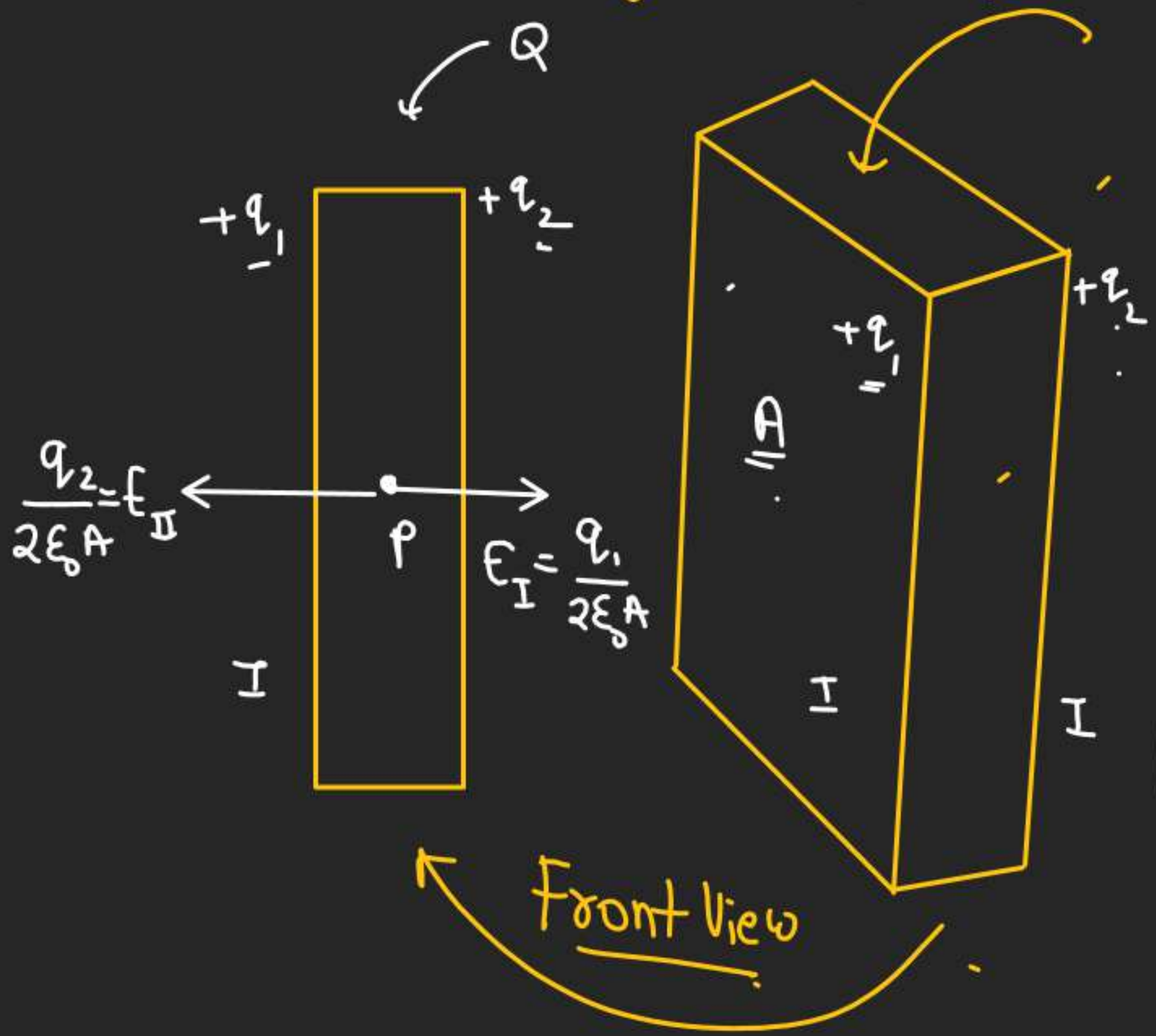
# Conductor

(*) Charge distribution on parallel [Conducting] Identical plates (Very large)

⇒ Isolated Conducting plate :- +Q




$Q = q_1 + q_2$ — ①

'P' → Inside point of a Conductor.

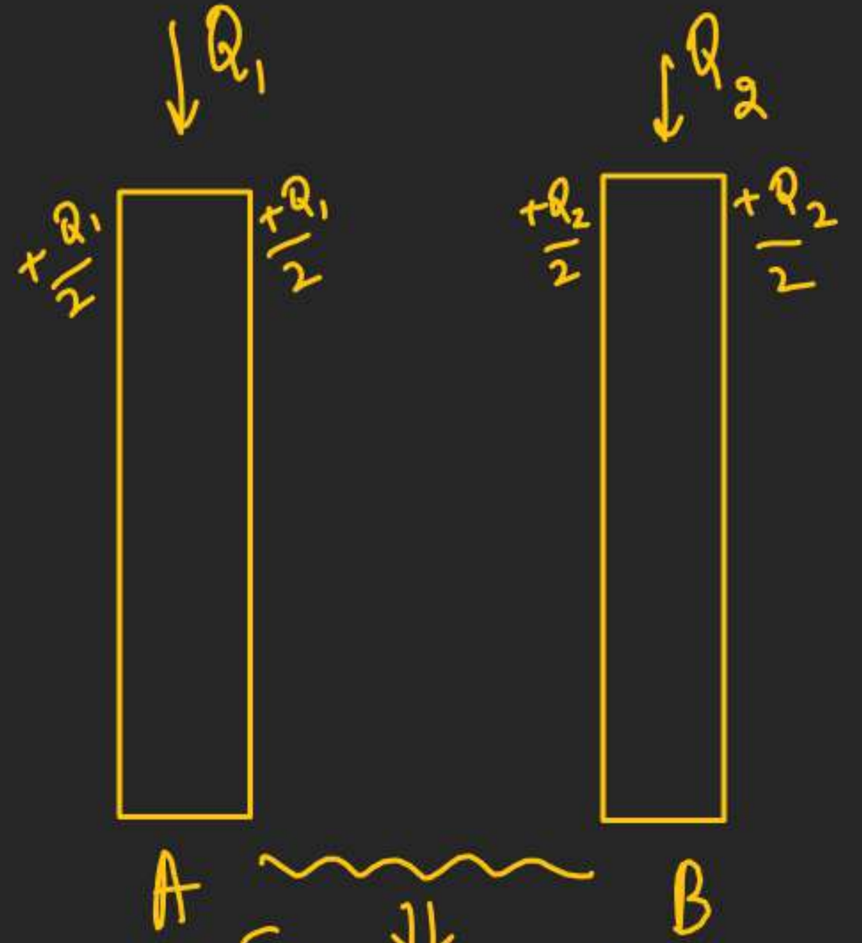
$$(E_P)_{net} = 0$$

$$\frac{q_1}{2\varepsilon_0 A} - \frac{q_2}{2\varepsilon_0 A} = 0$$

$$q_1 = q_2 \quad — ②$$

$$\boxed{q_1 = q_2 = \frac{Q}{2}}$$

# Conductor




[At very large distance]

No Induced effect.

$\Rightarrow$ When kept closed to each other :- Due to induced charges net charge distribution on both the plate changes.

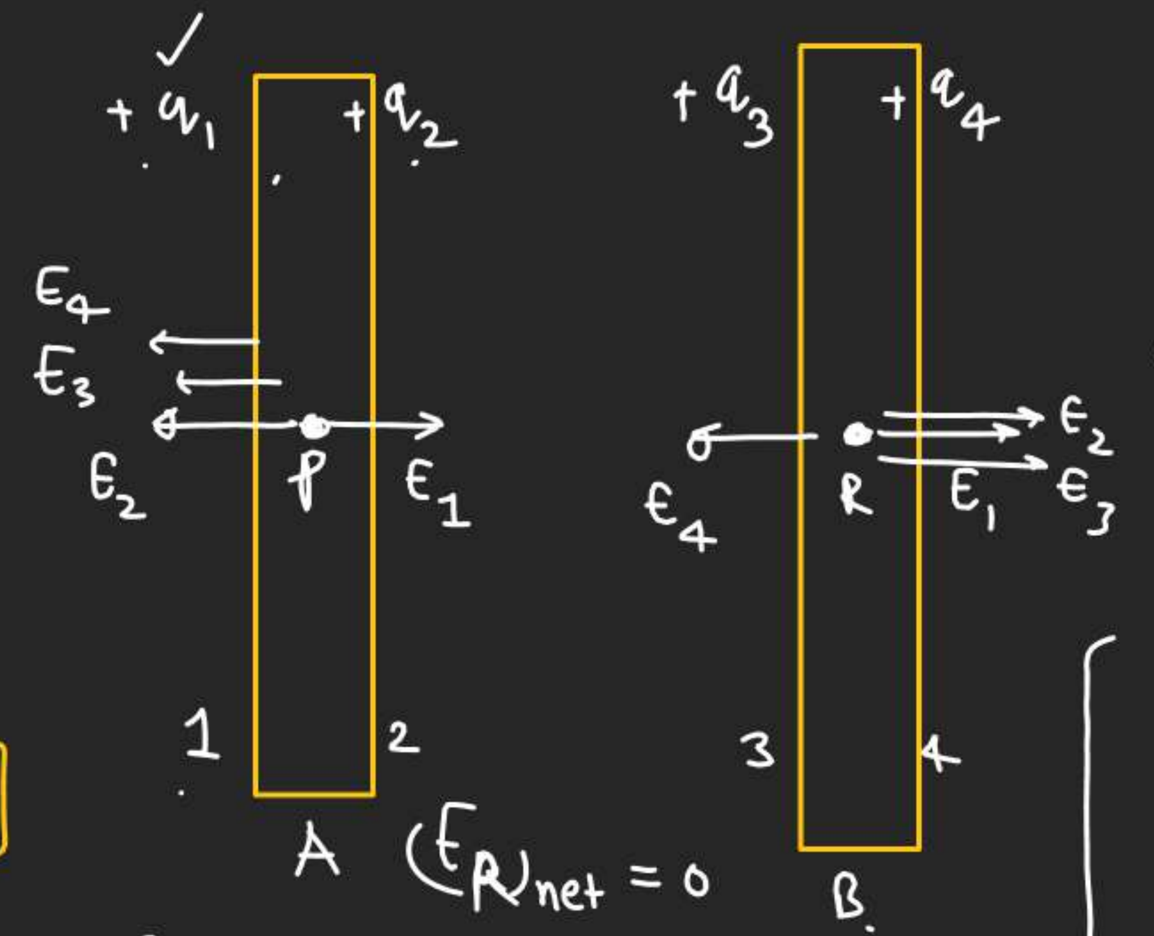



Plate A & plate B

Conservation of charge

$$q_1 + q_2 = Q_1 \quad - (1)$$

$$q_3 + q_4 = Q_2 \quad - (2)$$

$$(E_P)_{net} = 0 \qquad q_1 - q_2 = Q_2$$

$$E_1 - E_2 - E_3 - E_4 = 0$$

$$E_1 = E_2 + E_3 + E_4$$

$$\frac{q_1}{2\varepsilon_0 A} = \frac{q_2}{2\varepsilon_0 A} + \frac{q_3}{2\varepsilon_0 A} + \frac{q_4}{2\varepsilon_0 A}$$

$$q_1 - q_2 = q_3 + q_4 \quad — (3)$$

$$(E_R)_{net} = 0$$

$$\frac{q_1}{2\varepsilon_0 A} + \frac{q_2}{2\varepsilon_0 A} + \frac{q_3}{2\varepsilon_0 A} = \frac{q_4}{2\varepsilon_0 A}$$

$$q_1 + q_2 = q_4 - q_3 \quad - (4)$$

(3) − (4)

$$2q_2 = -2q_3$$

$$\boxed{q_2 = -q_3}$$

(3) + (4)

$$2q_1 = 2q_4$$

$$\boxed{q_1 = q_4}$$

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$$q_1 = q_4 = \left[\frac{Q_1+Q_2}{2}\right]$$

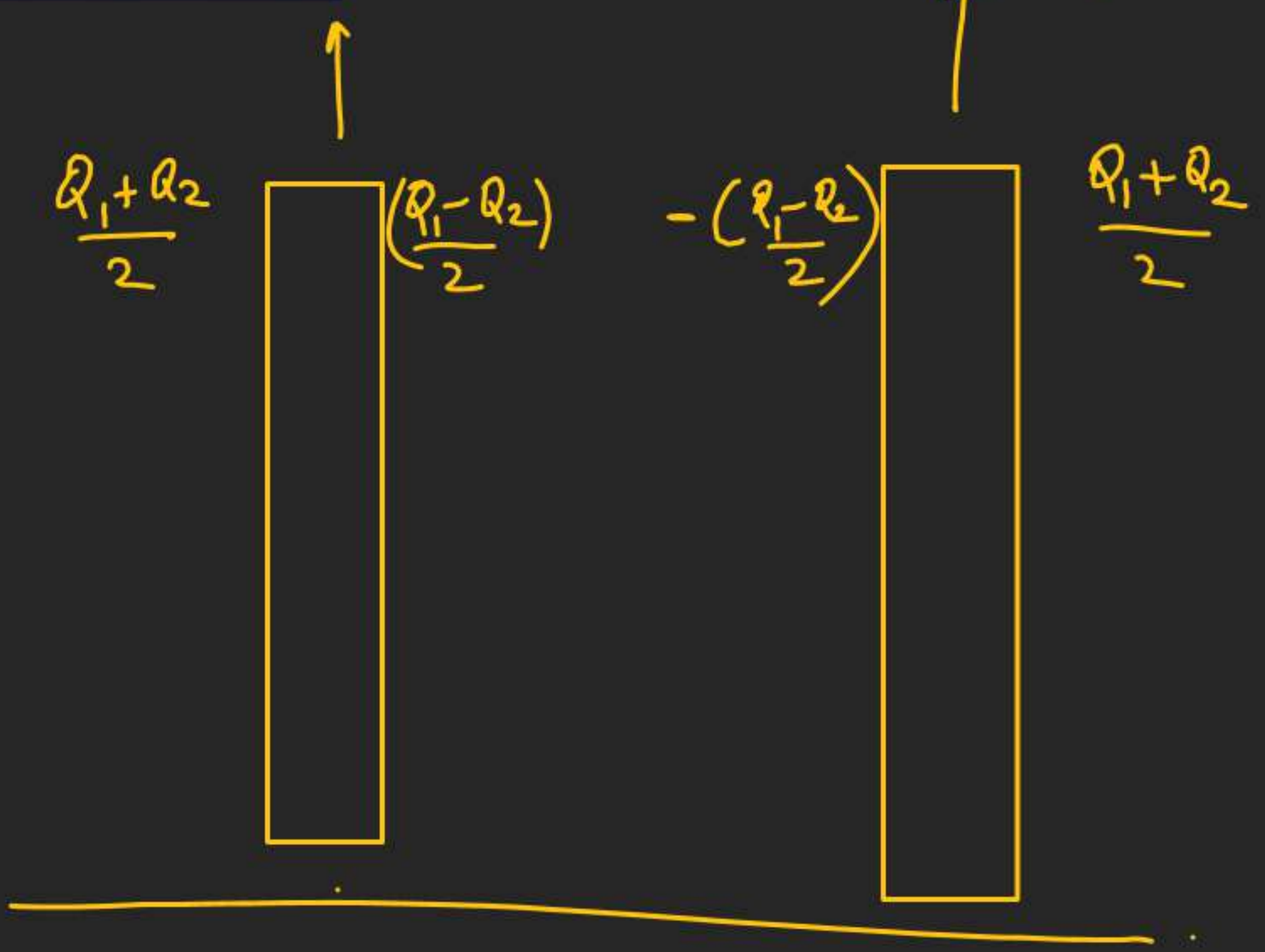
$$q_2 = Q - q_1 = Q_1 - \left(\frac{Q_1+Q_2}{2}\right)$$

$$\boxed{q_2 = \frac{Q_1-Q_2}{2}}$$

$$\boxed{q_3 = -q_2 = -\left(\frac{Q_1-Q_2}{2}\right)}$$

# Conductor

Trick



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# Conductor

⇒ General apporach
for charge distribution in Conducting plates when Close to each other.

Step.

⇒ ① ⇒ Add the total Charge and divide it by 2.
give the result to outer Surface of 1st and last plate.

② Apply Charge Conservation on individual plates and
the Sides of the plates which are face to face
are equal and opposite.

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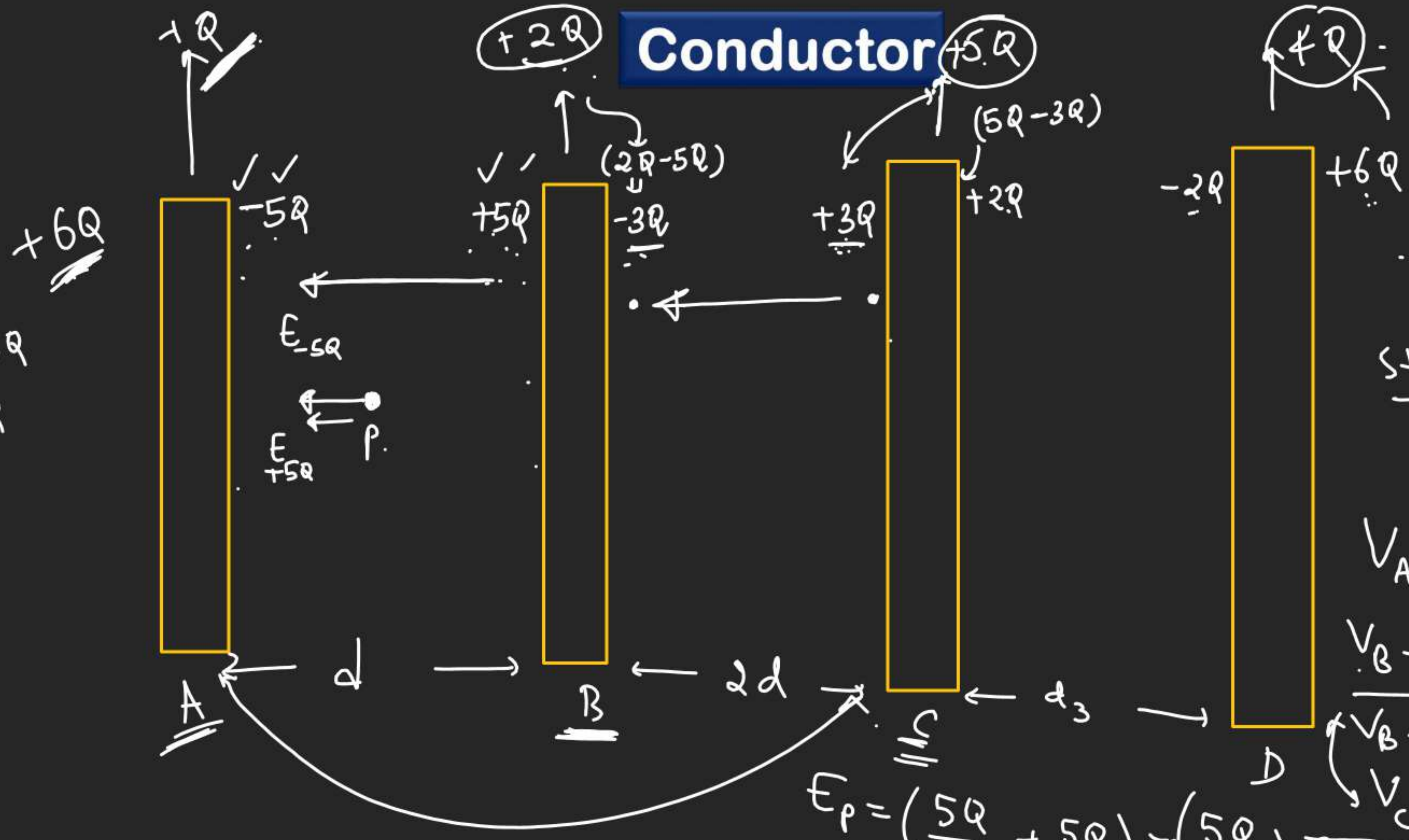
# Conductor




$\Rightarrow Q - 6Q$

$-5Q$

Q, 2Q, 5Q & 4Q Charges on plates A, B, C, & D When isolated

Step-1 → $\frac{Q+2Q+5Q+4Q}{2}$

$\Rightarrow 6Q$

$V_A - V_C = ??$

$V_B - V_A = (E_p d)$

$V_B - V_A = \frac{5Qd}{\varepsilon_0 A}$ — ①

$V_C - V_B = \frac{3Q}{\varepsilon_0 A}(2d)$ — ②

$E_p = \left(\frac{5Q}{2\varepsilon_0 A} + \frac{5Q}{2\varepsilon_0 A}\right) = \left(\frac{5Q}{\varepsilon_0 A}\right)$

$V_A - V_C = \frac{11Qd}{\varepsilon_0 A}$ Ans