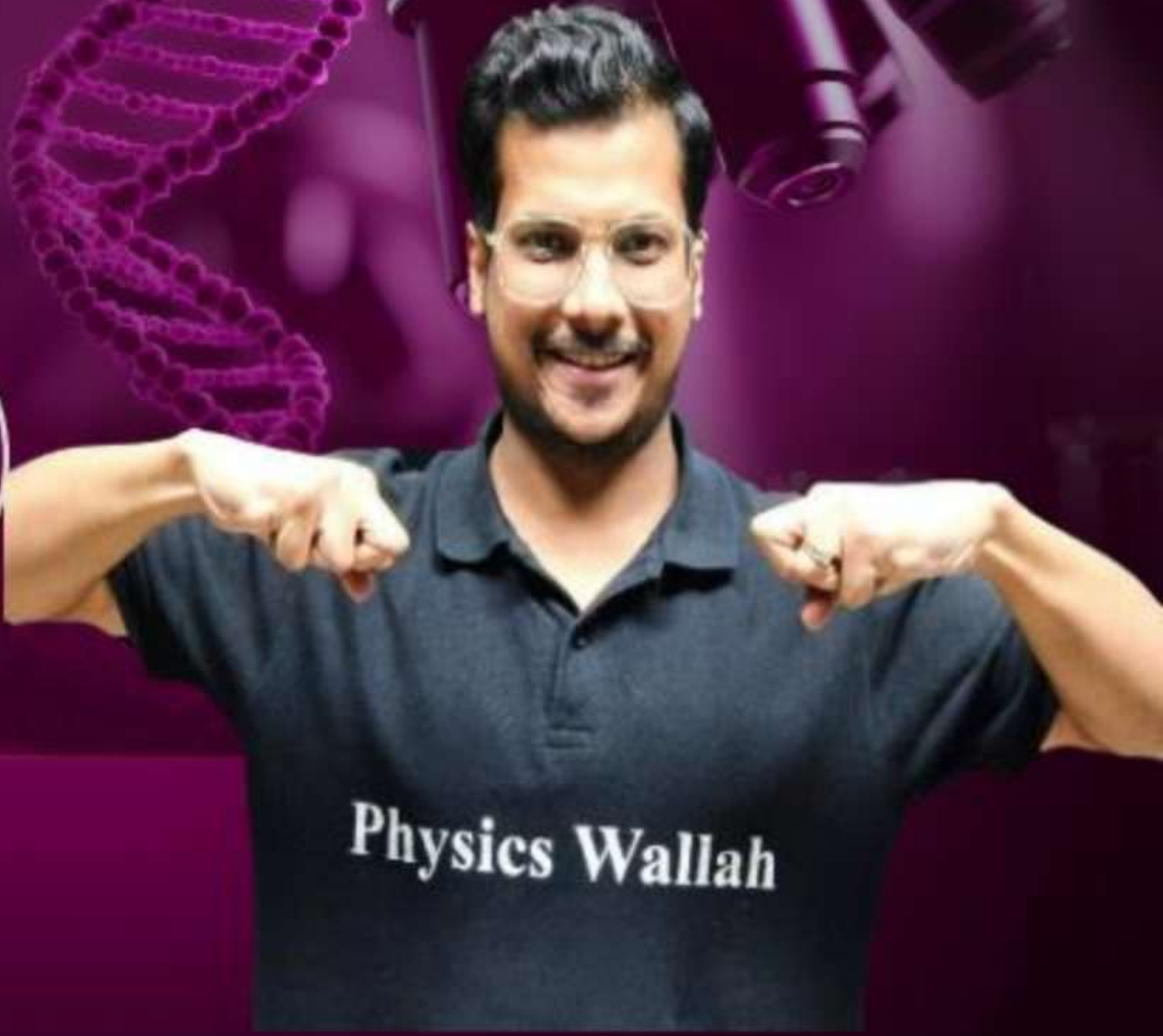
PRACHAND NEET

ONE SHOT

PHYSICS

Electrostatic Potential and Capacitance

TANUJ BANSAL SIR (TBS)



Topics *to be covered*

1. Electrostatic Potential Energy and Potential
2. Relation b/w Electric Field and Potential
3. Electric Dipole, Conductors
4. Capacitance, Energy Stored, Dielectrics

Rukega Nai... in the chat box !!!


PRACHAND SERIES
TELEGRAM CHANNEL
@PW_YAKEENDROPPER

Chapter Weightage

- 19 Questions from 2019 to 2024
- 2-3 Question Expected, 2024 – 3 Questions
- Part of Electrostatics

Concepts Related to Work, energy

* $W_{cons} = -\Delta U$

* $W_{elec} = -\Delta U$

* $W_{ext} = \Delta U$ (Slowly)

$\xrightarrow{}$ external agent

Electrostatic Potential Energy (Sher Bakri Concept)

The work done in bringing a test charge from infinity to a given point in the electrostatic field of another charge (source) slowly is stored in the form of electrostatic potential energy.

$$\boxed{W_{ext} = \Delta U = \frac{kqq_0}{r}} \Rightarrow U_f - U_i = U_f - 0 = \frac{kqq_0}{r}$$

$$\boxed{U_f = \frac{kqq_0}{r}}$$

$$\boxed{U = \frac{kq_1q_2}{r}} \quad q_1 \xleftrightarrow[r]{} q_2$$

TBS points about potential energy

- Scalar Quantity ✓
- SI Unit – Joule (J)
- Defined for a system of charges (minimum two charges)
- Defined for conservative forces
- Put value of charges with sign

q_1, q_2

* $\boxed{U = -\frac{Gm_1m_2}{r}}$

$\Downarrow$

always -ve

QUESTION

An electron moves away from another electron, the electrostatic potential energy of the system

① becomes zero

② increases

[✓ ③ decreases]

④ remains same

$$U = \frac{k(-e)(-e)}{r} = \frac{+ke^2}{r}$$

$$\boxed{U \propto \frac{1}{r}} \qquad \boxed{r\uparrow \Rightarrow U\downarrow}$$

QUESTION

$r\uparrow$

If we take electron away from proton, the electrostatic potential energy of the system

$\downarrow -e$ $\downarrow +e$

① becomes zero

② [✓ increases]

③ decreases

④ remains same

$$U = \frac{k(-e)(+e)}{r} = \frac{-ke^2}{r} = \boxed{-ve}$$

$$r\uparrow \Rightarrow U\uparrow$$

$-6J = U_i$

$-4J = U_f$

$\boxed{-4 > -6}$

TBS $\Rightarrow$ If $U = +ve \Rightarrow r\uparrow \Rightarrow U\downarrow$

$r\downarrow \Rightarrow U\uparrow$

If $\boxed{U = -ve} \Rightarrow r\uparrow \Rightarrow U\uparrow$

$r\downarrow \Rightarrow U\downarrow$

Ques Grav. P.E. $\Rightarrow U = -\frac{Gm_1m_2}{r}$

$\Downarrow$

always -ve

$r\uparrow \Rightarrow U\uparrow$

$r\downarrow \Rightarrow U\downarrow$.

QUESTION

When the separation between two charges is decreased, the electric potential energy of the charges

charges → sign ×

① increases

② decreases

③ remains the same

[✓ ④] may increases or decrease

QUESTION

Two positive point charges of 18 μC and 15 μC are 1 m apart. What is the work done in bringing them 0.4 m apart?

① 1540 J

[✓ ② 3.645 J]

③ 4125 J

④ 2360 J

$q_1 = 18\times10^{-6}\,C$

$q_2 = 15\times10^{-6}\,C$

$\downarrow$

$r_2 = 0.4m = \frac{4}{10}\,m$

$W_{ext} = \Delta U = U_2 - U_1$

$$= \frac{kq_1q_2}{r_2} - \frac{kq_1q_2}{r_1}$$

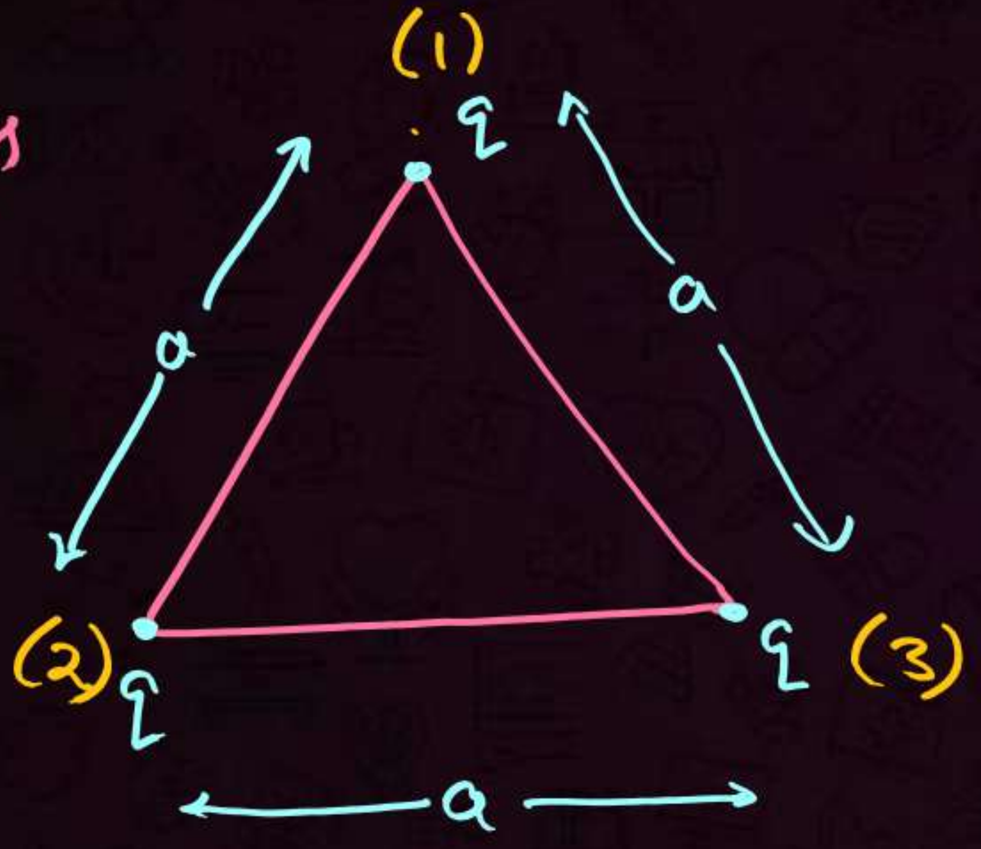
$$= kq_1q_2\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

$\downarrow$

$9\times10^{9}.$

Potential Energy of system containing more than two charges

Ques



U of system?

Love Δ.

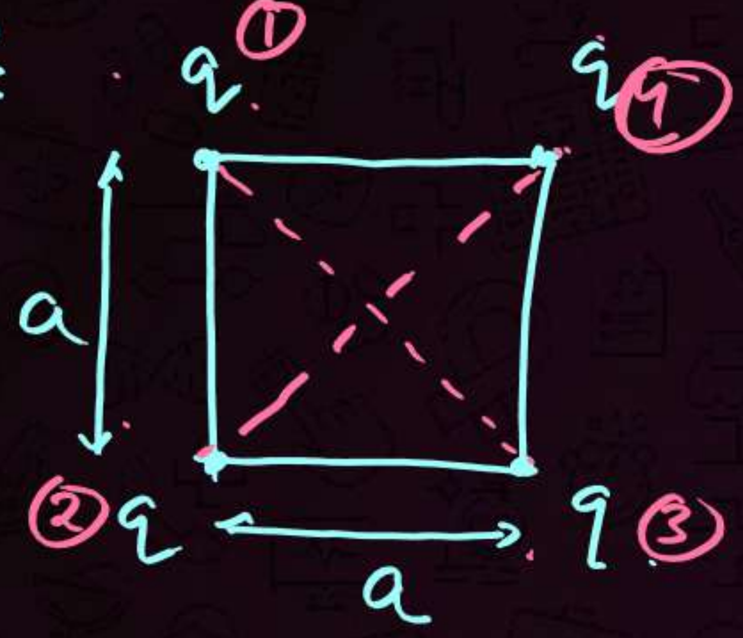
3 terms.

$$U = \frac{kqq}{a} + \frac{kqq}{a} + \frac{kqq}{a}$$

$$= \frac{kq^2}{a} + \frac{kq^2}{a} + \frac{kq^2}{a}$$

$$= \frac{3kq^2}{a} \checkmark$$

Ques



No. of terms = $\boxed{N = \frac{n(n-1)}{2}}$

n = no. of charges

$$n = 4 \Rightarrow N = \frac{4(4-1)}{2}$$

$$= \frac{4\times3}{2} = \frac{12}{2} =$$ ⑥

$$U = \frac{kq^2}{a} + \frac{kq^2}{a} + \frac{kq^2}{a} + \frac{kq^2}{a}$$

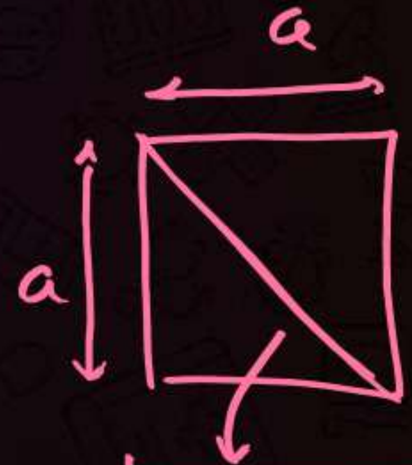
$$+ \frac{kq^2}{\sqrt{2}a} + \frac{kq^2}{\sqrt{2}a}$$

$$= \frac{4kq^2}{a} + 2\frac{kq^2}{\sqrt{2}a}$$

$$= \frac{4kq^2}{a} + \sqrt{2}\frac{kq^2}{a}$$

$$= \frac{kq^2}{a}(4+\sqrt{2})$$

Ans



Diagonal = $\sqrt{2}a$

Half = $\frac{a}{\sqrt{2}}$

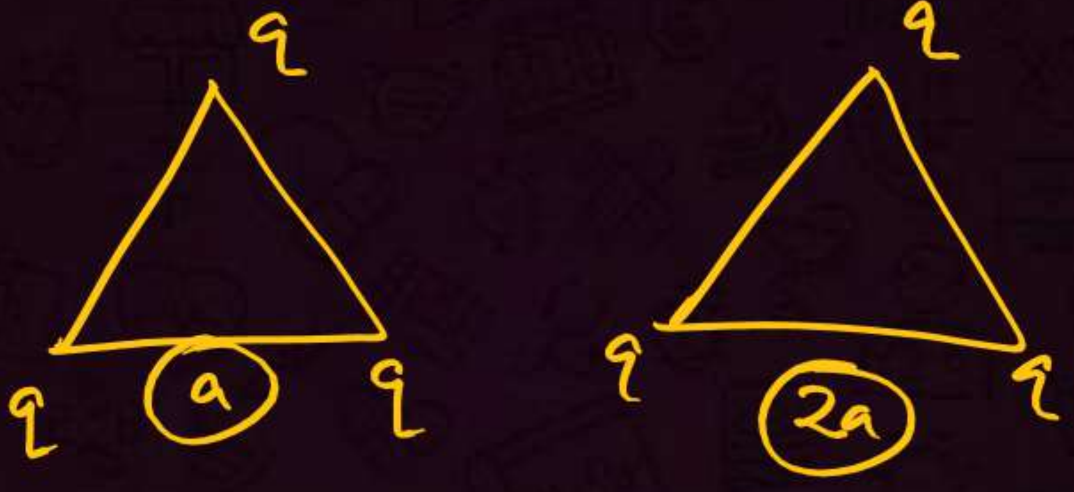
$$\frac{2}{\sqrt{2}} = \frac{\cancel{\sqrt{2}}\times\sqrt{2}}{\cancel{\sqrt{2}}}$$

$$= \sqrt{2}$$

QUESTION

Three equal positive point charges of value q are placed at the corners of equilateral triangle of side length a. Find work done in increasing the side length to 2a.

1. $\frac{3kq^2}{a}$
2. $\frac{3kq^2}{2a}$
[✓ 3.] $-\frac{3kq^2}{2a}$
4. None



$U_1 = \frac{3kq^2}{a}$ $\quad$ $U_2 = \frac{3kq^2}{2a}$

$$\boxed{\text{Ans}\quad W_{elec} = -\Delta U = +\frac{3kq^2}{2a}}$$

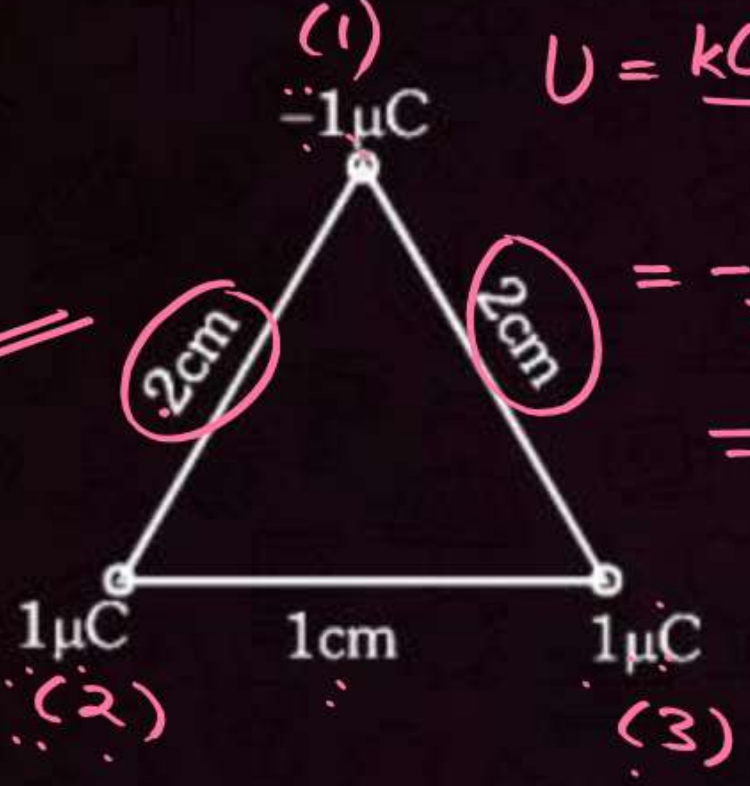
$$W_{ext} = \Delta U$$
$$= U_2 - U_1$$
$$= \frac{3kq^2}{2a} - \frac{3kq^2}{a}$$
$$= \frac{3kq^2}{a}\left(\frac{1}{2} - 1\right)$$
$$= \frac{3kq^2}{a}\left(-\frac{1}{2}\right) = -\frac{3kq^2}{2a}$$

QUESTION

Which of the following systems of charges have zero electrostatic potential energy?

(Medium)

①

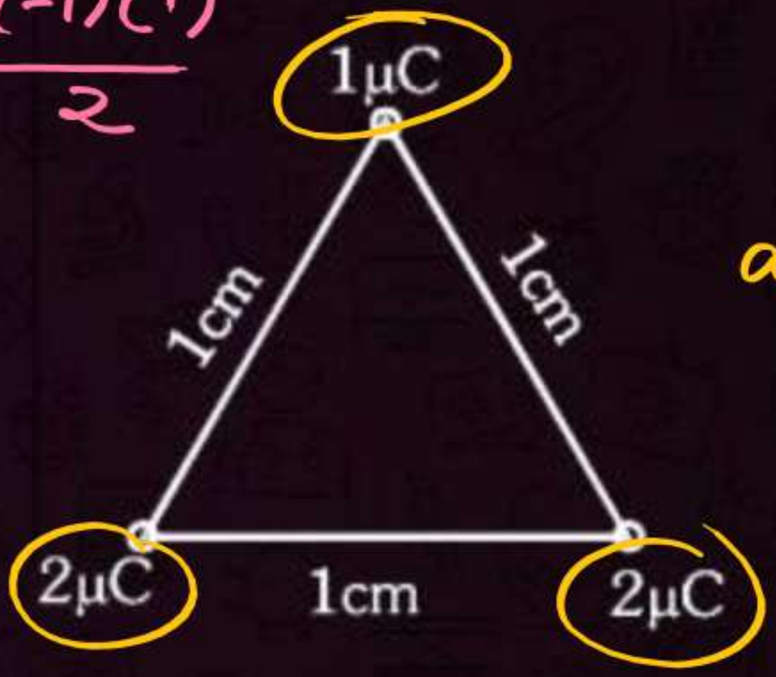


$$U = \frac{k(-1)(1)}{2} + \frac{k(1)(1)}{1} + k\frac{(-1)(1)}{2}$$

$$= -\frac{k}{2} + k - \frac{k}{2}$$

$$= k - k = 0$$

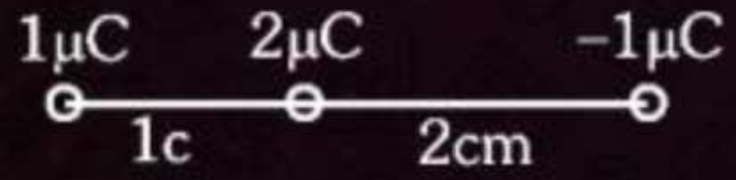
②



all charges = +ve

$U \neq 0$

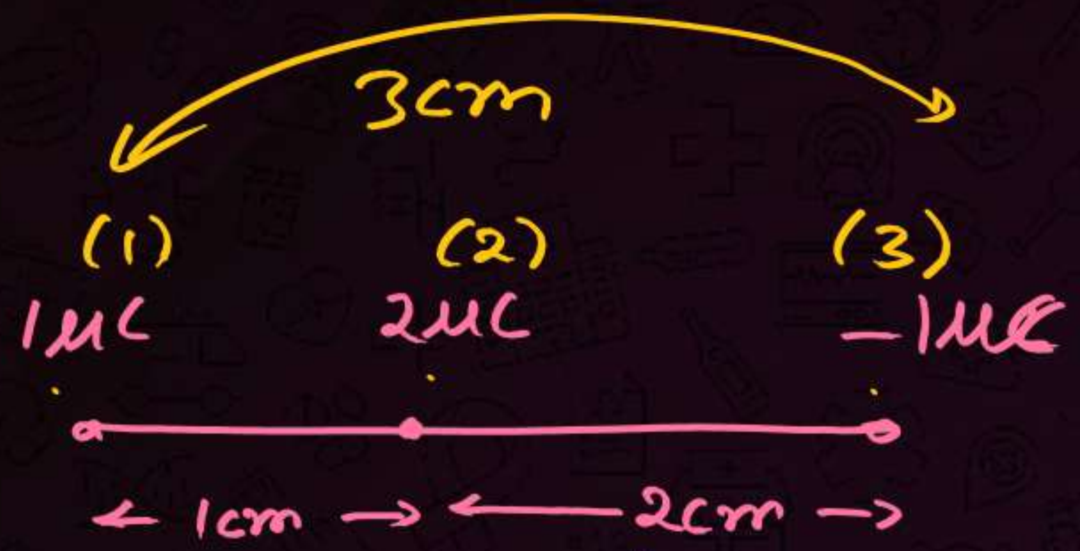
③



↳ HW → Practice?

④ None of these

(3)



$$U = \frac{k\times 1\times 2}{1} + \frac{k\times \cancel{2}\times(-1)}{\cancel{2}} + \frac{k(1)(-1)}{3}$$

$$= 2k - k - \frac{k}{3}$$

$$= k - \frac{k}{3} = \boxed{\frac{2k}{3}}$$

Electrostatic Potential

It is work done or potential energy per unit test charge.

$$\boxed{\frac{F}{q_0} = E = \frac{kq}{r^2}}$$

$$\boxed{V=0}$$

$q_0 \to \infty$

$$U = \frac{kqq_0}{r}$$

$$\boxed{\frac{U}{q_0} = \frac{W}{q_0} = \frac{kq}{r} = V}$$

$$\boxed{V = \frac{kq}{r}}$$

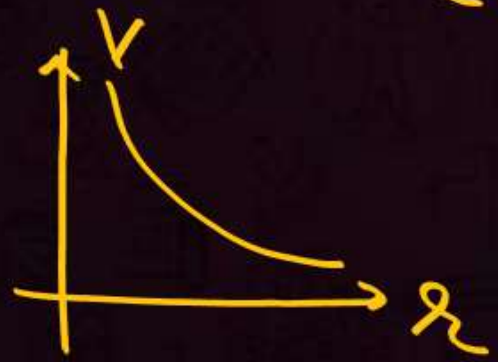
TBS points about potential

- Scalar Quantity
- SI Unit – J/C or Volt

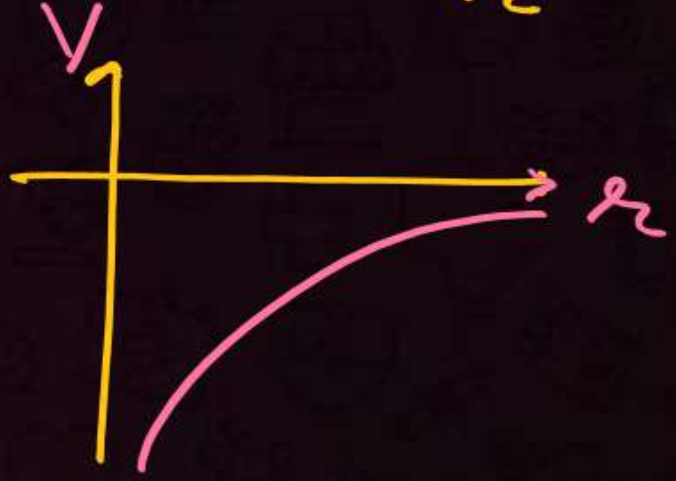
$V = \frac{U}{q_0} \Rightarrow \frac{J}{C}$

- Put value of charge with sign
- Graph

$\underline{\underline{+ve}} \Rightarrow V = \frac{+kq}{r} \Rightarrow \boxed{V \propto \frac{1}{r}}$



$\underline{\underline{-ve}} \Rightarrow V = \frac{-kq}{r}$



$\boxed{\text{rec. hyperbola}} \Rightarrow \boxed{y \propto \frac{1}{x}}$

QUESTION

Electric potential at a point 'P' due to a point charge of 5×10^{-9} C is 50 V. The distance of 'P' from the point charge is:

[8 April, 2023 (Shift-II)]

JEE Mains

(Assume, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2 C^{-2})

① 3 cm

② 9 cm

[✓ ③ 90 cm]

④ 0.9 cm

$$V = \frac{kq}{r}$$

$$r = \frac{kq}{V} = \frac{9 \times \cancel{10^9} \times \cancel{5} \times \cancel{10^{-9}}}{\cancel{50}\ 10}$$

$$= \frac{9}{10} m = 0.9 m.$$

$$= \frac{9}{\cancel{10}} \times 10\cancel{0} = 90 cm.$$

Ans

$$V = ? = \frac{kq}{r} = \frac{\overset{3}{\cancel{9}} \times \overset{10^3}{\cancel{10^9}} \times 2 \times \cancel{10^{-6}}}{\cancel{3} \times 10^{-2}}$$

$$= \frac{6 \times 10^3}{10^{-2}} = 6 \times 10^3 \times 10^2$$

$$= 6 \times 10^5 \, V$$

QUESTION

✓ → $\boxed{V_\infty = 0}$

Assertion (A): Electrostatic potential is a $\boxed{\text{relative}}$ physical quantity.

Reason (R): Electric potential difference is an absolute physical quantity.

$\boxed{U = 0 \text{ at } \infty}$ ← assume

✓ $\Delta V = \frac{kq}{r}$ ✓ $\Delta U = \frac{kqq_0}{r}$

1. If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of Assertion (A).
2. If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).
3. If Assertion (A) is True but the Reason (R) is False.
4. Assertion (A) is False but the Reason (R) is True.

$U = \frac{kqq_0}{r}$, $V = \frac{kq}{r}$

QUESTION

The electric field intensity at a point at a distance 2 m from a charge q is 4 N/C. Find the amount of work done (in joule) in bringing a charge of 1 coulomb from infinity to this point.

q_0

① 2 J

② 4 J

[✓ ③] 8 J

④ 16 J

$$\boxed{W = \frac{kqq_0}{r}}$$

$$= \frac{k \times q \times 1}{r}$$

$$= \boxed{\frac{kq}{r}}$$

$$E = \boxed{\frac{kq}{r^2} = 4}$$

$$\frac{kq}{r \times r} = 4$$

$$\frac{kq}{r} = 4r = 4 \times 2 = 8$$

QUESTION

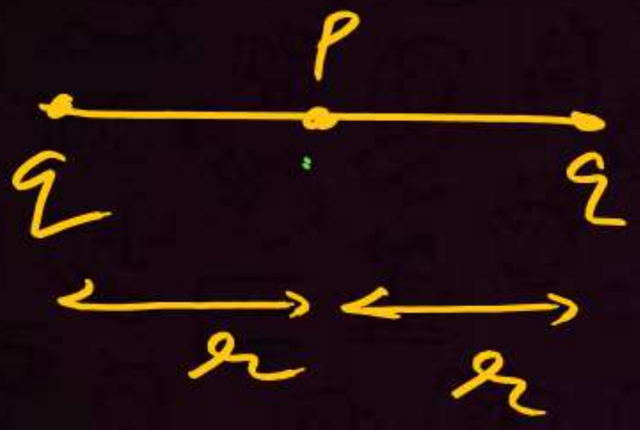
Find electric potential at a point midway between the two equal positive charges.

A) $\frac{kq}{r}$

[✓ B)] $\frac{2kq}{r}$

C) Zero

D) Humein Kya Pta!!



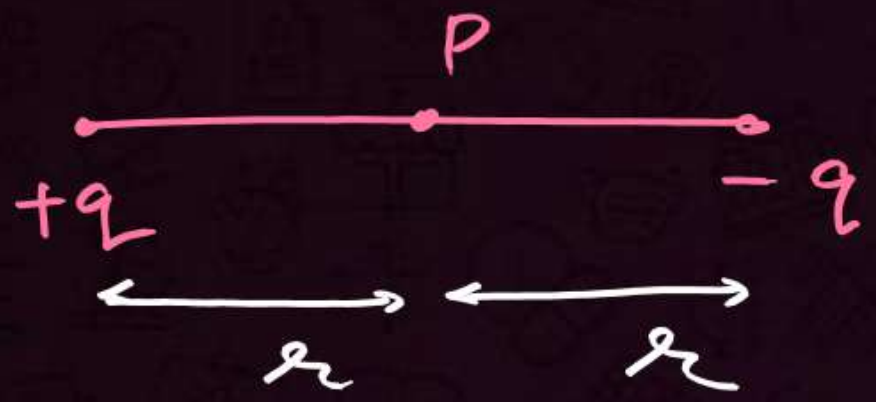
$$V = V_1 + V_2$$

$$= \frac{kq}{r} + \frac{kq}{r}$$

$$= \frac{2kq}{r}$$

QUESTION

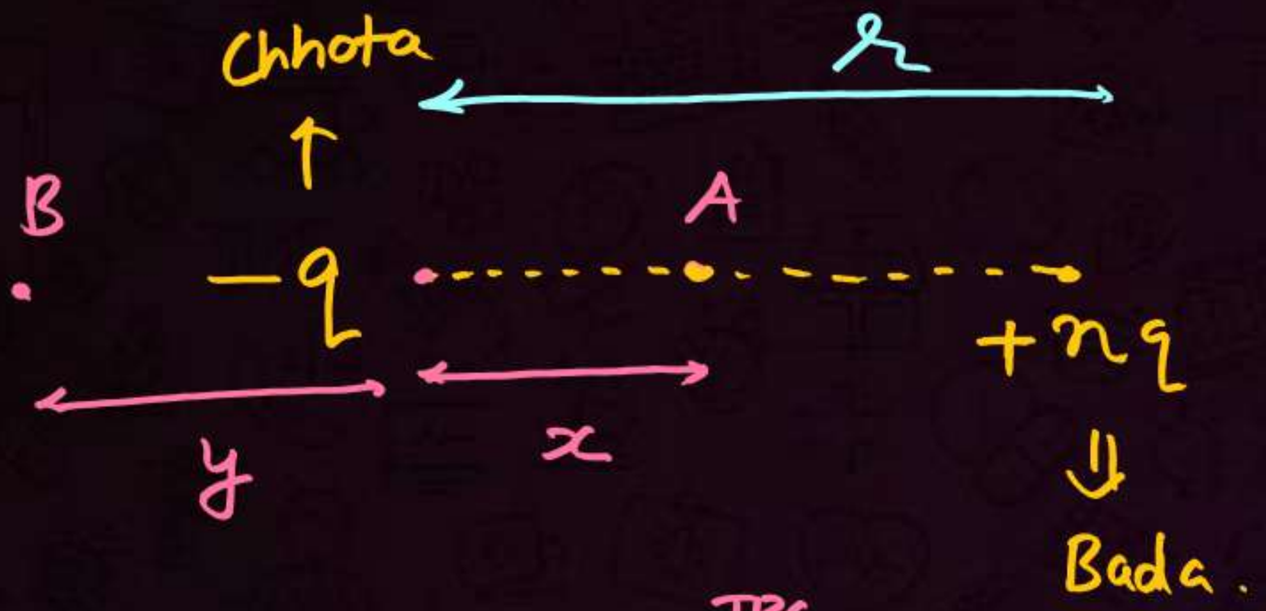
Find electric potential at a point midway between the two equal and opposite charges.



$$V = \frac{kq}{r} + \frac{k(-q)}{r}$$

$$= \frac{kq}{r} - \frac{kq}{r} = 0$$

Zero Potential Points



$$\boxed{n = \frac{\text{Bada } q}{\text{Chhota } q}} \rightarrow$$ without sign.

TBS

$$V_A = 0 \Rightarrow \boxed{x = \frac{r}{n+1}} \rightarrow$$ from Chhota q

$$V_B = 0 \Rightarrow \boxed{y = \frac{r}{n-1}} \rightarrow$$ from chhota q

TBS

Ques

Distances from q where V=0?

$$n = \frac{3q}{q} = 3$$

$$x = \frac{r}{n+1} = \frac{r}{3+1} = \frac{r}{4}$$

$$y = \frac{r}{n-1} = \frac{r}{3-1} = \frac{r}{2}$$

QUESTION

Three isolated equal charges are placed at the three corners of an equilateral triangle as shown in figure. The statement which is true for net electric potential V and net electric field intensity E at the centre of the triangle

① $V = 0, E = 0$

② $V = 0, E \neq 0$

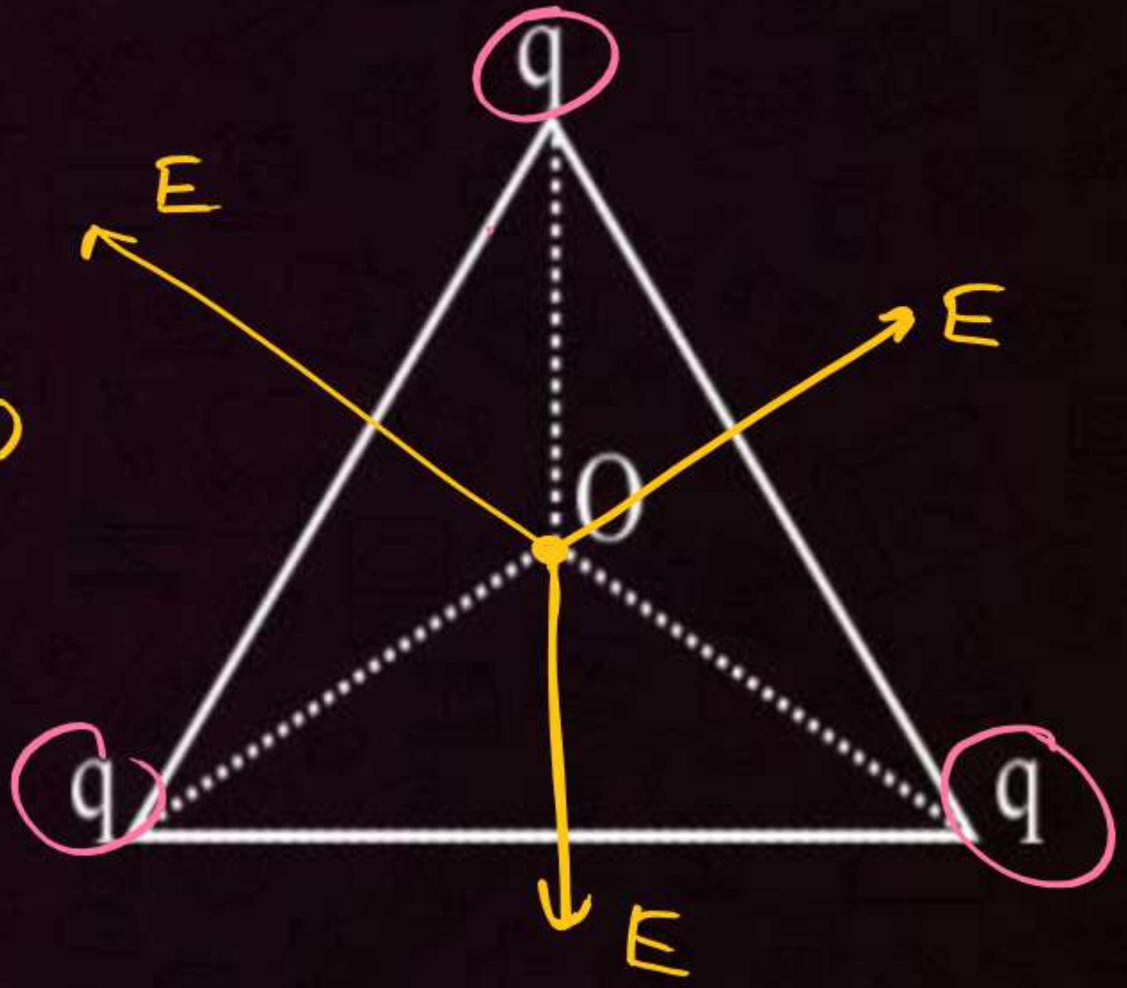
[✓ ③ $\underline{V \neq 0}, \underline{E = 0}$]

④ $V \neq 0, E \neq 0$

$E = 0$

$V \neq 0$

(all charges $\underline{\underline{+ve}}$)



QUESTION

Considering a group of positive charges, which of the following statements is correct?

[31 Jan, 2023 (Shift-II)]
(JEE Main)

[✓ 1] Net potential of the system cannot be zero at a point but net electric field can be zero at that point. ✓ ✓

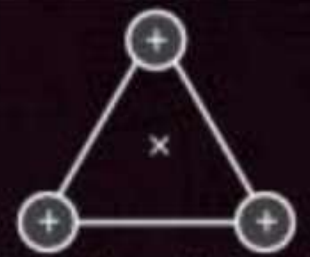
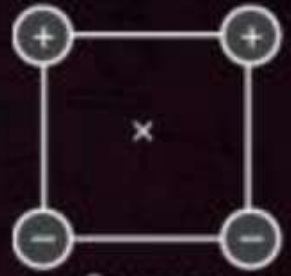
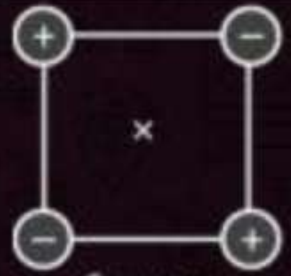
2. Net potential of the system at a point can be zero but net electric field can't be zero at that point. ✗

3. Both the net potential and the net field can be zero at a point. ✗

4. Both the net potential and the net electric field cannot be zero at a point.

QUESTION

In the following diagrams, all the charges have equal magnitude

Column-I		Column-II	
(A)	 Equilateral triangle	(P)	The potential is zero at the centre
(B)	 Square	(Q)	The electric field is zero at the centre
(C)	 Square		
(D)	 Rectangle		

1. A → Q; B → P; C → P,Q; D → P
2. ~~A → P, Q; B → P; C → P,Q; D → Q~~
3. A → Q; B → P, Q; C → P; D → P, Q
4. ~~A → P, Q; B → P; C → Q; D → P~~

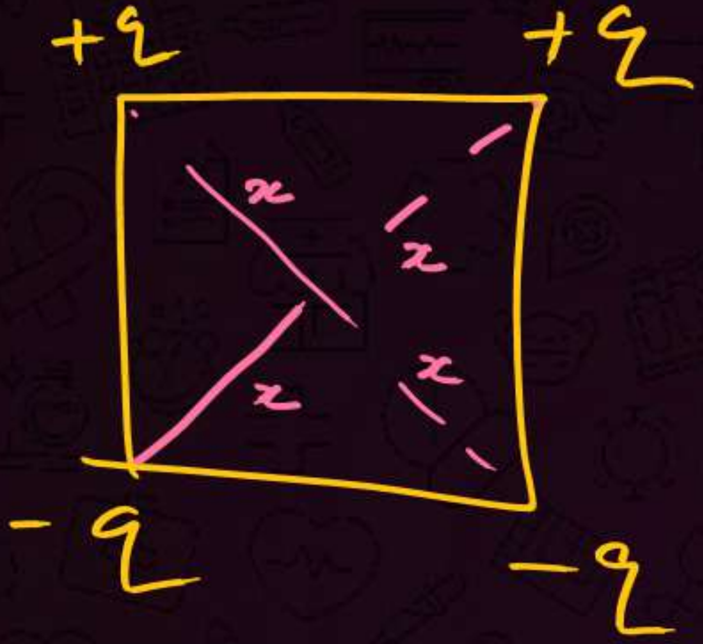
E = 0

V ≠ 0

A → Q

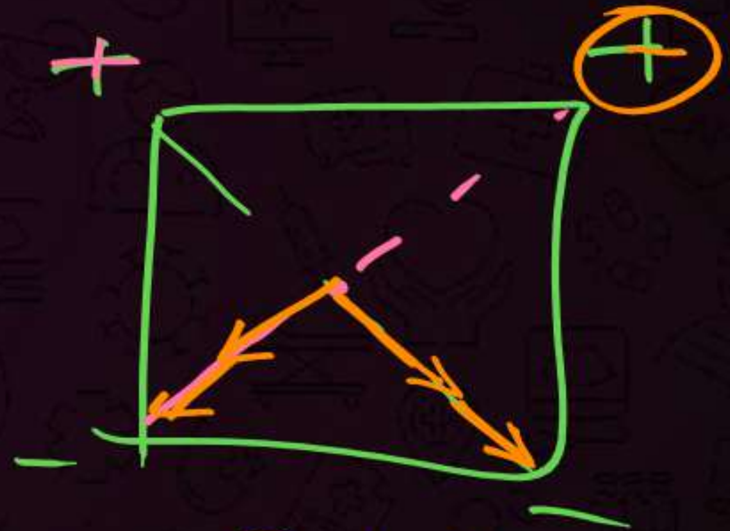
B → P

HW



$$x = \frac{a}{\sqrt{2}}$$

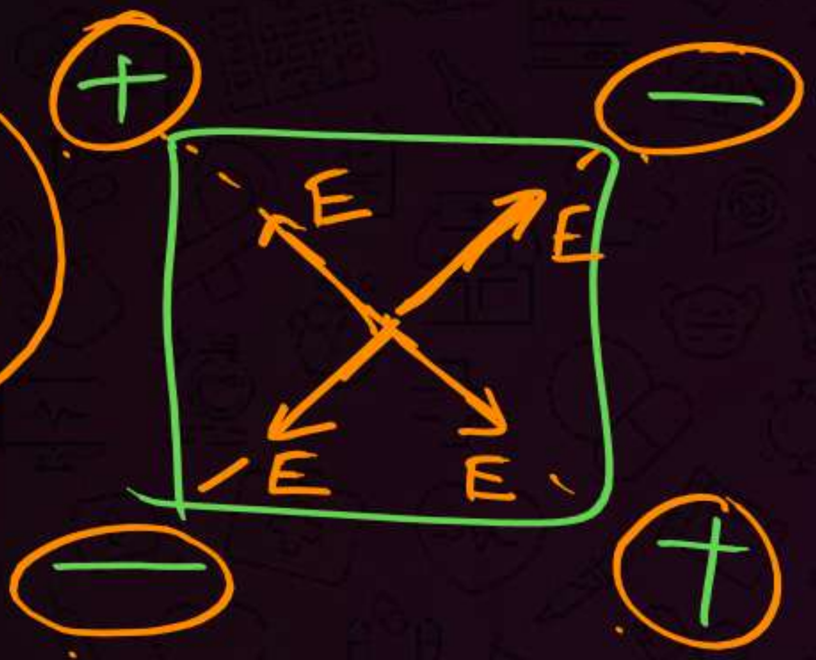
$$V = \frac{kq}{x} + \frac{kq}{x} - \frac{kq}{x} - \frac{kq}{x} = 0$$



$E \neq 0$

$V = 0$

$E = 0$



Work done in terms of Potential Difference

* $\frac{U}{q_0} = V$

$\frac{\Delta U}{q_0} = \Delta V$

$$\boxed{\Delta U = q_0 \Delta V}$$

$$\boxed{W_{ext} = \Delta U = q_0 \Delta V}$$

$$\boxed{W_{elec} = -\Delta U = -q_0 \Delta V}$$

$q_0 \rightarrow \underline{\underline{\text{sign}}}$

Ans

$W_{elec} = -\underline{\underline{12J}}$

W_{ext} in moving q_0 from

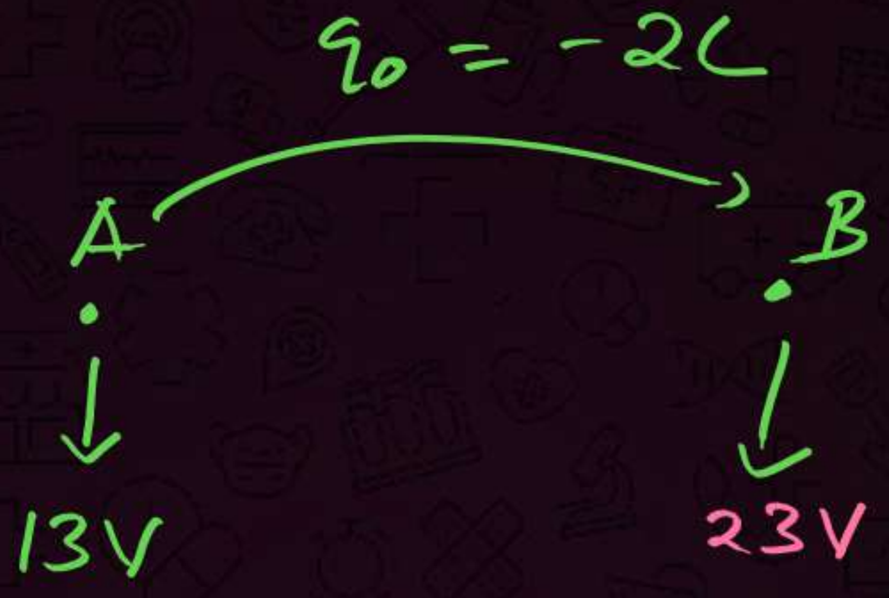
$\underline{\underline{A \text{ to } B}}$

$\Delta V = V_B - V_A = 8 - 5 = 3$

$W_{ext} = 4 \times 3$

$= \underline{\underline{12J}}$

Ans



$$W_{elec} = -q_0 \Delta V$$

$$= -(-2)(23-13)$$

$$= +2 \times 10$$

$$\underline{= 20\,J}$$

QUESTION

15 joule of work has to be done against an existing electric field to take a charge of 0.01 C from A to B. Then the potential difference $(V_A - V_B)$ is :

1. 1500 volts ✗
2. [✓ –1500 volts]
3. 0.15 volts
4. none of these

$W_{ext} = 15$

$q_0 = 0.01$

$W_{ext} = q_0 \Delta V$

$15 = 0.01 \times \Delta V$

$15 = \frac{1}{100} \times \Delta V$

$\Delta V = 1500$

$V_B - V_A = 1500$

$V_A - V_B = -1500$

QUESTION

The work done in bringing a 10 coulomb charge from point A to point B for distance 0.2 m is 2 J. The potential difference between the two points will be (in volt):

- [✓ 1] 0.2
- 2 8
- 3 0.1
- 4 0.4

$W = q_0 \Delta V$

$2 = 10 \Delta V$

$\frac{2}{10} = 0.2 = \Delta V$

Relation between Electric Potential and Electric Field

$$dV = -\vec{E}\cdot\vec{dr}$$

$$\boxed{\int dV = -\int \vec{E}\cdot\vec{dr}} \longrightarrow \text{If } E \rightarrow \text{known}, \quad V \rightarrow \text{find}$$

$$* \quad \boxed{E = -\frac{dV}{dr}} \Longrightarrow \text{If } V \text{ known}, \quad E \rightarrow \text{find}$$

$$\boxed{\begin{aligned} E_x &= -\frac{\partial V}{\partial x} \longrightarrow y, z \text{ cons} \\ E_y &= -\frac{\partial V}{\partial y} \longrightarrow x, z \text{ const} \\ E_z &= -\frac{\partial V}{\partial z} \longrightarrow x, y \text{ const.} \end{aligned}}$$

d → diff.

∂ → del. operator

↓

(partial diff)

QUESTION

The electric potential V at any point (x, y, z) all in metres in space is given by $V = 3x^2$ volt. The electric field at the point (1, 0, 3) in volt/metre is (JEE Main 29 June)

① 3 along negative X-axis

② 3 along positive X-axis

[✓ ③ 6 along negative X-axis] ✓

④ 6 along positive X-axis ×

$V = 3x^2$ ✓

$E = E_x = -\frac{\partial V}{\partial x}$

$= -3 \times 2x$

$= -6x$

$= -6 \times 1$

$= -6$

← E

$E_y = 0$

$E_z = 0$

$$\boxed{\begin{array}{l} x^2 \rightarrow 2x \\ x \rightarrow 1 \\ c \rightarrow 0 \end{array}}$$

Ques $V = 4y^2$

Find E at $y = 2$.

$$E = E_y = \frac{-\partial V}{\partial y}$$

$$= -4 \times 2y$$

$$= -8y$$

$$= -8 \times 2$$

$$= -16$$

$\downarrow E$

Ques $V = 5z^2$

Find E at $z = 3$

$$E = E_z = \frac{-\partial V}{\partial z}$$

$$= -5 \times 2z$$

$$= -10z$$

$$= -10 \times 3$$

$$= -30$$

Ques

$V = 4x + 3y + 5z$

Find E ?

~~A) 12~~

[✓ B) $5\sqrt{2}$]

C) 50

D) Humein Kya Pta!

$$E_x = -\frac{\partial V}{\partial x} = -(4\times1 + 0 + 0)$$

$$= -4$$

$$E_y = -\frac{\partial V}{\partial y} = -(0 + 3\times1 + 0)$$

$$= -3$$

$$E_z = -5.$$

$$\vec{E} = -4\hat{i} - 3\hat{j} - 5\hat{k}$$

$$E = \sqrt{4^2+3^2+5^2} = \sqrt{50} = 5\sqrt{2}$$

Qus. If $\vec{E} = \boxed{2\hat{i}} \longrightarrow$ const.

$A \rightarrow x = 0$

$B \rightarrow x = 4$

$V_A - V_B = ?$

$$dV = -\vec{E}\cdot\vec{dr}$$

$$\boxed{\Delta V = -\vec{E}\cdot\vec{\Delta r}}$$

If E = const = uniform.

$$\Delta V = -E_x \Delta x$$

$$V_B - V_A = -2 \times 4$$

$$V_B - V_A = -8$$

$$\boxed{V_A - V_B = +8}$$

Ans.

$E = 3x$

$\hookrightarrow 2x^2$

Variable

$\Delta x = 4 - 0 = 4$

BPU Ques $\vec{E} = 3\hat{i}$

$A \rightarrow x = 2$

$B \rightarrow x = 8$

$\Delta x = 8-2 = 6 \Leftarrow$

$V_A - V_B = ?$

$$\Delta V = -E_x \Delta x$$
$$= -3 \times 6$$
$$V_B - V_A = -18$$
$$V_A - V_B = +18.$$

Ques $\vec{E} = 4\hat{i} + 3\hat{j}$

$A\,(0, 1)$

$B\,(3, 6)$

$V_A - V_B = ?$

$V_A - V_B = +27$

$\Delta x = 3-0 = 3$

$\Delta y = 6-1 = 5.$

$$\Delta V = -E_x \Delta x - E_y \Delta y$$
$$= -4 \times 3 - 3 \times 5$$
$$= -12 - 15 = -27$$

Ques

$E = \underline{2}\hat{i} + \underline{3}\hat{j} + \underline{4}\hat{k}$

$A(0, 1, 2)$

$B(2, 4, 5)$

$V_A - V_B = ?$

A) 13 V B) 12 V [✓ C) 25 V] D) None

$2 \times 2 = 4$

$3 \times 3 = 9$

$3 \times 4 = 12$

~~Ques~~

$$\vec{E} = \underline{x}\hat{i} + \underline{y}\hat{j}$$

A $(\underline{1}, \underline{0})$

B $(\underline{2}, \underline{2})$

$V_A - V_B = ?$

$$dV = -\vec{E}\cdot\vec{dr}$$

$$\boxed{dV} = -\int E_x\,dx - \int E_y\,dy$$

$\int E_x\,dx$

$$= \int_1^2 x^1\,dx = \frac{x^2}{2}$$

$$= \frac{2^2-1^2}{2} = \frac{4-1}{2} = \frac{3}{2}$$

$$\boxed{\begin{aligned}\int x\,dx &= \frac{x^2}{2}\\ \int y\,dy &= \frac{y^2}{2}\end{aligned}}$$

$$\int E_y\,dy = \int_0^2 y\,dy = \frac{y^2}{2} = \frac{2^2-0^2}{2}$$

$$= \frac{4}{2} = 2$$

$$\Delta V = -\left[\frac{3}{2}+2\right] = -\frac{7}{2}.$$

$$V_B - V_A = -\frac{7}{2}$$

$$V_A - V_B = +7/2 = +3.5\,V$$

QUESTION

A charge 3 coulomb experiences a force 3000 N when placed in a uniform electric field. The potential difference between two points separated by a distance of 1 cm along the field lines is

① [✓ 10 V]

② 90 V

③ 1000 V

④ 9000V

E → uniform

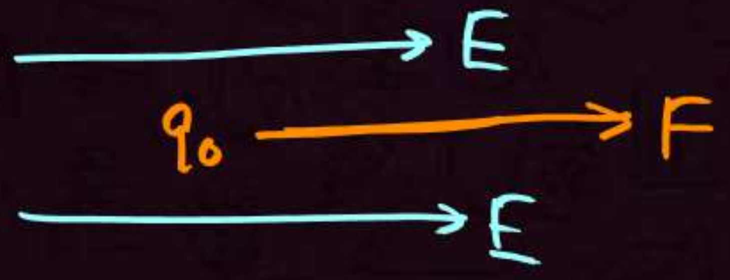
$$\Delta V = -E_x \Delta x$$

$$= -1000 \times \frac{1}{100}$$

$$= \boxed{-10 V}$$

$\Delta x = 1 cm = \frac{1}{100} m$

$$\frac{F}{q_0} = E$$



$$F = q_0 E$$

$$3000 = 3 \times E$$

$$E = 1000$$

Clarity

$$E = -\frac{dV}{dx}$$

$$E_x = -3$$

$$E_y = -4$$

$$E_z = -5$$

$$E = \sqrt{3^2 + 4^2 + 5^2}$$

↓

Vector

$$\Delta V = -\vec{E} \cdot \vec{\Delta r}$$

↓

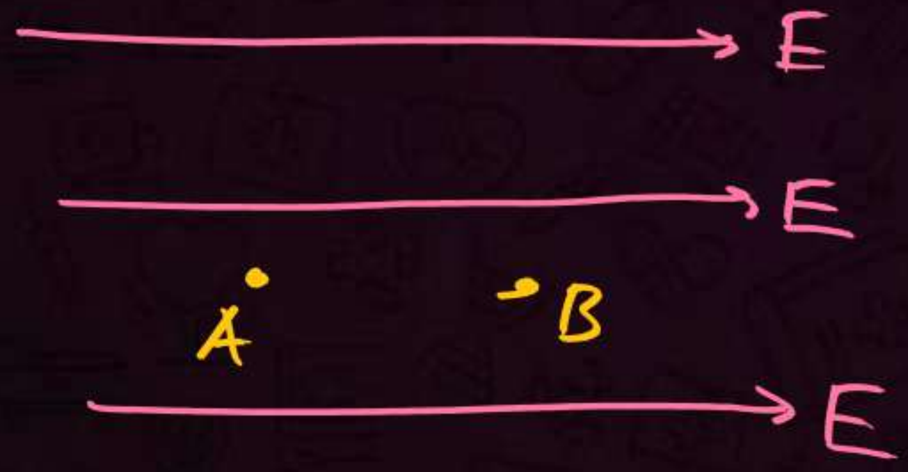
Scalar

↓

directly added

TBS Points

1. Electric Potential decreases in the direction of Electric Field



$V_A > V_B$.

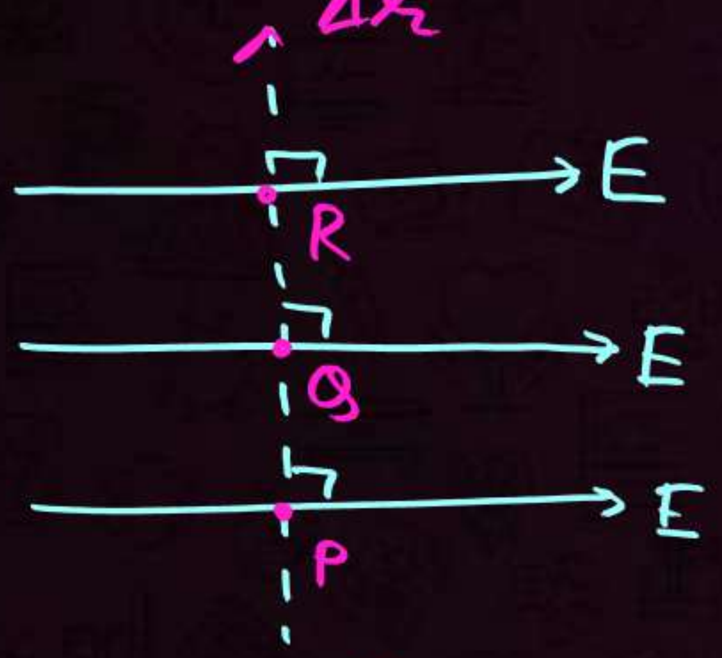
$E = -\frac{dV}{dr}$. = -ve of Potential gradient

-ve

Variation wrt gradient.

2. In a direction perpendicular to electric field, potential remains constant.

The surface on which potential remains constant is called 'Equipotential Surface'



$V_P = V_Q = V_R$

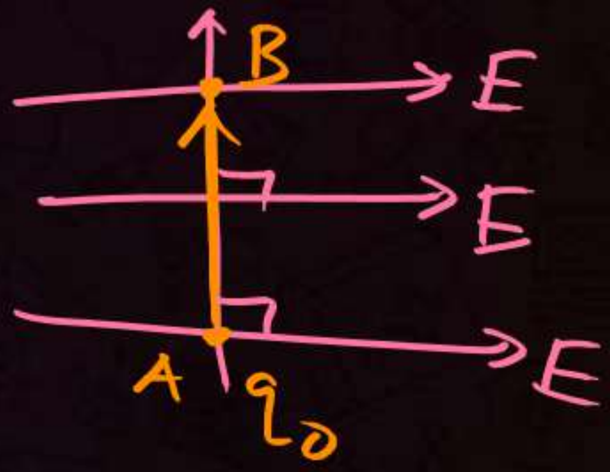
$$dV = -\vec{E}\cdot\vec{dr}$$

$$\Delta V = -\vec{E}\cdot\vec{\Delta r}$$

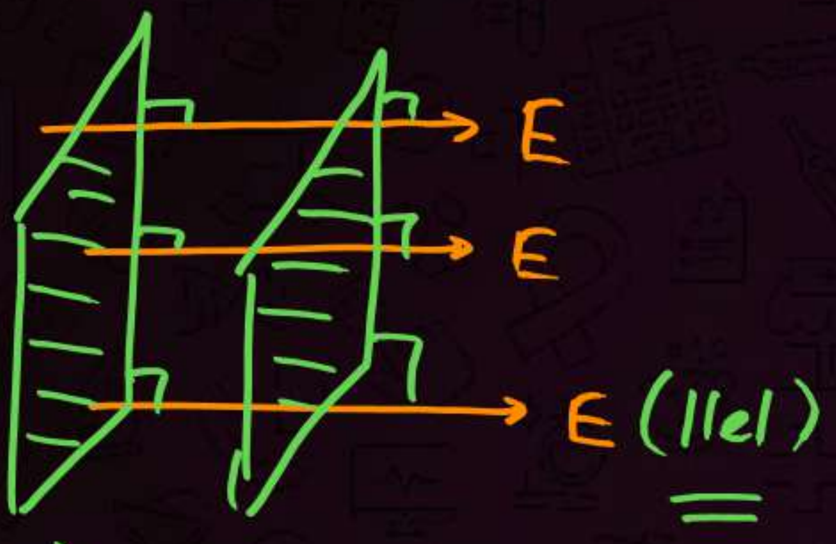
$$\Delta V = -E\,\Delta r\cos 90^\circ$$

$$\boxed{\Delta V = 0}$$

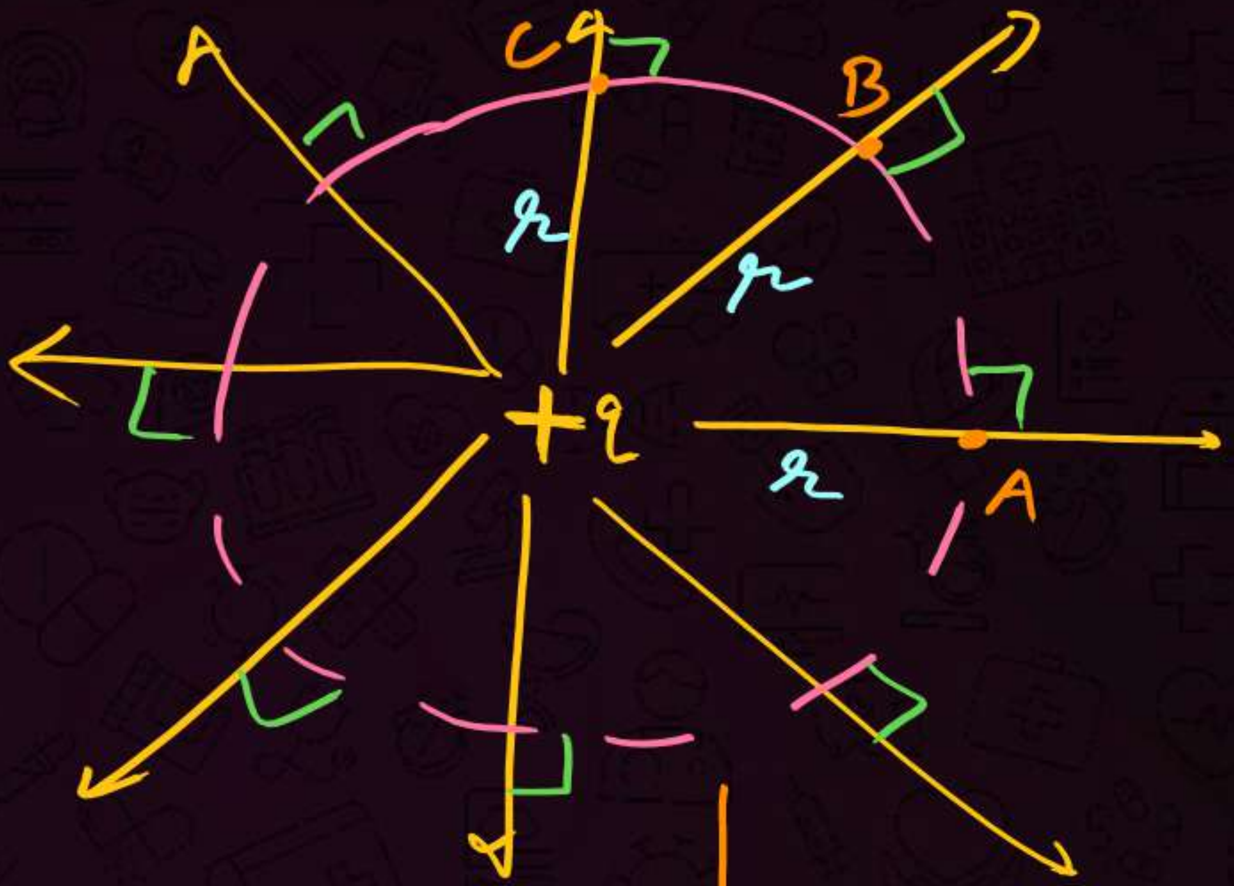
$$\boxed{V \rightarrow \text{const.}}$$



$$\begin{aligned} W &= q_0\Delta V \\ &= q_0 \times 0 \\ &= 0 \end{aligned}$$



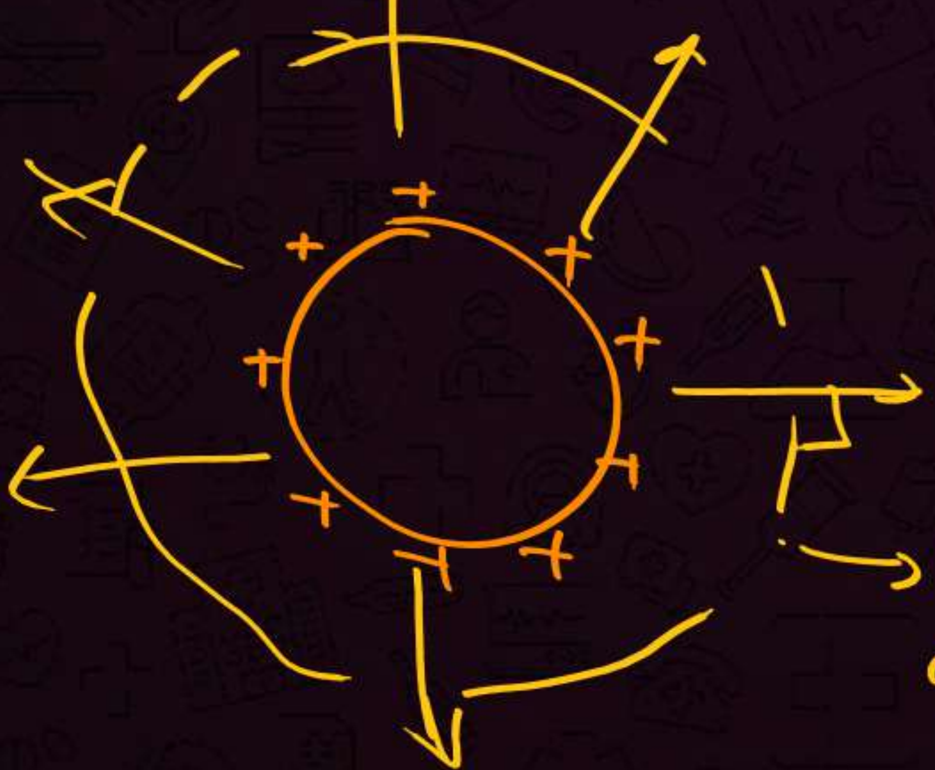
Planar



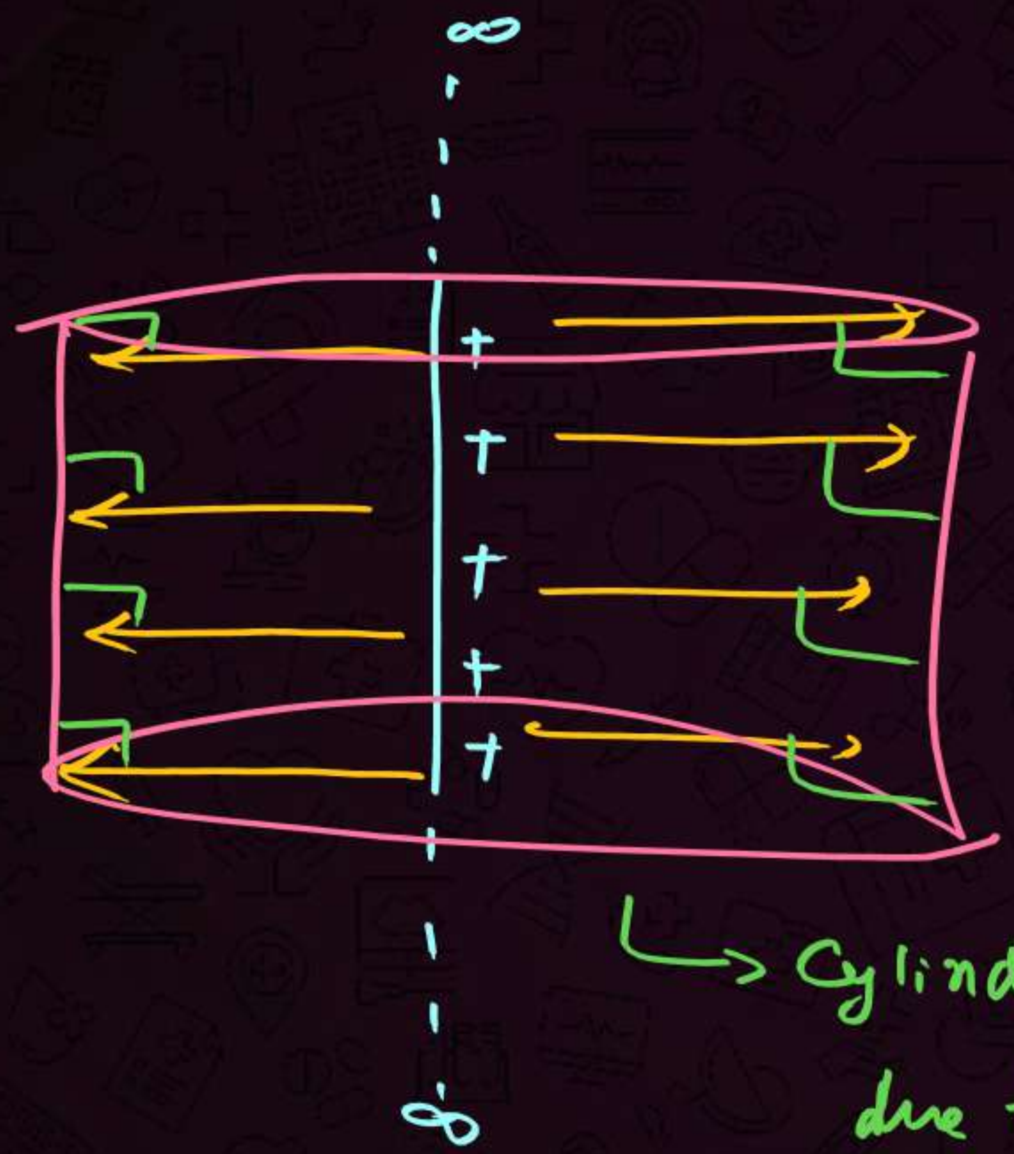
Spherical
(Pt. Charge)

$V_A = V_B = V_C$

$= \frac{kq}{r}$



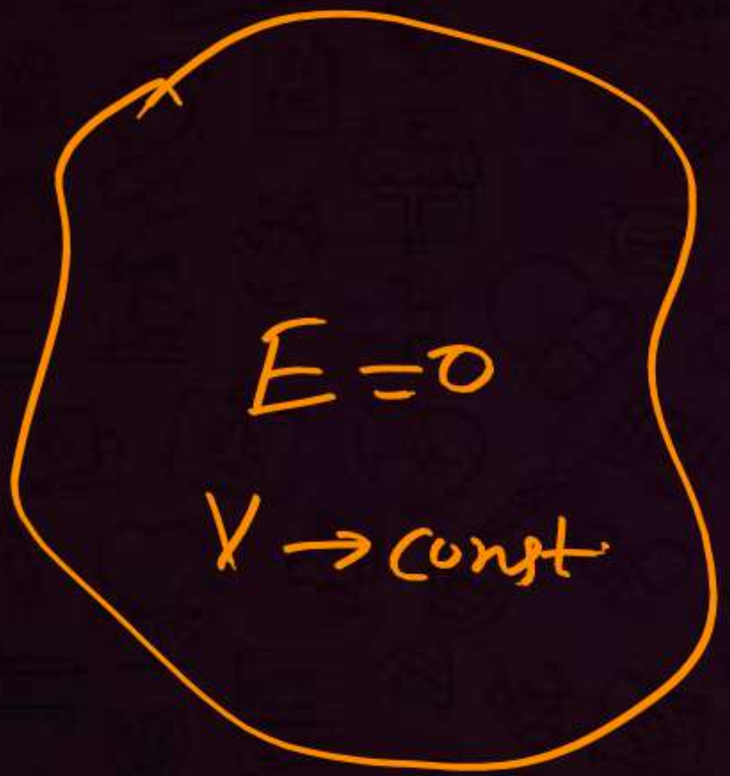
Spherical
due to sphere



↳ Cylindrical

due to line charge (rod)

3. In a region (volume), where electric field is zero, the potential is constant.



$$E = -\frac{dV}{dr}$$

$$0 = -\frac{dV}{dr}$$

$$dV = 0 \Rightarrow \Delta V = 0$$

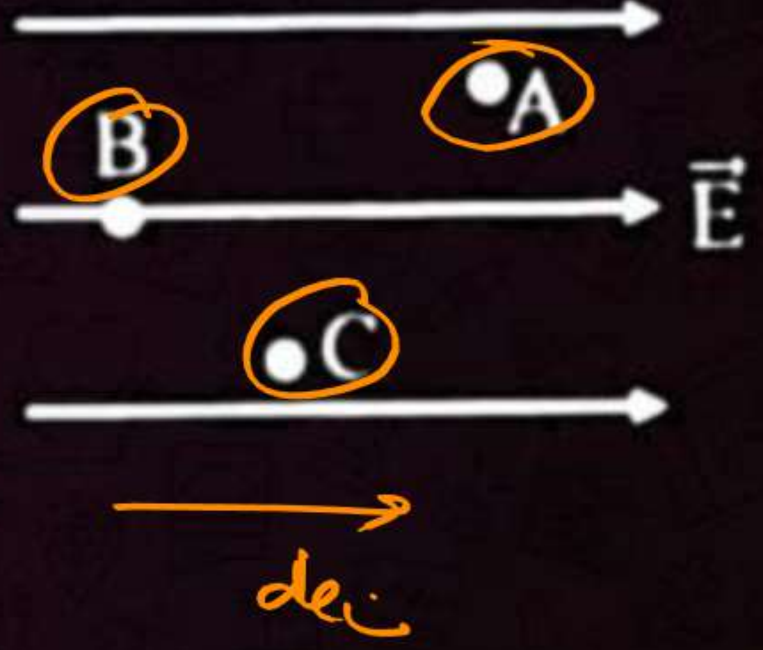
$$\boxed{V \to \text{const}}$$

QUESTION

A, B and C are three points in a uniform electric field. The electric potential is **(2013)**

1. maximum at A.
[✓ 2.] maximum at B.
3. maximum at C.
4. same at all the three points A, B and C.

$V_B > V_C > V_A$



QUESTION

Statement-I: Work done by electric field on moving a positive charge on an equipotential surface is always zero.

Statement-II: Electric lines of forces are perpendicular to equipotential surface.

[✓ ①] Statement-I is True, Statement-II is True; Statement-II is a correct explanation for Statement-I

② Statement-I is True, Statement-II is True; Statement-II is NOT a correct explanation for Statement-I

③ Statement-I is True, Statement-II is False

④ Statement-I is False, Statement-II is True.

QUESTION

Assertion: At a point electrostatic field is zero, then potential at that point is also zero.

$E = 0 \rightarrow V$ const.

Reason: Negative of potential gradient is equal to the electric field intensity.

$$E = -\boxed{\frac{dV}{dr}}$$

1. A & R both correct, R explains A
2. A & R both correct, R doesn't explain A
3. A is correct, R is correct.
4. [✓] A is incorrect, R is correct.

QUESTION

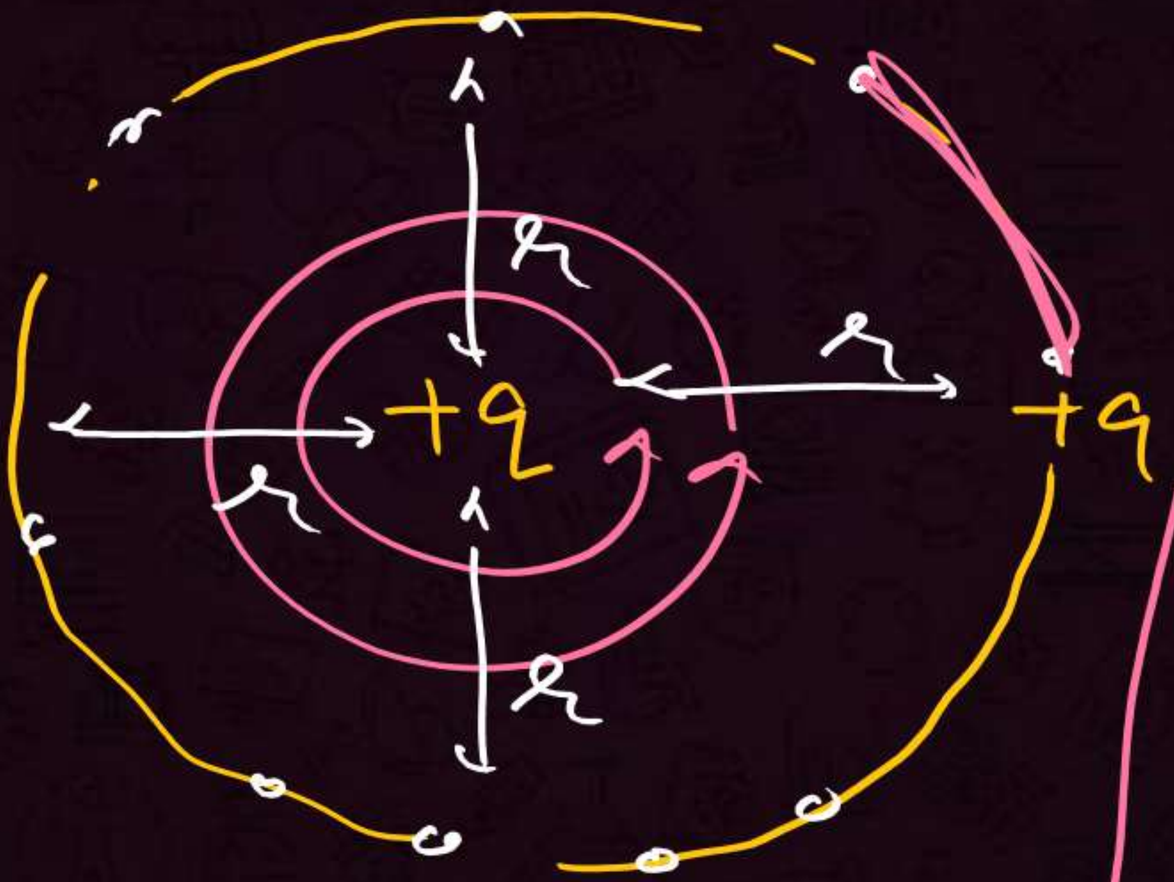
The force acting between two point charges $+q$ and $+q$ separated by distance r is F. If one charge is fixed and another charge completes two rounds in circular path around it, then work done will be:

(1) $F \times 4\pi r$

(2) $F \times 2r$

[✓ (3) Zero]

(4) $F \times \pi r^2$



Eq. pot surface

$\Delta V = 0$

$W = 0$

$\Delta V = 0$

$W = 0$

QUESTION

In a certain region of space with volume $0.2\ \text{m}^3$, the electric potential is found to be 5V throughout, the magnitude of electric field in this region is **(2020)**

① 0.5 N/C

② 1 N/C

③ 5 N/C

[✓ ④ Zero]

$V \to$ const.

$E = 0$

QUESTION

There is an electric field E in x-direction. If the work done on moving a charge of 0.2 C through a distance of 2 m along a line making an angle 60° with x-axis is 4 J, then what is the value of E?

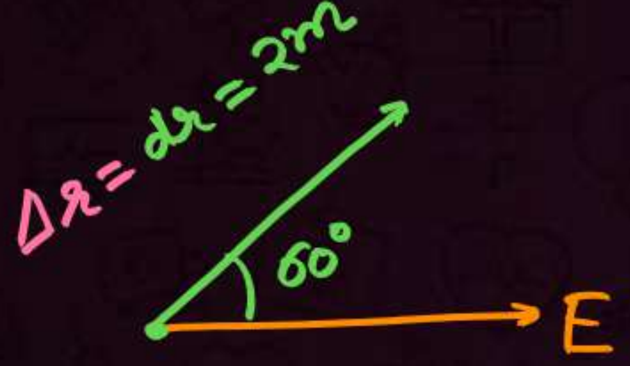
(1995)

① 5 N/C

[✓ ②] 20 N/C

③ $\sqrt{3}$ N/C

④ 4 N/C



$q_0 = 0.2C$

$W_{ext} = \underline{4\,J}$

$W_{ext} = q_0 \Delta V$

$4 = 0.2 \times \Delta V$

$\Delta V = \frac{4}{0.2} = 20$

$\Delta V = -\vec{E} \cdot \vec{\Delta r}$

$\Delta V = E \Delta r \cos 60^\circ$

$20 = E \times \cancel{2} \times \frac{1}{\cancel{2}}$

$\boxed{E = 20}$

M-2

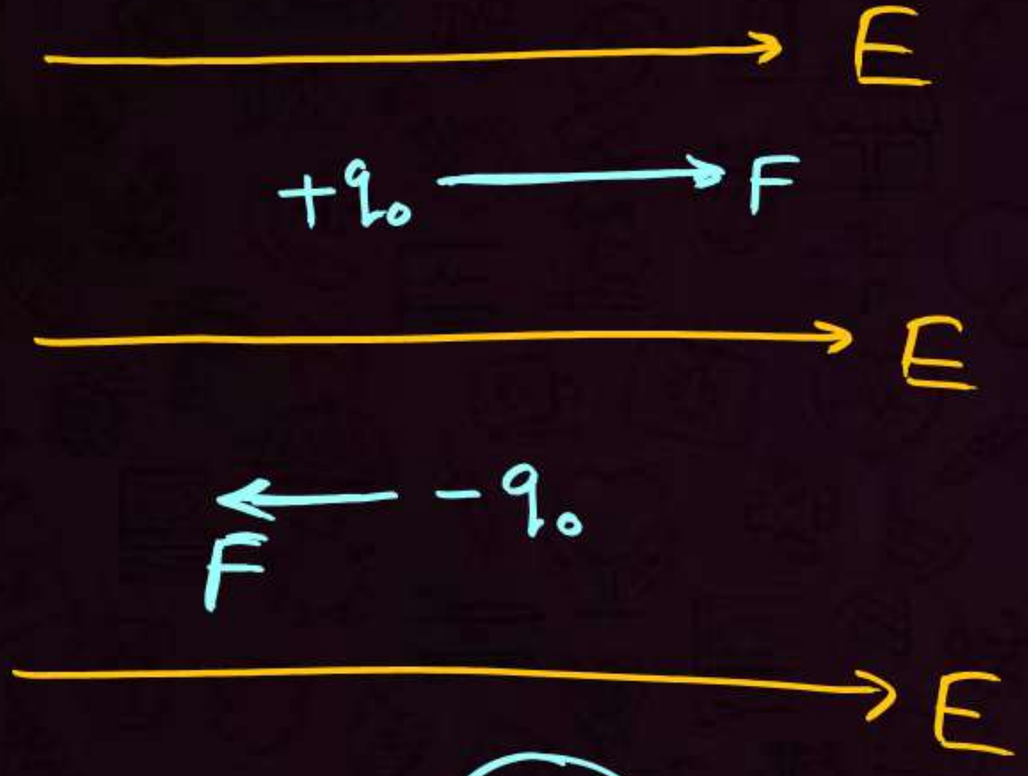
$W = \vec{F} \cdot \vec{\Delta r}$

$W = F \Delta r \cos 60^\circ$

$$\boxed{\begin{aligned} W &= q_0 E \Delta r \cos 60^\circ \\ 4 &= 0.2 \times E \times 2 \times \frac{1}{2} \end{aligned}}$$

Free Charge in Electric Field

→ Aawara



move → $\frac{K.E \uparrow}{U \downarrow}$

E → cons. force field.

+q =>	moves toward	dec. V	dec. U
-q =>	moves towards	inc. V	dec. U

+q ⇒ high to low V

-q ⇒ low to high V

Duniya ka Rule

U = mgh

h↓ ⇒ U↓

QUESTION

When a negative charge is released and moves in electric field, it moves towards a position of

① lower electric potential and lower potential energy

② lower electric potential and higher potential energy

[✓ ③] higher electric potential and lower potential energy

④ higher electric potential and higher potential energy

Conservation of Energy

$q \longrightarrow$ move

q ↓ $\bigcirc\!\!\!\!\!\;K_i = 0$ ↓ rest

dec in U = inc. in K.E.

$$q_0 \Delta V = \Delta K = K_f - \cancel{K_i}^{\,0}$$

✓ $\boxed{K_f = q_0 \Delta V}$

✓ $\boxed{\frac{1}{2} m v^2 = q_0 \Delta V}$

ΔV ↓ acc voltage

ques

$$v^2 = \frac{2 q_0 \Delta V}{m}$$

$$v = \sqrt{\frac{2 q_0 \Delta V}{m}}$$

QUESTION

A proton is accelerated from rest through a potential difference of 500 volts. The final kinetic energy is?

$q_0 = +e$

$$K_f = q_0 \Delta V$$

$$= +e \times 500\,V$$

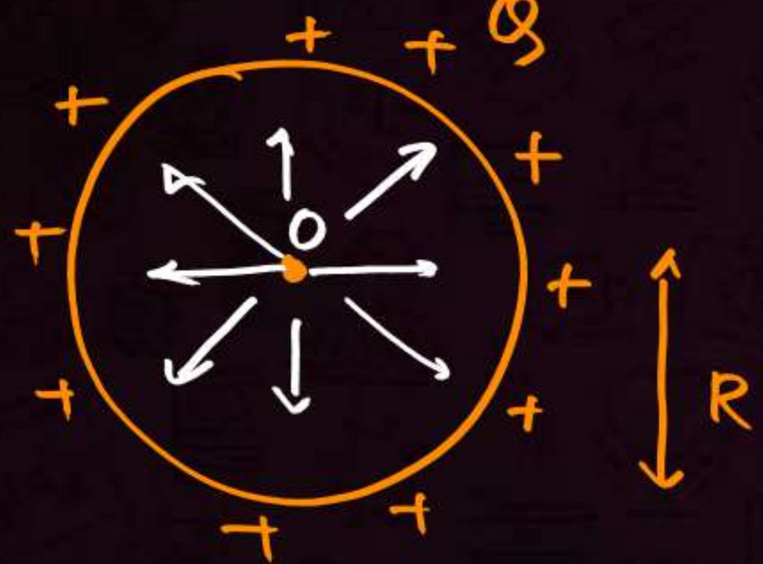
$$K_f = 500\,eV$$ ✓

$$= 500 \times 1.6 \times 10^{-19}\,J$$

$$= 8 \times 10^{-17}\,J$$

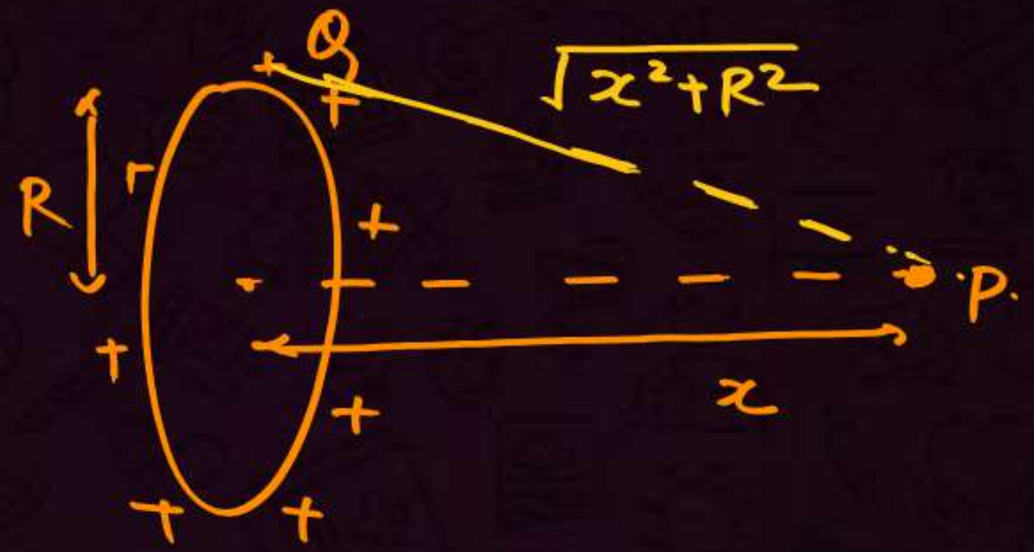
Electric Potential due to continuous charge distributions

(i) Ring



$$\boxed{E_0 = 0}$$

$$\boxed{V_0 = \frac{kQ}{R}}$$



$$E = \frac{kQx}{(x^2+R^2)^{3/2}}$$

$$E_{max} \Rightarrow x = \pm \frac{R}{\sqrt{2}}$$

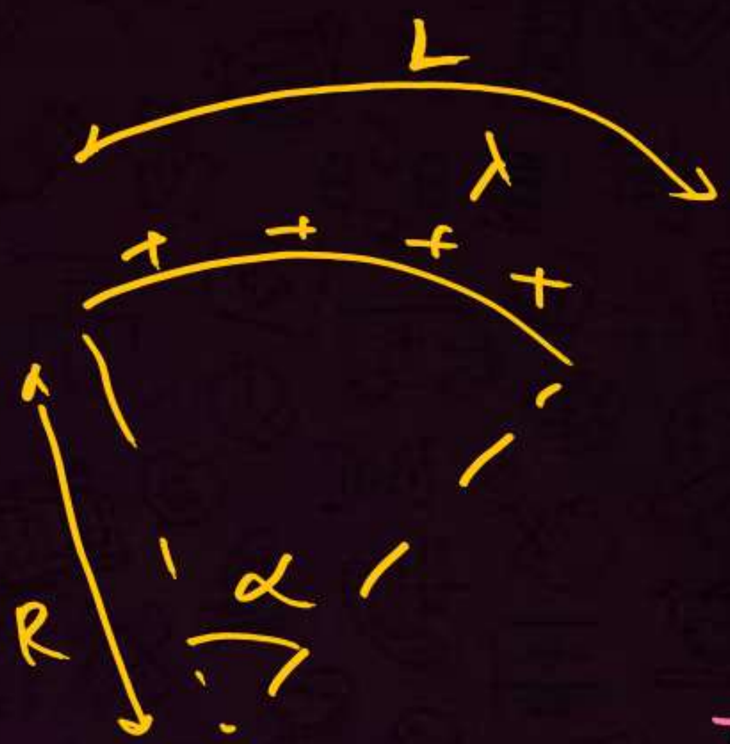
Rare chance

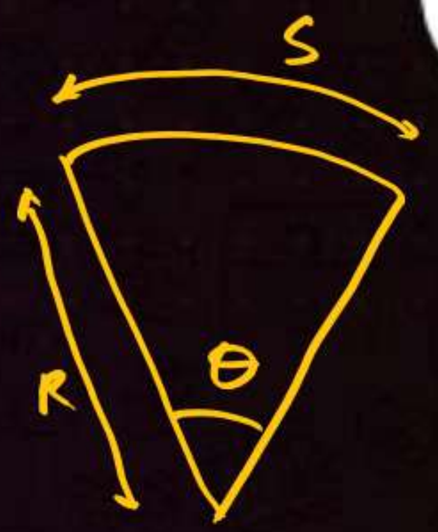
$$\boxed{V_P = \frac{kQ}{\sqrt{x^2+R^2}}}$$

(ii) Arc at Centre

$$\boxed{V = \frac{kQ}{R}}$$

✓ $E = \frac{2k\lambda}{R}\sin\left(\frac{\alpha}{2}\right)$





$$s = R\theta$$

$$\lambda = \frac{Q}{L} = \frac{Q}{R\alpha}$$

$$Q = \lambda R\alpha.$$

$$V = \frac{kQ}{R} = \frac{k \times \lambda \cancel{R}\alpha}{\cancel{R}.}$$

Charge Less ← $\boxed{V = k\lambda\alpha.}$ → radian

Ques

$V_0 = ?$

(A) $\frac{\lambda}{12\epsilon_0}$ B) $\frac{\lambda}{24\epsilon_0}$

C) $\frac{\lambda}{36\epsilon_0}$ D) None

$$V = k\lambda\alpha$$

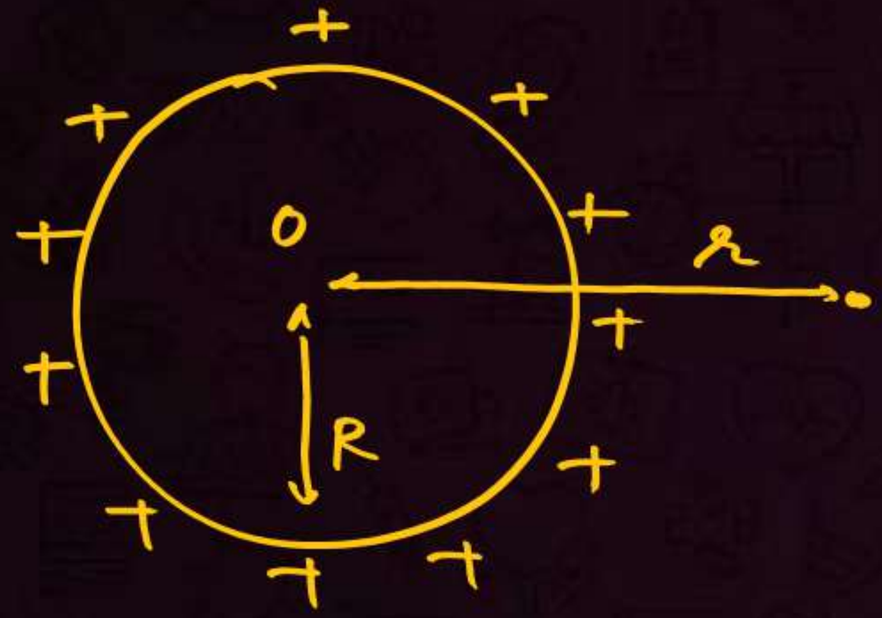
$$= \frac{1}{4\cancel{\pi}\epsilon_0} \times \lambda \times \frac{\cancel{\pi}}{3}$$

$$= \frac{\lambda}{12\epsilon_0}$$

$$\alpha = 60^\circ = \frac{\pi}{3}$$

$$\frac{\cancel{60} \times \pi}{\underset{3}{\cancel{180}}} = \frac{\pi}{3}$$

(iii) Hollow sphere (Conducting, Non conducting) and Solid Sphere (Conducting)



$$E_{out} = \frac{kQ}{r^2}$$

$$E_{sur} = \frac{kQ}{R^2}$$

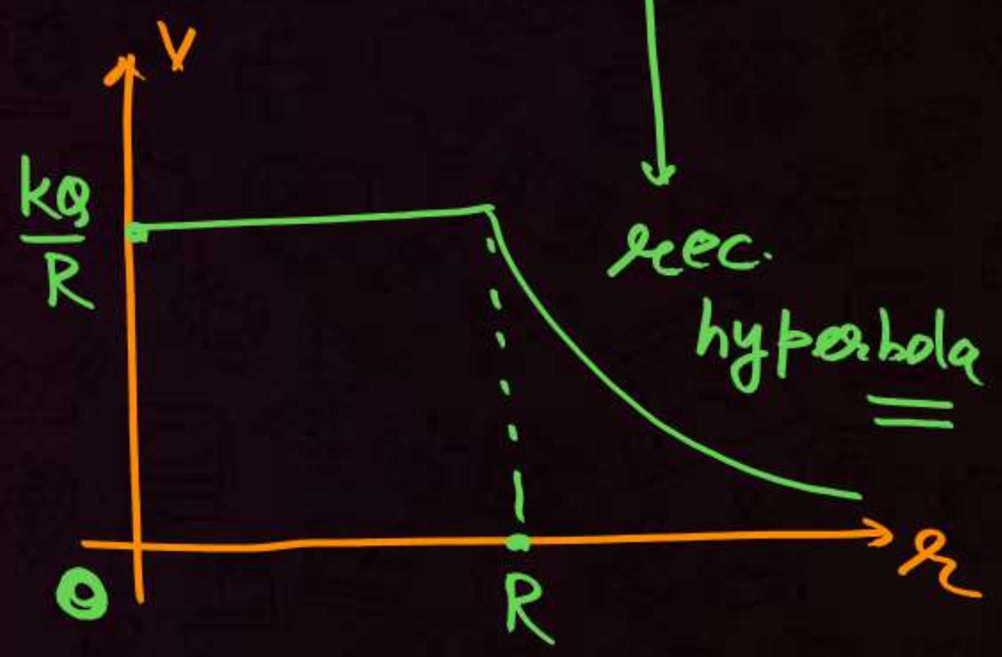
$$E_{in} = 0$$

$$V_{out} = \frac{kQ}{r}$$

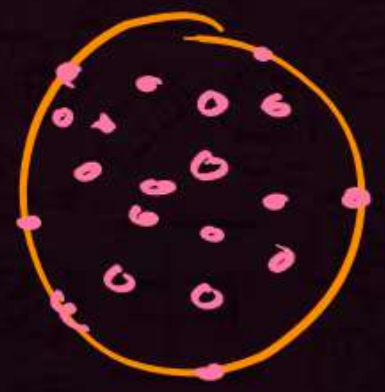
$$V_{sur} = \frac{kQ}{R}$$

$$V_{in} = \frac{kQ}{R}$$

$$\Longrightarrow V_{out} \propto \frac{1}{r}$$



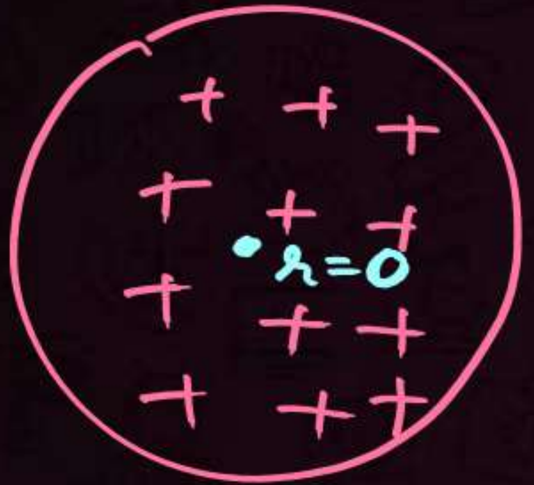
- If $E = 0 \rightarrow V = \text{const}$



$V = \frac{kQ}{R}$ at each pt.

(iv) Solid Sphere (Non conducting)

↳ Less Chance



$$E_{in} \neq 0 = \frac{kQr}{R^3}$$

$$V_{in} \neq \text{const.}$$

$$V_{out} = \frac{kQ}{r}$$

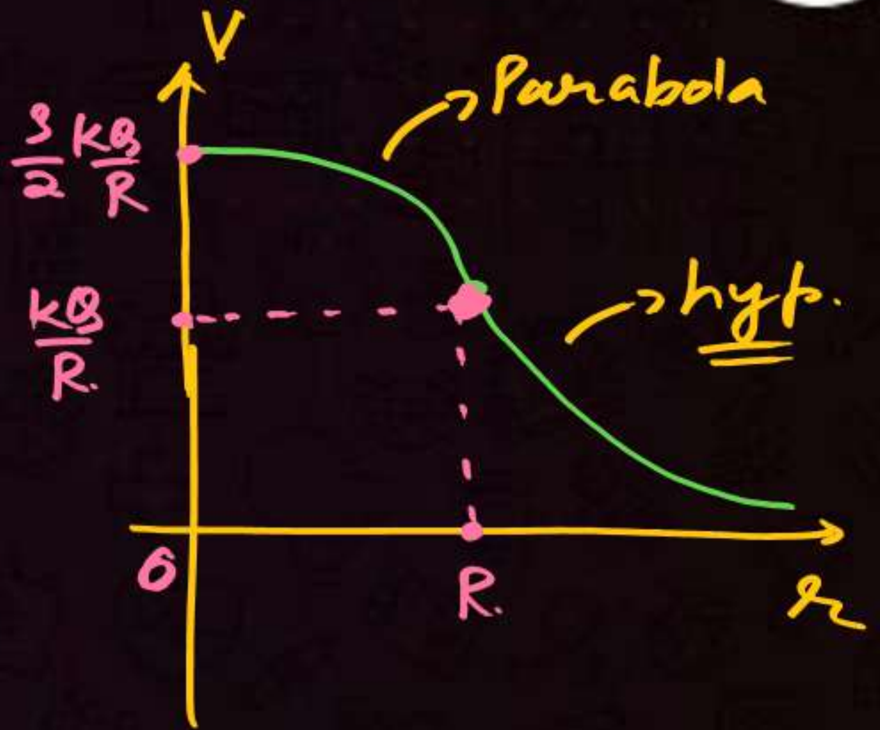
$$V_{sur} = \frac{kQ}{R}$$

$$\boxed{V_{in} = \frac{kQ}{2R^3}\left(3R^2 - r^2\right)}$$

At center $(r=0)$

$$V_c = \frac{kQ}{2\cancel{R^3}} \times 3\cancel{R^2}$$

$$\boxed{V_c = \frac{3}{2}\frac{kQ}{R}}$$



$$\boxed{y \propto x^2}$$

↳ Parabola

QUESTION

A hollow conducting sphere of radius R has a potential of 200 V at its outer surface. The potential at its inner point at a distance of R/2 from center is

① 50 V

② 100 V

[✓ ③ 200 V]

④ 150 V

$$V_{sur} = V_{in} = \frac{kQ}{R}$$

QUESTION

Electric potential at the surface of uniformly charged solid sphere is V. Find electric potential at its center.

Non-cond.

① V

② 2V/3

③ [✓ 3V/2]

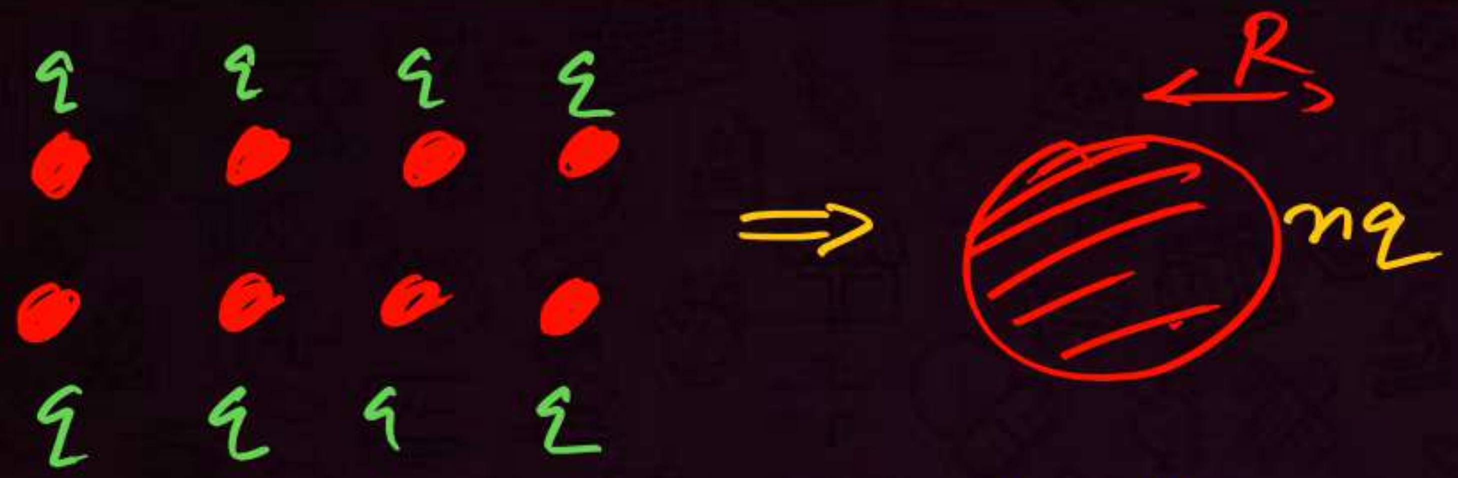
④ 3V

$$V_{sur} = \frac{kQ}{R} = V$$

$$V_C = \frac{3}{2}\frac{kQ}{R} = \frac{3V}{2}$$

Potential due to combination of drops (Tamaatar Bde Mazedaar)

2 baar



n charges

$$\boxed{V = \frac{kq}{r}}$$

$$\boxed{q' = nq}$$

Volume cons

$$\frac{4}{3}\pi r^3 \times n = \frac{4}{3}\pi R^3$$

☆ $\boxed{R = n^{1/3} r}$ TBS

☆ $\boxed{V' = n^{2/3} V}$

$$V' = \frac{k \times nq}{R}$$

$$= \frac{k\,nq}{n^{1/3} r} = \frac{kq}{r} \times \frac{n^1}{n^{1/3}} = \frac{kq}{r} n^{1-1/3}$$

$$= n^{2/3} \times \frac{kq}{r} = n^{2/3} V$$

QUESTION

27 small drops of same size are charged to 4 V volts each. If they combine to form a single large drop, then its potential will be

① 27 V

② 108 V

[✓ ③ 36 V]

④ 54 V

$$V' = n^{2/3} V$$

$$= (27)^{2/3} \times 4$$

$$= (3^{\cancel{3}})^{2/\cancel{3}} \times 4$$

$$= 3^2 \times 4 = 9 \times 4 = 36$$

QUESTION

512 small drops of same size are charged to 2 V volts each. If they coalesce to form a single large drop, then its potential will be **(JEE Mains)**

↓ combine.

① 1024 V

② 512 V

③ 256 V

[✓ ④] 128 V

$$V' = (512)^{2/3} \times 2$$

$$= (8^{\cancel{3}})^{2/\cancel{3}} \times 2$$

$$= 8^2 \times 2$$

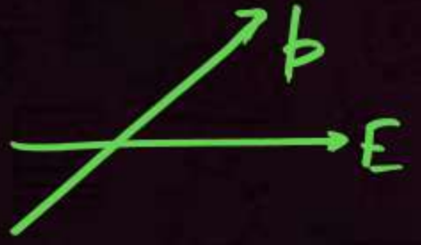
$$= 64 \times 2 = 128.$$

$$512 = 2^9 = 8^3$$

Potential Energy of Dipole in external Electric Field

Dekho Va A Gya!

$$-q \xrightarrow[p]{} +q$$



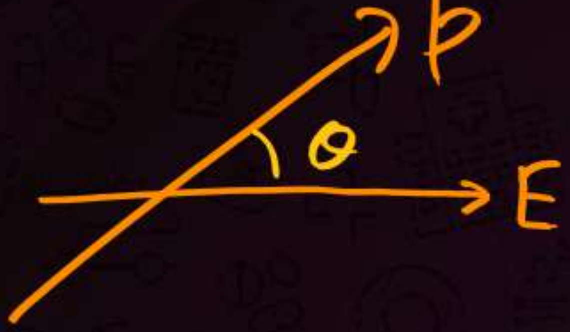
$F_{net} = 0$ (uniform)

$\tau = pE\sin\theta$

$\vec{\tau} = \vec{p} \times \vec{E}$

$\underline{\theta = 0^\circ, 180^\circ}$

↳ $\tau = 0$



$$\boxed{U = -pE\cos\theta}$$

$$\boxed{U = -\vec{p}\cdot\vec{E}}$$

$\theta = 0°$

$U = -pE\cos 0°$

$$\boxed{U = -pE}$$

↓

min^m

↓

Stable eqb^m

$\tau = 0$

$\theta = 180°$

$U = -pE\cos 180°$

$U = -pE(-1)$

$$\boxed{U = +pE}$$

↓

max^m

↓

Unstable eqb^m

$\tau = 0$

$\theta = 90°$

$$\boxed{U = 0}$$

$\tau = pE\sin 90°$

$\tau = pE$

↓

max^m

QUESTION

An electric dipole has the magnitude of its charge as *q* and its dipole moment is *p*. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field. the force on it and its potential energy are respectively (2004)

① 2 q.E. and minimum

② q.E and minimum

[✓ ③ zero and minimum]

④ q.E. and maximum

$\xrightarrow{\qquad} p$

$\xrightarrow{\qquad} E$

$\theta = 0^\circ$

$U = -pE$

↳ min^{m}

$+q \longrightarrow qE$

$\overset{qE}{\longleftarrow} -q$

$F_{net} = 0$

QUESTION

(Famous)

Work done in moving dipole from stable equilibrium position to unstable position in electric field is

① pE

② $\sqrt{2}pE$

③ $pE/2$

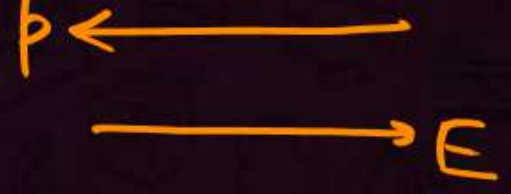
[✓ ④ $2pE$]

$$W_{ext} = \Delta U = U_2 - U_1 = pE - (-pE)$$

$$= pE + pE = \boxed{2pE}$$

$U_1 = -pE$

$U_2 = +pE$



QUESTION

An electric dipole of dipole moment is 6.0×10^{-6} C-m placed in a uniform electric field of 1.5×10^{3} NC^{-1} in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be_18_ mJ. **[08 April, 2023 (Shift-I)]**

1. 6
2. 9
3. 18 ✓
4. 36

$\theta = 0°$

$U_1 = -pE$

$U_2 = +pE$

$$W = 2pE = \underline{2} \times \underline{6} \times 10^{-6} \times \underline{1.5} \times 10^{3}$$

$$= 18 \times 10^{-3}\ \text{J}$$

$$= 18\ \text{mJ}$$

QUESTION

Ulta swaal

A dipole is placed in uniform electric field such that potential energy of dipole is maximum (U). The work done in rotating a dipole by 180° is

$pE = U$

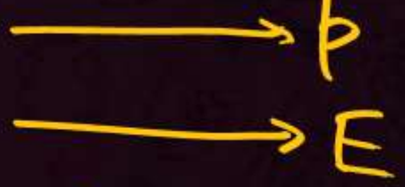
① U

② 3U

[✓ ③] −2U

④ −U

$U_1 = +pE$



$U_2 = -pE$

$$W = \Delta U$$
$$= U_2 - U_1$$
$$= -pE - pE$$
$$= -2pE$$
$$= -2U.$$

QUESTION

An electric dipole of moment $\vec{p}$ is lying along a uniform electric field $\vec{E}$. The work done in rotating the dipole by 90° is

(2006, similar in 2013)

[✓ ① pE]

② $\sqrt{2}pE$

③ $pE/2$

④ $2pE$

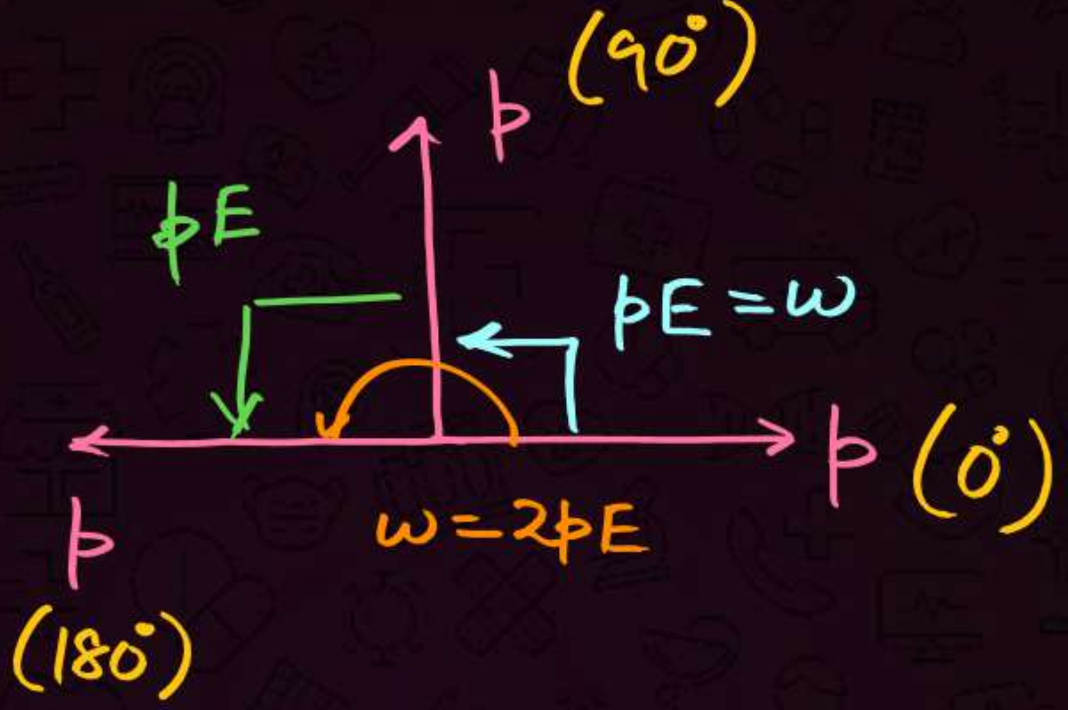
$$\longrightarrow p \longrightarrow E$$

$$U_1 = -pE$$

$$U_2 = 0$$

$$\omega = \Delta U = U_2 - U_1$$
$$= 0 - (-pE)$$
$$= +pE$$

TBS

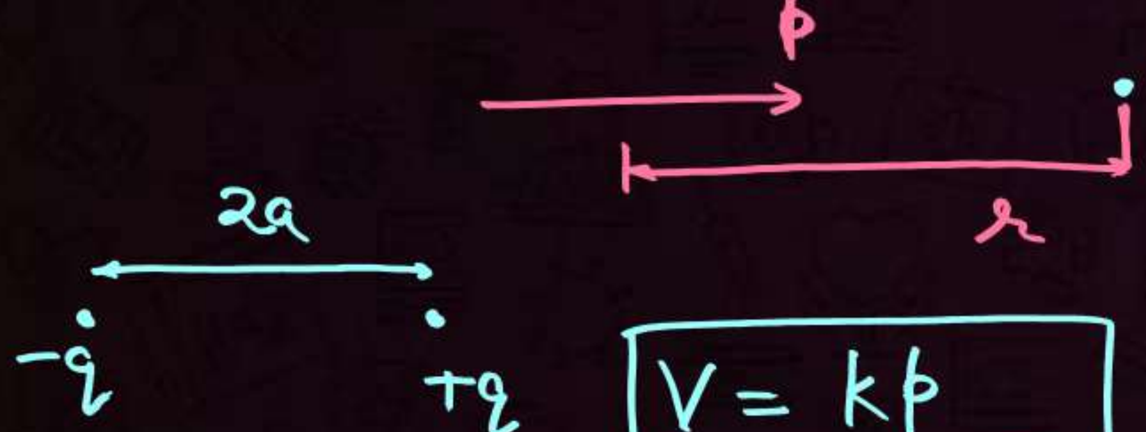


Ques 90° to 180°

$\boxed{pE}$ Ans.

Electric potential due to a dipole

a) Axial pt.



$$\boxed{V = \frac{kp}{r^2 - a^2}}$$

If short dipole a << r

∴ a = 0

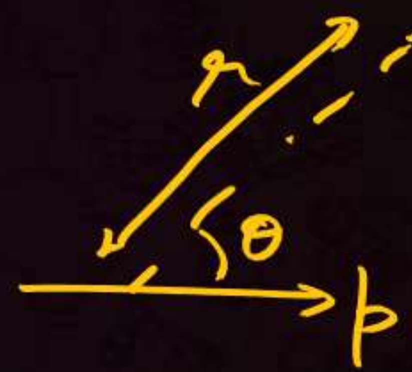
$$\boxed{V_{ax} = \frac{kp}{r^2}}$$

b) Eq. pt.

$$V = \frac{-kq}{x} + \frac{kq}{x} = 0$$

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

c) General pt.



$$\boxed{V = \frac{kp\cos\theta}{r^2}}$$

* $E \propto \frac{1}{r^3}$, $V \propto \frac{1}{r^2}$

QUESTION

$V_{eq} = 0$

Statement-I: Electric potential at a point on equatorial line of an electric dipole is half the potential at as point at the same distance on axial line of dipole.

Statement-II: The electric potential due to a dipole varies as $1/r^2$, where r is distance of the point from the dipole.

① Statement-I is True, Statement-II is True; Statement-II is a correct explanation for Statement-I

② Statement-I is True, Statement-II is True; Statement-II is NOT a correct explanation for Statement-I

③ Statement-I is True, Statement-II is False

[✓ ④] Statement-I is False, Statement-II is True.

QUESTION

A short electric dipole has a dipole moment of 16×10^{-9} C m. The electric potential due to the dipole at a point at a distance of 0.6 m from the centre of the dipole, situated on a line making an angle of 60° with the dipole axis is:

$\left(\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ \mathrm{Nm^2/C^2}\right)$ **(2020)**

① 400 V

② zero

③ 50 V

[✓ ④ 200 V]

* $p = 16 \times 10^{-9}$
* $r = 0.6\,m.$
* $\theta = 60^\circ$

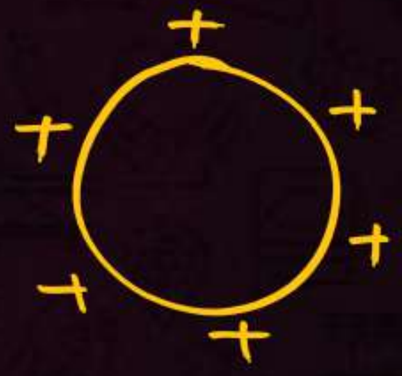
$$V = \frac{kp\cos\theta}{r^2}$$

Properties of Conductors

1. The electric field inside a conducting material of an isolated conductor is zero.

↓ not conn. to battery.

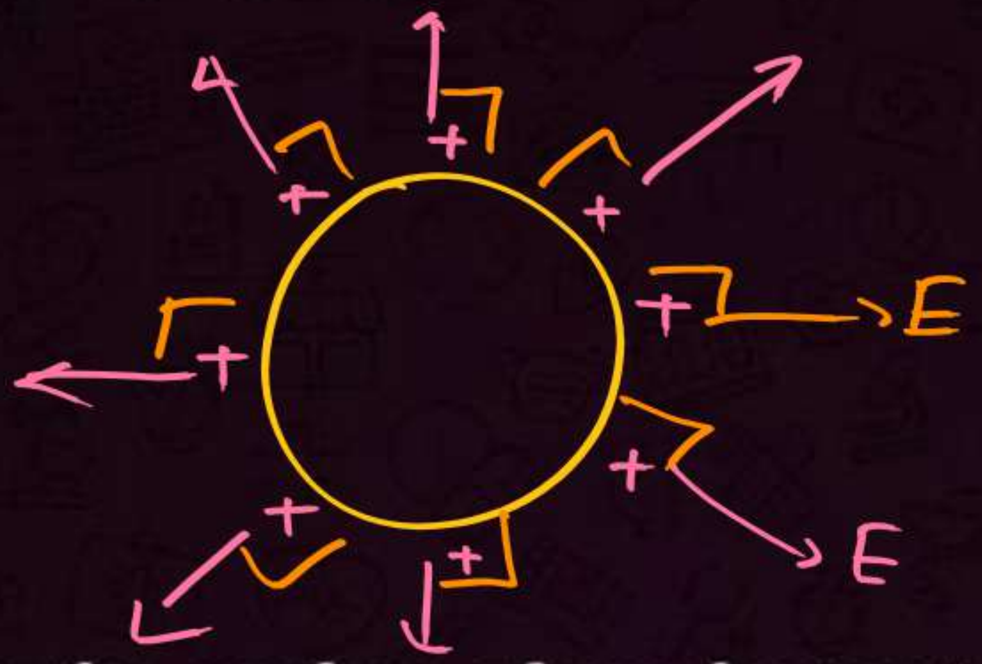
2. There is no excess charge inside a conductor.



3. The conducting material is equipotential.

$E = 0 \rightarrow V_{const}$.

4. The electric field is always perpendicular to the surface of conductor.



5. The electric field on the surface of conductor is $\boxed{\frac{\sigma}{\epsilon_0}}$, irrespective of the shape.

$$\boxed{E_{sur} = \frac{\sigma}{\epsilon_0}}$$

QUESTION

Match the Column-I with Column-II.

① A-(Q); B-(P); C-(S); D-(R)
×

② A-(R); B-(S); C-(P); D-(Q)
×

③ A-(R); B-(Q); C-(S); D-(P)
×

④ ✓ A-(R); B-(P); C-(S); D-(Q)

Column-I		Column-II	
A.	Potential due to a point charge varies as $V \propto \frac{1}{r}$ (R)	P.	$1/r^2$
B.	Potential due to an electric dipole varies as $V \propto \frac{1}{r^2}$ (P)	Q.	Constant
C.	Potential difference between any two points on an equipotential surface is $\Delta V = 0$ (S)	R.	$1/r$
D.	Potential inside a charged conductor is $V \to$ const (Q)	S.	Zero

QUESTION

Some charge is being given to a conductor. Then its potential is [2002]

→ V → const.

① maximum at surface

② maximum at centre

[✓ ③] remain same throughout the conductor

④ maximum somewhere between surface and centre

QUESTION

How is the electric field at the surface of a charged conductor related to the surface charging density.

(E_{sur})

(σ)

[✓ 1] Proportional to each other

2. Indirectly proportional

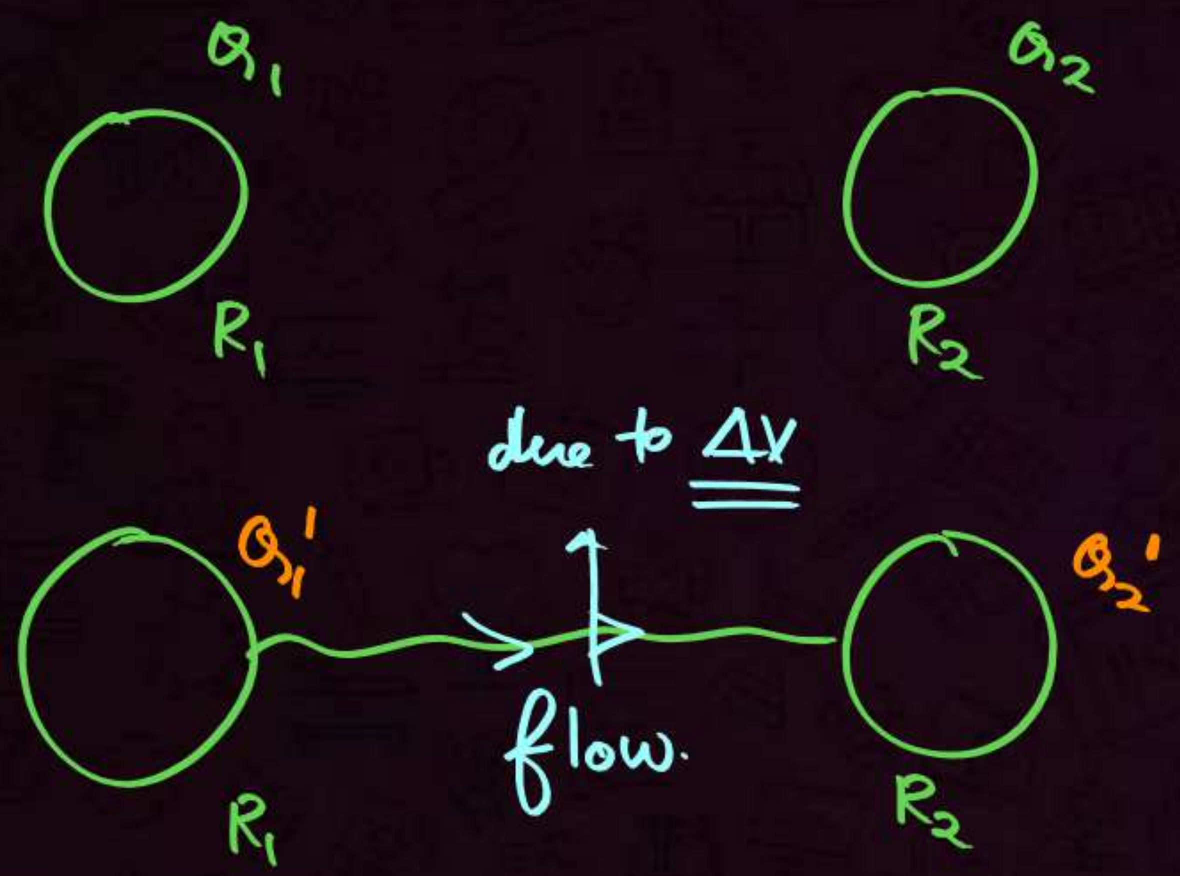
3. Independent

4. Exponential

$$E_{sur} = \frac{\sigma}{\epsilon_0}$$

$$E_{sur} \propto \sigma$$

Connecting two conductors



+ve charge => flows from high V to low V.

* flows till V become $\underline{\underline{\text{equal}}}$

① Total charge cons.

② Final pot. equal.

$$\boxed{\begin{aligned} &* \quad Q_1' = \frac{\textcircled{R_1}}{R_1+R_2}(Q_1+Q_2) \\ &* \quad Q_2' = \frac{\textcircled{R_2}}{R_1+R_2}(Q_1+Q_2) \end{aligned}}$$

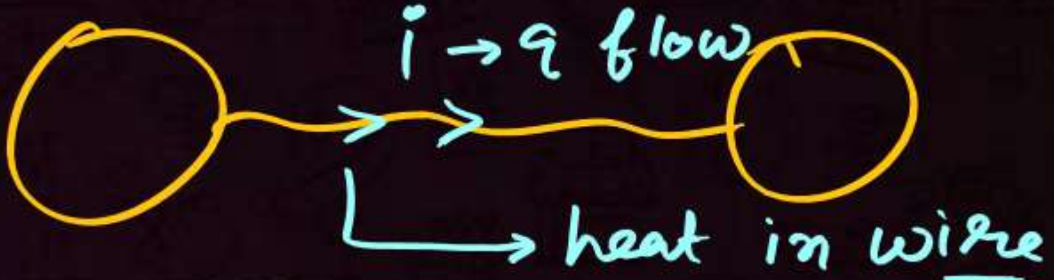
* If $R_1 = R_2 \Rightarrow Q_1' = Q_2' = \dfrac{Q_1+Q_2}{2}$

$$\boxed{\frac{Q_1'}{Q_2'} = \frac{R_1}{R_2}} \Rightarrow \textcircled{Q \propto R}$$

QUESTION

Statement-I: When charges are shared between two bodies, there occurs no loss of charge, but there does occur a loss of energy. ✓

Statement-II: Energy conservation fails. ✗



① Statement-I is True, Statement-II is True; Statement-II is a correct explanation for Statement-I

② Statement-I is True, Statement-II is True; Statement-II is NOT a correct explanation for Statement-I

[✓ ③] Statement-I is True, Statement-II is False

④ Statement-I is False, Statement-II is True.

Heat energy
Loss

electrostatic energy → Heat energy

QUESTION

→ +ve

Assertion: Charge flows from a conductor at high potential to conductor at low potential.

Reason: On connecting the two conductors, the potentials do not become equal.

① A & R both correct, R explains A

② A & R both correct, R doesn't explain A

[✓ ③] A is correct, R is incorrect.

④ A is incorrect, R is correct.

QUESTION

The radius of two metallic spheres A and B are r_1 and r_2 respectively $(r_2 > r_1)$. They are connected by a thin wire and the system is given a certain charge. The charge will be lesser

1. On the surface of the sphere B
[✓ 2.] On the surface of the sphere A
3. Equal on both
4. Zero on both

$r_1 < r_2$

$q_1 < q_2$

QUESTION

Two metallic spheres of radii 1 cm and 2 cm are given charges 5 C and 4 C respectively. If they are connected by a conducting wire, the final charge on both spheres will be

① [✓ 3 C, 6 C]

② 6 C, 3 C

③ 4.5 C, 4.5 C

④ Humein kya Pta !!!

$R_1 = 1$

$R_2 = 2$

$Q_1 = 5$

$Q_2 = 4$

Total = 9

$$Q_1' = \frac{1}{1+2}(5+4) = \frac{R_1}{R_1+R_2}(Q_1+Q_2)$$

$$= \frac{9}{3} = 3C$$

$$Q_2' = 9 - 3 = 6$$

QUESTION

Two charged spherical conductors of radii R_1 and R_2 are connected by a wire. Then, the ratio of surface charge densities of the spheres (σ_1/σ_2) is **(2021)**

1. $\frac{R_1}{R_2}$
2. [✓ $\frac{R_2}{R_1}$]
3. $\sqrt{\frac{R_1}{R_2}}$
4. $\frac{R_1^2}{R_2^2}$

$$\sigma = \frac{Q}{4\pi R^2}$$

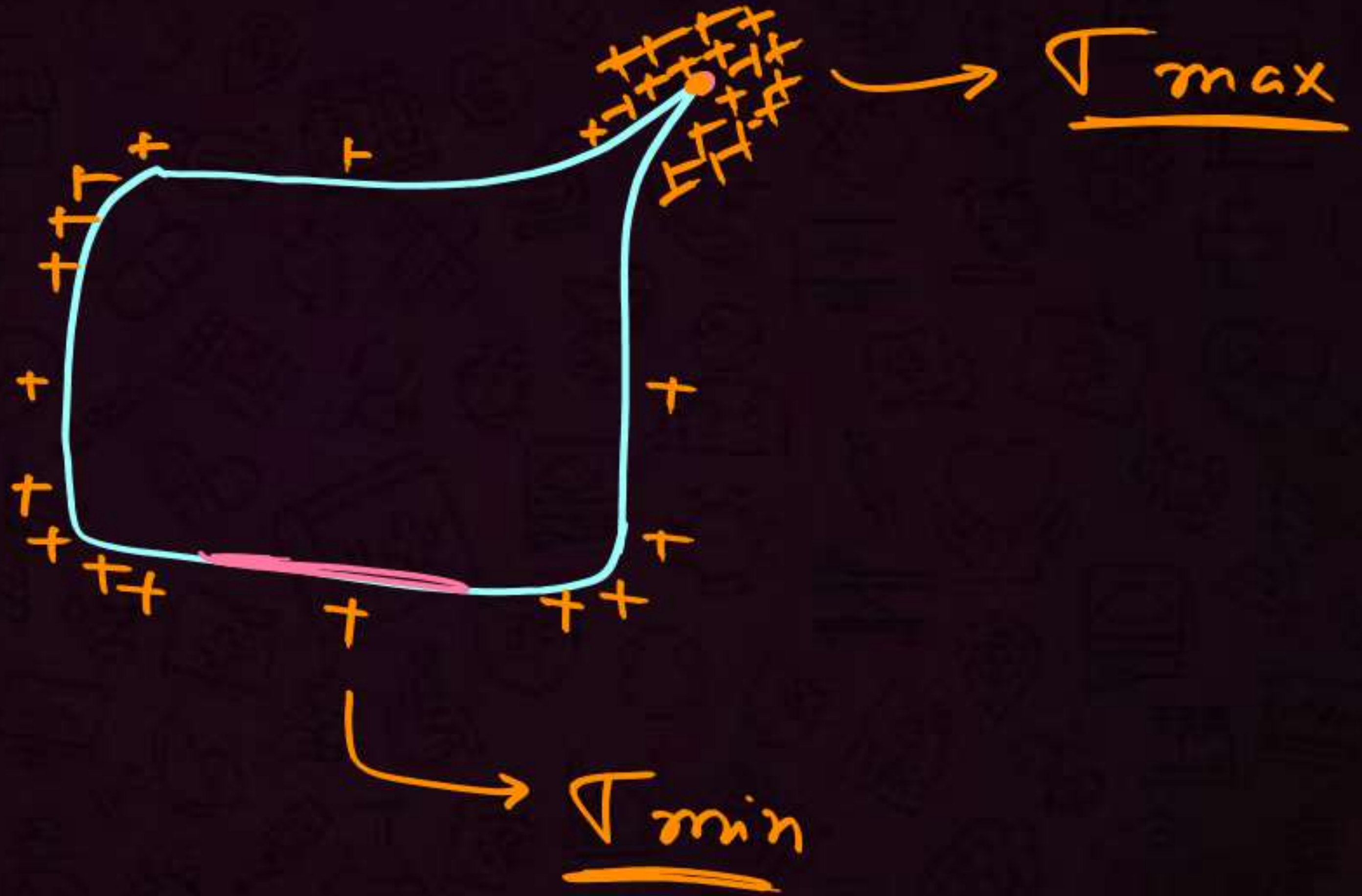
$$\boxed{\sigma \propto \frac{1}{R}}$$

$$\sigma \propto \frac{Q}{R^2} \propto \frac{\cancel{R}}{R^{\cancel{2}}} \propto \frac{1}{R}.$$

$$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$$

6. The surface charge density (σ) is inversely proportional to the radius of curvature (*r*).

$$\boxed{\sigma \propto \frac{1}{r}}$$ ✓

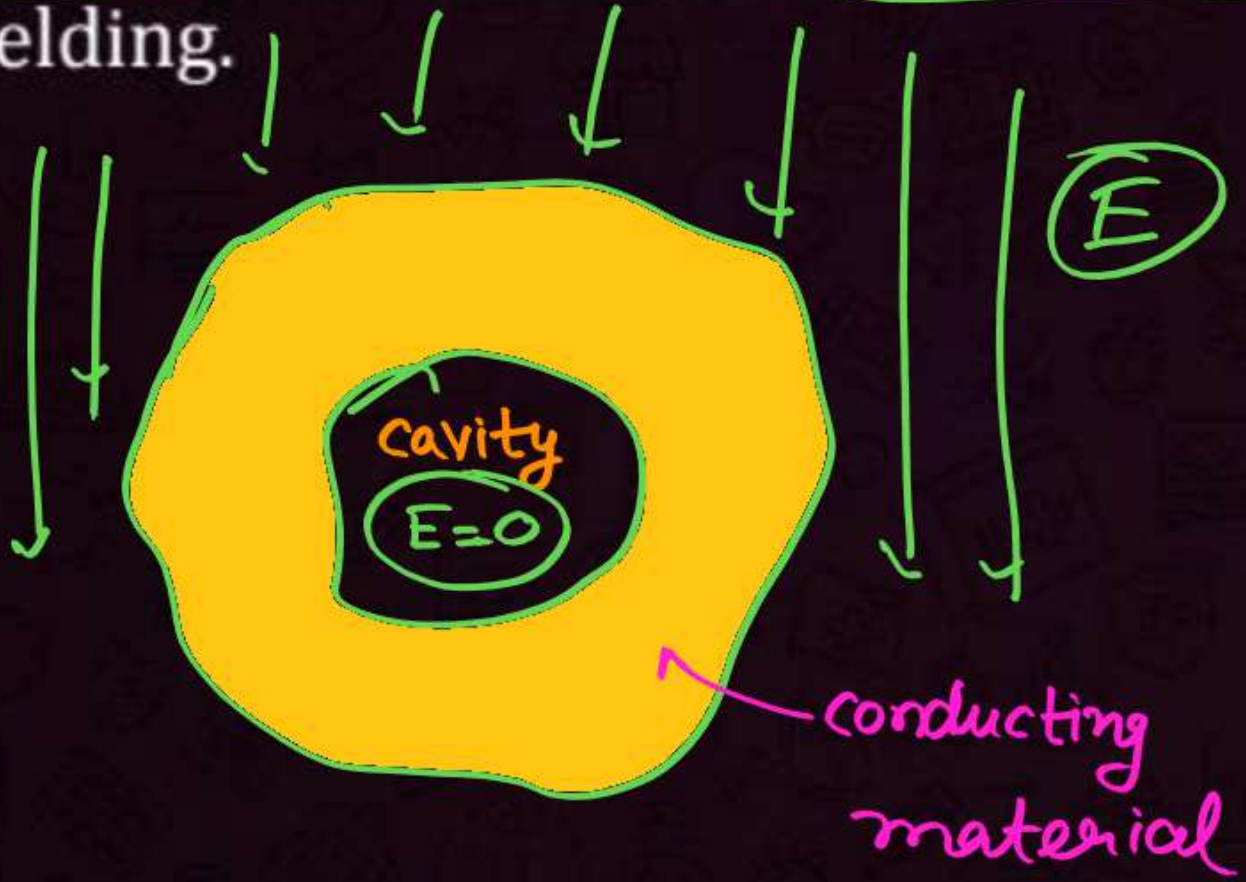


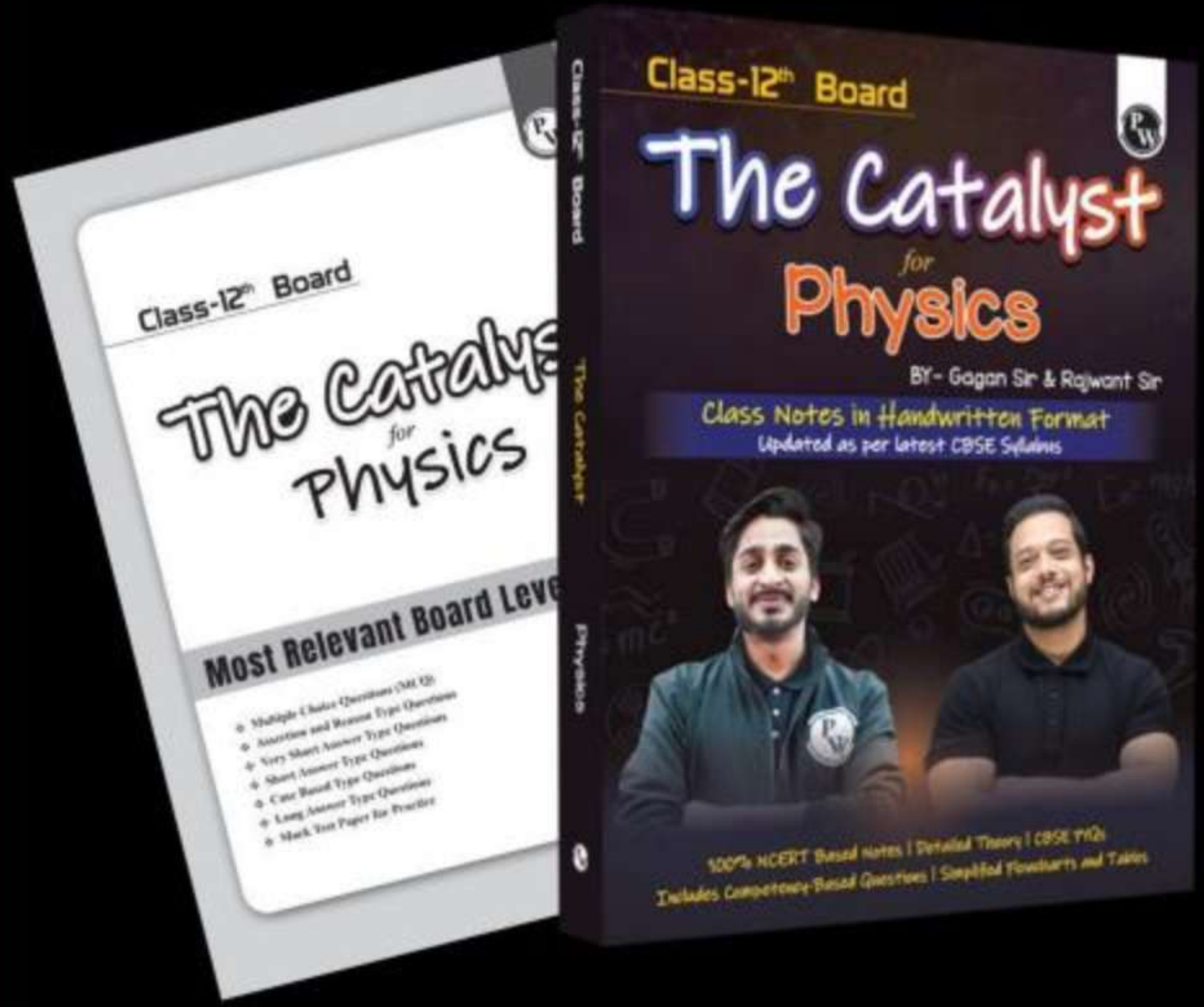
Flat $\Rightarrow r \to \infty$

- $r = 0$ (Sharp edge)

Electrostatic Shielding

The process involves the making a region free from any electric field is called electrostatic shielding.

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The Catalyst for Physics
BY- Gagan Sir & Rajwant Sir
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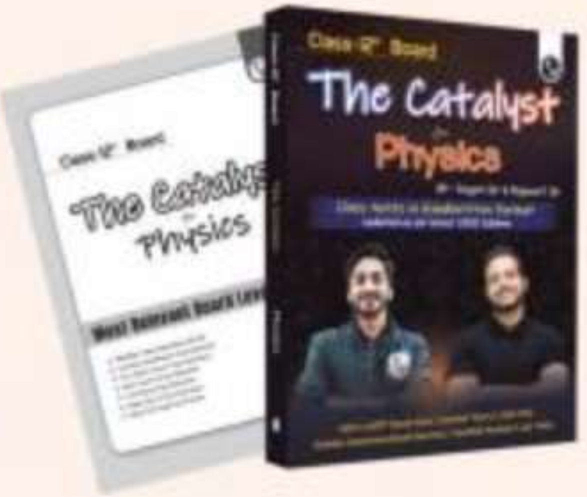


Capacitance

Capacitor

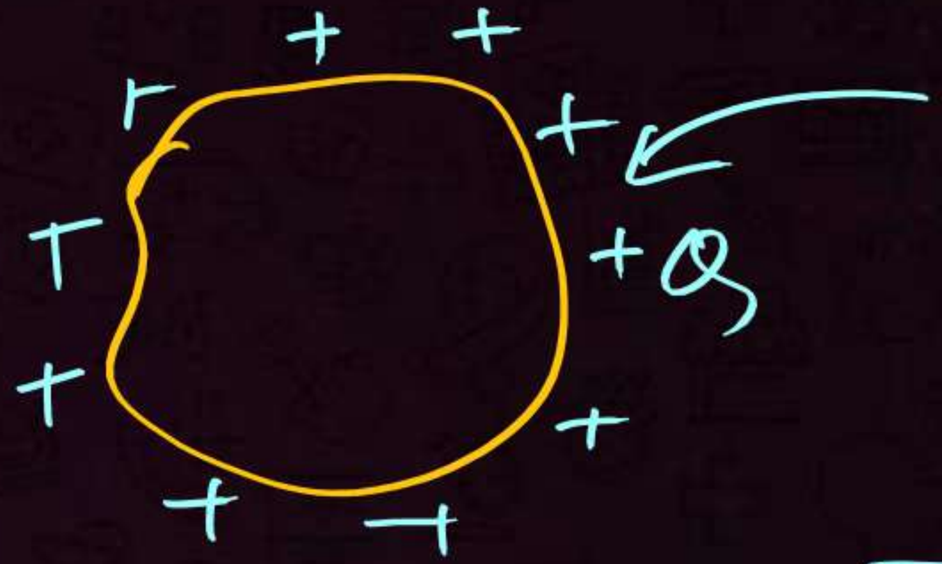
- Device used to store charge (or energy).
- Scalar Quantity
- Also called condensers
- SI Unit: Farad (F)
- Farad (F) is a very large unit.
- Generally used units are μF, nF

10^{-6}F $\rightarrow 10^{-9}$F

AC

6μF

4μF



$Q \propto V$

$$\boxed{Q = CV}$$

C = capacitance

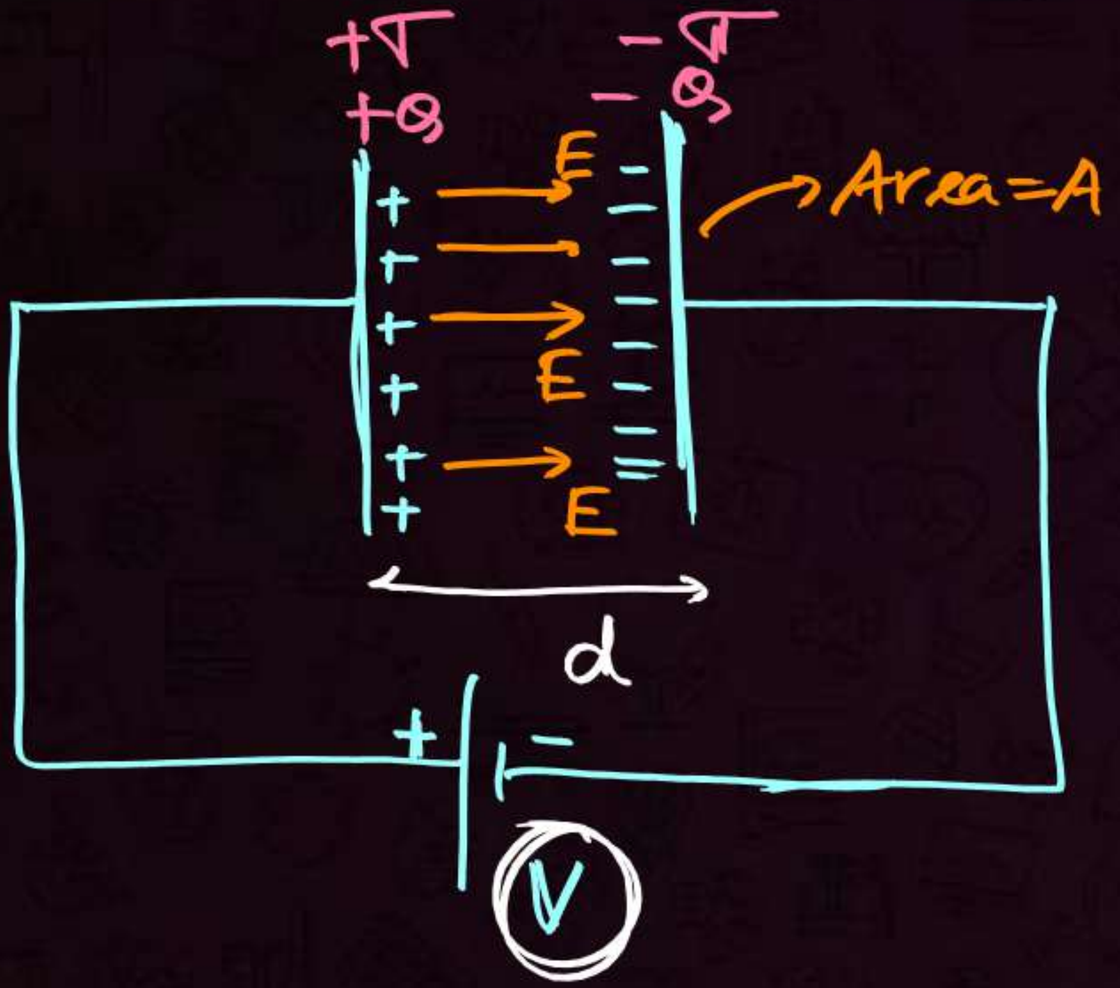
$$\boxed{C = \frac{Q}{V}}$$

$$\Rightarrow \frac{\text{coulomb}}{\text{volt}} = \text{Farad}$$

$$\Rightarrow \frac{\text{coulomb}}{\frac{\text{Joule}}{\text{coulomb}}}$$

$$\Rightarrow \frac{\text{coulomb}^2}{\text{Joule}}$$

Capacitance of a Parallel Plate Capacitor



$$\boxed{E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}}$$

↓

uniform.

$$\Delta V = E\,\Delta r$$

$$\boxed{V = Ed}$$

$$V = \frac{Qd}{A\epsilon_0}$$

$$C = \frac{Q}{V} = \frac{\cancel{Q}}{\frac{\cancel{Q}d}{A\epsilon_0}}$$

$$\boxed{C = \frac{A\epsilon_0}{d}}$$

C → depends on

A, d (shape|size|geometry)

& ϵ_0 (medium b/w plates)

C → Q ✗

→ V ✗

(doesn't depend)

$Q \propto V$

$Q = CV$

× ×

$V \propto i$

$V = iR$

× ×

*

$$\boxed{F = \frac{Q^2}{2A\epsilon_0}} \rightarrow$$ Force b/w plates of capacitor

QUESTION

The intensity of electric field at a point between the plates of a charged capacitor

① Is directly proportional to the distance between the plates

$$E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$$

② Is inversely proportional to the distance between the plates

$E \rightarrow d$ ✗

③ Is inversely proportional to the square of the distance between the plates

[✓ ④] Does not depend upon the distance between the plates

QUESTION

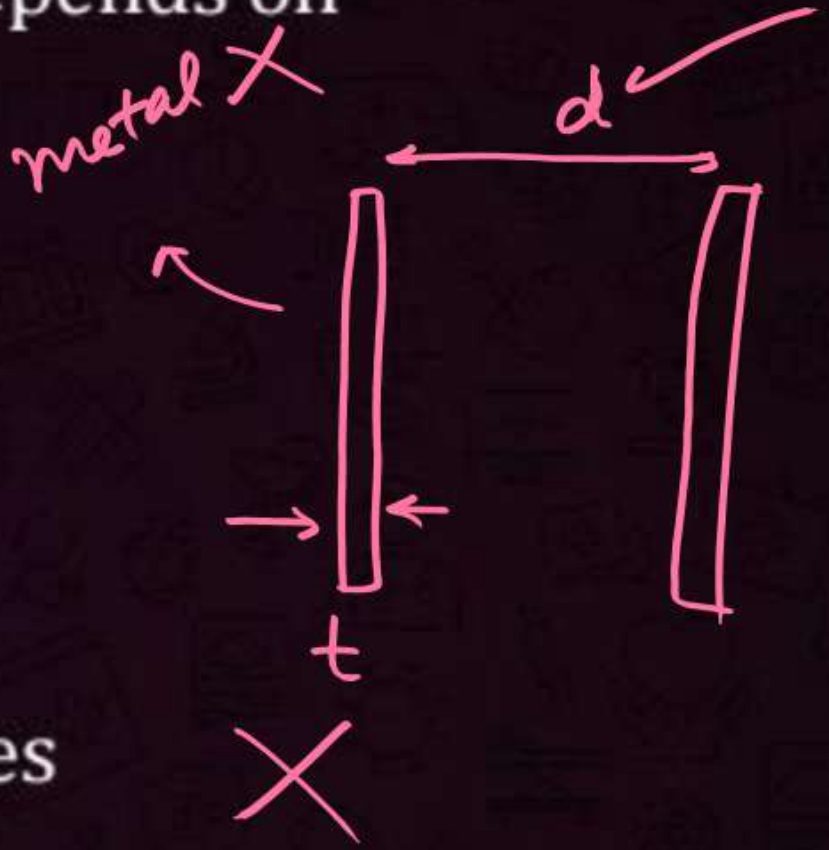
The capacity of parallel plate condenser depends on

① The type of metal used ×

② The thickness of plates ×

③ The potential applied across the plates V ∝

④ ✓ The separation between the plates ✓ (d)



$$C = \frac{A\epsilon_0}{d}$$

$$C \propto \frac{1}{d}$$

QUESTION

The capacity of a parallel plate condenser is C, when the distance between its plates is 6 cm, if the distance between the plates is reduced to 2 cm, then the capacity of this parallel plate condenser will be?

d d_2

① C/3

[✓ ② 3C]

③ 2C

④ C/2

BPU

$$\boxed{C \propto \frac{1}{d}}$$

$$d = 6cm \longrightarrow 2cm$$

$\boxed{d}$ $\boxed{\frac{d}{3}}$

$\boxed{C \propto \frac{1}{d}}$ $\boxed{3C}$

$* \quad C \propto \frac{1}{d}$

$$\frac{C_2}{C_1} = \frac{d_1}{d_2}$$

$$\frac{C_2}{C_1} = \frac{6}{2} = 3$$

$$C_2 = 3C_1$$

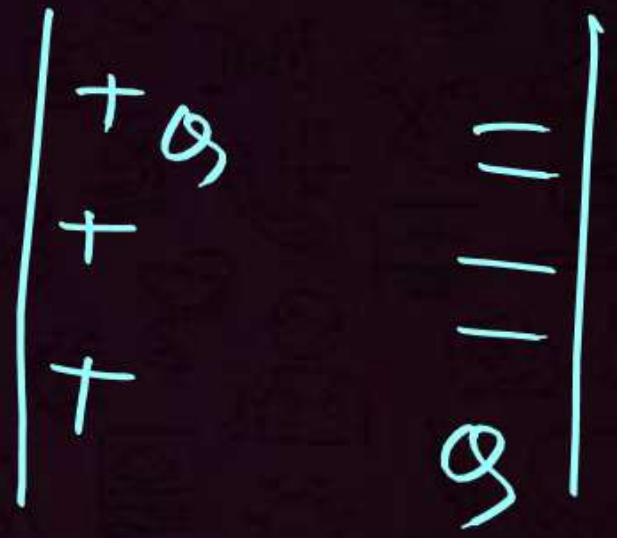
$$= 3 \times C$$

$$= \boxed{3C}$$

QUESTION

What is the net charge stored on the capacitor

1. Q
2. - Q
3. [✓ 3] Zero
4. Humein Kya pta !



Net = Q − Q = 0

TBS

$$\boxed{\begin{array}{l}\text{Charge on cap} = Q \\ \text{Net charge on cap} = 0\end{array}}$$

QUESTION

A parallel plate capacitor of plate area $\overset{A}{4\ \text{cm}^2}$ & distance between plates is $\overset{d}{1.77}$ mm is connected to 2V battery. Find capacitance & charge stored?

1. 2 pF, 2 pC ✗
2. 4 pF, 4 pC
3. [✓ 2 pF, 4 pC]
4. 4 pF, 8 pC

$$C = \frac{A\epsilon_0}{d} = \frac{(4 \times 10^{-4}) \times \overset{5}{\cancel{8.85}} \times 10^{-12}}{\cancel{1.77} \times 10^{-3}}$$

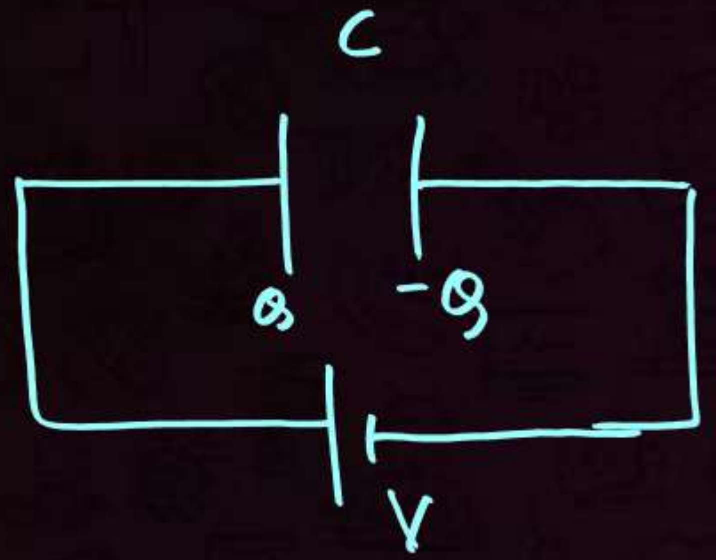
$$= 2 \times 10^{-12}\ \text{F}$$

$$= 2\ \text{pF (pico Farad)}$$

$$Q = CV = 2 \times 2 = \underline{\underline{4\ \text{pC}}}$$

$$\boxed{\begin{aligned} 1\ \text{cm}^2 &= 10^{-4}\ \text{m}^2 \\ 1\ \text{cm} &= 10^{-2}\ \text{m} \\ 1\ \text{mm} &= 10^{-3}\ \text{m} \end{aligned}}$$

Energy, Energy Density and Work Done by Battery



$U = \frac{1}{2}CV^2$

$U = \frac{1}{2}CV \times V$

$U = \frac{1}{2}QV = \frac{1}{2}Q \times \frac{Q}{C} = \frac{Q^2}{2C}$

$Q = CV$

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

$$\boxed{U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{Q^2}{2C}}$$ → energy stored

$$\boxed{H = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1\,Q^2}{2C}}$$

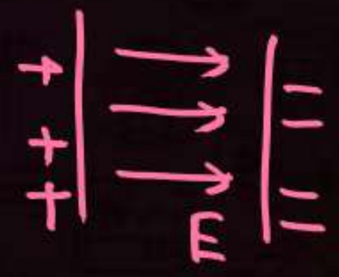
→ Half of work goes into heat energy.

W_b → work done by battery.

$$\boxed{W_b = CV^2 = QV = \frac{Q^2}{C}}$$

* $$\boxed{u = \frac{U}{\text{Volume}} = \frac{1}{2}\epsilon_0 E^2}$$

→ stored in form of E Lines.



QUESTION

A 6 pF capacitor is connected to a 50 V battery. How much electrostatic energy is stored in the capacitor?

① 7.5×10^{-8} J

② 7.5×10^{-7} J

[✓ ③ 7.5×10^{-9} J]

④ None

$$U = \frac{1}{2} CV^2$$

$$= \frac{1}{\cancel{2}} \times (\overset{3}{\cancel{6}} \times 10^{-12}) \times 50 \times 50$$

$$= 7500 \times 10^{-12}$$

$$= 7.5 \times 10^{-9} \text{ J}$$

QUESTION

A capacitor of capacitance 4 μF is connected with an emf source 3V. Electrostatic energy stored in the capacitor is

① 3 μJ

[✓ ② 18 μJ]

③ 27 μJ

④ 36 μJ

$$U = \frac{1}{\cancel{2}} \times \overset{2}{\cancel{4}} \times 3^2$$

$$= 2 \times 9 = 18\ \mu J$$

QUESTION

A parallel plate capacitor has a uniform electric field E in the space between the plates. If the distance between the plates is d and area of each plate is A, the energy stored in the capacitor is

(2021, 2012, 2011, 2008)

① $\varepsilon_0 E A d$

[✓ ② $\frac{1}{2}\varepsilon_0 E^2 A d$]

③ $\frac{1}{2}\varepsilon_0 E^2$

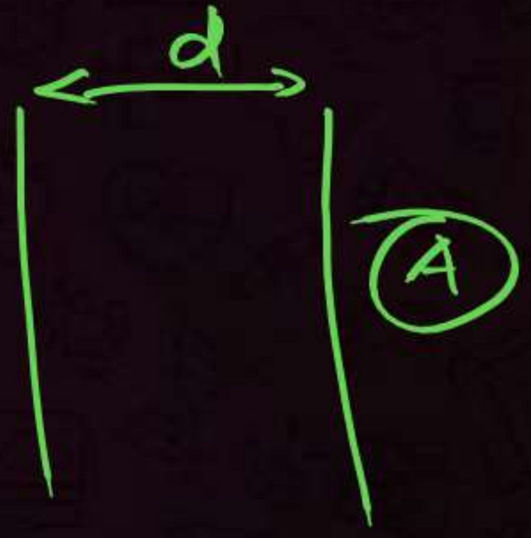
④ $\frac{E^2 A d}{\varepsilon_0}$

$$u = \frac{1}{2}\epsilon_0 E^2$$

$$\frac{U}{Vol.} = \frac{1}{2}\epsilon_0 E^2$$

$$U = \frac{1}{2}\epsilon_0 E^2 (Vol.)$$

$$= \frac{1}{2}\epsilon_0 E^2 \boxed{Ad} \longrightarrow \text{Aedi Pair Ki}$$



QUESTION

An uncharged capacitor is fully charged with a battery. The ratio of energy stored in the capacitor to the work done by the battery in this process is

[✓ ① 1 : 2]

② 2 : 1

③ 1 : 1

④ 2 : 3

$$\frac{U}{W_b} = \frac{\frac{1}{2}cv^2}{cv^2} = \frac{1}{2}.$$

Question

The energy stored in the capacitor is 200 J. The work done by battery is

↓

double

↓

2×200

$= 400$

1 200 J

2 100 J

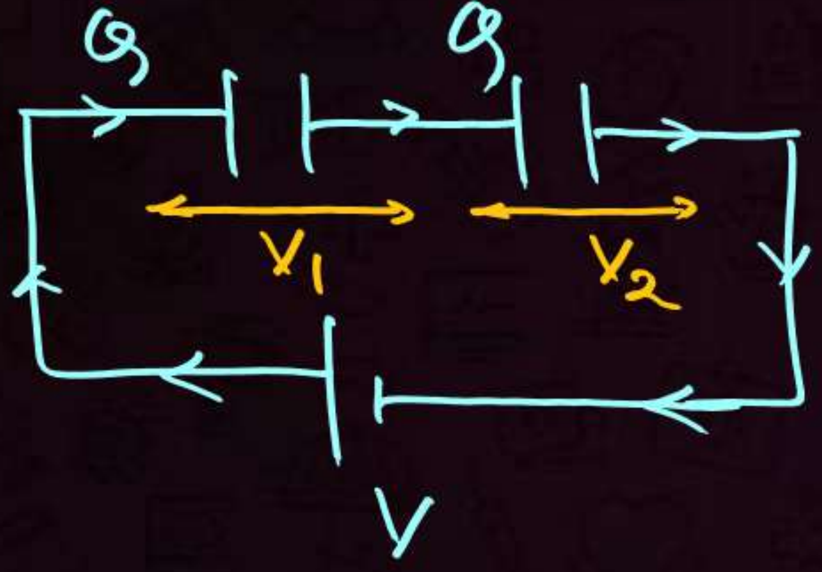
3 50 J

[✓ 4] 400 J

> Chhota Sa Break

Black Screen.

Capacitors in Combination – a) Series



* $Q \rightarrow$ same.

* $V = V_1 + V_2$

* $Q = CV$

$V = \frac{Q}{C} \Rightarrow \boxed{V \propto \frac{1}{C}}$

$$\boxed{\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{-----} \frac{1}{C_n}}$$

Two capacitors

$$\boxed{C_s = \frac{C_1 C_2}{C_1 + C_2}}$$

Identical

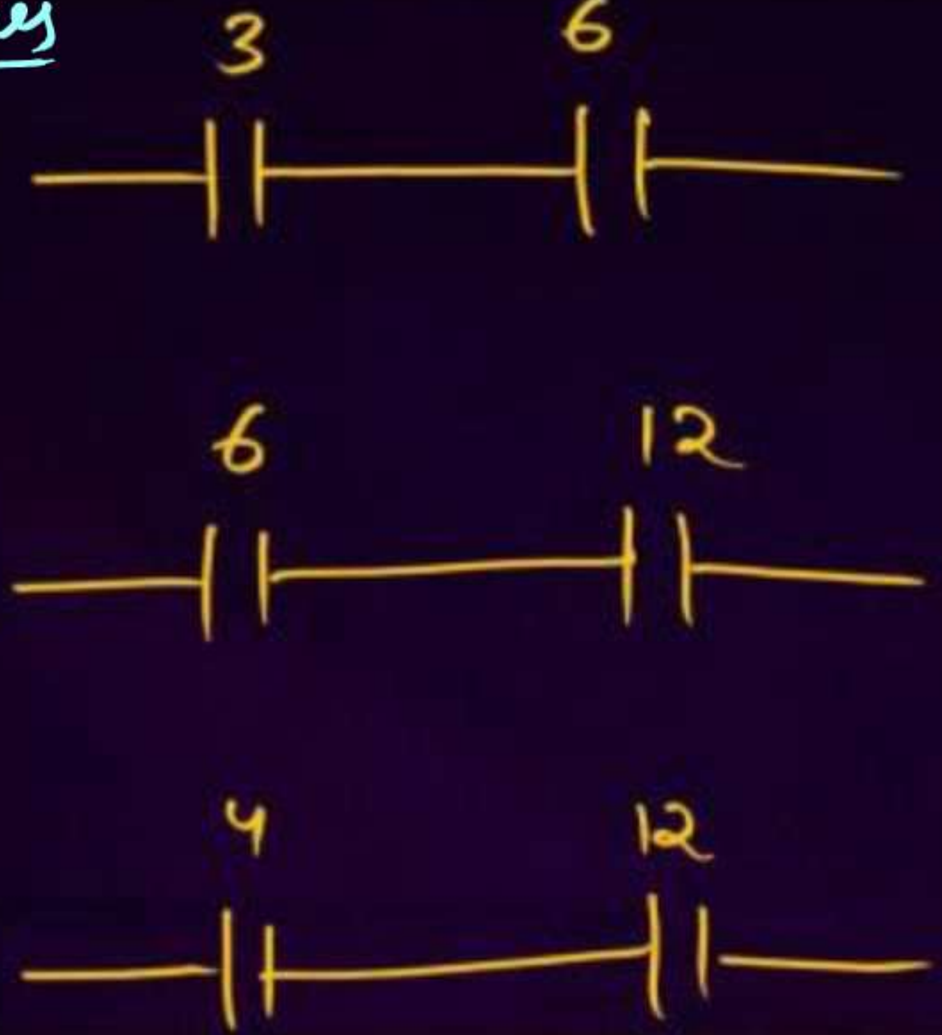
$$\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \cdots \frac{1}{C}$$

$$\frac{1}{C_s} = \frac{n}{C} \Rightarrow \boxed{C_s = \frac{C}{n}}$$

Ques

$C_s = \frac{C}{3}$

Famous values



Ques

TBS

$$\Rightarrow \frac{C_1C_2}{C_1+C_2} = \frac{3\times 6}{3+6} = \frac{18}{9} = 2$$

Ques

$$\Rightarrow \frac{6\times 12}{6+12} = \frac{72}{18} = 4$$

Ques

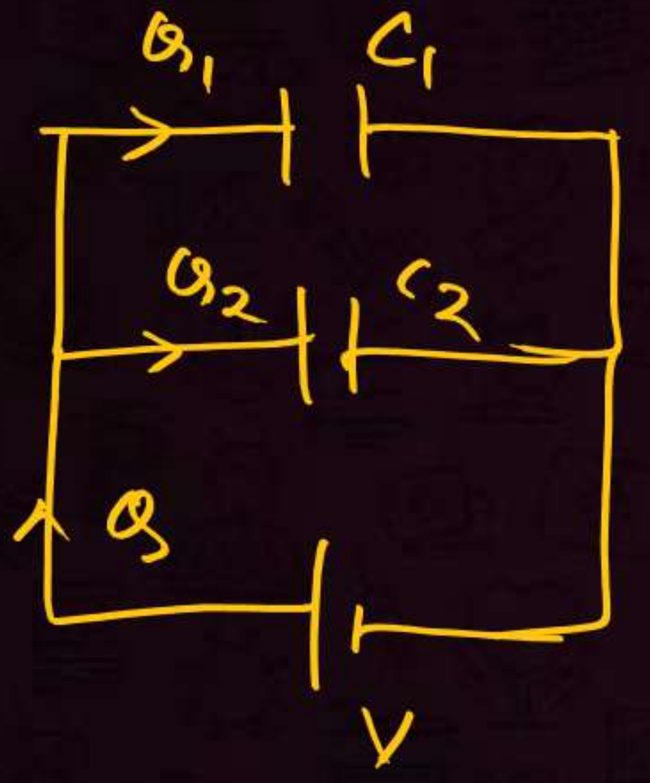
$$\Rightarrow \frac{4\times 12}{4+12} = \frac{48}{16} = 3$$

3, 6 → 2
6, 12 → 4
4, 12 → 3

→ Bhut Use

Capacitors in Combination – b) Parallel

*



* V → same

* $Q = Q_1 + Q_2$.

* $Q = CV$
  ↳ same

$\boxed{Q \propto C}$

If $C_1 > C_2$.

$Q_1 > Q_2$

* $\boxed{C_p = C_1 + C_2 + C_3 + \cdots C_n.}$

* Identical

$C_p = C + C + C + \cdots C$

$\boxed{C_p = nC}$

$$\frac{C_p}{C_s} = \frac{nC}{C/n} = n^2$$

$$\boxed{\frac{C_p}{C_s} = n^2 \qquad \frac{C_s}{C_p} = \frac{1}{n^2}}$$

Identical

QUESTION

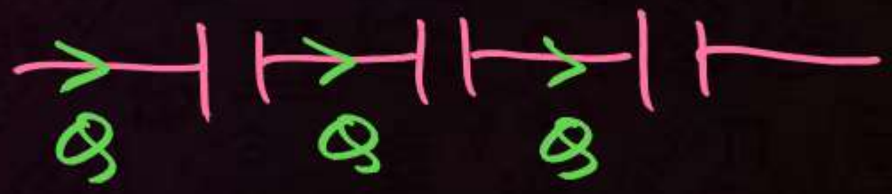
Assertion (A): In a series combination of capacitors, charge on each capacitor is same.

Reason (R): In such a combination, charge can move only along one route.

[✓ 1] If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of Assertion (A).

2. If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).

3. If Assertion (A) is True but the Reason (R) is False.



4. Assertion (A) is False but the Reason (R) is True.

QUESTION

Assertion (A): Two condensers of same capacity are connected first in parallel and then in series. The ratio of resultant capacities in the two cases will be 4 : 1.

Reason (R): In parallel combination, equivalent capacity increases and in series equivalent capacity decreases.

identical ×

$$\frac{C_p}{C_s} = n^2 = 2^2 = 4 = \frac{4}{1}$$

1. If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of Assertion (A).
2. If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).
3. If Assertion (A) is True but the Reason (R) is False.
4. Assertion (A) is False but the Reason (R) is True.

$C_p = nC \rightarrow$ inc.

$C_s = \frac{C}{n} \longrightarrow$ dec

QUESTION

Three capacitors of capacitances 3μF, 9μF and 18μF are connected once in series and another time in parallel. The ratio equivalent capacitance in the two cases (C_S/C_P) will be

[✓ ① 1 : 15]

② 15 : 1

③ 1 : 1

④ 1 : 3

$$\frac{1}{C_s} = \frac{1}{3} + \frac{1}{9} + \frac{1}{18} = \frac{6+2+1}{18} = \frac{9}{8} = \frac{1}{2} \to \frac{1}{n^2} \times$$

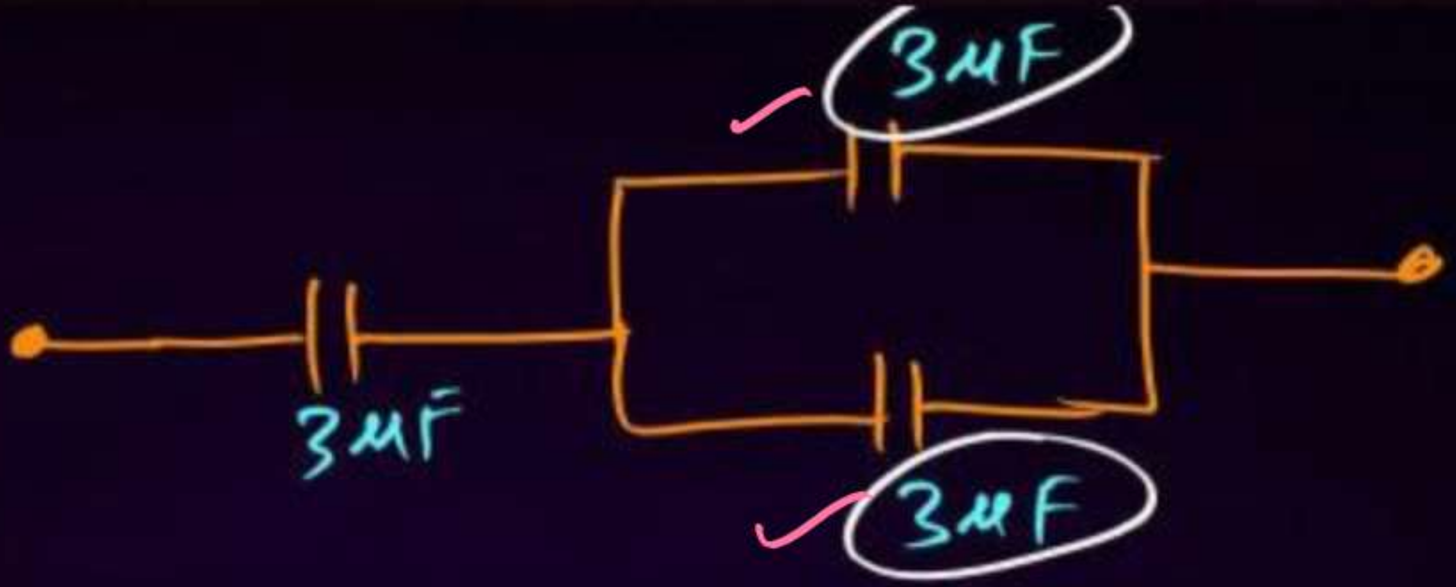
$$\boxed{C_s = 2}$$

$$C_p = 3+9+18 = 30$$

$$\frac{C_s}{C_p} = \frac{2}{30} = \frac{1}{15} \checkmark$$

Ques

2023

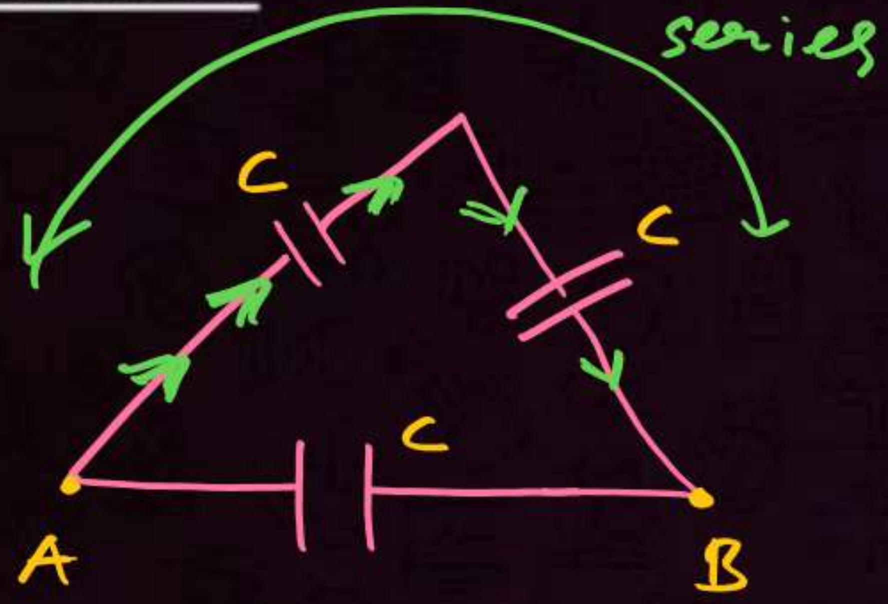


A) 6   B) 9   [✓ C) 2]   D) None

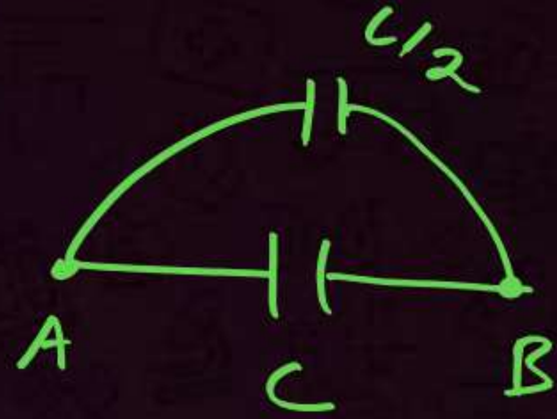
$$\frac{3\times6}{3+6} = 2.$$

TBS Patterns

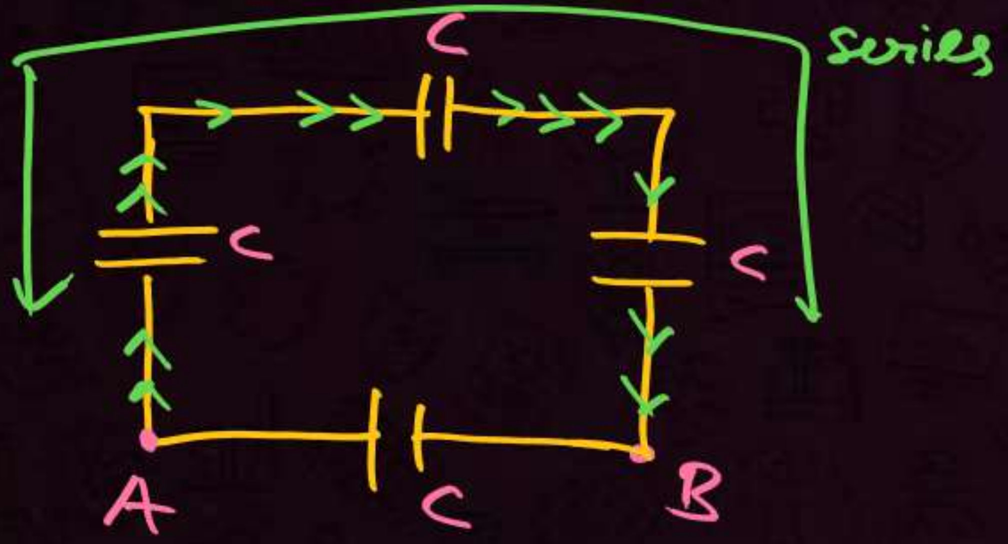
→ optional

- 

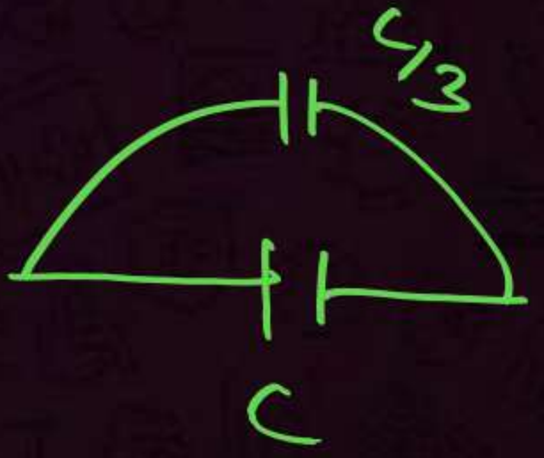
⇒



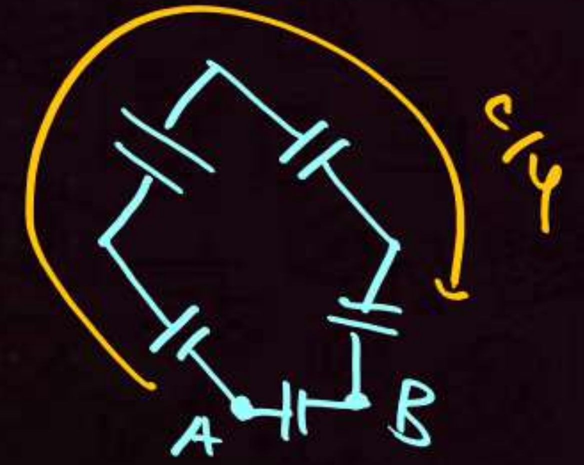
$$\Rightarrow C_{eq} = C + \frac{C}{2} = \boxed{\frac{3C}{2}}$$ ✓

- 

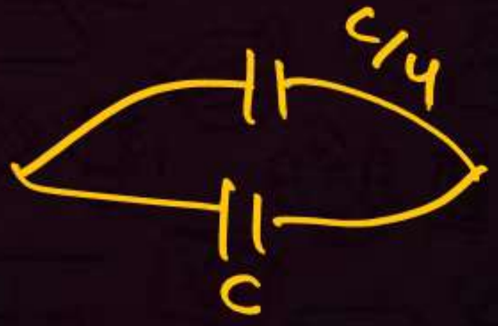
⇒



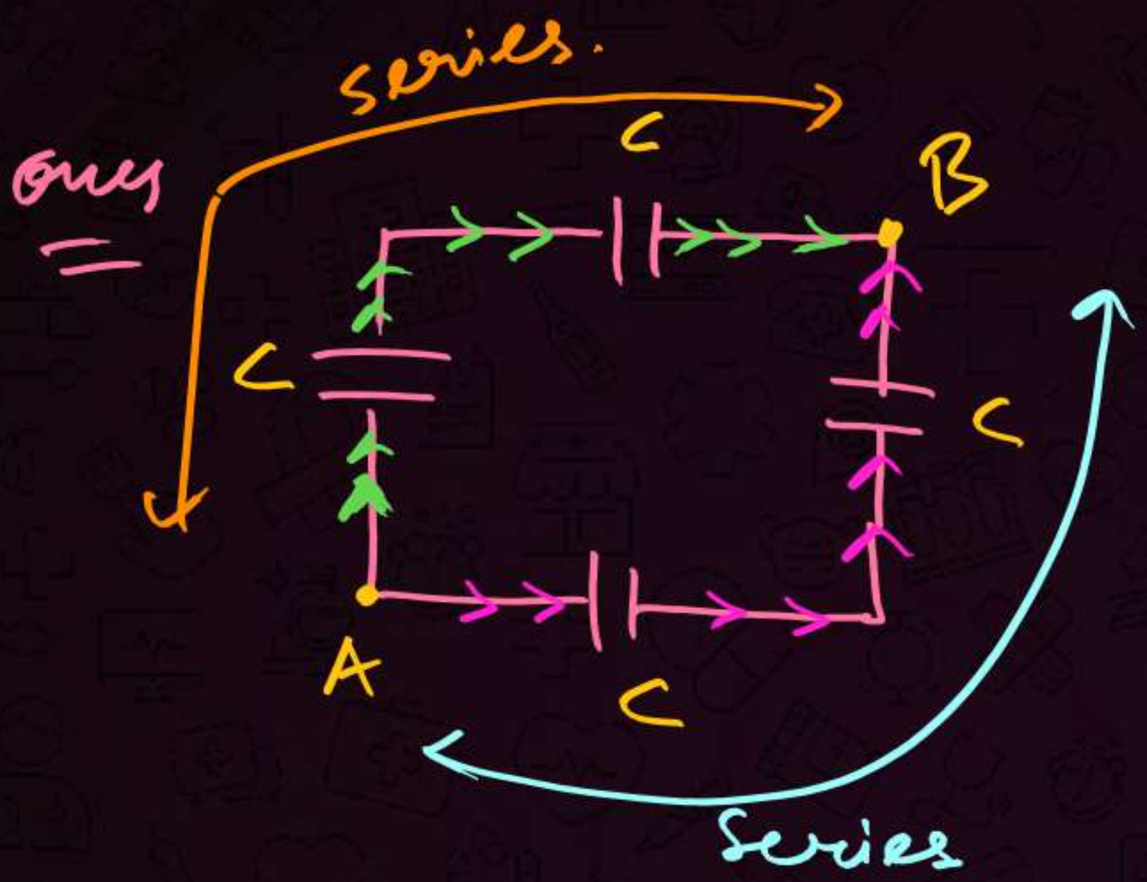
$$\Rightarrow C_{eq} = C + \frac{C}{3} = \boxed{\frac{4C}{3}}$$ ✓

- 

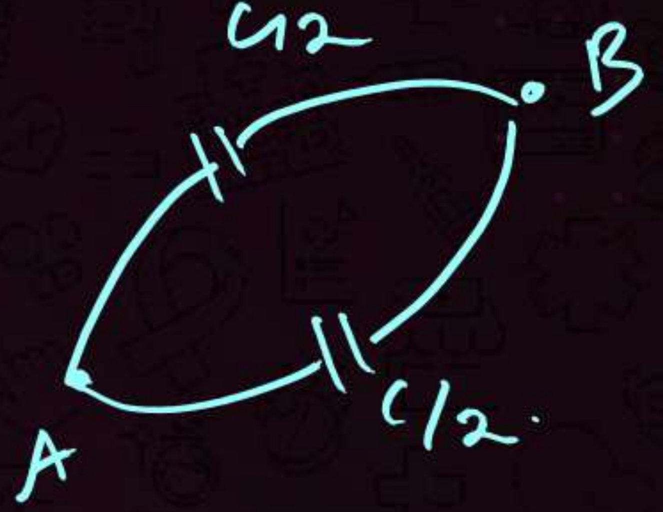
⇒



$$\Rightarrow C_{eq} = C + \frac{C}{4} = \boxed{\frac{5C}{4}}$$ ✓

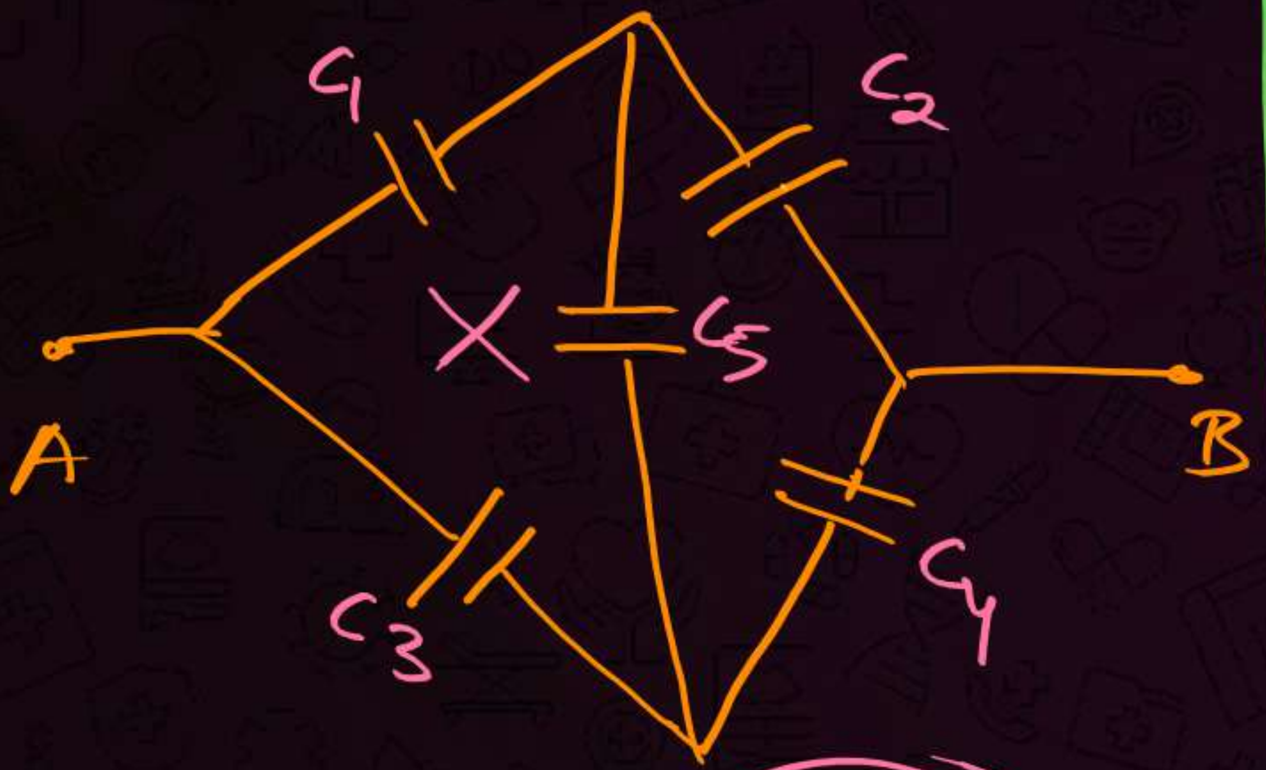


⇒



$$C_{eq} = \frac{C}{2} + \frac{C}{2} = \boxed{C}$$ Ans.

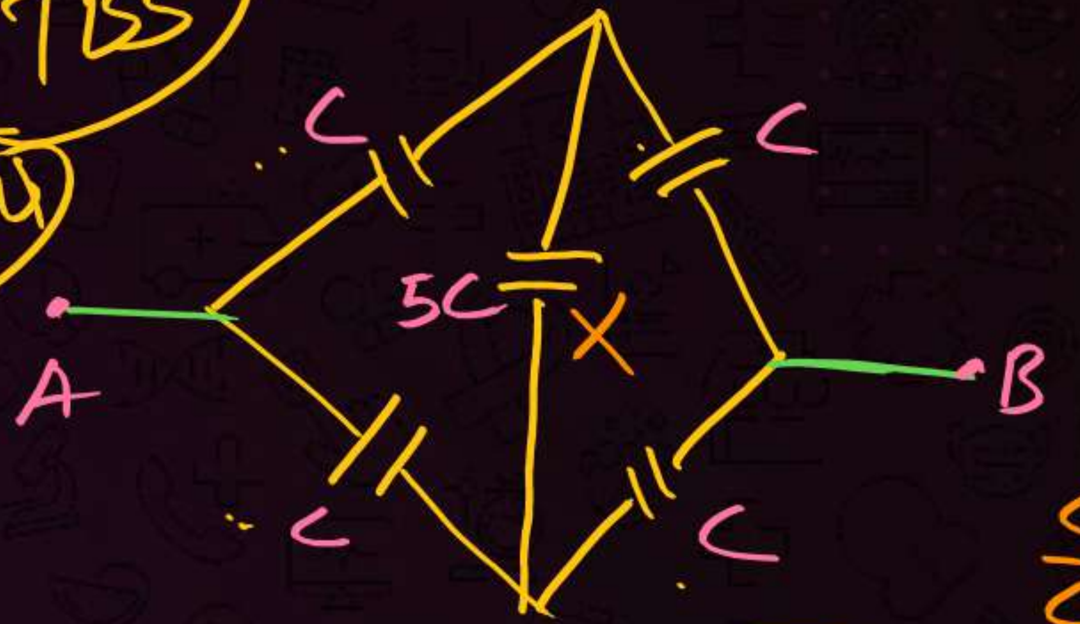
Wheat stone Bridge



If $\boxed{\frac{C_1}{C_2} = \frac{C_3}{C_4}}$ ⇒ No charge flow in C_5 ×

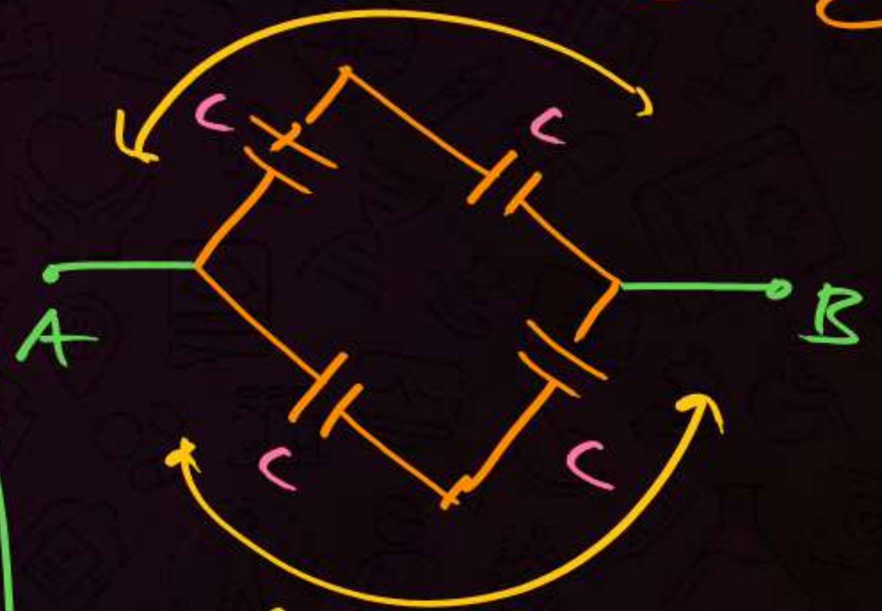
TBS

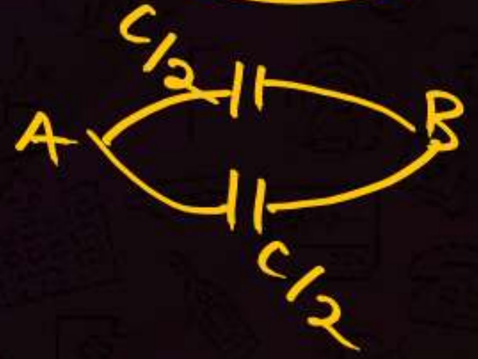
BPU



$C_{eq} = ?$

$\frac{C}{C} = \frac{C}{C}$





$C_{eq} = \frac{C}{2} + \frac{C}{2}$

$= C.$

QUESTION

The charge on capacitor of capacitance 15 μF in the figure given below is:

[26 June, 2022 (Shift-II)]

① 60 μC ✓

② 130 μC

③ 260 μC

④ 585 μC

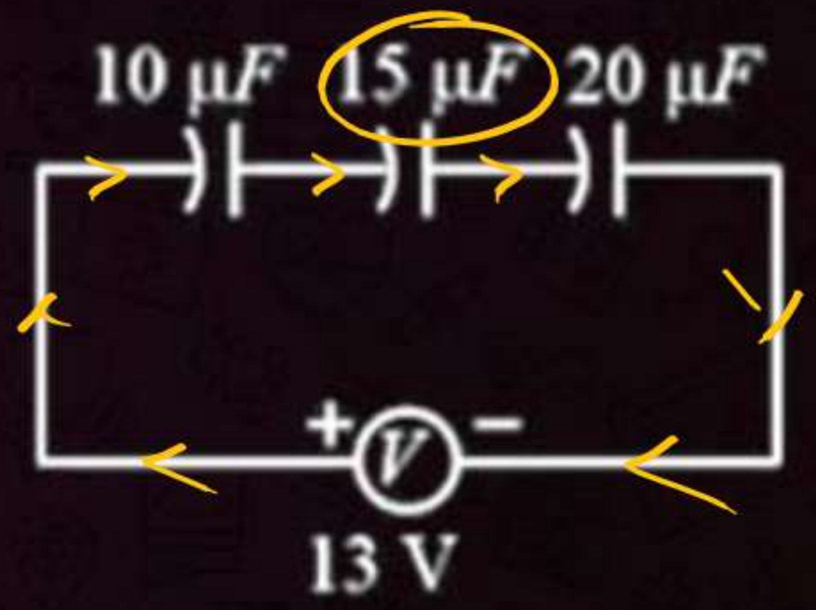
Series → Q same.

↓

$$\frac{1}{C_{eq}} = \frac{1}{10} + \frac{1}{15} + \frac{1}{20}$$

$$\frac{1}{C_{eq}} = \frac{6+4+3}{60} = \frac{13}{60}$$

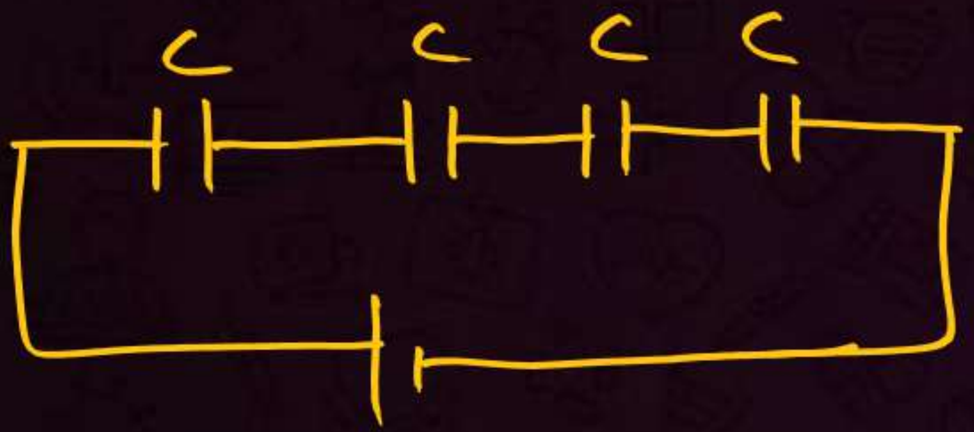
$$C_{eq} = \frac{60}{13}$$



$$Q = C_{eq}V = \frac{60}{\cancel{13}} \times \cancel{13} = 60$$

Short Circuiting in Capacitors

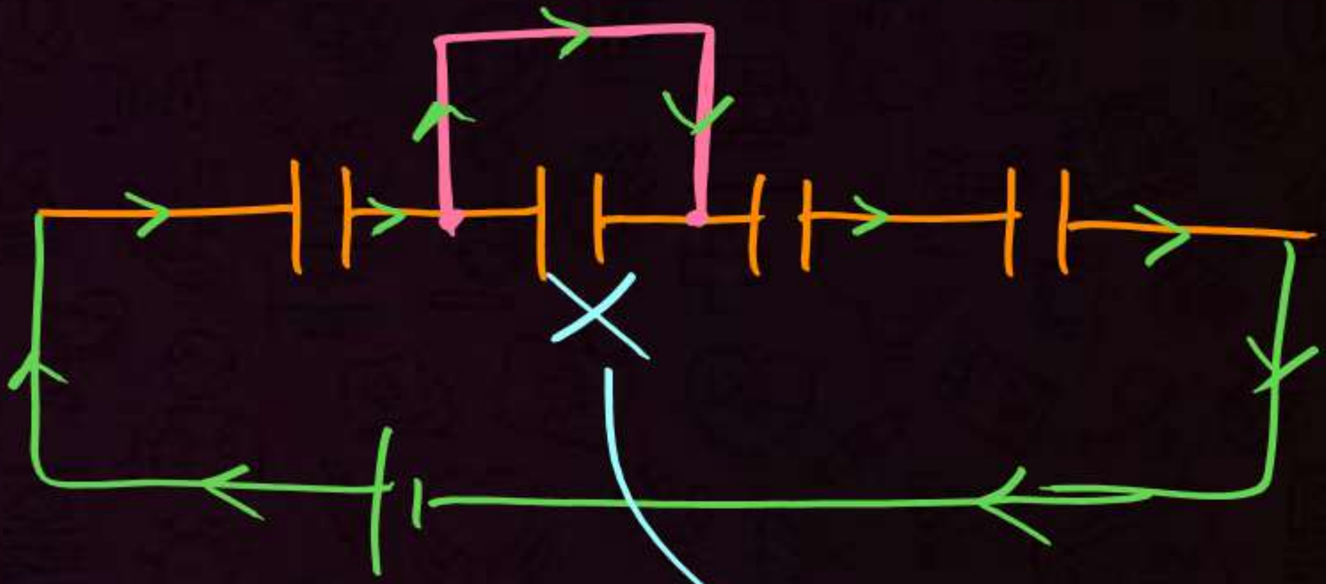
$\boxed{V = 0}$ → across a capacitor.



$C_{eq} = \frac{C}{4}$

conducting wire (R=0)

$V = iR = i \times 0 = 0$



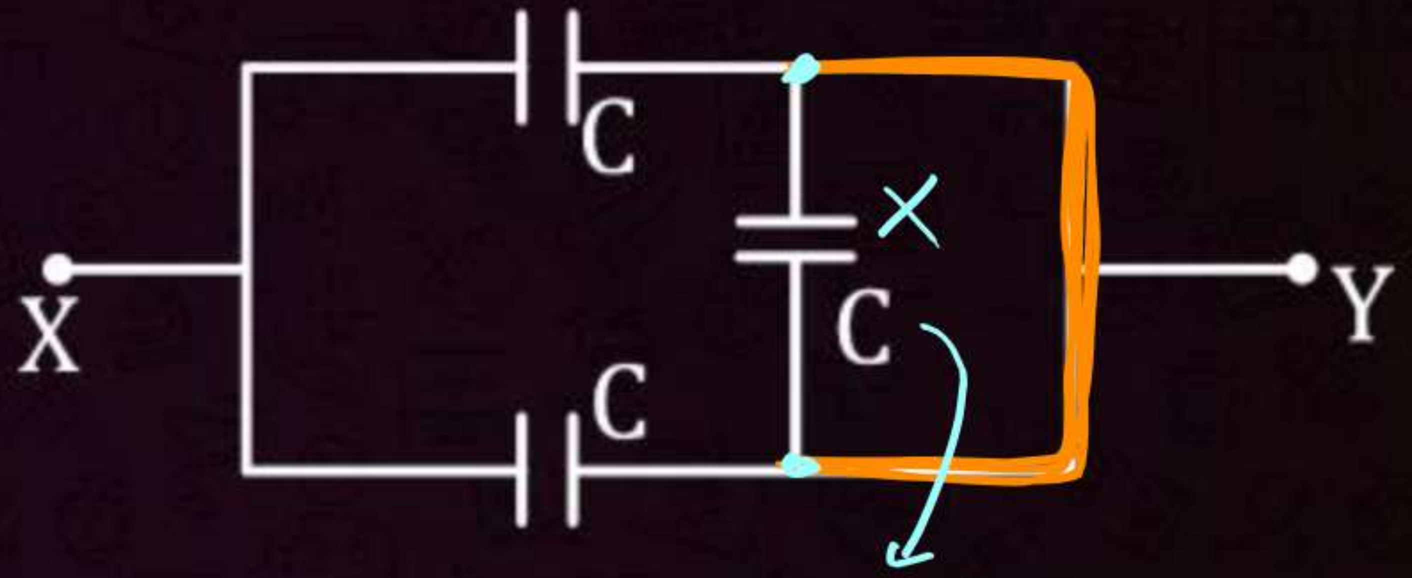
$C_{eq} = \frac{C}{3}$

$Q = 0$

QUESTION

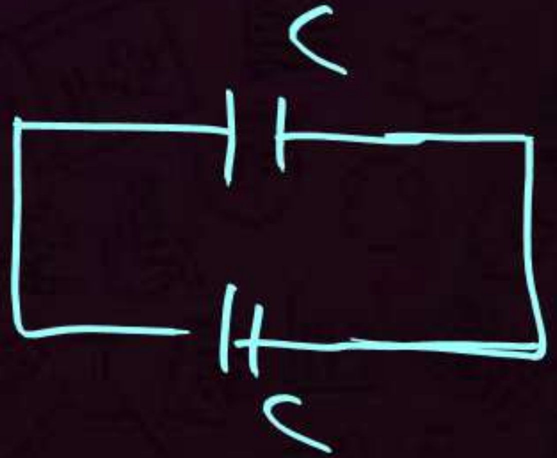
Find equivalent capacitance: **(2021)**

$C_{eq} = C + C = 2C$



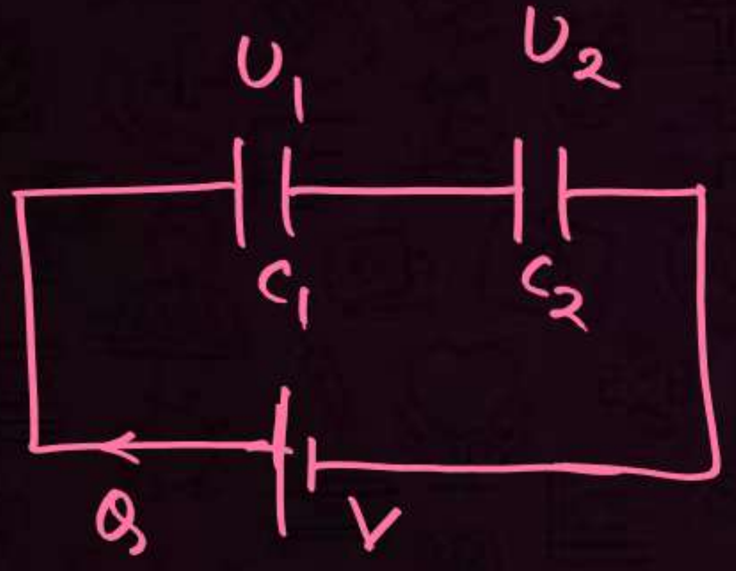
$V = 0$

$Q = 0$



Energy Stored in Combination

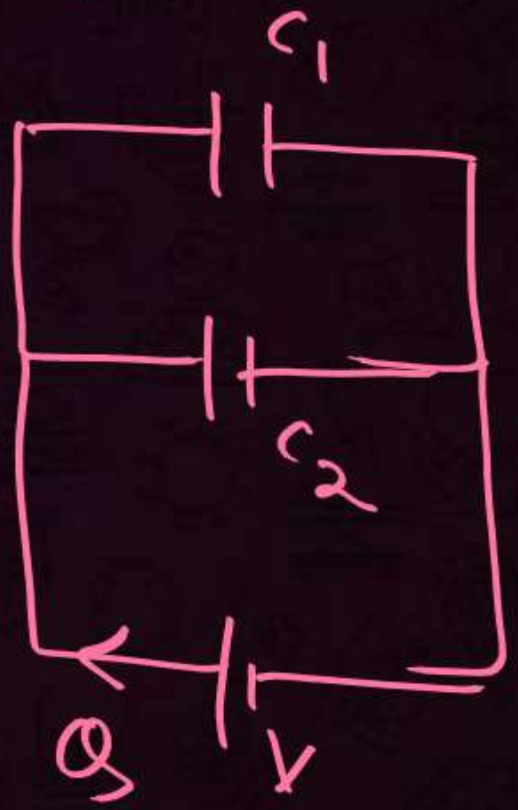
Series



$U_T = U_1 + U_2$ ✓

$U_T = \frac{1}{2} C_s V^2 = \frac{Q^2}{2C_s}$

Parallel



$U_T = U_1 + U_2$ ✓

$U_T = \frac{1}{2} C_p V^2 = \frac{Q^2}{2C_p}$

Question

If *n* identical capacitors of capacitance C are connected in parallel to V volt source, then the energy stored is equal to

$$U_T = \frac{1}{2} C_P V^2 = \frac{1}{2} nCV^2$$

[✓ 1 $\frac{1}{2} ncV^2$]

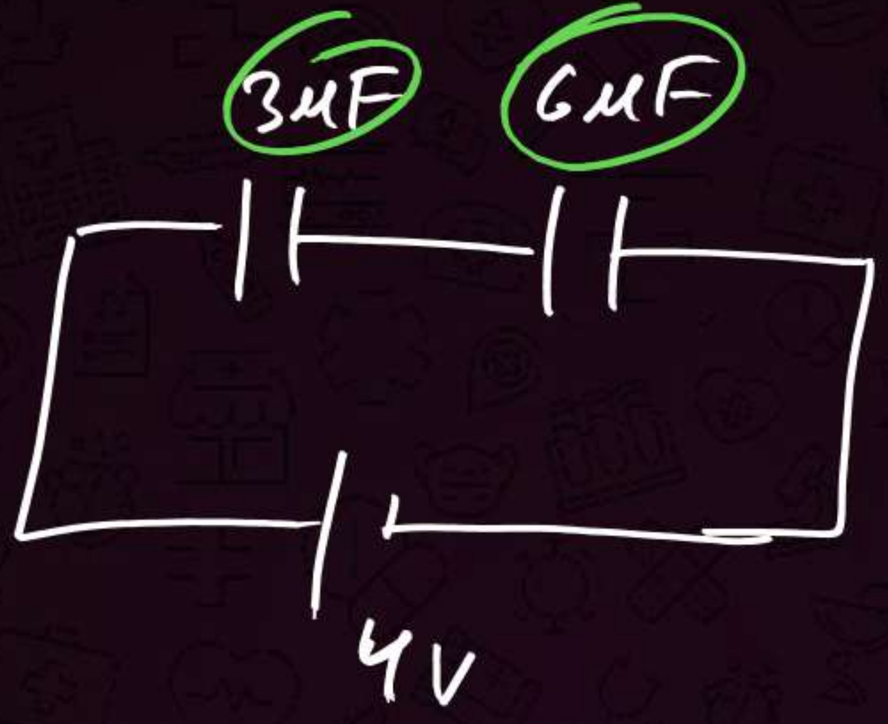
2 $\frac{1}{2} \frac{cV^2}{n}$

3 $\frac{1}{2} cV^2$

4 None

[redacted]

Ques
=



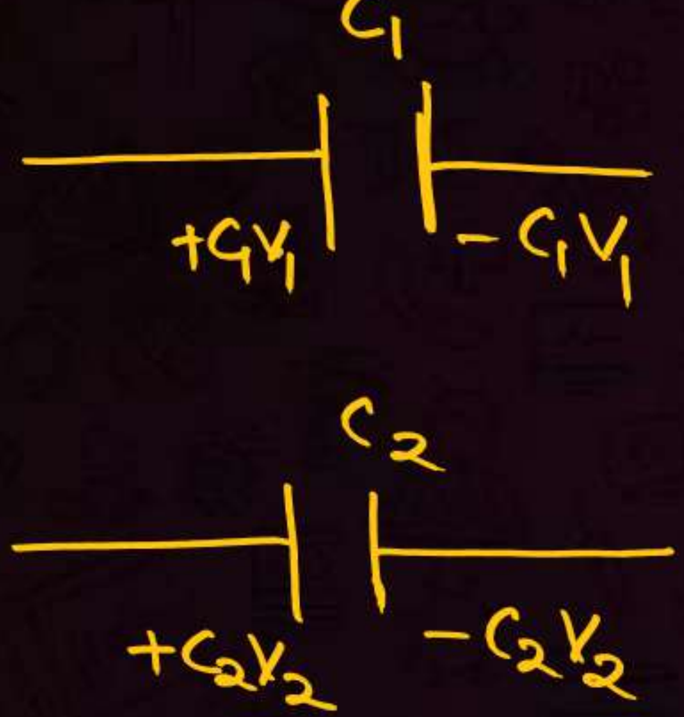
Total energy stored = ?

$$\frac{1}{2} C_s V^2$$

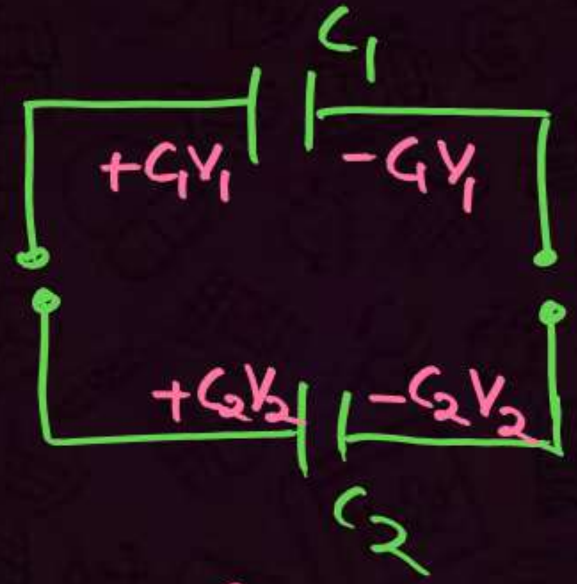
$$= \frac{1}{\cancel{2}} \times \cancel{2} \times 4^2$$

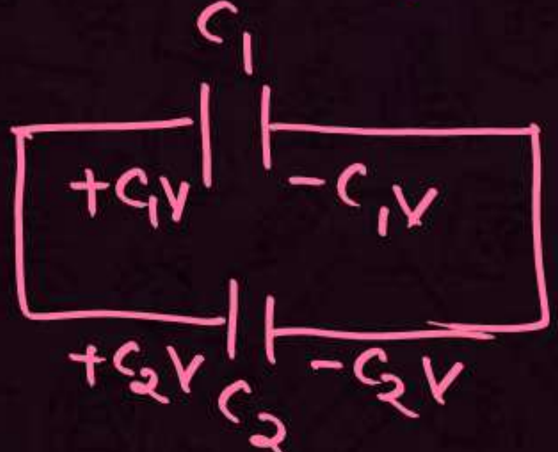
$$= \underline{\underline{16\ \mu J}}$$

Sharing of Charges and Common Potential



a) Same terminal





$V \rightarrow$ same

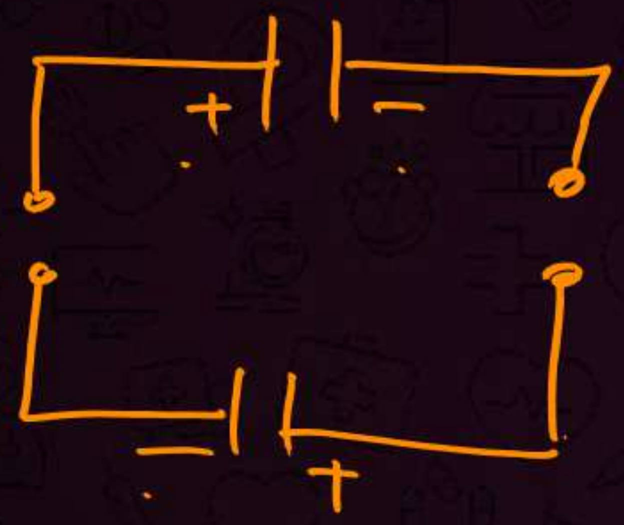
$$\boxed{V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}} \rightarrow Q \text{ cons.}$$

$$C_1V_1 + C_2V_2 = C_1V + C_2V$$

$$\boxed{\text{Loss of } U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1-V_2)^2}$$

$\rightarrow$ Heat ✓

b) opp. terminal



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

$$\boxed{\text{Loss of } U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1+V_2)^2}$$

QUESTION

A capacitor of capacity C_1 charged upto V volt and then connected to an uncharged capacitor of capacity C_2. The final potential difference across each will be **(2002)**

① $\frac{C_2V}{C_1+C_2}$

[✓ ② $\frac{C_1V}{C_1+C_2}$]

③ $\left(1+\frac{C_2}{C_1}\right)$

④ $\left(1-\frac{C_2}{C_1}\right)V$

$C_1, V_1 = V$

$C_2, V_2 = 0$

$$V' = \text{com. pot.} = \frac{C_1V + C_2\times 0}{C_1+C_2}$$

$$= \frac{C_1V}{C_1+C_2}.$$

QUESTION

A 3 μF capacitor is charged to a potential of 300 V and 2 μF capacitor is charged to 200 V. The capacitors are then connected in parallel with plates of opposite polarity joined together. Find the common potential after connecting.

[✓ ① 100 V]

② 200 V

③ 300 V

④ 400 V

$$V = \frac{C_1V_1 - C_2V_2}{C_1 + C_2} = \frac{3 \times 300 - 2 \times 200}{3+2}$$

$$= \frac{900 - 400}{5} = \frac{500}{5} = \underline{\underline{100\,V}}$$

Junction of Capacitors

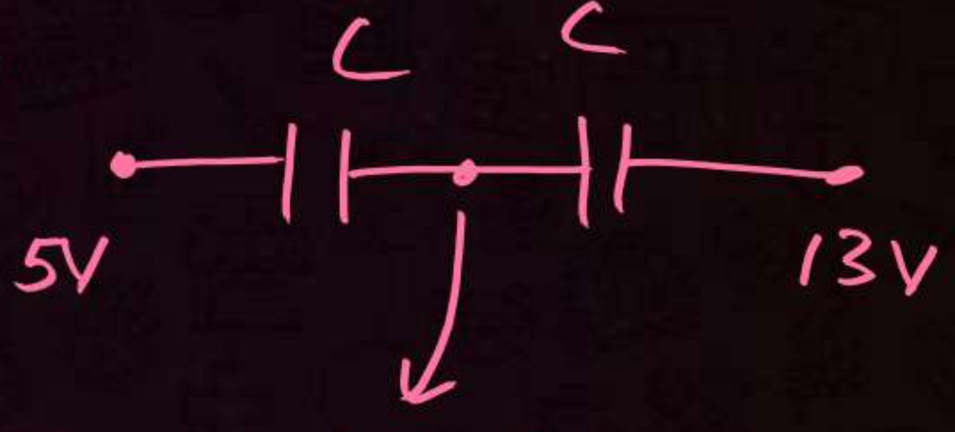
$$\boxed{V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

If $C_1 = C_2 = C$

$$V = \frac{CV_1 + CV_2}{C+C} = \frac{\cancel{C}(V_1+V_2)}{2\cancel{C}}$$

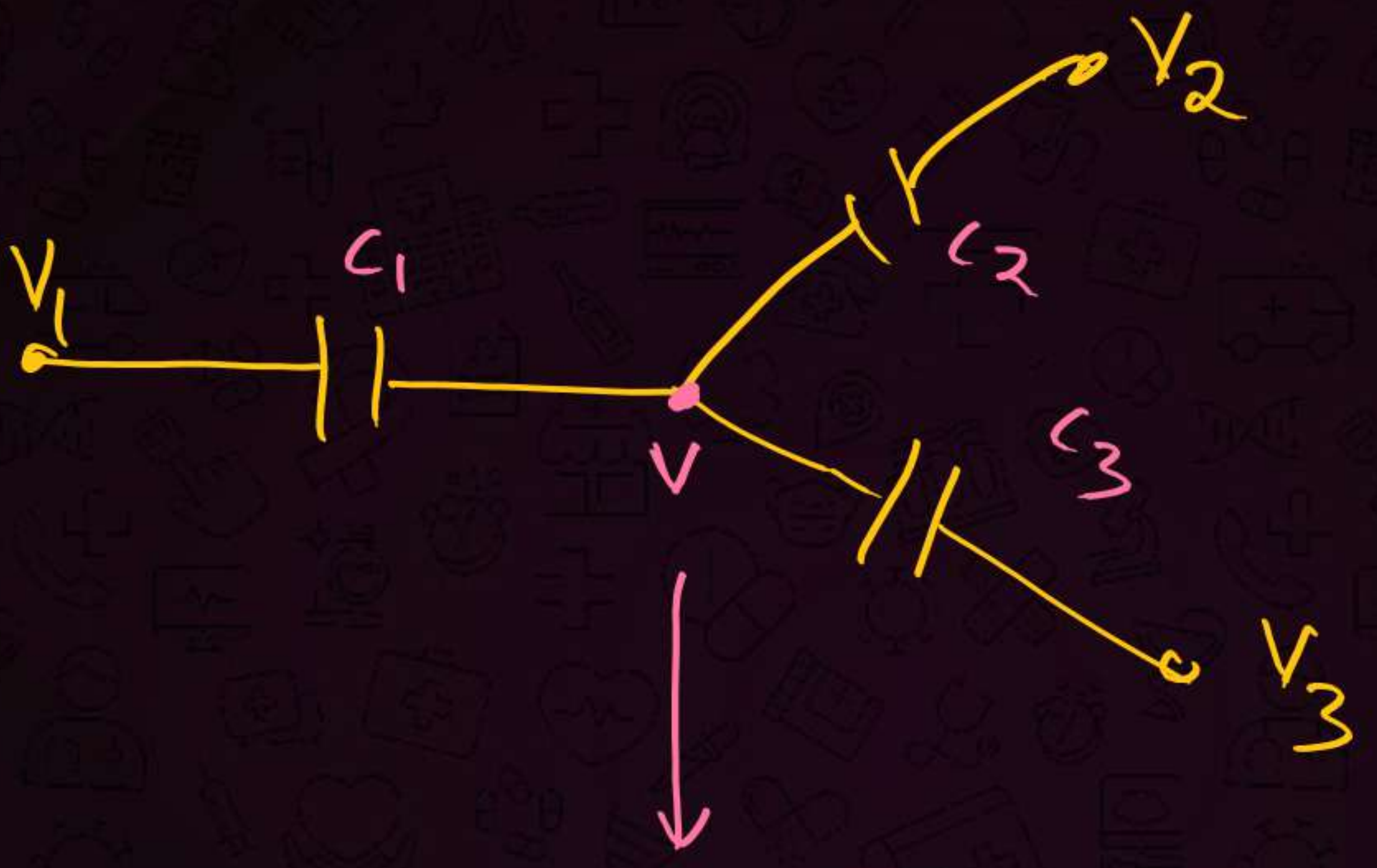
$$\boxed{V = \frac{V_1+V_2}{2}}$$

Ques =



$V = ?$

$$V = \frac{5+13}{2} = \frac{18}{2} = 9$$



$$\boxed{V = \frac{C_1V_1 + C_2V_2 + C_3V_3}{C_1 + C_2 + C_3}}$$

If identical

$$\boxed{V = \frac{V_1 + V_2 + V_3}{3}}$$

QUESTION

Three uncharged capacitors of capacitance C_1, C_2 and C_3 are connected to one another as shown in figure. Find the potential at O.

① 6.45 V

② 5.45 V

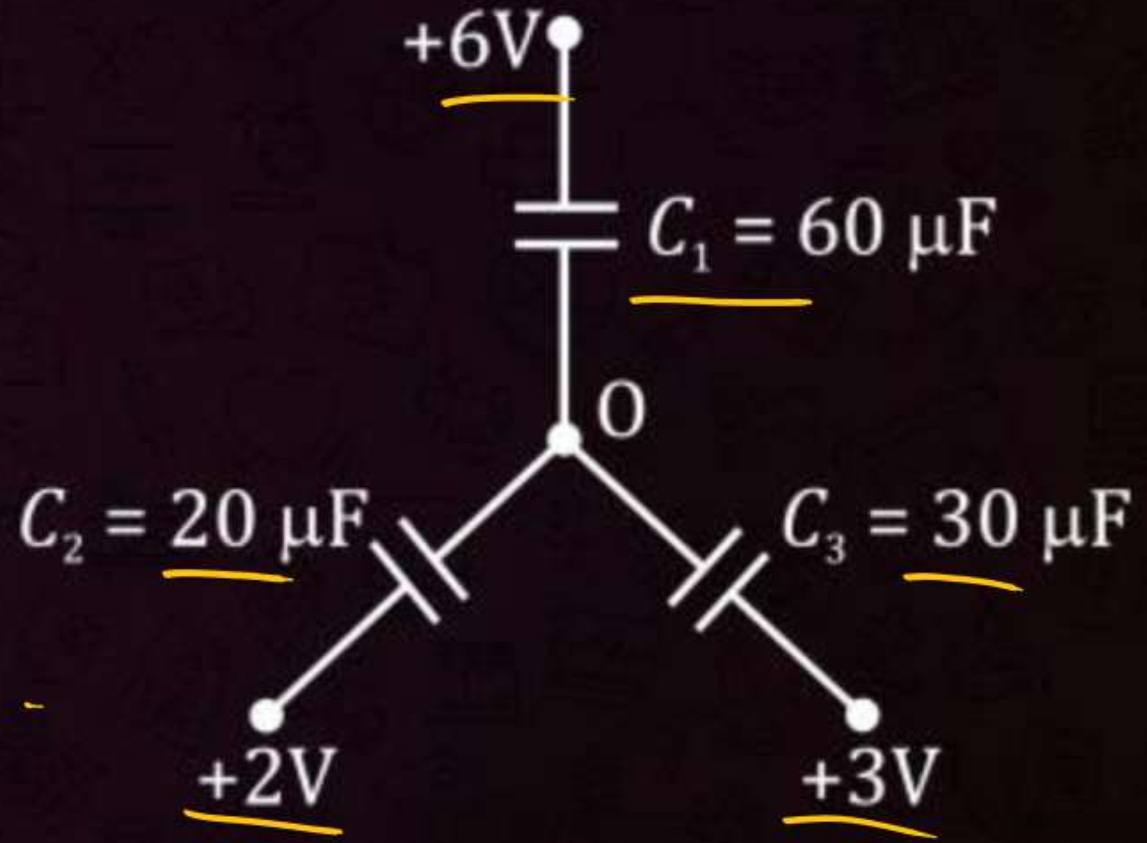
[✓ ③ 4.45 V]

④ None

$$V = \frac{60 \times 6 + 20 \times 2 + 30 \times 3}{60 + 20 + 30}$$

$$= \frac{490}{110} = \frac{49}{11}$$

$$= 4.454545 - - -$$



Dielectrics

Dielectrics are the insulators which transfer electrical effects without conduction.

✓ (moving) ×

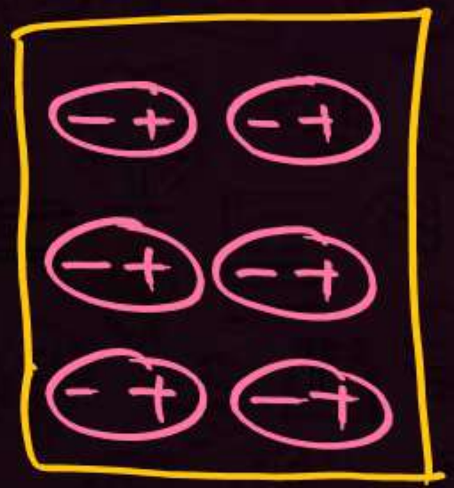
① Polar

eg: HCl.

H — Cl

δ^+ δ^-

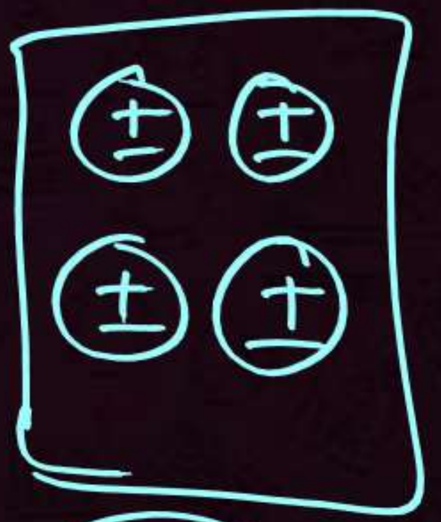
$\vec{p}$



$\vec{p}$ $\vec{p}$

$p \neq 0$

② Non-polar



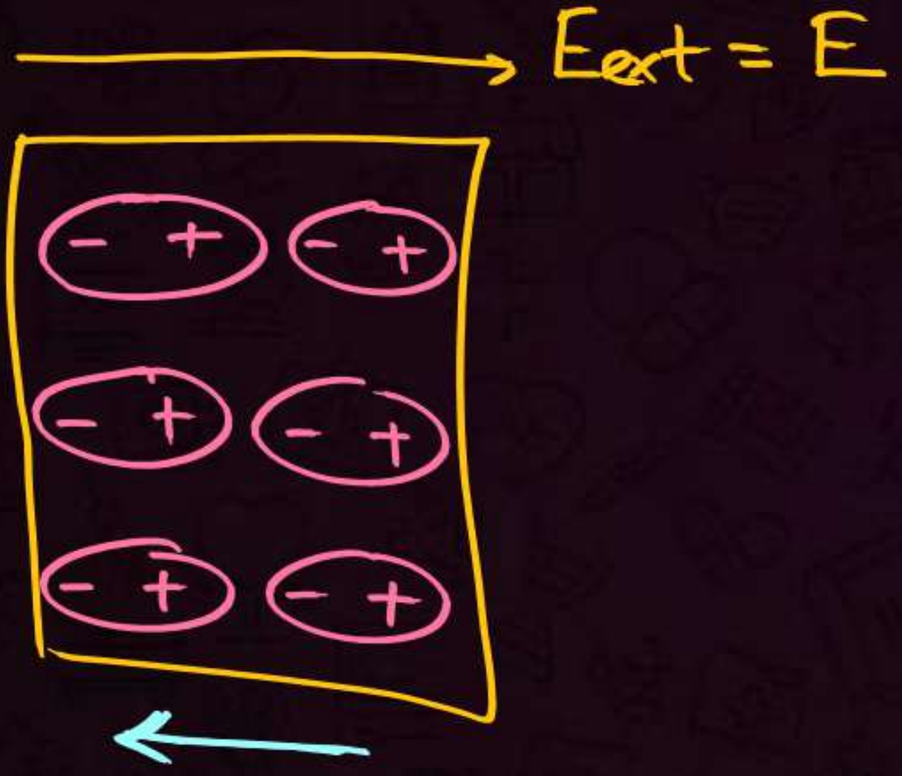
$\boxed{p=0}$

eg: H_2

H — H

$p=0$

Electric Field inside Dielectrics



$E_{in} \Rightarrow$ due to induced charges.

$K =$ dielec. const $= \epsilon_r = \frac{\epsilon}{\epsilon_0}$

$$E_{net} = E - E_{in} = \boxed{\frac{E}{K}}$$

$$E - \frac{E}{k} = E_{in}.$$

$$\boxed{E_{in} = E\left(1 - \frac{1}{K}\right)}$$

$$\boxed{\sigma_{in} = \sigma\left(1 - \frac{1}{K}\right)}$$

$$\boxed{Q_{in} = Q\left(1 - \frac{1}{K}\right)}$$

QUESTION

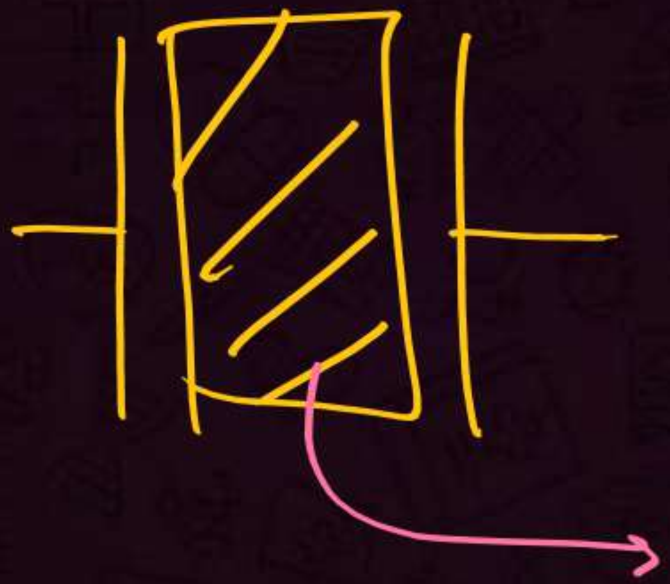
Charge on the capacitor is q. Now a mica sheet of dielectric constant $K = 5$ is introduced in it. Find induced charge in the capacitor.

[✓ 1] $4q/5$

2. $q/5$

3. $5q/4$

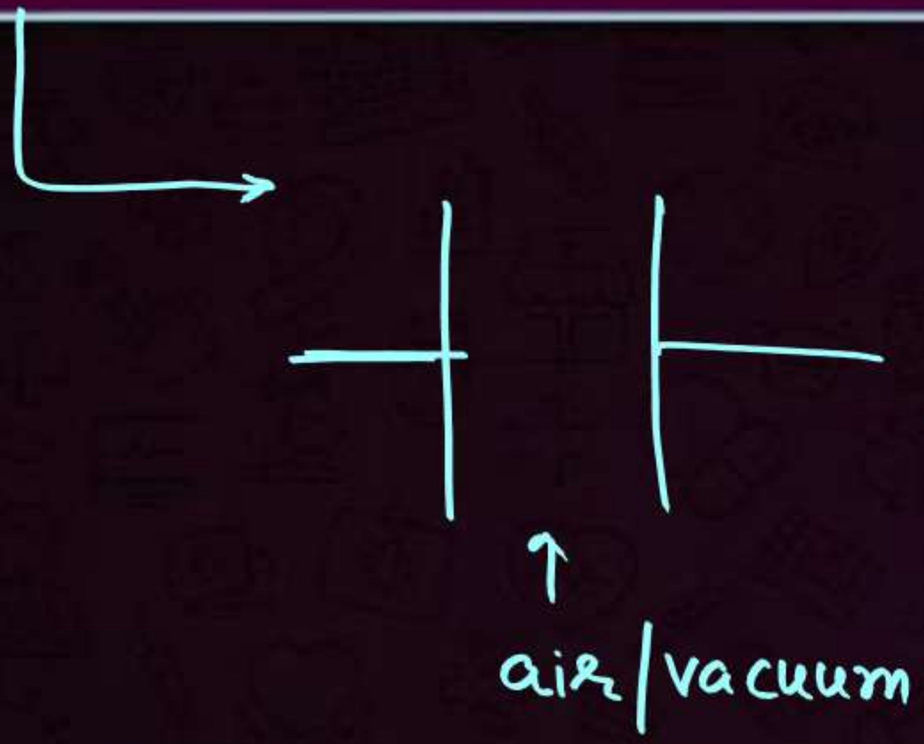
4. $5q$



$$q_{in} = q\left(1-\frac{1}{K}\right)$$

$$= q\left(1-\frac{1}{5}\right) = \frac{4q}{5}.$$

Effect of Dielectric on Capacitance



$$\boxed{C_0 = \frac{A\epsilon_0}{d}}$$

$$C = \frac{A\epsilon}{d} = \frac{AK\epsilon_0}{d} = K\frac{A\epsilon_0}{d}$$

$$K = \frac{\epsilon}{\epsilon_0}$$

$$\boxed{\epsilon = K\epsilon_0}$$

$$\boxed{C = KC_0}$$

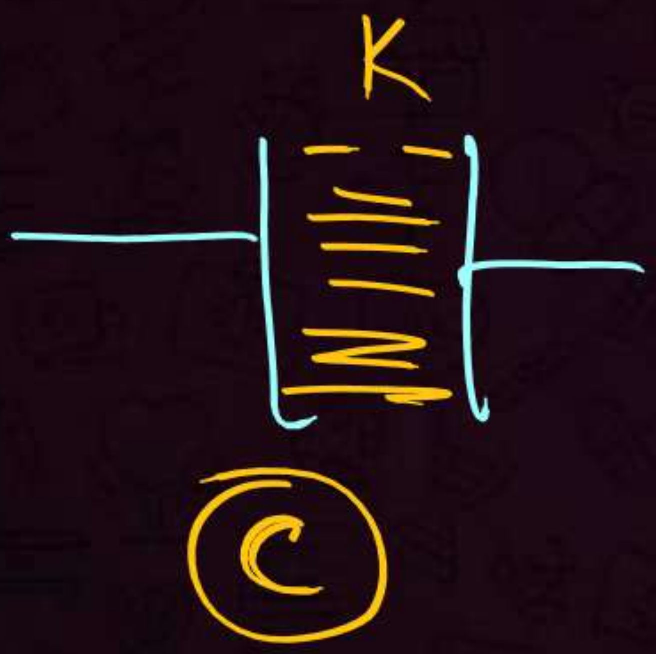
inc.

$$\boxed{C > C_0}$$

QUESTION

A parallel plate condenser with oil between the plates (dielectric constant of oil $k = 2$ has a capacitance C. If the oil is removed, then capacitance of the capacitor becomes (1999)

1. $C/\sqrt{2}$
2. $2\,C$
3. $\sqrt{2}\,C$
4. [✓ $C/2$]



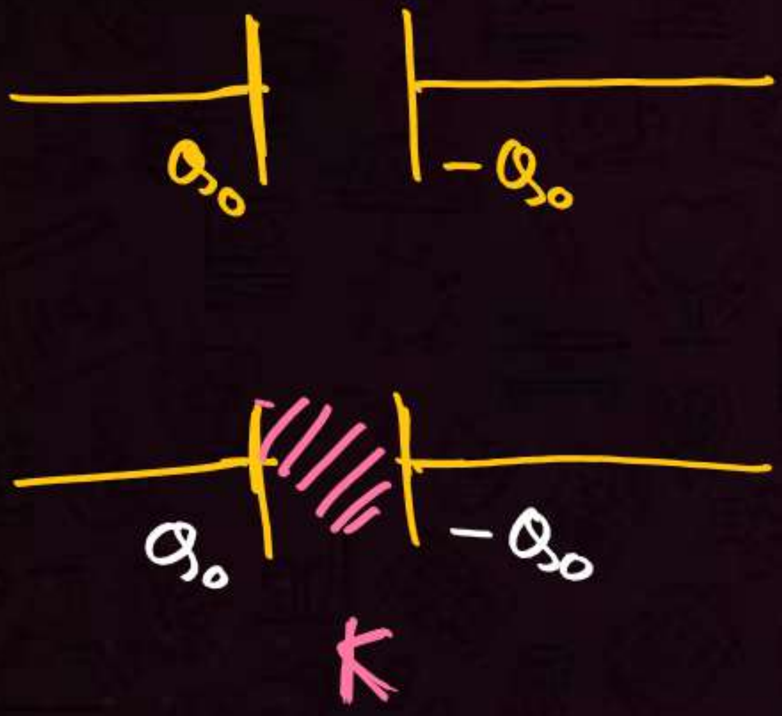
$C_0 = ?$

$C = KC_0$

$C_0 = \frac{C}{K} = \boxed{\frac{C}{2}}$

Effect of Dielectric on Different Variables

A) Battery not connected (Isolated Capacitor)



① $\boxed{C = KC_0}$

inc

② $\boxed{Q = Q_0}$

cons.

③ $V_0 = \frac{Q_0}{C_0}$

$$V = \frac{Q}{C} = \frac{Q_0}{KC_0}$$

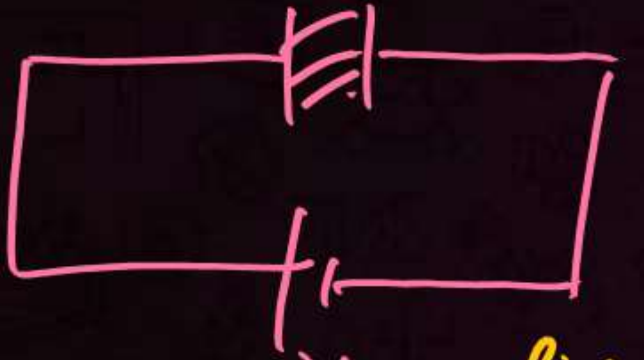
$$\boxed{V = \frac{V_0}{K}} \to \text{dec}$$

④ $E = \frac{V}{d}$ ✓ ✓

$$\boxed{E = \frac{E_0}{K}} \to \text{dec}$$

⑤ $\boxed{U = \frac{U_0}{K}} \to$ dec

B) Battery connected → Kuch bhi dec. Nhi Hota.



$V_0 \to$ fix

① $\boxed{C = KC_0}$

inc.

② $\boxed{V = V_0}$

const.

③ $Q_0 = C_0 V_0$

$Q = CV$

$Q = KC_0 V_0$

$\boxed{Q = KQ_0} \to$ inc

✓ ✓

④ $E = \frac{V}{d}$

$\boxed{E = E_0}$

const.

⑤ $\boxed{U = KU_0} \to$ inc

$U_0 = \frac{1}{2} C_0 V_0^2$

$U = \frac{1}{2} CV^2$

$U = \frac{1}{2} KC_0 V_0^2$

$U = KU_0$

QUESTION

Two parallel metal plates having charges +Q and –Q face each other at a certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

(2010)

1. become zero
2. increase
3. [✓ decrease]
4. remain same

TBS Note:- If not given, then assume isolated capacitor

$$\boxed{E = \frac{E_0}{K}}$$

QUESTION

Assertion (A): A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times of the initial value.

$U = KU_0$ ✓

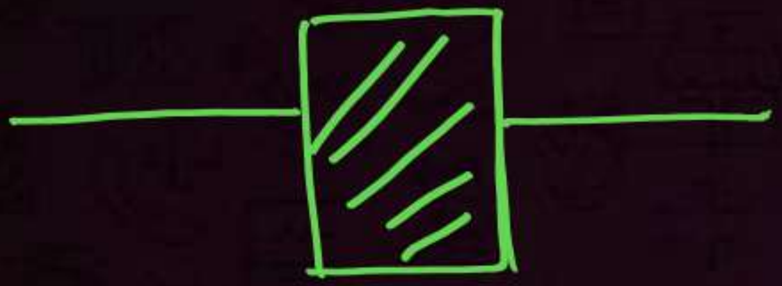
Reason (R): The surface density of charge is charge per unit volume.

$\sigma = \frac{Q}{A}$ ✗ $\rho = \frac{Q}{V}$

1. If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of Assertion (A).
2. If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).
3. [✓ If Assertion (A) is True but the Reason (R) is False.]
4. Assertion (A) is False but the Reason (R) is True.

Capacitor Filled with Conducting Slab

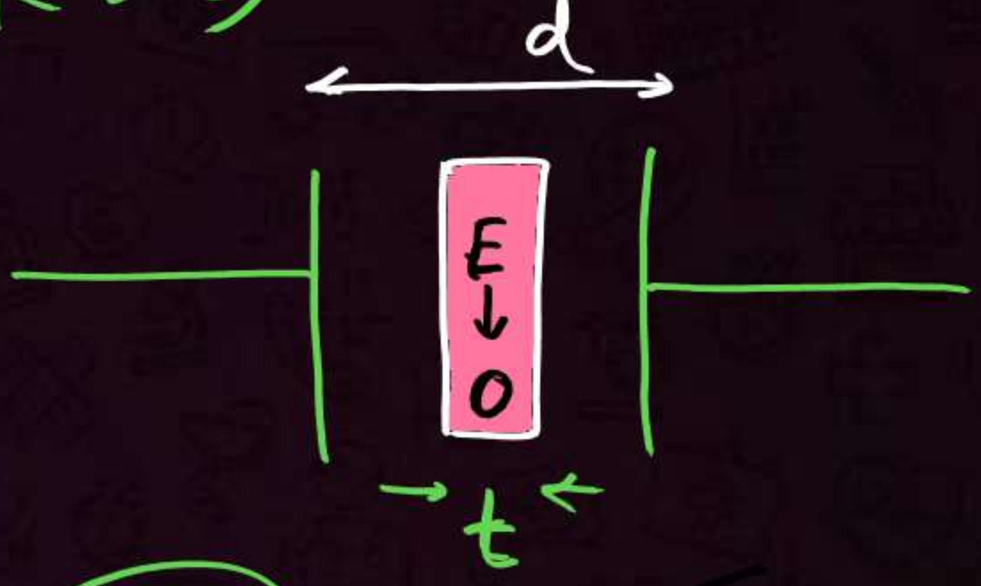
(K→∞)



K→∞

$$C = KC_0$$

$$\boxed{C \to \infty}$$



$$C_0 = \frac{A\epsilon_0}{d}$$

before

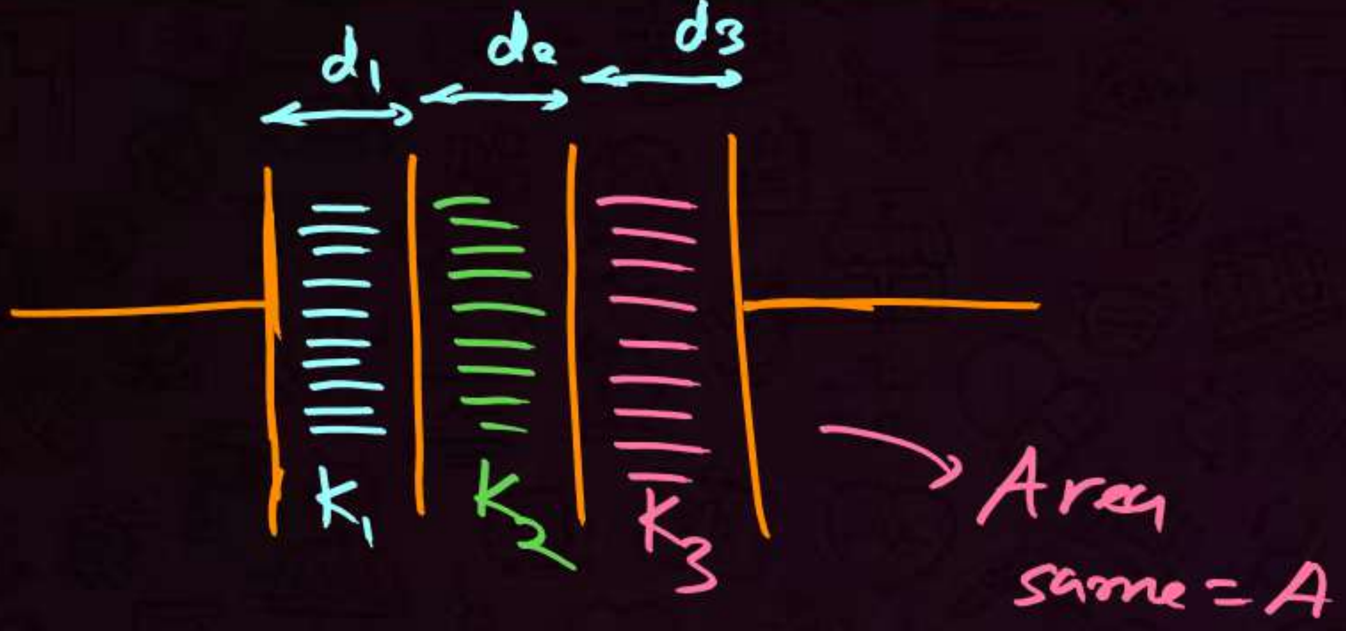
$$\boxed{C = \frac{A\epsilon_0}{d-t}}$$

$$C > C_0$$

Den↓.

C↑.

Series Combination

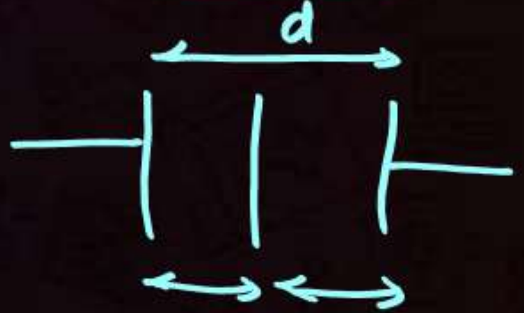


$$\boxed{C_s = \frac{A\epsilon_0}{\frac{d_1}{K_1} + \frac{d_2}{K_2} + \frac{d_3}{K_3}}}$$

Two → diel.

$$\boxed{C_s = \frac{A\epsilon_0}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}}$$

TBS case



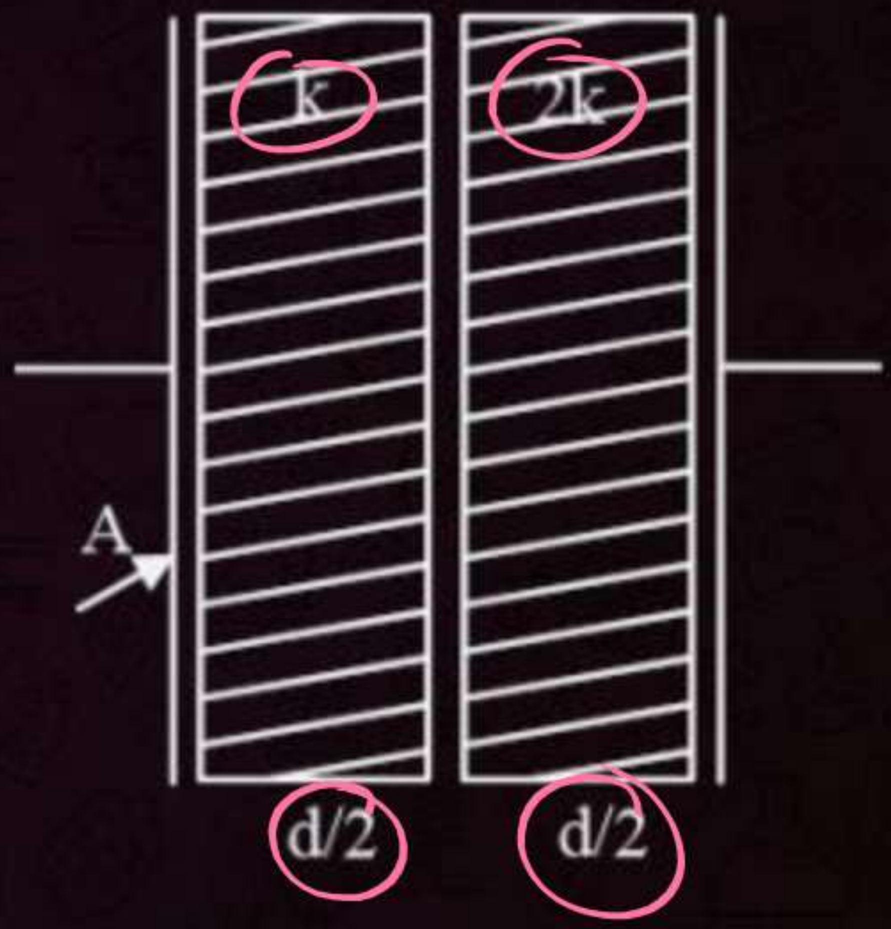
$d_1 = d_2 = \frac{d}{2}$

$$\boxed{C = \frac{2K_1K_2}{K_1+K_2} C_0}$$

$C_0 = \frac{A\epsilon_0}{d}$ ✓

QUESTION

Find the capacitance of the given arrangement.

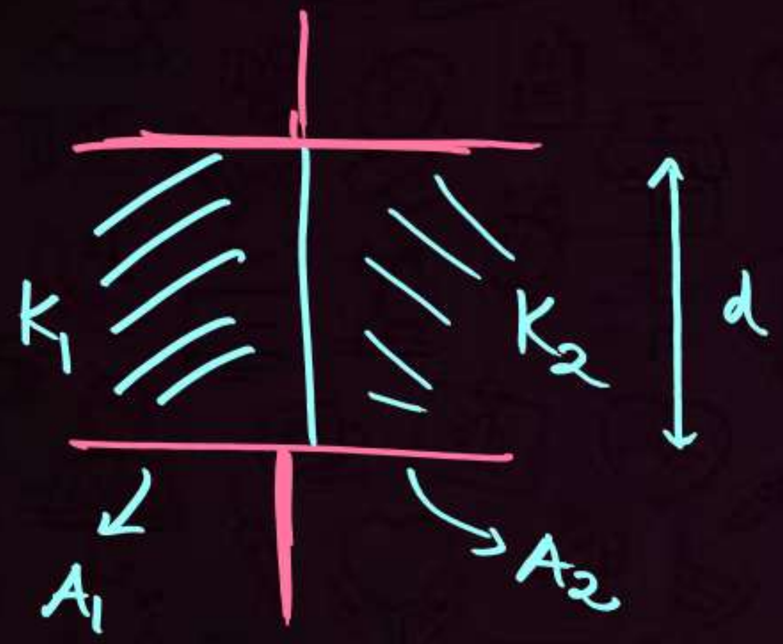


$$C_s = \frac{2 \times K_1 K_2}{K_1 + K_2} C_0$$

$$= \frac{2 \times K \times 2K}{K + 2K} \times \frac{A\epsilon_0}{d}$$

$$= \boxed{\frac{4K}{3} \frac{A\epsilon_0}{d}}$$ Ans.

Parallel Combination



$$\boxed{C_p = \frac{\epsilon_0}{d}(K_1A_1 + K_2A_2)}$$

TBS case If $A_1 = A_2 = \frac{A}{2}$

$$C_p = \frac{\epsilon_0}{d}\left(K_1\frac{A}{2} + K_2\frac{A}{2}\right)$$

$$C_p = \frac{K_1+K_2}{2} \times \frac{A\epsilon_0}{d}$$

$$\boxed{C_p = \left(\frac{K_1+K_2}{2}\right)C_0}$$

QUESTION

BPU

A parallel plate capacitor with air as medium between the plates has a capacitance of 10µF. The area of capacitor is divided into two equal halves and filled with two media as shown in the figure dielectric constant $k_1 = 2$ and $k_2 = 4$. The capacitance of the system will now be

① 10 µF

② 20 µF

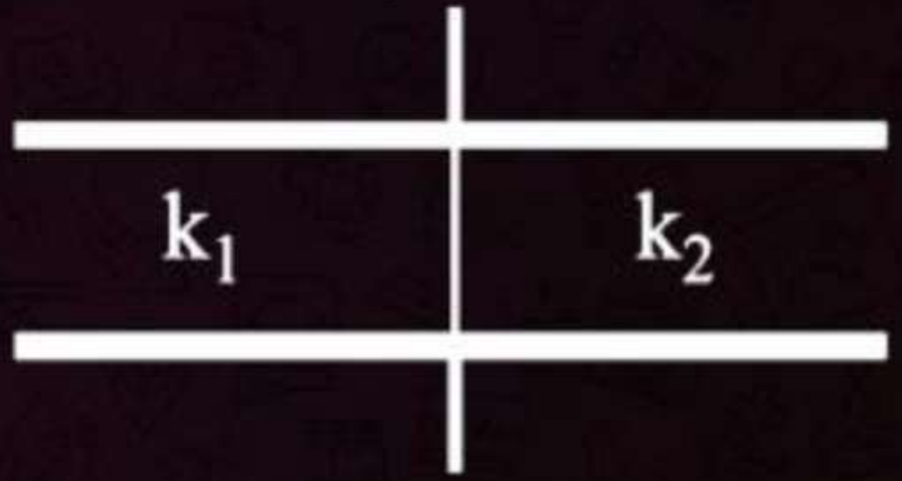
[✓ ③] 30 µF

④ 40 µF

$$C = \left(\frac{K_1 + K_2}{2}\right) C_0$$

$$= \left(\frac{2+4}{2}\right) \times 10$$

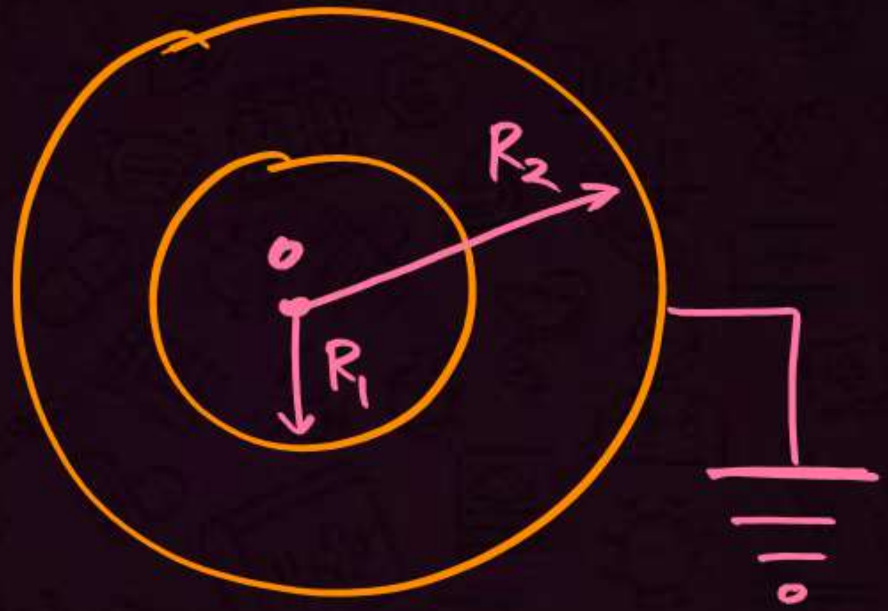
$$= 3 \times 10 = 30$$



Spherical and Cylindrical Capacitors

$$\boxed{C = 4\pi\epsilon_0 R}$$

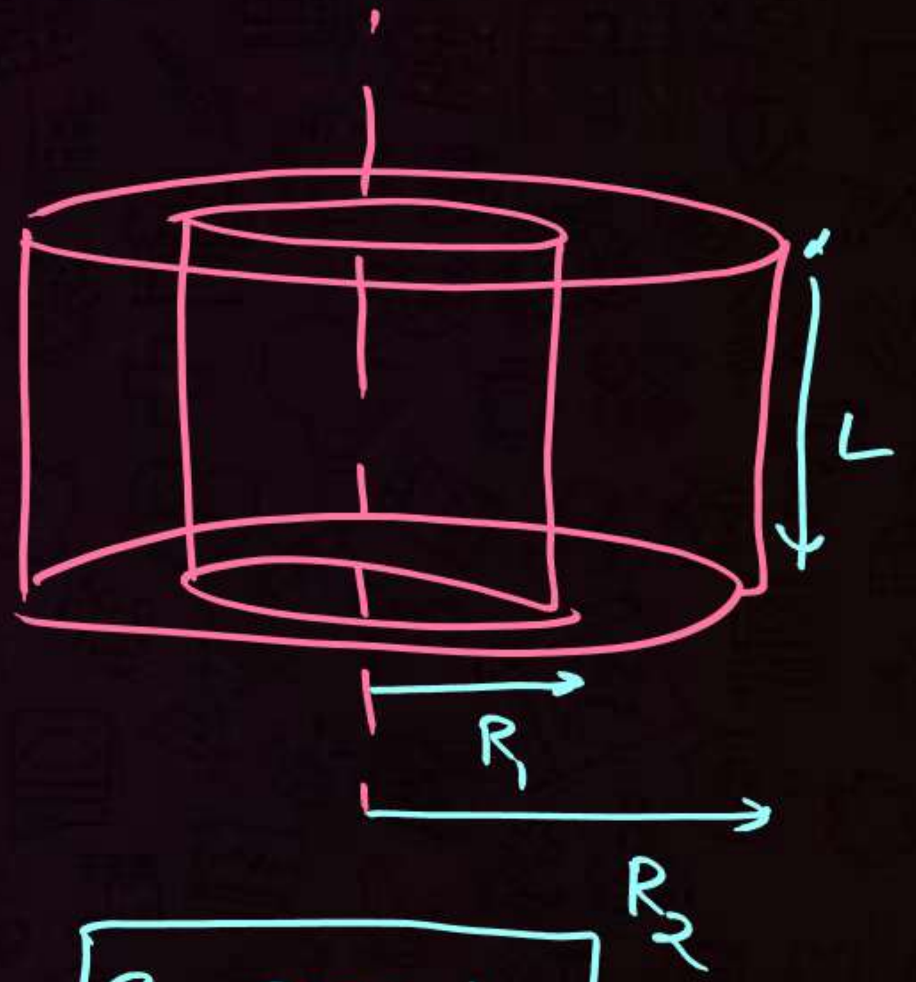
$$C \propto R$$



Concentric Spheres

Outer sphere earthed.

$$\boxed{C = 4\pi\epsilon_0 \frac{R_1 R_2}{R_2 - R_1}}$$



$$\boxed{C = \frac{2\pi\epsilon_0 L}{\ln\left(\frac{R_2}{R_1}\right)}} \rightarrow \text{Rare chance}$$

QUESTION

Two concentric conducting spheres of radius R and 2R with outer sphere earthed has capacitance equal to

A) $4\pi\epsilon_0 R$

[✓ B) $8\pi\epsilon_0 R$.]

C) $12\pi\epsilon_0 R$

D) None

$$C = 4\pi\epsilon_0 \frac{R_1 R_2}{R_2 - R_1}$$

$$= 4\pi\epsilon_0 \times \frac{R \times 2R}{2R - R.}$$

$$= 8\pi\epsilon_0 R.$$

QUESTION

64 drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is:

① 8 times

[✓ ② 4 times]

③ 2 times

④ 32 times

$$\boxed{C \propto R}$$

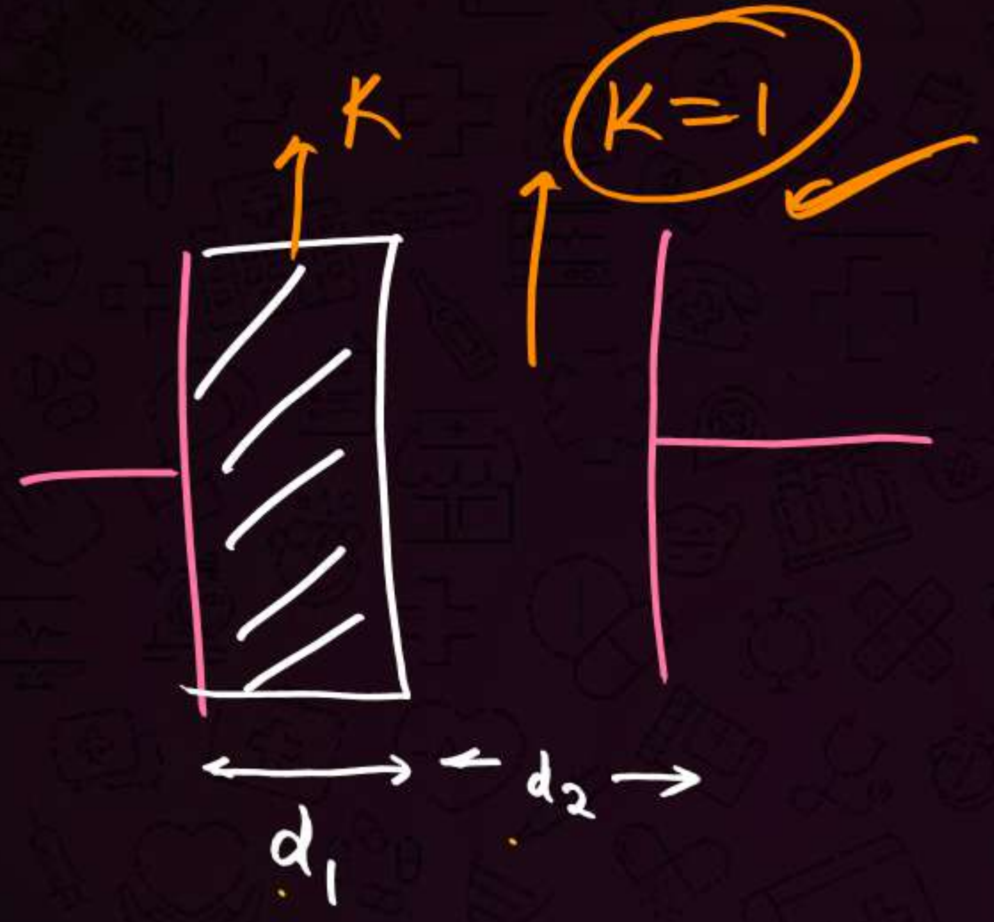
$$\boxed{R = n^{1/3} r}$$

✓ $$\boxed{C' = n^{1/3} C}$$

$$= (64)^{1/3} C$$

$$= (4^3)^{1/3} C = \boxed{4C}$$

Ques



$$C = \frac{A\epsilon_0}{\frac{d_1}{K} + \frac{d_2}{1}}$$

Apne Hath se Likhna ←

TBS Capsule ①

* $W_{cons} = -\Delta U$

$W_{elec} = -\Delta U$

$W_{ext} = \Delta U$ (Slowly)

* $W_{ext} = \Delta U = \frac{kqq_0}{r}$

At ∞ ⇒ $U = 0$

$$\boxed{U = \frac{kq_1q_2}{r}}$$

- $U \rightarrow$ scalar

SI Unit → J

Value of charge with sign.

TBS

If $U = +ve$

$r\uparrow \Rightarrow U\downarrow$

$r\downarrow \Rightarrow U\uparrow$

If $U = -ve$

$r\uparrow \Rightarrow U\uparrow$

$r\downarrow \Rightarrow U\downarrow$

* More than two charges

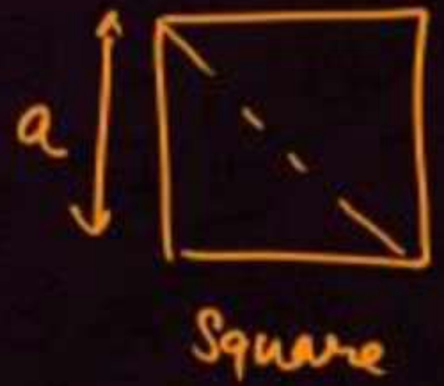
$$\boxed{N = \frac{n(n-1)}{2}}$$

No. of terms

n = no. of charges

eg:- $n = 3 \Rightarrow N = 3$

$n = 4 \Rightarrow N = 6$



Diagonal $= \sqrt{2}a$

Half of diagonal $= \frac{a}{\sqrt{2}}$

TBS capsule ②

* Potential

$$\boxed{\frac{W}{q_0} = \frac{U}{q_0} = V}$$

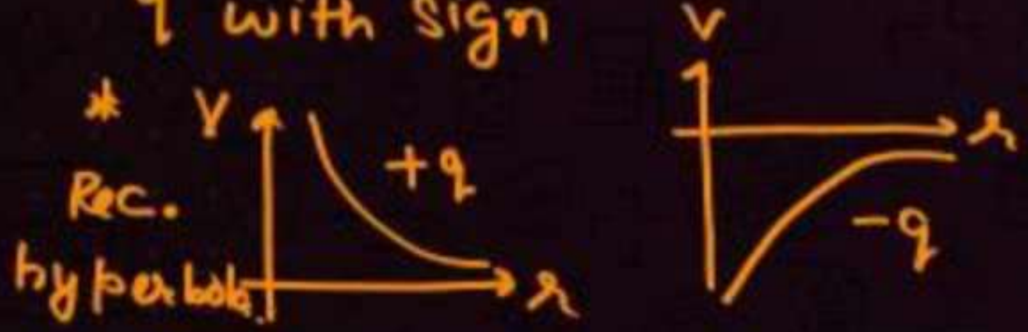
$$\boxed{V = \frac{kq}{r}}$$

* At ∞ ⇒ $V = 0$

* Scalar

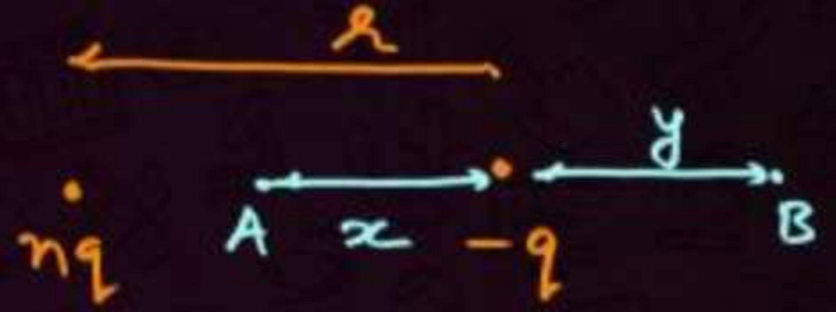
SI unit → J/C

q with sign



* $V = V_1 + V_2 + V_3 + \cdots$

* Zero potential



$$V_A = V_B = 0$$

$$\boxed{x = \frac{r}{n+1}} \qquad \boxed{y = \frac{r}{n-1}}$$

→ from chhota q

$$\boxed{n = \frac{\text{Bada } q}{\text{chhot } q}}$$

→ without sign

* $W_{ext} = \Delta U$

$W_{ext} = q_0 \Delta V$

* $W_{elec} = -\Delta U$

$W_{elec} = -q_0 \Delta V$

TBS Capsule ③

* $\int dV = -\int \vec{E}\cdot\vec{dr}$

If E → known
V → find

* $E = -\frac{dV}{dr}$

$E_x = -\frac{\partial V}{\partial x}$

$E_y = -\frac{\partial V}{\partial y}$

$E_z = -\frac{\partial V}{\partial z}$

If V known,
E find

* If E = const.
(uniform)

$\Delta V = -\vec{E}\cdot\vec{\Delta r}$

* TBS Points

a) V dec in direction of E. $E = -\frac{dV}{dr}$

b) ⊥cular to E → V const.
Called equipotential surface.

c) If E = 0 (region)
V → const.

* Equipotential surfaces

Pt. charge → Spherical

Sphere → Spherical

Rod (Line charge) → Cylindrical

llel lines of E → planar

TBS → Free Charge Concept

+q move	dec. V	dec. U
-q move	inc. V	dec. U

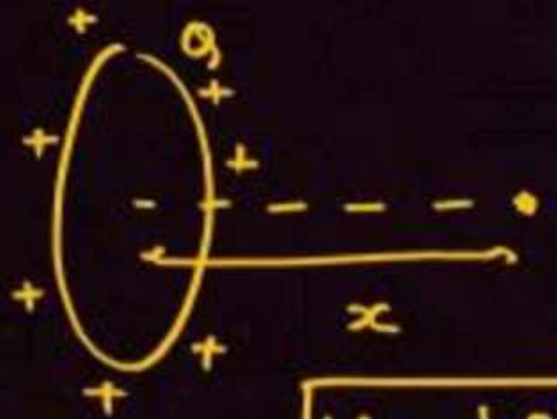
Cons. of energy ⇒ $-\Delta U = +\Delta K = q_0\Delta V$

$$\boxed{\frac{1}{2}mv^2 = q_0\Delta V}$$

TBS capsule ④

a) Ring

$V_0 = \frac{kQ}{R}$

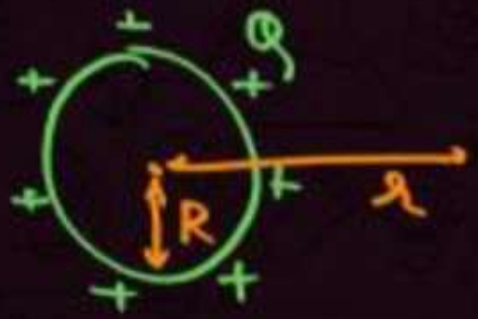


$$\boxed{V = \frac{kQ}{\sqrt{x^2+R^2}}}$$

b) Arc

$$\boxed{V_0 = \frac{kQ}{R} = k\lambda\alpha}$$

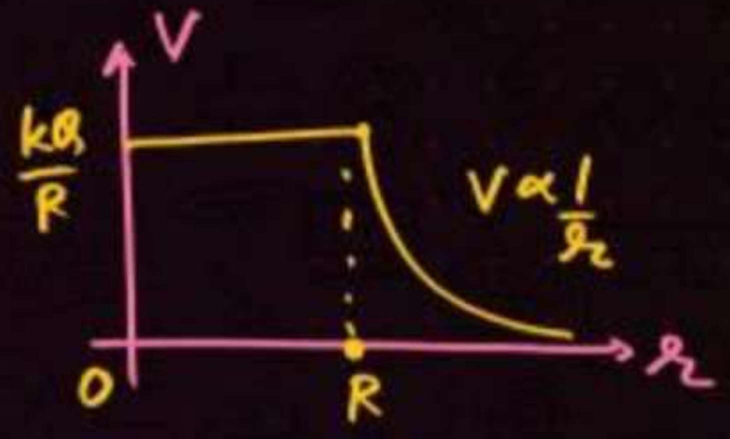
c) Hollow Sphere & Solid Cond.



$V_{out} = \frac{kQ}{r}$

$V_{in} = \frac{kQ}{R}$

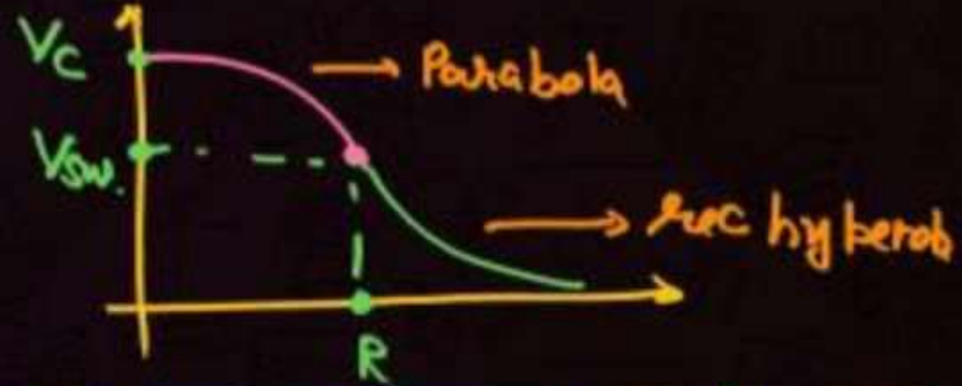
$V_{sur} = \frac{kQ}{R}$



d) Solid Sphere (Non-cond.)

$V_{in} = \frac{kQ}{2R^3}(3R^2 - r^2)$

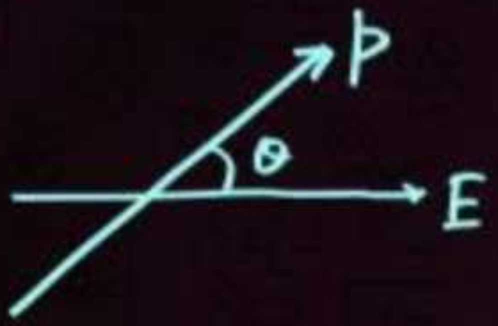
$V_c = \frac{3}{2}\frac{kQ}{R} = \frac{3}{2}V_{sur}$



e) Drop comb. → $\boxed{V' = n^{2/3} V}$

TBS Capsule ⑤

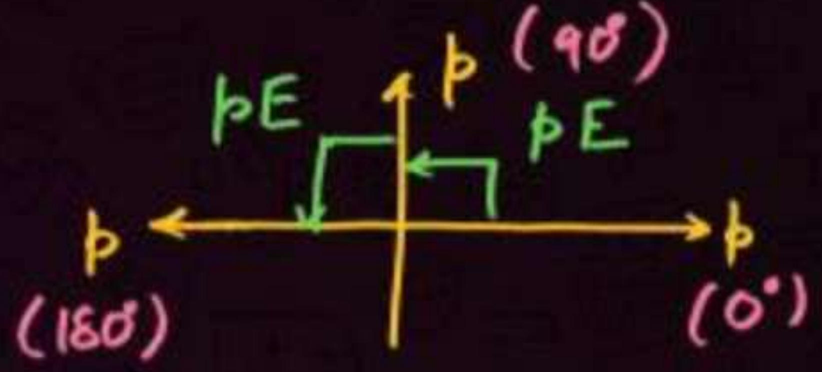
- **Dipole**



- F = 0 (uniform E)
- $\tau = pE\sin\theta$

  $\vec{\tau} = \vec{p} \times \vec{E}$
- $U = -pE\cos\theta = -\vec{p}\cdot\vec{E}$

a) $\theta = 0°$	b) $\theta = 180°$	c) $\theta = 90°$
$U = -pE$	$U = +pE$	$U = 0$
$\min^m$	$\max^m$	
Stable eq.	Unstable eq.	



TBS Work Chart

⇓

Wext.

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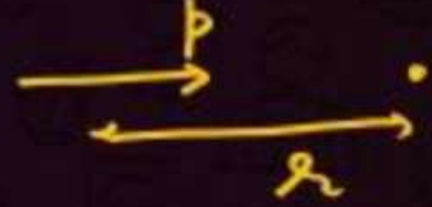
* **Potential due to dipole**

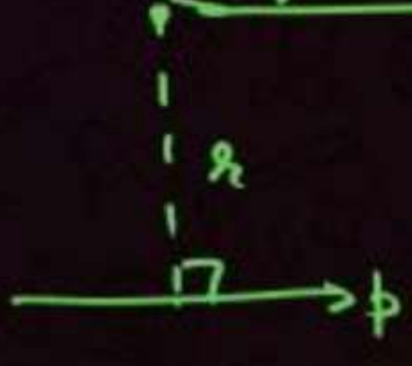


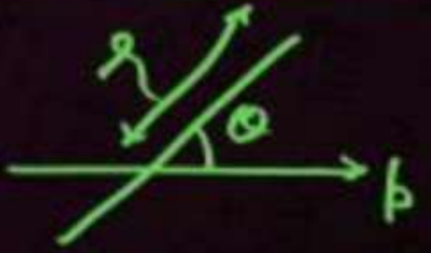
$$V_{ax.} = \frac{kp}{r^2 - a^2} \simeq \boxed{\frac{kp}{r^2}}$$

↓

Short dipole.

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





$$V = \frac{kp\cos\theta}{r^2} \quad \text{(Short dipole)}$$

TBS Capsule ⑥

a) Isolated Conductor

E = 0 inside material.

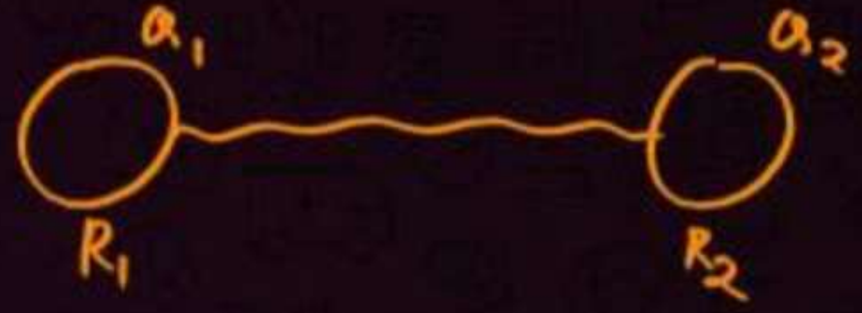
b) no excess charge inside.

c) V → const. inside.

d) $E_{sur} \rightarrow \perp$ to surface.

e) $E_{sur} = \frac{\sigma}{\epsilon_0}$ (shape doesn't matter)

f)

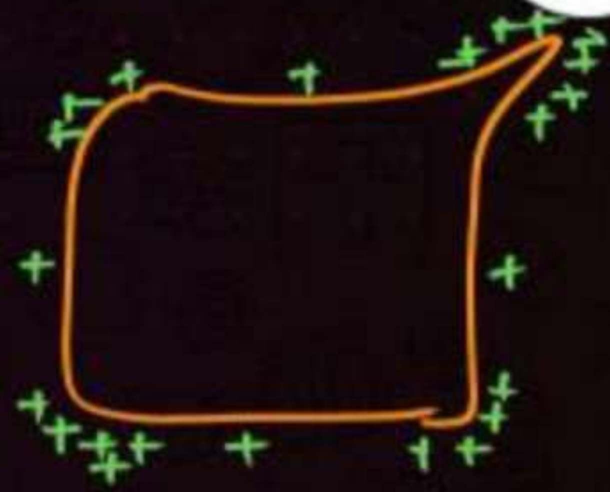


$$Q_1' = \frac{R_1}{R_1+R_2}(Q_1+Q_2)$$

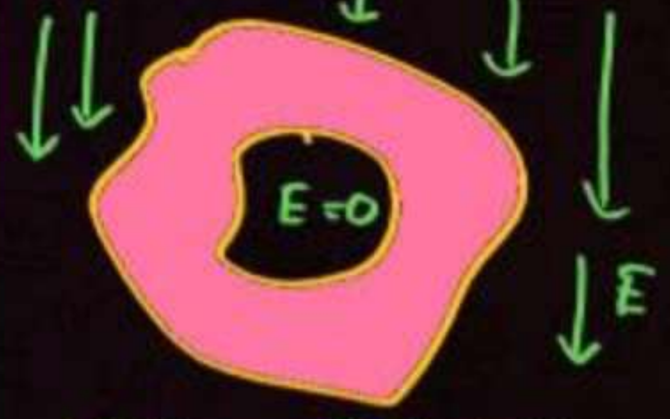
$$Q_2' = \frac{R_2}{R_1+R_2}(Q_1+Q_2)$$

$$\frac{Q_1'}{Q_2'} = \frac{R_1}{R_2} \Rightarrow \boxed{Q \propto R}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1} \Rightarrow \boxed{\sigma \propto \frac{1}{R}}$$



Elec. shielding



external field has no effect inside cavity.

TBS capsule ⑦

- Capacitor

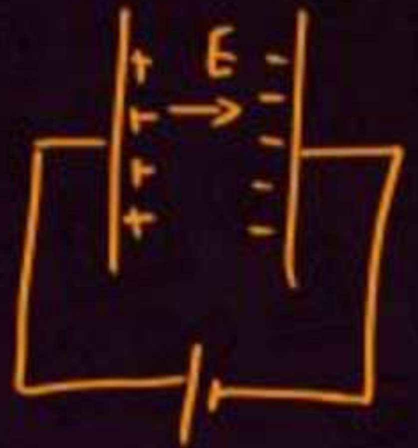
↓

- Stores energy/charge
- Scalar
- Also called Condsers.
- SI unit → Farad (F)

$\boxed{C=\frac{Q}{V}}$ or $\frac{\text{coulomb}}{\text{Volt}} = \frac{(\text{coulomb})^2}{\text{Joule}}$

- Farad is a very large unit.
- Generally used ⇒ μF, nF

* ||el plate cap.



$E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$

$V = Ed$

$C = \frac{A\epsilon_0}{d}$

$C \rightarrow Q$ ×
$\searrow V$ ×

shape/size/ ✓
geometry ✓
medium ✓

- Net charge = Q − Q = 0
- $\boxed{F = \frac{Q^2}{2A\epsilon_0}}$ → b/w plates
- $U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{Q^2}{2C}$
- $u = \frac{1}{2}\epsilon_0 E^2$ (Energy density)

Energy stored in E field lines.

- $W_b = QV = CV^2 = \frac{Q^2}{C}$
- $H = \frac{1}{2}QV^2 = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$

TBS capsule ⑧

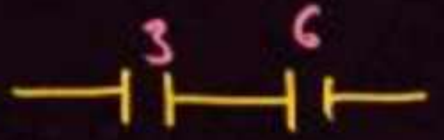
- Series → Q same ⇒ $Q=CV$ $\boxed{V \propto \frac{1}{C}}$

$$\frac{1}{C_S}=\frac{1}{C_1}+\frac{1}{C_2}+\cdots$$

$$\boxed{C_S=\frac{C_1C_2}{C_1+C_2}}$$ → Two capacitor

$$\boxed{C_S=\frac{C}{n}}$$ → Identical

* TBS



$C_S=2$

$C_S=4$

$C_S=3$

- Parallel

V → same

$Q=CV$

- $\boxed{Q \propto C}$
- $C_P=C_1+C_2+C_3+\cdots$
- $\boxed{C_P=nC}$ → Identical.

* $\frac{C_P}{C_S}=n^2$ $\frac{C_S}{C_P}=\frac{1}{n^2}$

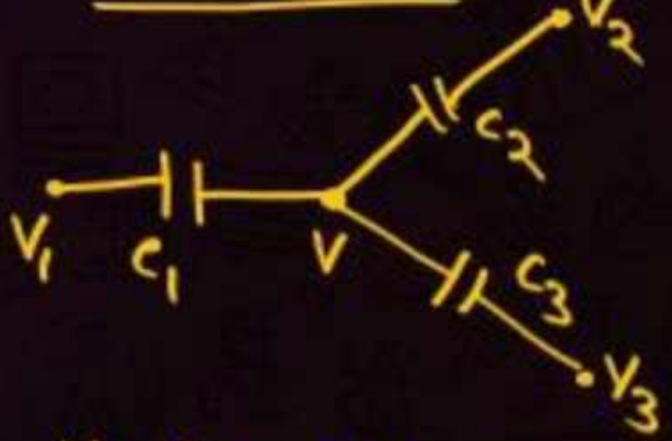
- Short-circuiting

↓

$V=0$

$C_{eq}=\frac{C}{2}$

- Junction pot.



$$V=\frac{C_1V_1+C_2V_2+C_3V_3}{C_1+C_2+C_3}$$

• **Energy stored in Comb.**

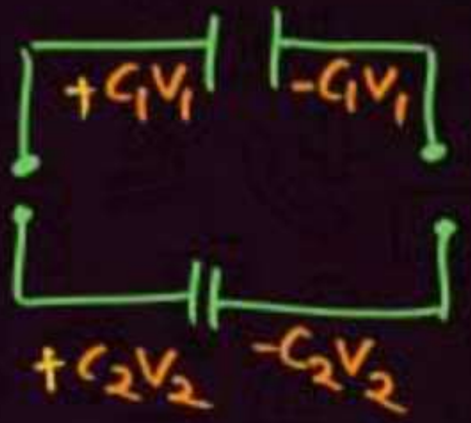
Series $U_T = \frac{1}{2} C_s V^2 = \frac{Q^2}{2C_s}$

Parallel $U_T = \frac{1}{2} C_P V^2 = \frac{Q^2}{2C_P}$

• **Sharing of charges & common pot.**

a) Same terminal joined

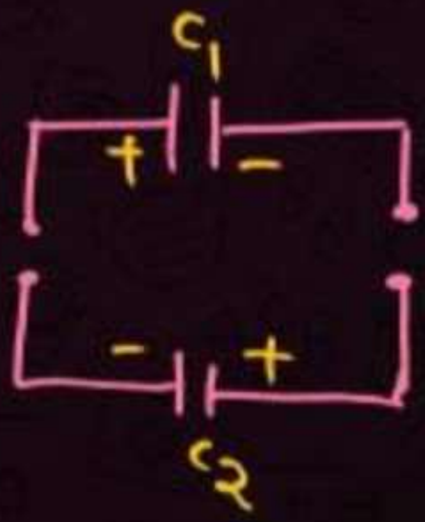
Like per. inelastic colli.



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

$$\text{Loss of } U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 - V_2)^2$$

b) Opp. terminal joined



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

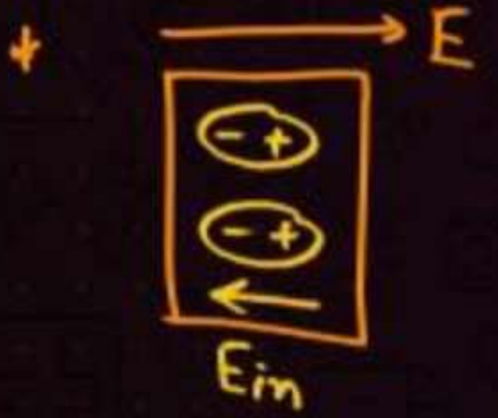
$$\text{Loss of } U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 + V_2)^2$$

TBS capsule ⑨

- Dielectrics → Insulators

Polar | Non-polar

$p \neq 0$ | $p = 0$



$$E - E_{in} = E/K$$

$$E_{in} = E\left(1 - \frac{1}{K}\right)$$

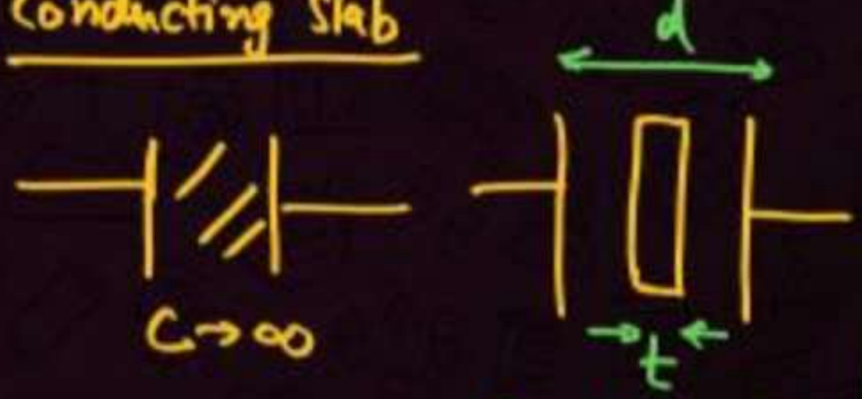
$$\sigma_{in} = \sigma\left(1 - \frac{1}{K}\right)$$

$$Q_{in} = Q\left(1 - \frac{1}{K}\right)$$

- $\boxed{C = KC_0}$ $C > C_0$

a) Battery disconn. (Isolated cap.)	b) Bat. connec.
KC_0	KC_0
Q_0	KQ_0
V_0/K	V_0
E_0/K	E_0
U_0/K	KU_0

Conducting Slab



$C \to \infty$

$$C = \frac{A\epsilon_0}{d-t} \rightarrow C > C_0$$

- Series

$$C = \frac{A\epsilon_0}{\frac{d_1}{K_1} + \frac{d_2}{K_2} + \frac{d_3}{K_3} + \cdots}$$

If $d_1 = d_2$

$$\boxed{C = \frac{2K_1K_2}{K_1+K_2} C_0} \rightarrow \text{TBS}$$

Parallel

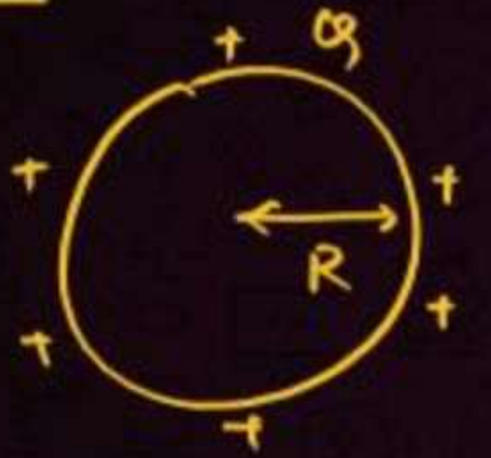
$$C = \frac{\epsilon_0}{d}(K_1A_1 + K_2A_2)$$

If $A_1 = A_2$

$$\boxed{C = \left(\frac{K_1+K_2}{2}\right) C_0} \rightarrow \text{TBS}$$

TBS capsule ⑩

* Spherical cap.

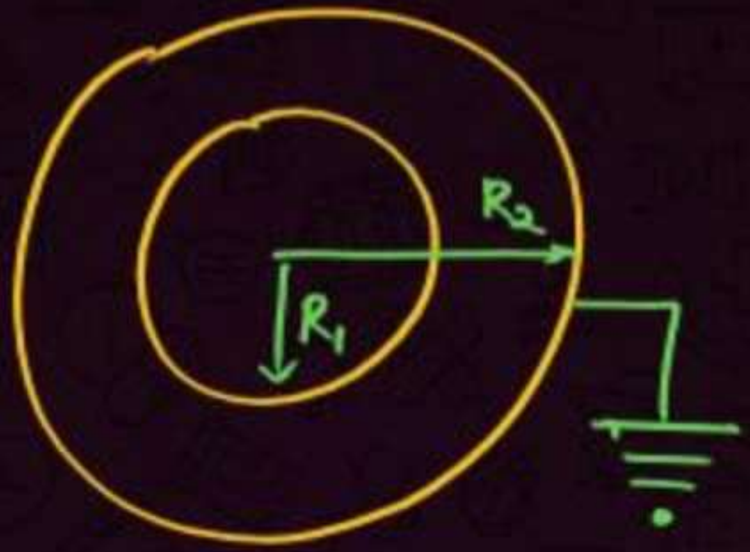


$$\boxed{C = 4\pi\epsilon_0 R.}$$

$$C \propto R$$

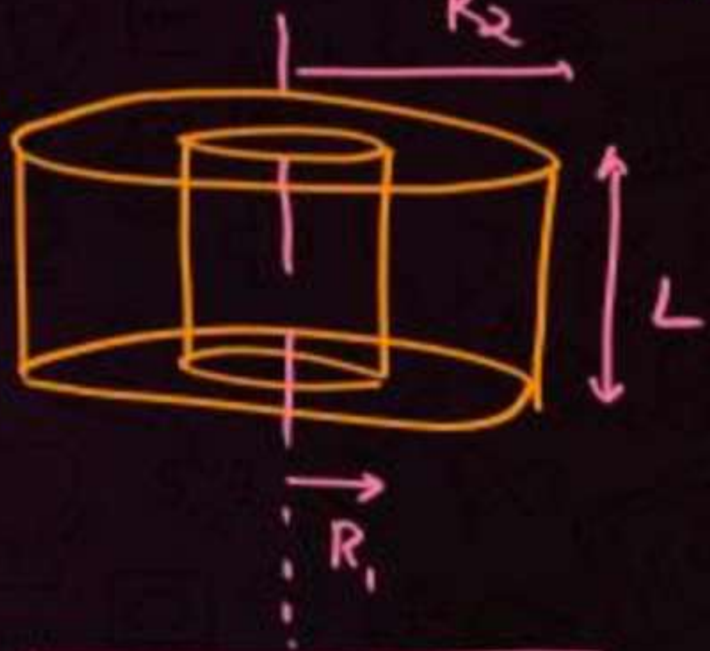
Drop.combine

$$\boxed{C' = n^{1/3} C}$$



$$\boxed{C = 4\pi\epsilon_0 \frac{R_1 R_2}{R_2 - R_1}}$$

Cylindrical Cap. → Very rare chance



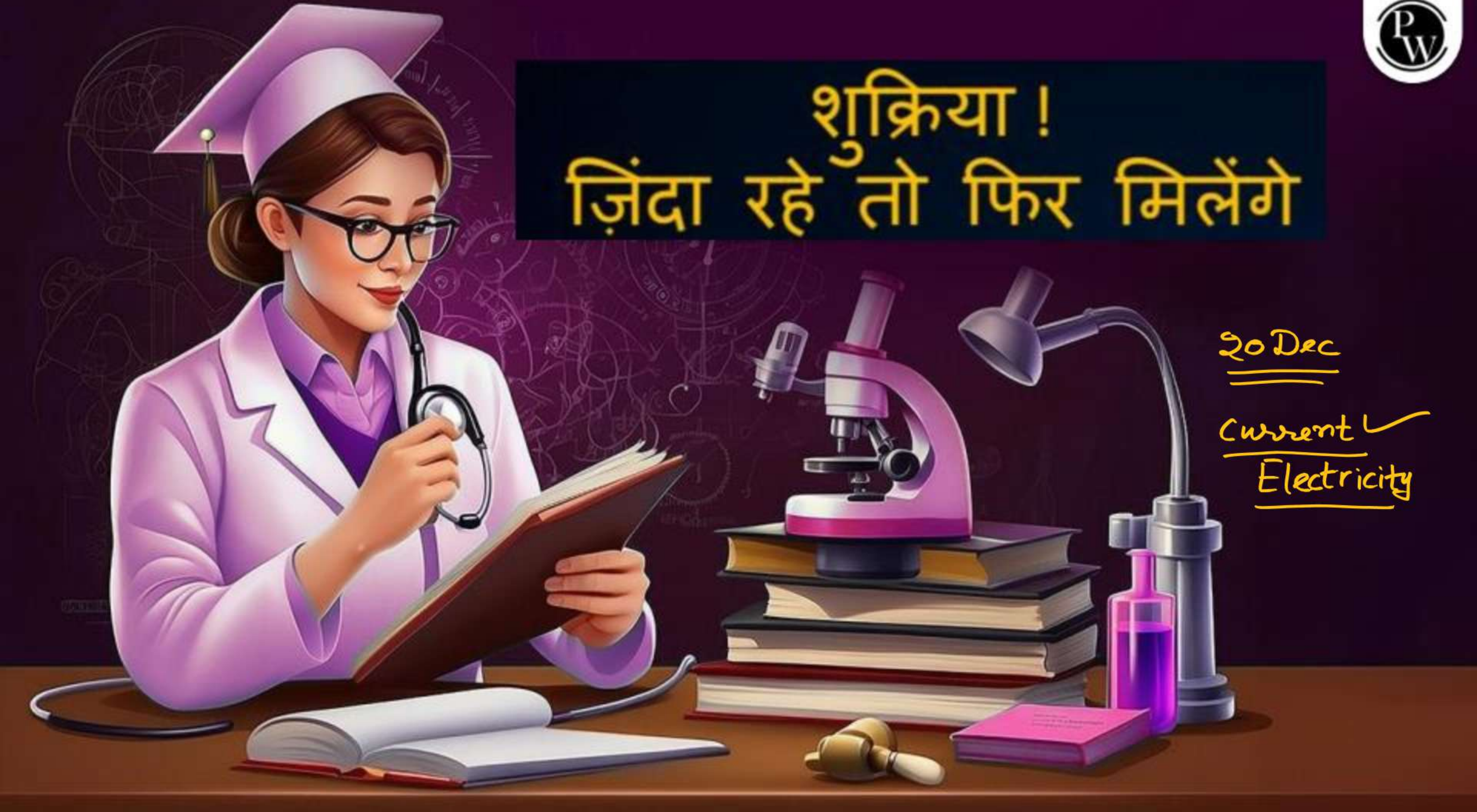
$$\boxed{C = \frac{2\pi\epsilon_0 L}{\ln\left(\frac{R_2}{R_1}\right)}}$$


AAE BAND KAR!
BAND KAR!

Homework

10 am Subah DPP Battle - Ground

FOR NOTES & DPP CHECK DESCRIPTION



शुक्रिया !
ज़िंदा रहे तो फिर मिलेंगे

20 Dec

Current ✓
Electricity