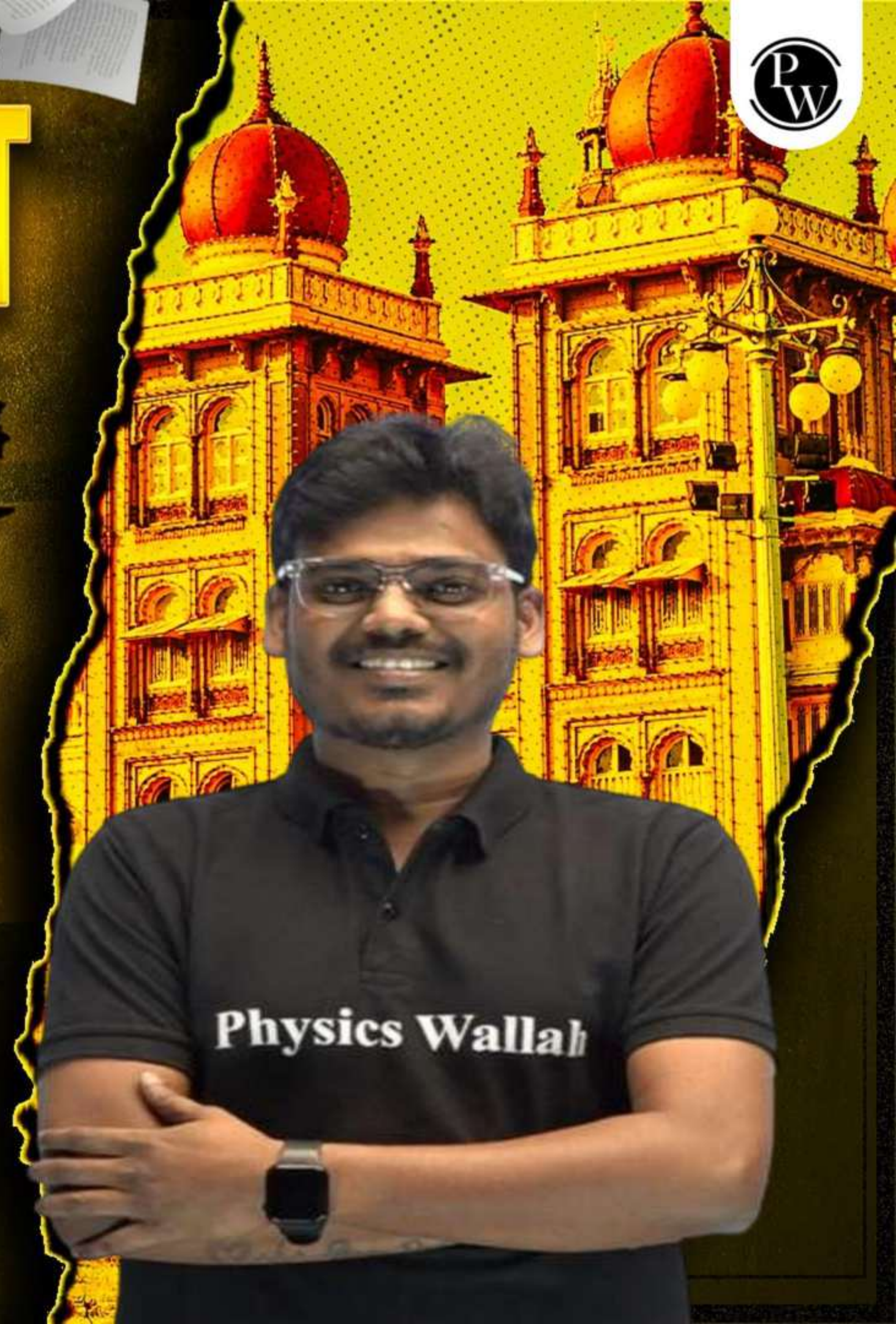
ULTIMATE KCET

CRASH COURSE 2026

PHYSICS | Lecture - 01

CURRENT ELECTRICITY

By – AK SIR



Recap *of previous lecture*

1. EQUIPOTENTIAL SURFACES
2. CAPACITANCE OF A CAPACITOR
3. PARALLEL PLATE CAPACITOR
4. QUESTIONS

Topics *to be covered*

1. COMBINATION OF CAPACITOR
2. ELECTRIC CURRENT AND SPECIAL CASES
3. RESISTANCE AND CONDUCTANCE
4. TEMPERATURE DEPENDENCE ON RESISTANCE AND QUESTIONS

Question

If $V = x^2y + y^2xz + 5$, find the electric field at $(1,1,0)$

x, y, z

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

$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$ → (1)

$E_x = -\frac{\partial V}{\partial x}\Big|_{y,z=\text{const}}$

$E_x = -[2xy + y^2(1)z + 0]$

$E_x = -[2(1)(1) + (1)^2(0)]$

$\boxed{E_x = -2}$

$E_y = -\frac{\partial V}{\partial y}\Big|_{x,z=\text{const}}$

$E_y = -[x^2(1) + 2yxz + 0]$

$E_y = -[(1)^2 + 2(1)(1)(0)]$

$\boxed{E_y = -1}$

$E_z = -\frac{\partial V}{\partial z}\Big|_{x,y=\text{const}}$

$E_z = -[0 + y^2x(1) + 0]$

$E_z = -[(1)^2(1)]$

$\boxed{E_z = -1}$

E equn (1)

$\boxed{\vec{E} = -2\hat{i} - \hat{j} - \hat{k}}$ N/C

$|\vec{E}| = E = \sqrt{(-2)^2 + (-1)^2 + (-1)^2}$

$E = \sqrt{4+1+1} = \sqrt{6}$

$\boxed{E = \sqrt{6}\ \text{N/C}}$

Energy and Energy density in capacitor

The total amount of work in charging the capacitor is stored up in the capacitor in the form of electric potential energy.

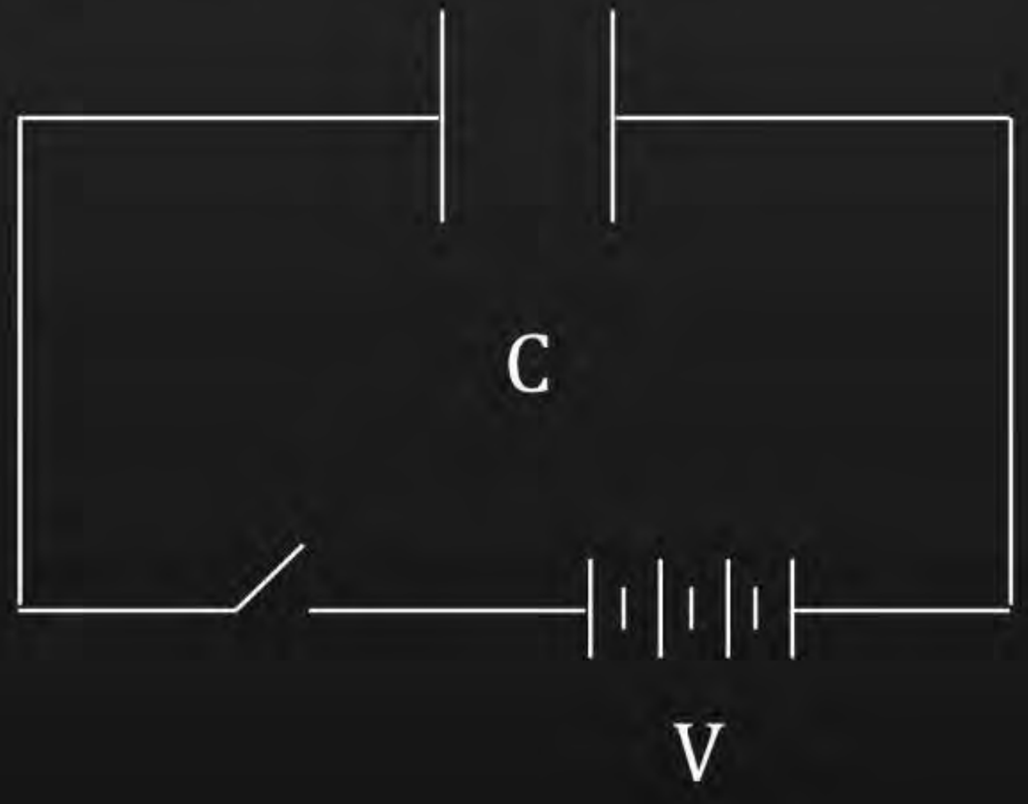
$$\boxed{U = \frac{1}{2} C V^2}, \quad Q = CV$$

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

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

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

$$\boxed{U = \frac{1}{2} Q V}$$



$\boxed{\text{Energy Density}}$

$$E_d = \frac{U}{\text{vol}} = \frac{\frac{1}{2}CV^2}{Ad} = \frac{1}{2}\frac{\cancel{A}\varepsilon_0}{d} \times \frac{V^2}{\cancel{A}d} = \frac{1}{2}\varepsilon_0\frac{V^2}{d^2}$$

$$E = \frac{V}{d}$$

$$\boxed{E_d = \frac{1}{2}\varepsilon_0 E^2}$$

$$\boxed{E_d = \frac{1}{2}\varepsilon_0 E^2}$$

Question

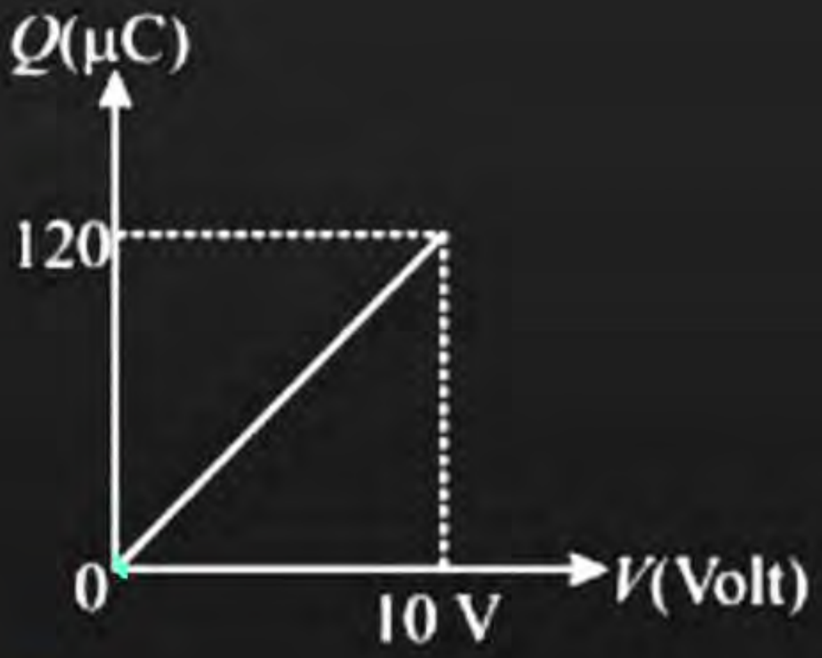
In figure, charge on the capacitor is plotted against potential difference across the capacitor. The capacitance and energy stored in the capacitor are respectively

(A) 12 μF, 1200 μJ

(B) $\boxed{12\ \mu F,\ 600\ \mu J}$

(C) 24 μF, 600 μJ ✗

(D) 24 μF, 1200 μJ ✗



$Q = CV$ The slope of Q-V graph = C

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

$C = \text{Slope} = m = \tan\theta = \frac{\Delta y}{\Delta x}$

$C = \frac{120-0}{10-0} = \frac{120}{10} = 12\ \mu F$

$\boxed{C = 12\ \mu F}$

$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 12 \times (10)^2 = 6 \times 100$

$\boxed{U = 600\ \mu J}$

Question

A capacitor of capacitance $10\mu F$ is charged to 10 V. The energy stored in it is

(A) $1\mu J$

(B) $100\mu J$

(C) $\boxed{500\mu J}$

(D) $1000\mu J$

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

$U = \frac{1}{\cancel{2}} \times \overset{5}{\cancel{10}} \times (10)^2$

$\boxed{U = 500 \mu J}$

Question

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

A parallel plate condenser has a uniform electric field E (v/m) in the space between the plates. If the distance between the plates is $d(m)$ and area of each plate is $A(m^2)$ the energy (joule) stored in the condenser is

(A) $\frac{1}{2}\varepsilon_o E^2$

(B) $\varepsilon_o EAd$

(C) $\boxed{\frac{1}{2}\varepsilon_o E^2 Ad}$

(D) $\frac{E^2 Ad}{\varepsilon_o}$

$E_d = \frac{U}{Vol} = \frac{1}{2}\varepsilon_0 E^2$

$\frac{U}{A \times d} = \frac{1}{2}\varepsilon_0 E^2$

$\boxed{U = \frac{1}{2}\varepsilon_0 E^2 Ad}$

Question

A parallel plate capacitor of capacitance 1μ F is charged to a potential difference of 20 V . The distance between plates is 1μ m. The energy density between plates of capacitor is.

(A) 2×10^{-4} J/m^3

(B) 1.8×10^{5} J/m^3

(C) $\boxed{1.8 \times 10^{3} \text{ J/m}^3}$

(D) 2×10^{2} J/m^3

$E_d = \frac{U}{Vol} = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2} \times 8.854 \times 10^{-12} \times (20 \times 10^6)^2$

$E = \frac{V}{d} = \frac{20}{1 \times 10^{-6}}$

$\boxed{E = 20 \times 10^6 \text{ V/m}}$

$= 1770.8 \times 10^{-12+12}$

$= 1770.8$

$\boxed{E_d = 1.77 \times 10^{+3}}$

$\to 7 > 5$

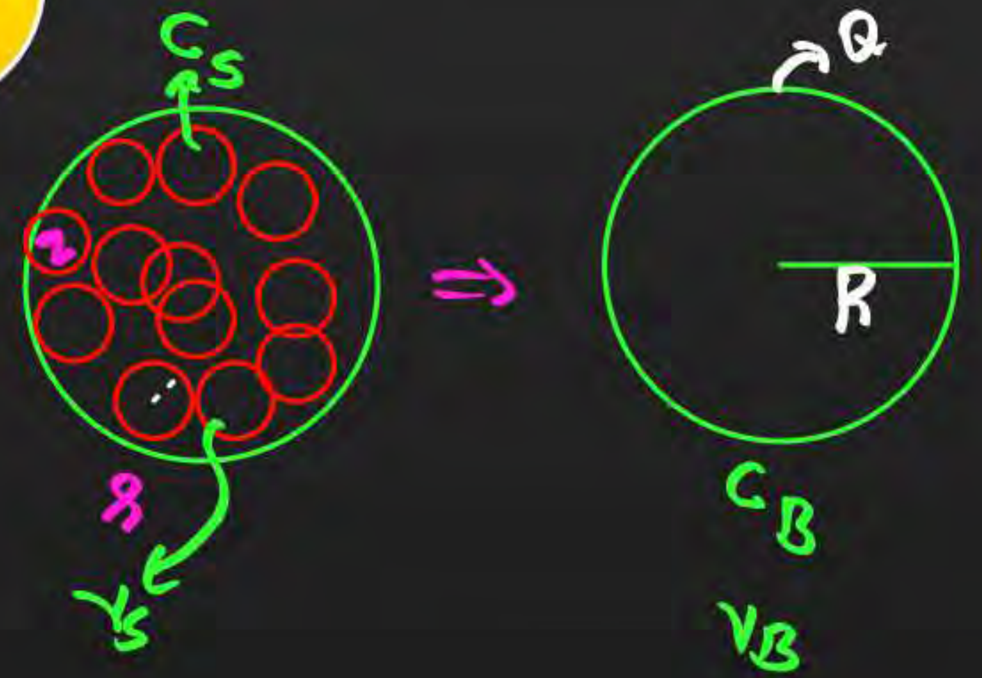
$= 1.8$

Cases of coalesce of N-drops

Coalesce : To grow together or grow into one body

✓ Radius comparison : $R = N^{1/3} r$.

N - No. of drops



✓ Charge comparison $Q = Nq$

✓ Capacitance comparison $C_B = N^{1/3} C_S$

✓ Potential comparison $V_B = N^{2/3} V_S$

Question

$2\times2\times2 = 2^3 = 8$ ✓

$N = 8$

Eight equally charged tiny drops are combined to form a big drop. If the potential on each drop is 10 V then potential of big drop will be:

V_S V_B

(A) $\boxed{40\text{ V}}$

(B) 10 V

(C) 30 V

(D) 20 V

$V_B = N^{2/3} V_S$

$V_B = (8)^{2/3} \times 10$

$V_B = (2^3)^{2/3} \times 10$

$V_B = 2^{3\times\frac{2}{3}} \times 10$

$V_B = 2^2 \times 10$

$V_B = 4\times10$

$\boxed{V_B = 40\text{V}}$

Question

$N = 8$

Eight drops of mercury of equal radii combine to form a big drop. The capacitance of a bigger drop as compared to each smaller drop is

(A) $\boxed{\text{2 times}}$

(B) 8 times

(C) 4 times

(D) 16 times

$C_B = N^{1/3} C_S$

$C_B = (8)^{1/3} C_S$

$C_B = (2^3)^{1/3} C_S$

$C_B = 2^{3 \times \frac{1}{3}} \times C_S$

$\boxed{C_B = 2 \times C_S} \Rightarrow \frac{C_B}{C_S} = 2$

Question

$N=8$ $\quad V_B$

The potential of a large liquid drop when eight liquid drops are combined is 20 V. Then the potential of each single drop was

V_S

(A) 10 V

(B) 7.5 V

(C) $\boxed{5\text{ V}}$

(D) 2.5 V

$$V_B = N^{2/3} V_S$$

$$20 = (8)^{2/3} V_S$$

$$20 = (2^3)^{2/3} V_S$$

$$20 = 2^2 \times V_S = 4V_S$$

$$\boxed{V_S = 5V}$$

Question

Twenty seven drops of same size are charged at 220 V each. They combine to form a bigger drop. Calculate the potential of the bigger drop: [H.W]

(A) 1520 V

(B) 1980 V

(C) 660 V

(D) 1320 V

Question

Under electrostatic condition of a charged $\boxed{\text{conductor,}}$ which among the following statements is $\boxed{\text{true?}}$

→ Non-conducting

A The electric field on the surface of a charged conductor is $\frac{\sigma}{2\varepsilon_0}$, where σ is the surface charge density.

r < R, E = 0

V = const

B The electric potential inside a charged conductor is always zero ✗

C $\boxed{\text{Any excess charge resides on the surface of the conductor.}}$ ✓

perpendicular.

D The net electric field is $\boxed{\text{tangential}}$ to the surface of the conductor. ✗

Question

A capacitor of capacitance $\boxed{5\ \mu F}$ is charged by a battery of emf 10 V. At an instant of time, the potential difference across the capacitor is $\boxed{4\ V}$ and the time rate of change of potential difference across the capacitor is $\boxed{0.6\ Vs^{-1}}$. Then the time rate at which energy is stored in the capacitor at that instant is

$\frac{dv}{dt}$

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

A) $\boxed{12\mu W}$

B) $3\ \mu W$

C) zero

D) $30\ \mu W$

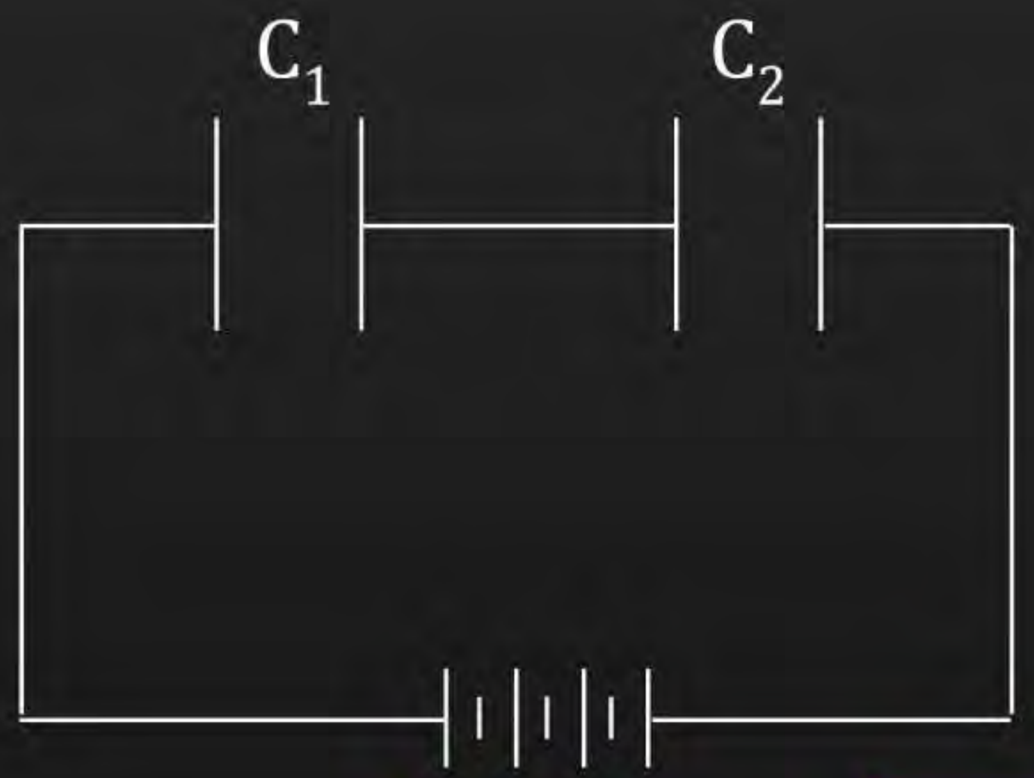
$$\frac{dU}{dt} = \frac{1}{\cancel{2}} \times C \times \cancel{2}V \frac{dV}{dt}$$

$$\frac{dU}{dt} = CV\frac{dV}{dt} = 5\times10^{-6} \times 4 \times 0.6$$

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

$$\boxed{\frac{dU}{dt} = 12\ \mu W}$$

Combination of capacitor



Q = const

V = vary

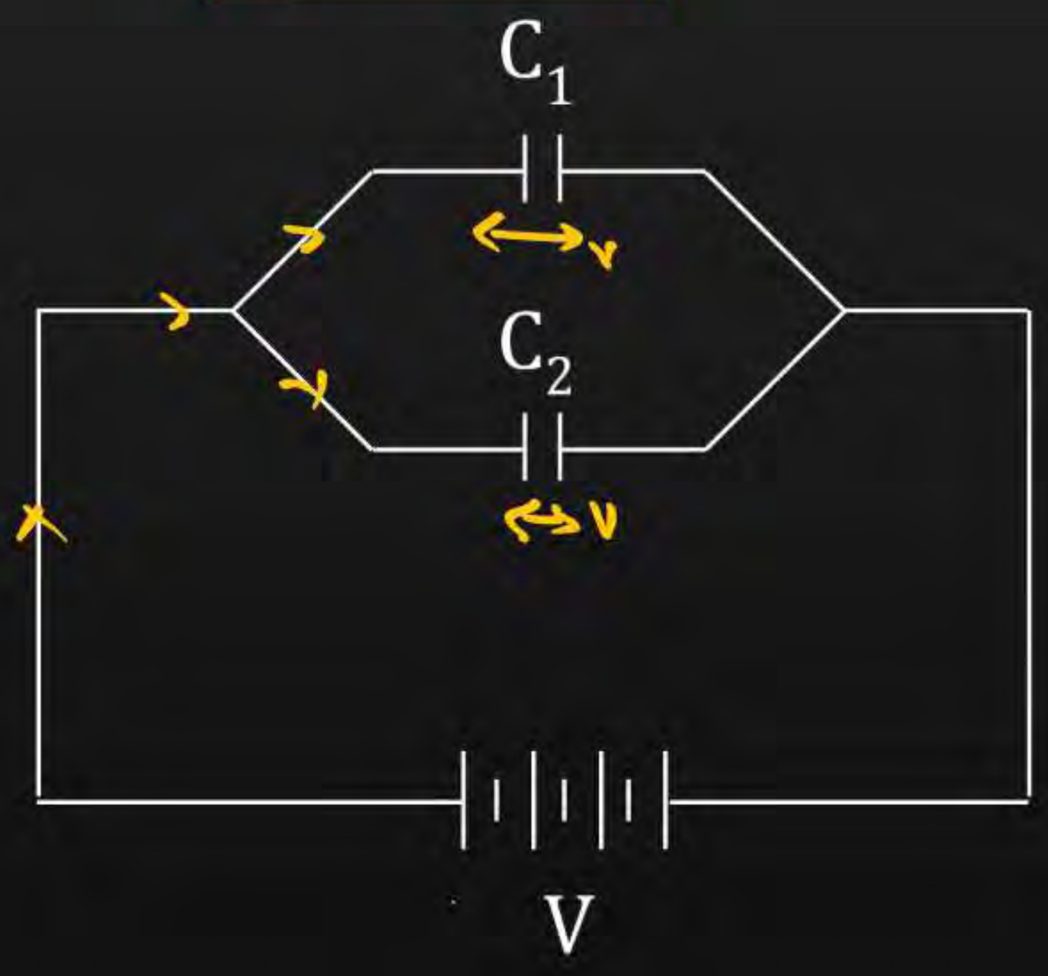
$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$$

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

Q = vary

V = const

$$\boxed{C_p = C_1 + C_2}$$



Question

In the following circuit, the equivalent capacitance between terminal A and terminal B is:

A 0.5 mF

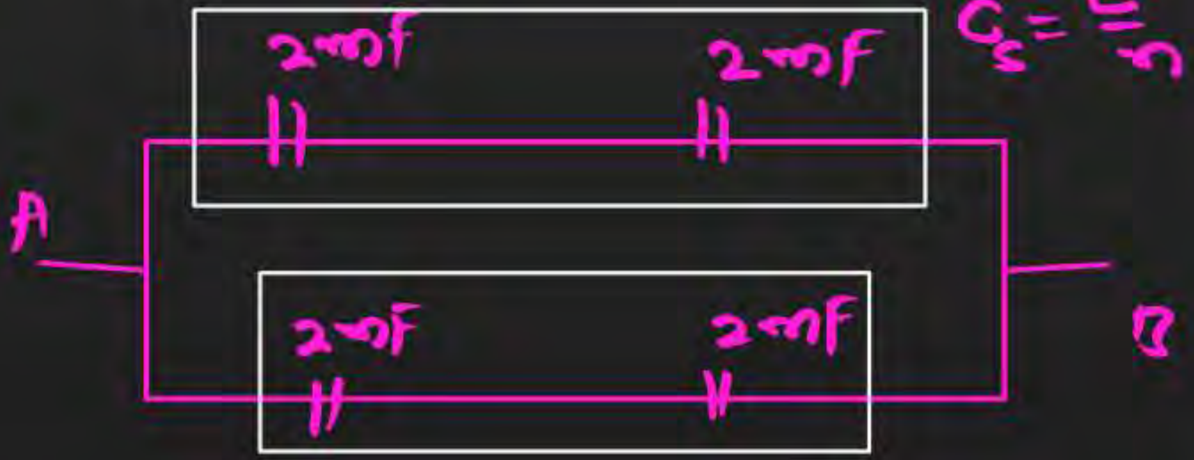
B 4 mF

C $\boxed{2\text{ mF}}$

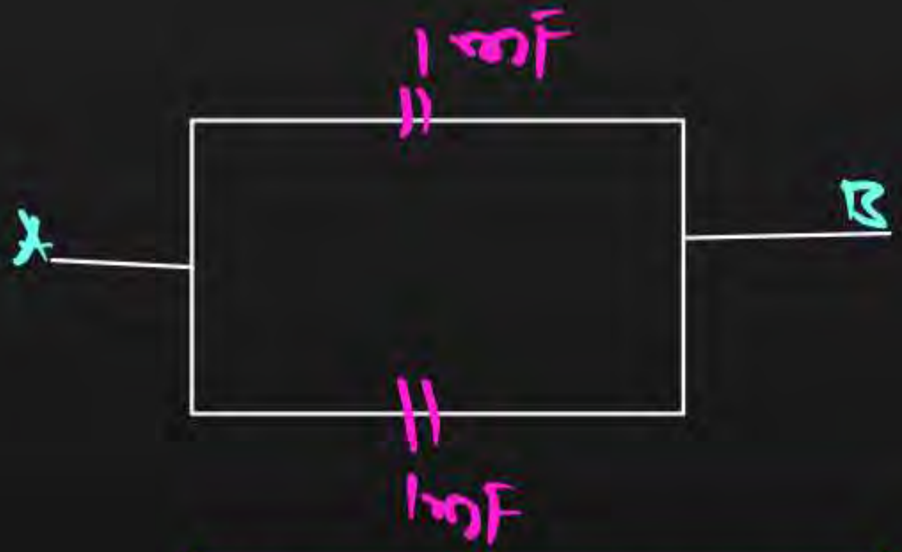
D 1 mF

$\frac{2}{2} = 1$

$\frac{2}{2} = 1$ WSB



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



$$\boxed{C_{AB} = C_p = 1+1 = 2\,mF}$$

Question

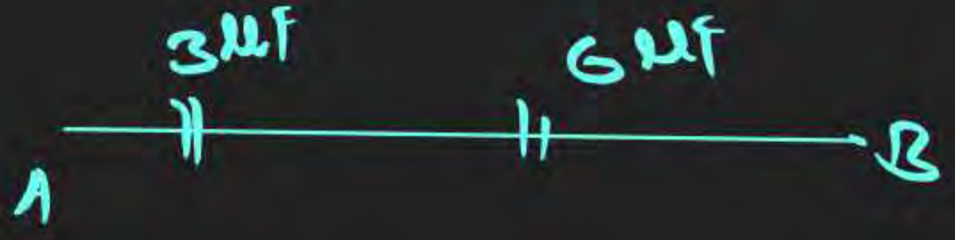
The equivalent capacitance of the system shown in the following circuit is

A. $\boxed{2\mu\ \text{F}}$

B. $9\mu\ \text{F}$

C. $6\mu\ \text{F}$

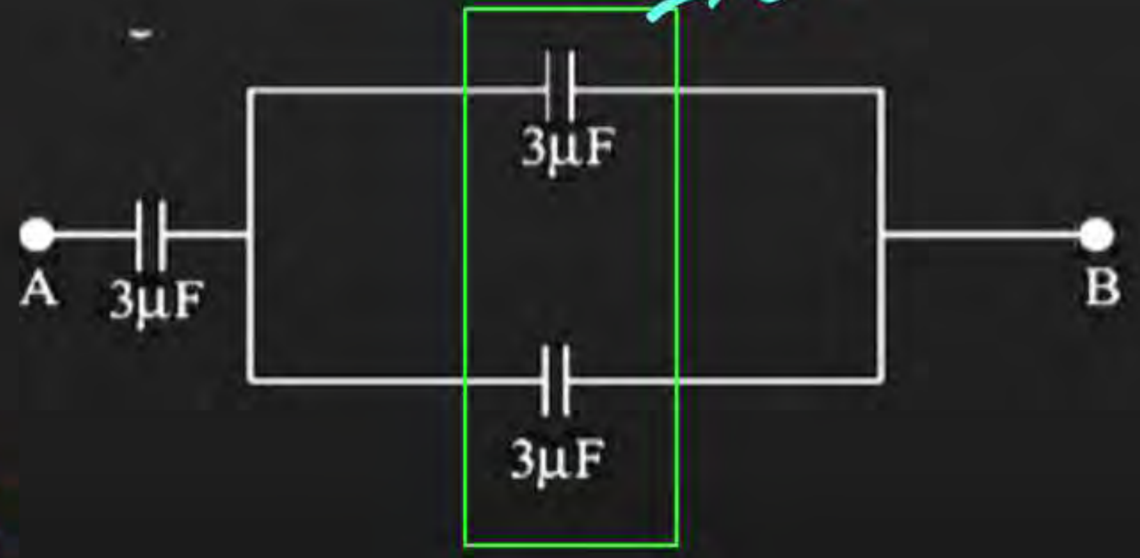
D. $3\mu\ \text{F}$



$$C_{AB} = C_s = \frac{C_1 C_2}{C_1 + C_2} = \frac{3\times 6}{3+6}$$

$$\boxed{C_{AB} = \frac{\cancel{3}\times 6}{\cancel{9}} = 2\mu F}$$

3+3=6



Question

The equivalent capacitance of the arrangement shown in figure is

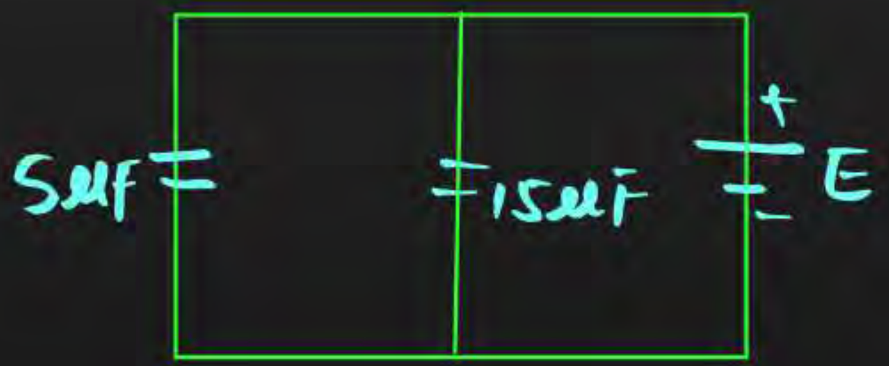
$C_s = \frac{C}{n} = \frac{15}{3} = 5\mu F$

(A) $30\ \mu F$

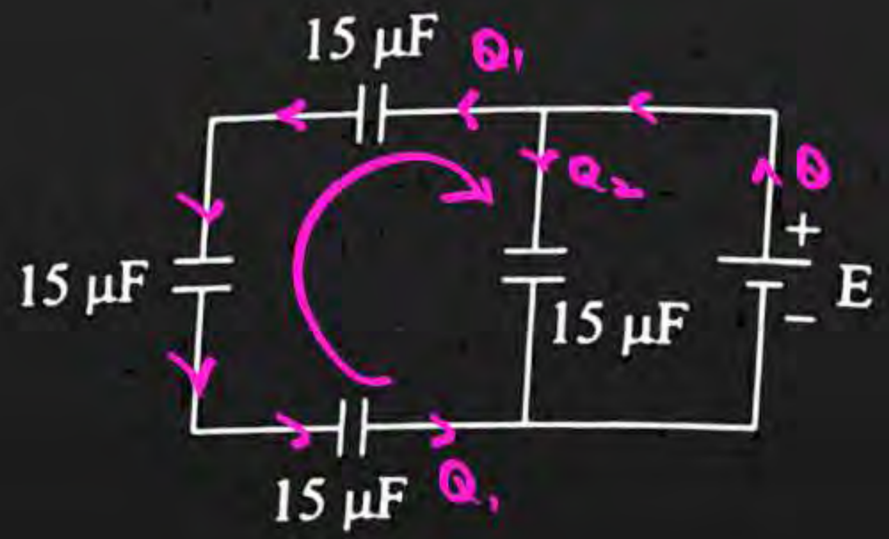
(B) $15\ \mu F$

(C) $25\ \mu F$

(D) $\boxed{20\ \mu F}$



$\boxed{C_p = 5+15 = 20\mu F}$



Question

The effective capacitances of two capacitors are 3μ F and $16\,\mu$F, when they are connected in series and parallel respectively The capacitance of two capacitors are:

(A) 1.2μF, 1.8μF

(B) 10μF, 6μF

(C) 8μF, 8μF

(D) $\boxed{12\mu\text{F}, 4\mu\text{F}}$

$C_s = \frac{C_1 C_2}{C_1 + C_2} = 3$ — (1)

$C_p = C_1 + C_2 = 16$ — (2)

(1) $\frac{C_1 C_2}{16} = 3$

$C_1 C_2 = 3 \times 16 = 48$

$\boxed{C_2 = \frac{48}{C_1}}$

(2) $\Rightarrow C_1 + \frac{48}{C_1} = 16$

$C_1^2 + 48 = 16C_1$

$$\boxed{\begin{array}{c} C_1^2 - 16C_1 + 48 = 0 \\ ax^2 + bx + c = 0 \end{array}}$$

$a = 1 \quad b = -16 \quad c = 48$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{(-16) \pm \sqrt{(-16)^2 - 4 \times 1 \times 48}}{2 \times 1}$

$x = \frac{16 \pm \sqrt{256 - 192}}{2} =$

$$x = \frac{16 \pm \sqrt{64}}{2}$$

$$x = \frac{16 \pm 8}{2}$$

$$x = \frac{16 + 8}{2} \qquad x = \frac{16 - 8}{2}$$

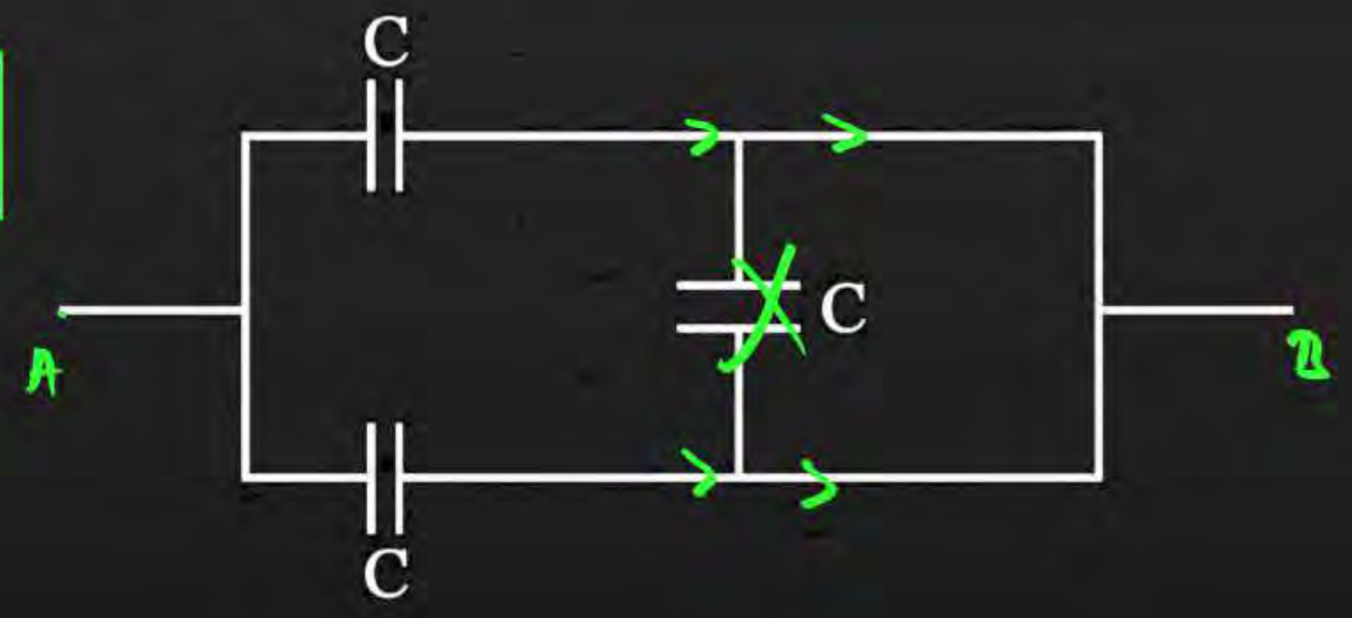
$$x = \frac{24}{2} \qquad x = \frac{8}{2}$$

$$\boxed{x = 12} \qquad \boxed{x = 4}$$

Question

The equivalent capacitance of the combination shown in figure is:

$$\boxed{C_{AB} = C_p = C + C = 2C}$$



A $\boxed{2C}$

B C/2

C 3C/2

D 3C

Question

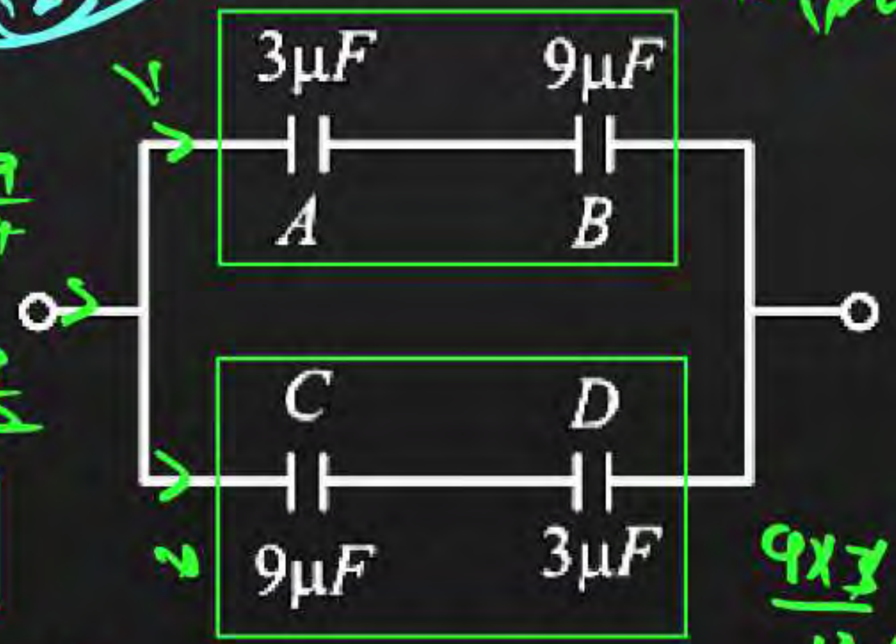
Four capacitors are arranged to form a circuit shown below. If this arrangement is connected across a voltage source, then charge supplied by the source is 36 mC. In this case, the charge on capacitor A is

(A) 30 mC

(B) 26 mC

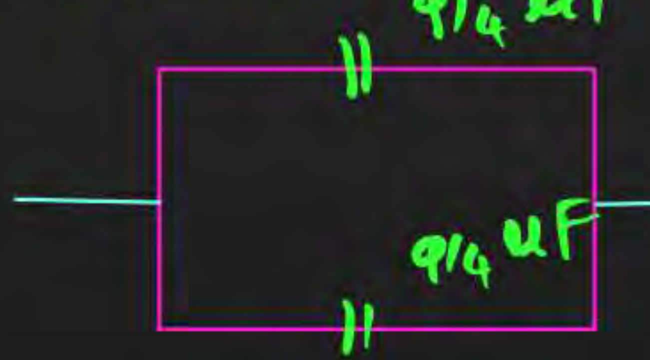
(C) $\boxed{18 \text{ mC}}$

(D) 12 mC



$\frac{3\times 9}{12} = \frac{9}{4}$

$\frac{9\times 3}{12} = \frac{9}{4}$



$\Rightarrow C_{eq} = \frac{9}{4} + \frac{9}{4}$

$C_{eq} = 2\times\frac{9}{4} = \frac{9}{2}$

$\boxed{C_{eq} = 4.5\,\mu F}$

$q = 36\,mC$

$C = 4.5\,\mu F$

$V = \frac{Q}{C} = \frac{36\times10^{-3}}{4.5\times10^{-6}}$

$V = 8\times10^{3}$

Charge across 'A'

$q_A = CV$

$\boxed{q_A = \frac{9}{4}\times 8\times10^{3}\times10^{-6}}$

$q_A = 18\,mC$

Question

Three capacitors of capacitance $1\mu F$,$2\mu F$ and $3\mu F$ are connected in parallel. Find the total capacitance of combination.

(A) $\frac{6}{11}\mu F$

(B) $6\ \mu F$

(C) $3\ \mu F$

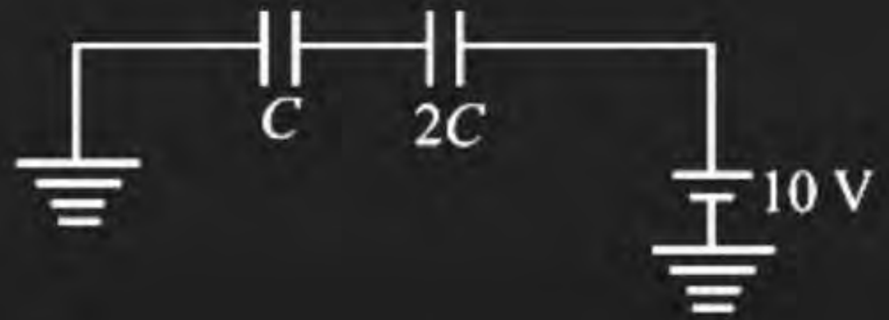
(D) $11\ \mu F$

$C_p = C_1 + C_2 + C_3$

$\boxed{C_p = 1+2+3 = 6\mu F}$

Question

In the circuit shown in figure, $C = 6\mu F$. The charge stored in the capacitor of capacity C is:



$$C_s = \frac{C \times 2C}{C + 2C}$$

$$= \frac{2C \times \cancel{C}}{3\cancel{C}}$$

$$= \frac{2C}{3} = \frac{2}{\cancel{3}} \times \cancel{6}^{2}$$

$$= \boxed{4\mu F}$$

$$Q = CV$$

$$= 4 \times 10$$

$$\boxed{= 40\mu C}$$

(A) Zero

(B) $90\ \mu C$

(C) $\boxed{40\ \mu C}$

(D) $60\ \mu C$

Question

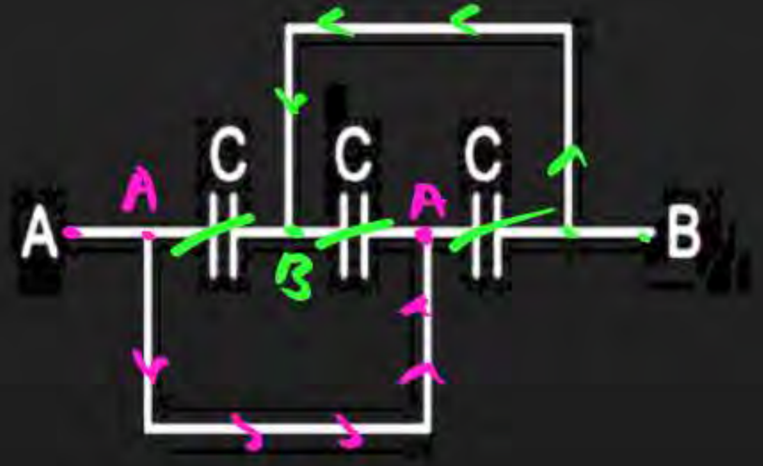
Find the equivalent capacitance between A and B of the following arrangement :

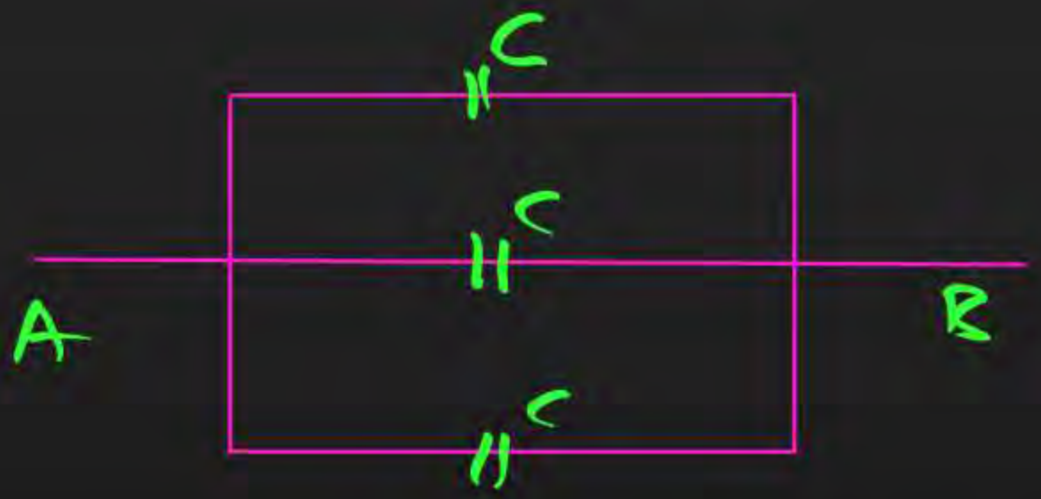
(A) C

(B) $\boxed{3C}$

(C) $\frac{2C}{3}$

(D) $\frac{3C}{2}$





$C_{AB} = C_p = C + C + C$

$\boxed{= 3C}$

Question

The total charge on the system of capacitance $C_1 = 1\mu F, C_2 = 2\mu F, C_3 = 4\mu F$ and $C_4 = 3\mu F$ and connected in parallel is (Assume a battery of 20 V is connected to the combination)

(A) $200 \mu C$

(B) $\boxed{200\mu C}$

(C) $10\mu C$

(D) $10\mu C$

$C_p = C_1 + C_2 + C_3 + C_4$

$C_p = 1 + 2 + 4 + 3$

$\boxed{C_p = 10 \mu F}$

$Q = C_p V = 10 \times 20$

$\boxed{Q = 200 \mu C}$

Insulators

Dielectrics and Polarisation

Polar dielectrics: The polar dielectrics are those in which the centres of positive and negative charges are separated even there is no external field. Such molecules have a permanent dipole moment.

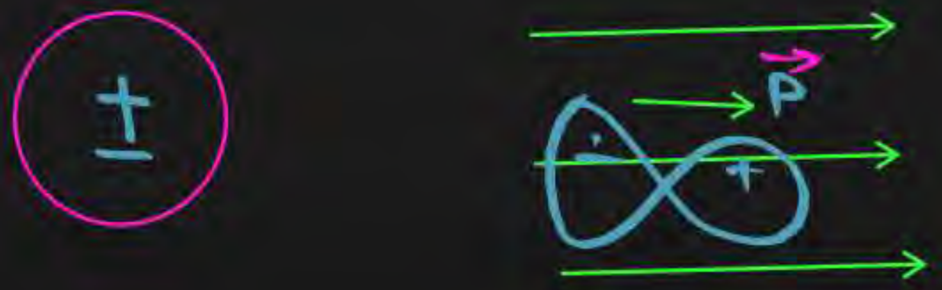
Examples: Molecules such as HCl, CO and H_2O , NH_3

Dielectrics and Polarisation

Non-Polar dielectrics: The polar dielectrics are those in which the centres of positive and negative charges coincides. Such molecules do not have a permanent dipole moment.

Examples: Molecules such as H_2, O_2, N_2. CO_2

$$pol = \frac{\vec{P}}{Vol}$$



Dielectrics and Polarisation

Electric Polarisation: When a dielectric is placed in an external electric field, the dielectric develops a net dipole moment. The dielectric now said to be polarized.

The induced dipole moment acquired per unit volume is known as polarisation.

$\vec{P} = \aleph_e E$ where $\aleph_e$- Electric Susceptibilty

$\vec{P} \propto \vec{E}$

$\vec{P} = \chi_e E$

$\chi_e = \frac{\vec{P}}{\vec{E}} \Rightarrow$ 1 molecule

$\chi_e = \left(\frac{N}{Vol}\right)\frac{\vec{P}}{\vec{E}} \Rightarrow$ N molecules.

Question

$\Rightarrow 1\times10^{-2}\,m = l$ $\qquad V = L^3$

$V = 10^{-6}\,m^3$

A cube of side 1 cm contains 100 molecules each having an induced dipole moment of 0.2 × 10^{-6} C-m in an external electric field of 4 NC^{-1}. The electric susceptibility of the material is__________ $C^2N^{-1}\,m^{-2}$.

(A) 50

(B) $\boxed{5}$

(C) 0.5

(D) 0.05

$$\chi_E = \frac{N}{Vol} \times \frac{\vec{P}}{\vec{E}}$$

$$\chi_E = \frac{100}{\cancel{10^{-6}}} \times \frac{0.2\times\cancel{10^{-6}}}{4}$$

$$\boxed{\chi_E = \frac{20}{4} = 5}$$

Question

Polar molecules are the molecules:

A. Acquire a dipole moment only in the presence of electric field due to displacement of charges.

B. Acquire a dipole moment only when magnetic field is absent.

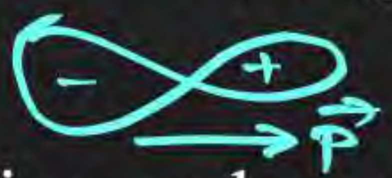
C. Having a permanent electric dipole moment.

D. Having zero dipole moment.

Question

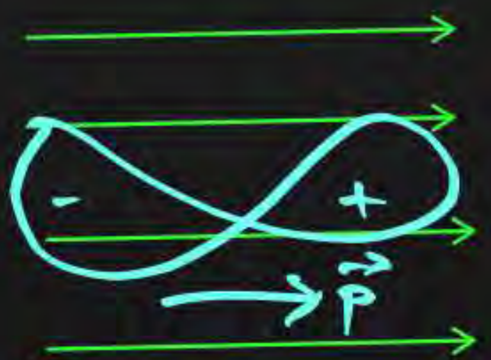
Which of the following statements is $\boxed{\text{false}}$ in the case of polar molecules?

(A) Centres of positive and negative charges are separated the absence of external electric field.



(B) Centres of positive and negative charges are separated, the presence of external electric field.

(C) $\boxed{\text{Do not possess permanent dipole moments.}}$ F



(D) Ionic molecule HCl is the example of polar molecule

KCET analysis of chapter - Marks weightage

Year	Topic
2025 (3Q)	Variation of resistance with temperature, Current carrying wire of non-uniform cross-section and Variation of resistivity with diametre
2024(5Q)	Ohm's Law, Resistance, Current, temperature coefficient of resistance, Bulb
2023(6Q)	Resistance, Colour coding(2), Combination of cells, Mobility & drift velocity, Work by Cell/Battery
2022(6Q)	Power, Specific resistance, Mobility & drift, Making of resistors, Combinations of cells, Meter bridge
2021(4Q)	Resistance, Meter bridge, Drift velocity and Electrical current

KCET analysis of chapter - Marks weightage

Year	Topic
2020(6Q)	Resistance, Potentiometer, Colour coding of resistors, Equivalent resistance, I-V characteristics graph
2019(5Q)	Drift velocity, Equivalent resistance, Kirchhoff's law, V-I graph, and Potentiometer
2018(6Q)	Ohm's Law, Tolerance, Effective resistance, Equivalent resistance, Combination of cells and I-V graph
2017(6Q)	Power dissipated, Kirchhoff's law, Resistance, Meter bridge, I-V Graph and Current density
2016(6Q)	Power consumed, Effective resistance, Quantity of charges, Potential difference, Kirchhoff's law, Mobility

Current - Flow.

ELECTRIC CURRENT

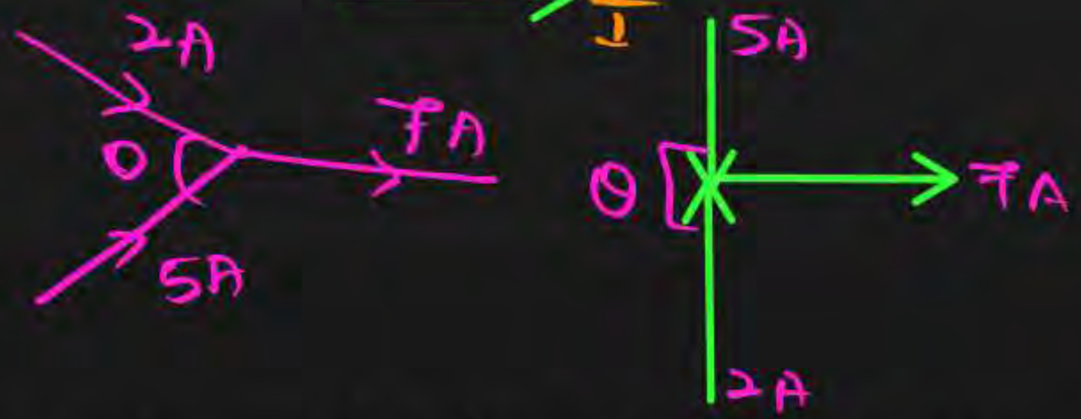
The rate of flow of charges(electrons) through a conductor is called Electric current.

$$\boxed{I = \frac{q}{t} = \frac{ne}{t}}$$

$\frac{C}{s} \Rightarrow 1A = 1Cs^{-1}$

SI Unit : ampere (A)

Dimensional formula : $[A^1]$ or $[M^0L^0T^0A^1]$



Quantity : Scalar

Direction : The direction of flow of electrons are opposite to the direction of current.

Question

If 16 C of charge is passing from a point in conducting wire in 8 s, Then find current in wire.

$$I = \frac{q}{t} = \frac{16}{8}$$

$$\boxed{I = 2A}$$

Question

If 10^{20} electrons are passing from a point in 4 s, Then find current

$q = ne$

$q = 10^{20} \times 1.6 \times 10^{-19}$

$q = 1.6 \times 10^{1}$

$\boxed{q = 16C}$

$I = \frac{q}{t}$

$I = \frac{16}{4}$

$\boxed{I = 4A}$

Question

The quantity of a charge that will be transferred by a current flow of 20 A over 1 h 30 min period is

A) 10.8×10^3 C

B) $\boxed{10.8 \times 10^4 \text{ C}}$

C) 5.4×10^3 C

D) 1.8×10^4 C

$I = 20A$

$t = 1h\,30min$

$1h = 60min$

$= 60 \times 1min$

$= 60 \times 60s$

$1h = 3600s$

$30min = 30 \times 1min$

$= 30 \times 60$

$= 1800$

$1h\,30min = 3600 + 1800 = 5400s$

$I = \frac{q}{t}$

$q = I \times t$

$q = 20 \times 5400$

$q = 108000$

$q = 1.08 \times 10^5 C$

$q = 10.8 \times 10^4 C$

ELECTRIC CURRENT

1. $q = 5C \Rightarrow$ const
2. $q = (1+2t)C$ ✓ $t = 0s, 1s, 2s, 3s.$

Case (i) If charge is function of time i.e $\boxed{q = f(t)}$

At 2s

Instantaneous current : $I = \frac{q}{t}$ 0-4s, 0-8s, At 3s, $I = \left.\frac{dq}{dt}\right|_{t=t_1}$

Graph : slope of q-t graph : → Inst current

$$\boxed{\text{slope} = I = \frac{\Delta y}{\Delta x} = \frac{\Delta q}{\Delta t} = \frac{dq}{dt}}$$

Question

Charge is flowing through a uniform conductor, which varies with time as shown in the figure. The current in conductor at $\boxed{t = 3\text{ sec}}$ is

(A) 4 A

(B) 3 A

(C) 12 A

(D) $\boxed{18\text{ A}}$

$q = 3t^2$

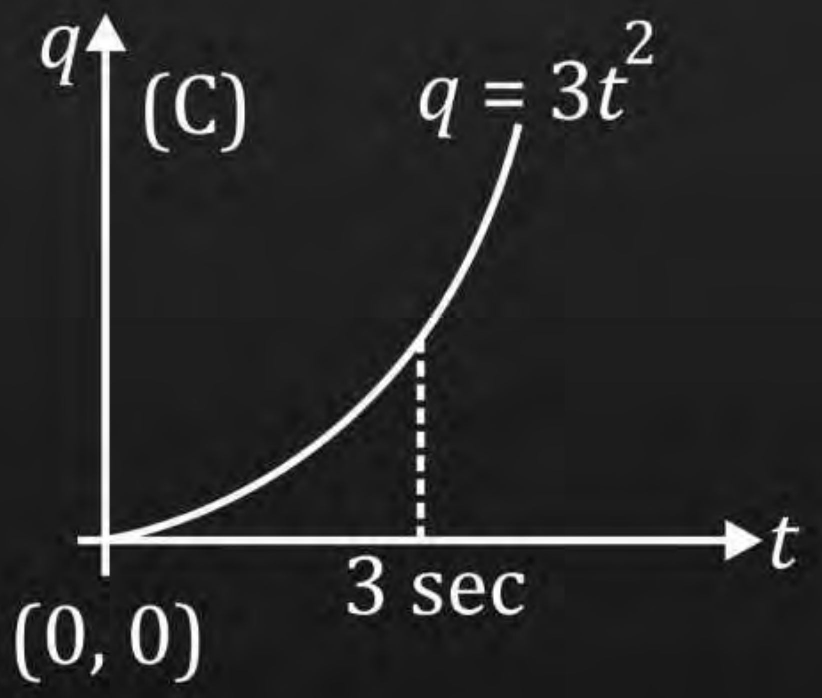
$q = f(t)$

$I = \frac{dq}{dt} = \frac{d}{dt}(3t^2)$

$I = 3 \times 2t = 6t$

At $t = 3s$, $I = 6 \times 3$

$\boxed{I = 18A}$



ELECTRIC CURRENT

Calculus

Differentiation → Slope

Integration → Area

Case (ii) If current is function of time i.e $I = f(t)$

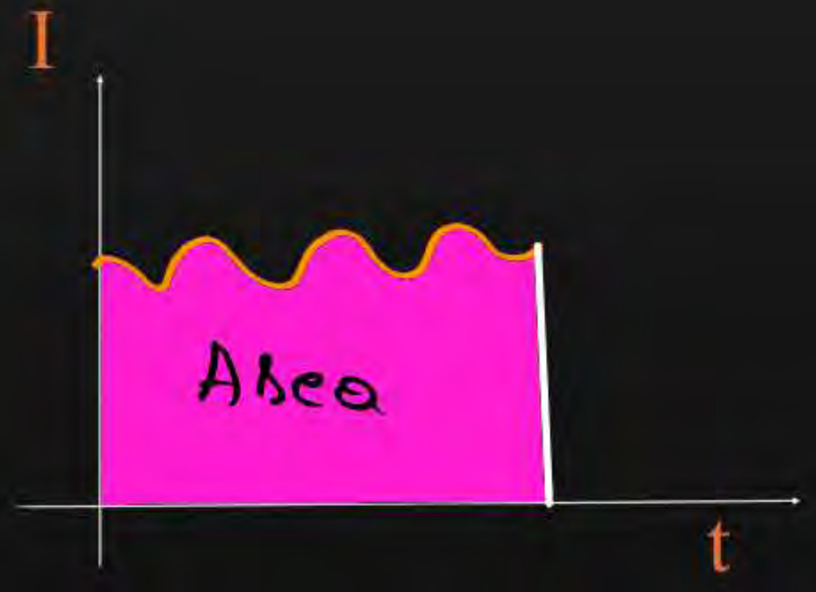
Instantaneous current : $I = \frac{dq}{dt} \Rightarrow dq = I.dt$

on Integration

Total charge : $\boxed{q = \int_{t_1}^{t_2} I(t).dt}$

Graph : Area of I-t graph : Total charge

$\boxed{q = \text{Area of I-t graph}}$



ELECTRIC CURRENT

Instantaneous current : $\boxed{I = \frac{dq}{dt}}$

Average current :

$$\bar{I}_{avg} = \frac{Q_T}{t_T} = \frac{\int_{t_1}^{t_2} I \cdot dt}{t_2 - t_1} = \frac{\text{Area of } I\text{-}t \text{ graph}}{\text{Total time}}$$

Question

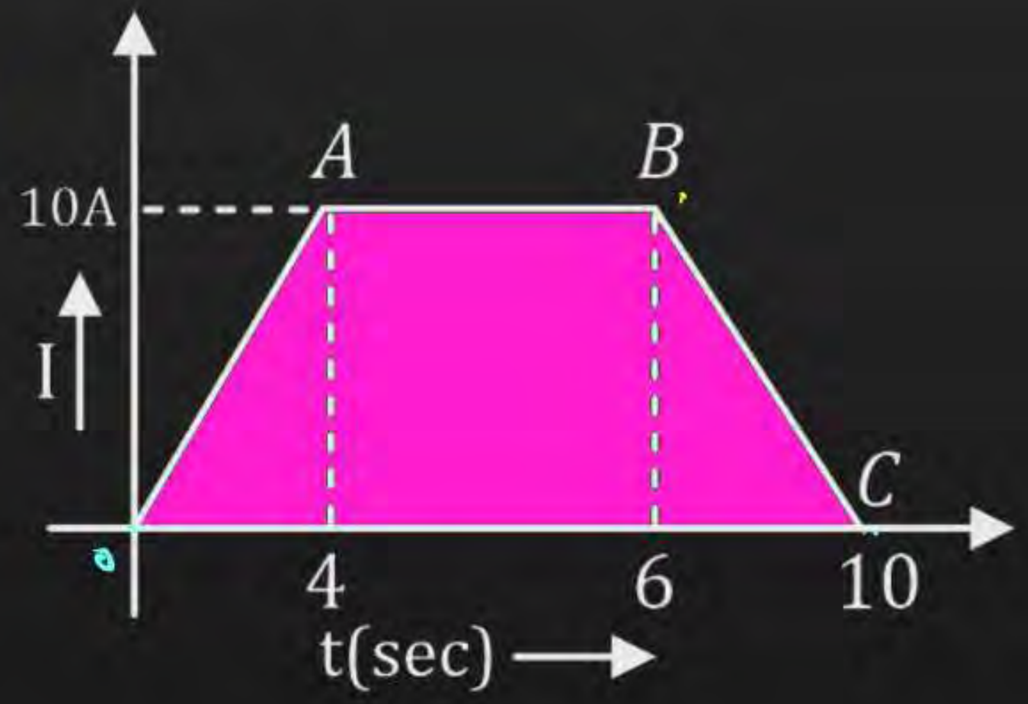
For given I vs t curve value of average current I_{avg} flowing in wire upto $t = 10$ sec is .

$$I_{avg} = \frac{\int_{t_1}^{t_2} I(t)\cdot dt}{t_2 - t_1} = \frac{\text{Area of I-t graph}}{\text{Total time}}$$

$$\text{Area} = \frac{1}{2}[(10+2)\times 10] = \frac{1}{2}(12\times 10)$$

$$\boxed{\text{Area} = 60C}$$

$$\boxed{I_{avg} = \frac{60}{10} = 6A}$$



Question

$I = f(t)$ $q = ne$ $n = \frac{q}{e}$

The electric current flowing through a given conductor varies with time as shown in the graph below. The number of free electrons which flow through a given cross-section of the conductor in the time interval $0 \le t \le 20s$ is

(A) $\boxed{3.125 \times 10^{19}}$

(B) 1.6×10^{19}

(C) 6.25×10^{18}

(D) 1.625×10^{18}

Total charge, q = Area of I-t graph

$q = A_1 + A_2$

$q = \frac{1}{2}[(20+10) \times 200 \times 10^{-3}] + [20 \times 100 \times 10^{-3}]$

$q = \frac{1}{2}[30 \times 200 \times 10^{-3}] + [2000 \times 10^{-3}]$

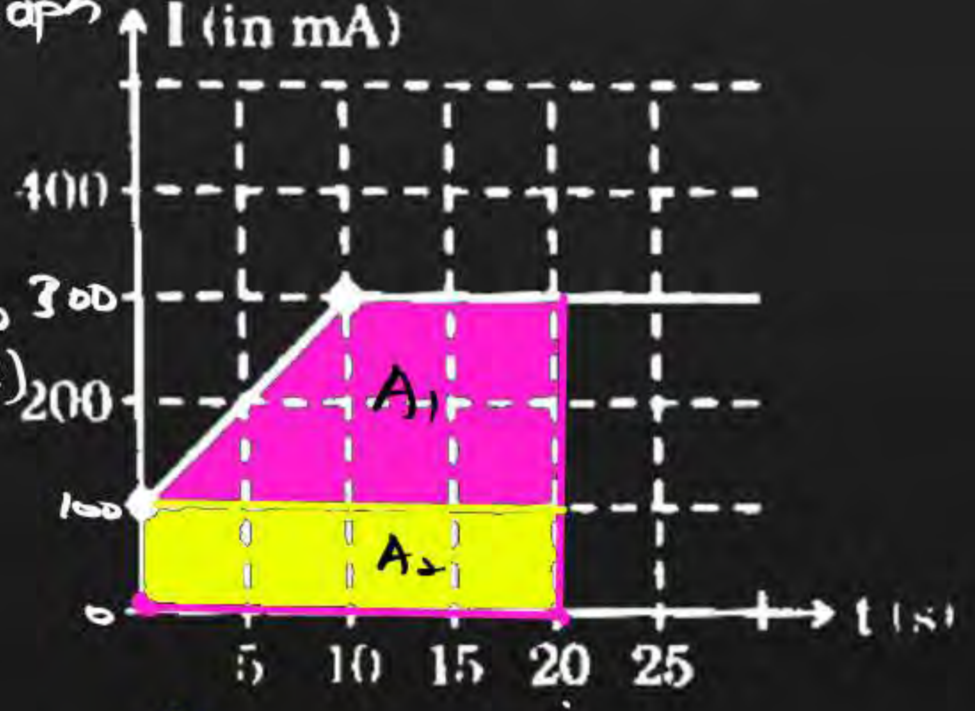
$q = \frac{1}{\cancel{2}}[\cancel{6}^{3}000 \times 10^{-3}] + [2000 \times 10^{-3}]$

$q = 3 + 2$

$\boxed{q = 5C}$

$n = \frac{q}{e} = \frac{5}{1.6 \times 10^{-19}} = 3.125 \times 10^{19}$

$\boxed{n = 3.125 \times 10^{19}}$



Question

$I = q(t)$

The current through a wire depends on time as $I = (2 + 3t)$ A. Calculate the charge crossed through a cross-section of the wire in first 10 sec.

$$I = f(t)$$

$$q = \int_{t_1}^{t_2} I(t)\,dt$$

$$q = \int_0^{10} (2+3t)\,dt$$

$$q = \left[2t + \frac{3t^2}{2}\right]_0^{10}$$

$$q = 2(10) + \frac{3\times 10^2}{2}$$

$$q = 20 + \frac{3\times 100}{2} = 20 + 150$$

$$\boxed{q = 170\,C}$$

Question

The electric current through a wire varies with time as $I = I_0 + \beta t$, where $I_0 = 20A$ and $\beta = 3\ As^{-1}$. The amount of electric charge crossed through a section of the wire in 20s is

(A) 80 C

(B) $\boxed{1000\ C}$

(C) 800 C

(D) 1600 C

$I = 20 + 3t$

$q = \int_{t_1}^{t_2} I(t).dt$

$q = \int_{t_1=0s}^{t_2=20s} (20+3t)dt$

$q = 20t + \frac{3t^2}{2}\Big]_0^{20}$

$q = (20\times20) + \frac{3}{2}\times(20)^2$

$q = 400 + \frac{3}{\cancel{2}}\times \overset{2}{\cancel{4}}00$

$q = 400 + 600$

$\boxed{q = 1000C}$

ELECTRIC CURRENT

Case (iii) If Current constitutes by an electron : Let an electron is moving on a circular path of radius r with a speed v. The current due to its motion at any section of path.

$$I = \frac{q}{t} = \frac{q}{\frac{2\pi r}{v}}$$

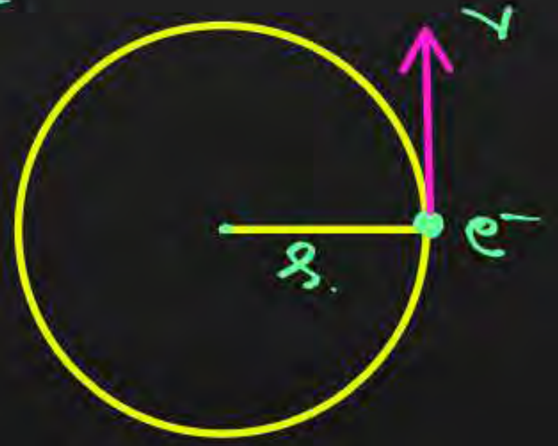
$$\boxed{I = \frac{qv}{2\pi r}}$$

$$\boxed{I = \frac{ev}{2\pi r}}$$ For electron.

$$\text{speed} = \frac{\text{Dist}}{\text{time}}$$

$$v = \frac{2\pi r}{t}$$

$$t = \frac{2\pi r}{v}$$



Question

$H_1^1 = X^A_{Z=1}$ $q_H = q = e$

In hydrogen atom, an electron moves in an orbit of radius $5.0 \times 10^{-11} m$ with a speed of $2.2 \times 10^{6} m/s$. Find the equivalent current. (Electric charge $= 1.6 \times 10^{-19} C$)

$$I = \frac{ev}{2\pi r} = \frac{1.6 \times 10^{-19} \times 2.2 \times 10^{6}}{2 \times 3.14 \times 5 \times 10^{-11}}$$

$$I = 0.1121 \times 10^{-2}$$

$$I = 1.12 \times 10^{-3} A$$

$$\boxed{I = 1.12 mA}$$

ELECTRIC CURRENT

Case (iv) If charge q is distributed over the ~~ring~~ Disc uniformly or non-uniformly, current at any section of Disc.

$$I = \frac{q}{t}$$

$$\boxed{I = \frac{q}{T} = qf}$$

$$T = \frac{2\pi}{\omega}$$

$$T = \frac{1}{f}$$

$$I = \frac{q}{T} = \frac{q}{\frac{2\pi}{\omega}}$$

$$\boxed{I = \frac{q\omega}{2\pi}}$$

Question

An electron is revolving with frequency $f = 10^{20}$ Hz, then current flowing in given conducting coil will be -

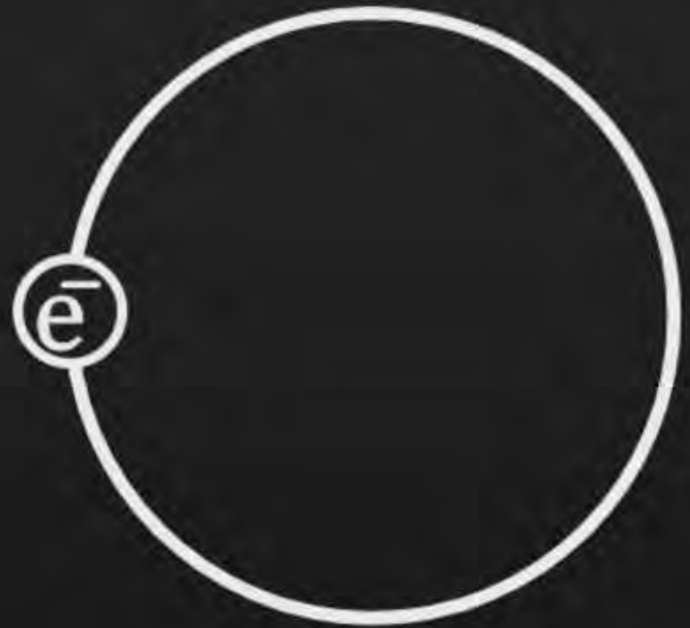
$$I = \frac{q}{t} = \frac{q}{T} = qf$$

$$I = ef$$

$$I = 1.6 \times 10^{-19} \times 10^{20}$$

$$I = 1.6 \times 10^{1}$$

$$\boxed{I = 16A}$$



CURRENT DENSITY

$D = \frac{m}{V}$

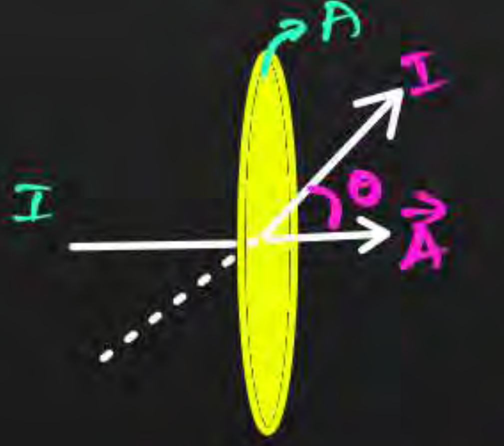
$\rho = \frac{Q}{V}$

$J = \frac{I}{A}$

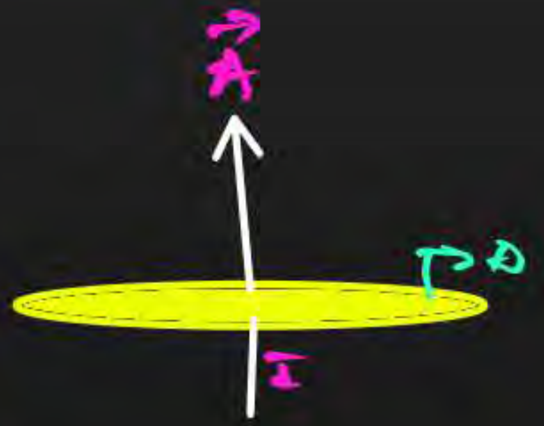
The amount of current passing perpendicular through area of cross-section of a conductor is called Current Density.

$\vec{J} = \frac{I}{\vec{A}} \Rightarrow I = \vec{J} \cdot \vec{A}$

$J = \frac{I}{A}$



$I = J.A.\cos\theta$



SI Unit : A/m^2

Quantity : vector.

Dimensions : $(A^1 L^{-2})$

Question

The current density at a point is $\vec{J} = 2 \times 10^4 \hat{j}\ A\,m^{-2}$. Find the rate of charge flow through a cross-sectional area $\vec{A} = (2\hat{i} + 3\hat{j})\ c\,m^2$.

$1\,cm = 10^{-2}\,m$ $\quad I$

$1\,cm^2 = 10^{-4}\,m^2$

$$I = \frac{dq}{dt} = \vec{J} \cdot \vec{A}$$

$$= (2 \times 10^4\,\hat{j}) \cdot (2\hat{i} + 3\hat{j}) \times 10^{-4}\,m^2$$

$$= 6 \times 10^4 \times 10^{-4}$$

$$\boxed{I = 6A}$$

Question

$0.1\times10^{-3}\,m = 1\times10^{-4}\,m.$

A cylindrical conductor of diameter 0.1 mm carries a current of 90 mA. The current density (in Am^{-2}) is ($\pi \approx 3$)

(A) $\boxed{1.2 \times 10^7}$

(B) 3×10^6

(C) 6×10^6

(D) 2.4×10^7

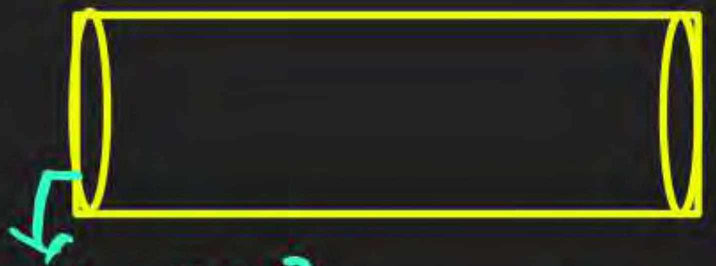
$J = \frac{I}{A} = I$

$J = \frac{I}{\pi r^2} = \frac{I}{\frac{\pi d^2}{4}}$

$J = \frac{4I}{\pi d^2} = \frac{4\times 90\times10^{-3}}{3\times(1\times10^{-4})^2}$

$J = \frac{4\times \cancel{90}^{\,30}\times10^{-3}}{\cancel{3}\times10^{-8}} = 12\times10^{5+1}$

$\boxed{J = 1.2\times10^{7}\ A/m^2}$



$A = \pi r^2$

$A = \frac{\pi d^2}{4}$

$d = 2r.$

$d^2 = 4r^2$

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

Question

A copper wire of length 10 m and radius $(10^{-2}/\sqrt{\pi})$ m has an electrical resistance of 10 Ω. The current density in the wire for an electric field strength of 10 (V/m) is

(A) $\boxed{10^5\ A/m^2}$

(B) $10^4\ A/m^2$

(C) $10^6\ A/m^2$

(D) $10^{-5}\ A/m^2$

$$J = \frac{I}{A} = \left(\frac{V}{R}\right) \times \frac{1}{A} = \frac{E\ell}{RA} = \frac{E\ell}{R\pi r^2}$$

$$E = \frac{V}{\ell}$$

$$J = \frac{10 \times \cancel{10}}{\cancel{10} \times \pi \times \left(\frac{10^{-2}}{\sqrt{\pi}}\right)^2}$$

$$\boxed{J = \frac{10}{\pi \times \frac{10^{-4}}{\pi}} = 10^5\ A/m^2}$$

DRIFT VELOCITY

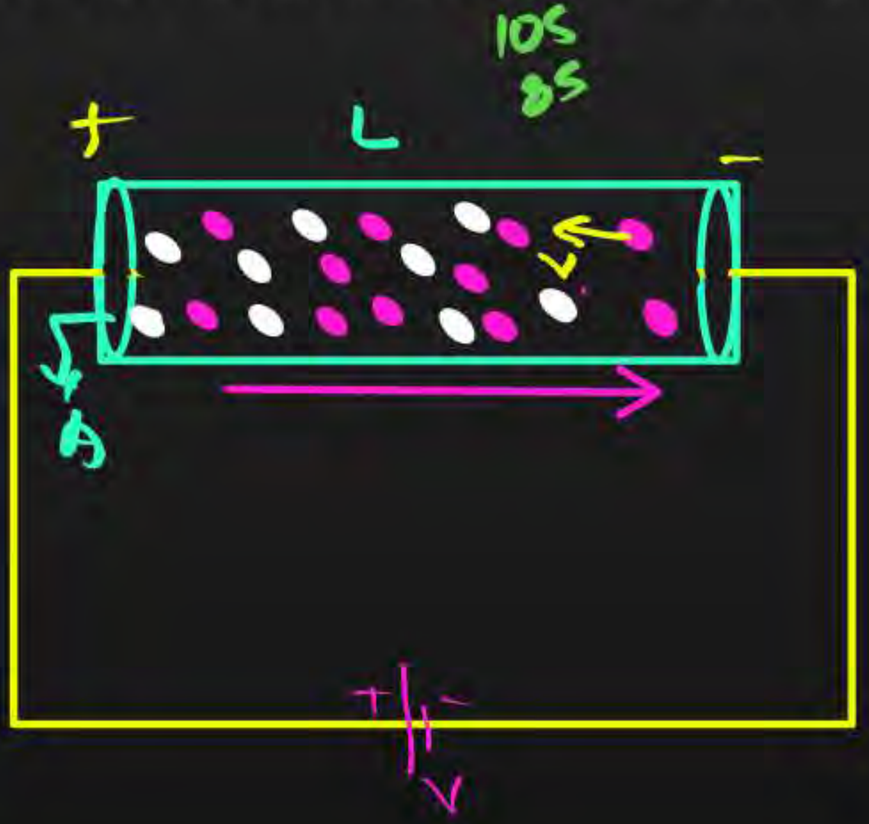
Drift velocity of free electrons : It is an average velocity with which the free electrons get drifted towards the positive end of the conductor under the influence of external applied field.

When conductor is ~~not~~ connected to a battery

$v = u + at$

$v = 0 + \frac{eE\tau}{m}$

$\boxed{v_d = \frac{eE\tau}{m}}$ $\boxed{\vec{v}_d = -\frac{e\vec{E}\tau}{m}}$



RELAXATION TIME

The average time of collision for all the electrons is called Relaxation time.

$$\tau = \frac{t_1 + t_2 + t_3 + \cdots\cdots}{N}$$

MOBILITY OF ELECTRONS

Drift velocity attained per unit electric field is called Mobility.

$$\boxed{\mu_e = \mu = \frac{v_d}{E}}$$

$$\mu = \frac{eE\tau}{m \times E}$$

$$\boxed{\mu = \frac{e\tau}{m}}$$

$1e = 1.6 \times 10^{-19} C$

$m = 9.1 \times 10^{-31} kg$

$\mu \propto \tau$

$T \propto \frac{1}{\tau}$ $T\uparrow \tau\downarrow \mu\downarrow$

$T\downarrow \tau\uparrow \mu\uparrow$

$T = const, \mu = const$

SI Unit : $\frac{m/s}{V/m} = m^2/s\text{-}V$

Question

A charged particle is moving in an electric field of 3×10^{-10} Vm^{-1} with mobility 2.5×10^{6} m^2/V-s its drift velocity is

(A) 8.33×10^{-4} m/s

(B) 2.5×10^{4} m/s

(C) 12×10^{-4} m/s

(D) $\boxed{7.5 \times 10^{-4}\ m/s}$

$$\mu = \frac{v_d}{E}$$

$$v_d = \mu \times E$$

$$= 2.5 \times 10^{6} \times 3 \times 10^{-10}$$

$$\boxed{v_d = 7.5 \times 10^{-4}\ m/s}$$

Question

A charged particle having drift velocity of $7.5 \times 10^{-4}\ ms^{-1}$ in an electric field of 3×10^{-10} vm^{-1}, has mobility of:

A) $\boxed{2.5 \times 10^{6}\ m^{2}v^{-1}s^{-1}}$

B) $2.5 \times 10^{-6}\ m^{2}v^{-1}s^{-1}$

C) $2.5 \times 10^{-15}\ m^{2}v^{-1}s^{-1}$

D) $2.5 \times 10^{15}\ m^{2}v^{-1}s^{-1}$

RELATION BETWEEN DRIFT VELOCITY OF FREE ELECTRONS AND ELECTRIC CURRENT

If electrons are moving, the current is developed

$$\boxed{\begin{aligned} I &= neV_d A \\ I &= V_d e n A \end{aligned}} \Rightarrow \boxed{V_d = \frac{I}{neA}}$$

Question

For a given electric current the drift velocity of conduction electrons in a copper wire is v_d and their mobility is μ. When the current is increased at constant temperature

(A) $\boxed{V_d \text{ increases, } \mu \text{ remains the same}}$

(B) v_d remains the same, μ increases

(C) v_d decreases, μ remains the same

(D) v_d remains the same, μ decreases

$V_d = \frac{I}{neA}$

$V_d \propto I$

$I\uparrow \; V_d\uparrow$

$\mu = \frac{e\tau}{m}$

$\mu \propto \tau$

↳ Temp = const

μ = const

Question

A current of 5 A is passing through a metallic wire of cross-sectional area $4 \times 10^{-6}\ \text{m}^2$ If the density of charge carriers of the wire is $5 \times 10^{26}\ \text{m}^{-3}$ the drift velocity of the electrons will be

(A) $1 \times 10^{2}\ \text{ms}^{-1}$

(B) $\boxed{1.56 \times 10^{-2}\ \text{ms}^{-1}}$

(C) $1.56 \times 10^{-3}\ \text{ms}^{-1}$

(D) $1 \times 10^{-2}\ \text{ms}^{-1}$

$$v_d = \frac{I}{neA}$$

$$v_d = \frac{5}{5 \times 10^{26} \times 1.6 \times 10^{-19} \times 4 \times 10^{-6}}$$

$$v_d = 0.156 \times 10^{-1}$$

$$\boxed{\begin{gathered} v_d = 1.56 \times 10^{-2}\ \text{m/s} \\ v_d = 15.6 \times 10^{-3}\ \text{m/s} \\ v_d = 15.6\ \text{mm/s} \end{gathered}}$$

Question

l A

A copper wire of length 1 m and uniform cross-sectional area 5×10^{-7} m^2 carries a current of 1 A. Assuming that, there are 8×10^{28} free electrons per m^3 in copper, how long will an electron take to drift from one end of the wire to the other?

(A) 0.8×10^3 s

(B) 1.6×10^3 s

(C) 32×10^3 s

(D) $\boxed{6.4 \times 10^3 \text{ s}}$

$$v = \frac{l}{t}$$

$$t = \frac{l}{v} = \frac{1}{v_d} = 64 \times 10^2 = \boxed{6.4 \times 10^3 \text{ s}}$$

$$v_d = \frac{I}{neA} = \frac{1}{8 \times 10^{28} \times 1.6 \times 10^{-19} \times 5 \times 10^{-7}}$$

$$v_d = \frac{1}{64 \times 10^2}$$

$$\frac{1}{v_d} = 64 \times 10^2$$

Question

H.W

A copper wire of radius 1 mm contains 10^{22} free electrons per cubic metre. The drift velocity for free electrons when 10 A current flows through the wire will be:
(Given, charge on electron = 1.6×10^{-19} c)

(A) $\frac{6.25 \times 10^4}{\pi} m/s$

(B) $\frac{6.25}{\pi} \times 10^3 \, m/s$

(C) $\frac{6.25}{\pi} m/s$

(D) $\frac{6.25 \times 10^5}{\pi} m/s$

ELECTRIC RESISTANCE

Resistance of a conductor is the property of a conductor by which it opposes the flow of the current through it.

The ratio of potential difference to the current is called Electric resistance.

$V = \frac{W}{q}$

Formula : $R = \frac{V}{I}$

$R = \frac{V}{I} = \frac{W}{qI} = \frac{[M^1L^2T^{-2}]}{[A^1T^1][A^1]}$

Unit : ohm (Ω)

$\boxed{R = [M^1L^2T^{-3}A^{-2}]}$

Dimensional formula : $[M^1L^2T^{-3}A^{-2}]$

ELECTRIC RESISTANCE

Resistance of conductor depends on

$R = \rho \frac{l}{A}$

$G = \frac{A}{\rho l}$

1. Length of the conductor $R \propto l$
2. Area of cross-section $R \propto \frac{1}{A}$
3. Nature of the material $R \propto \rho$ or n
4. Temperature of the conductor $R \propto T$

$R = \frac{ml}{ne^2 \tau A}$

$G = \frac{ne^2 \tau A}{ml}$

$T \uparrow \tau \downarrow R \uparrow$

Question

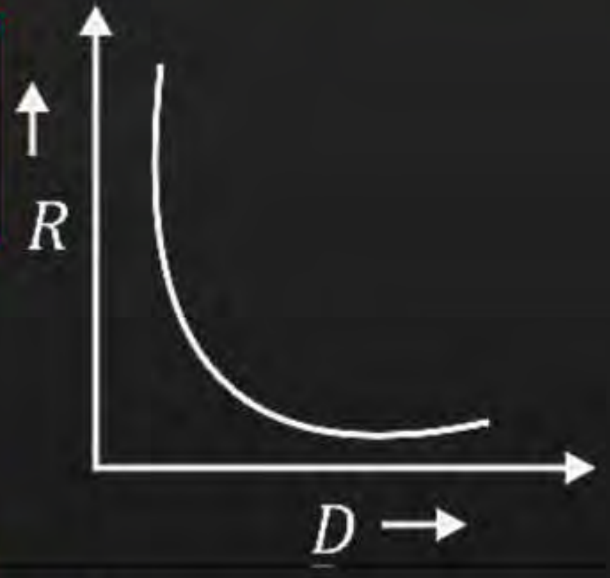
The graph between variation of resistance of a wire as a function of its diameter keeping other parameters like length and temperature constant is

$$R = \rho\frac{l}{A} = \frac{\rho l}{\pi r^2} = \frac{\rho l}{\pi \frac{d^2}{4}}$$

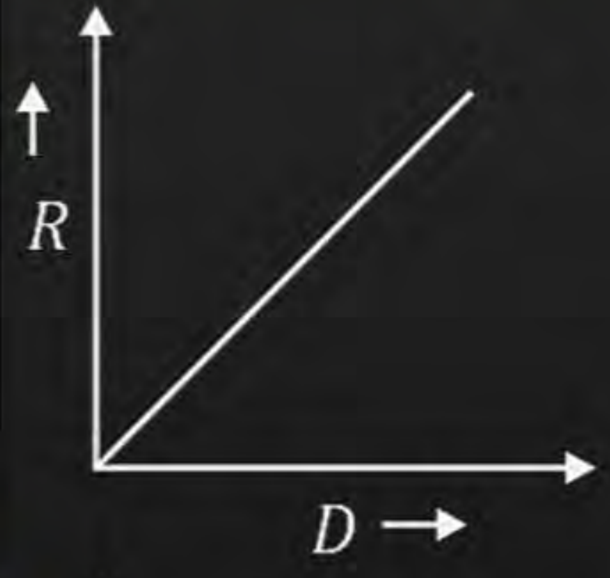
$$R = \frac{4\rho l}{\pi d^2} = \frac{4\rho l}{\pi D^2}$$

$$R \propto \frac{1}{D^2}$$

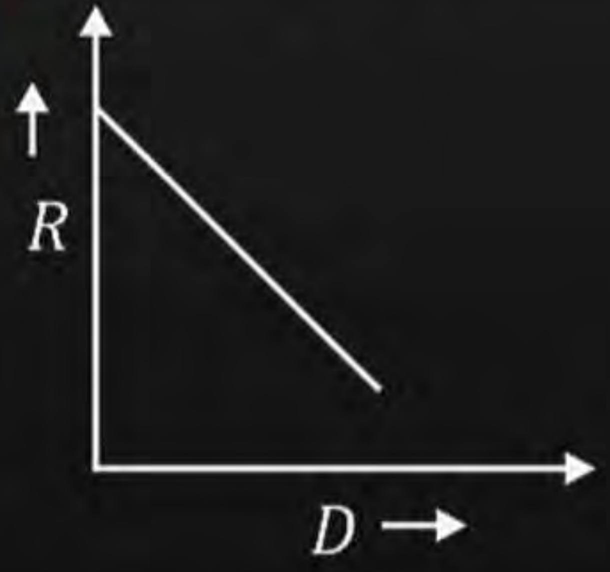
(A)



(B)



(C)



(D)

Question

Wire bound resistors are made by winding the wires of an alloy of

↳ Low Temp coefficient

(A) Si, Tu, Fe

(B) Ge, Au, Ga

(C) $\boxed{\text{Manganin, constantan, nichrome}}$

(D) Cu, Al, Ag

Question

contract

Ro compress

A wire of resistance 3 Ω is stretched to twice its original length. The resistance of the new wire will be

n

(A) 1.5 Ω

(B) 3 Ω

(C) 6 Ω

(D) $\boxed{12\ \Omega}$

$R' = n^2 R \rightarrow$ stretch case

$R' = (2)^2 \times 3$

$= 4 \times 3$

$\boxed{R' = 12\Omega}$

compress: $R' = \frac{R}{n^2}$

$R' = \frac{3}{4}\Omega$

Question

On the basis of electrical conductivity, which one of the following material has the $\boxed{\text{smallest resistivity?}}$

(A) Germanium

(B) $\boxed{\text{Silver}}$ ✓

(C) Glass

(D) Silicon

Question

A certain wire A has resistance 81 Ω. The resistance of another wire B of the same material and equal length but of diameter thrice the diameter of A will be

(A) 81 Ω

(B) $\boxed{9\Omega}$

(C) 729 Ω

(D) 243 Ω

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} = \frac{4\rho l}{\pi d^2}$$

$$R \propto \frac{1}{d^2}$$

$$\frac{R'}{R} = \frac{d^2}{d'^2} = \frac{d^2}{(3d)^2} = \frac{\cancel{d^2}}{9\cancel{d^2}} = \frac{1}{9}$$

$$\boxed{R' = \frac{R}{9} = \frac{81}{9} = 9\Omega}$$

Thank You