SOLUTION
ELECTRIC CHARGES AND FIELDS

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)
The path is a parabola, because initial velocity can be resolve into two rectangular components, one along $\vec{E}$ and other $\perp$ to $\vec{E}$. The former decrease at a constant rate and latter is unaffected. The resultant path is therefore parabola.

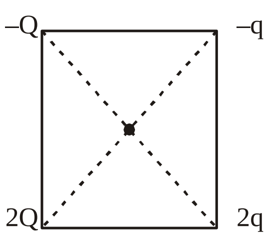
Q.2 (3)
Force acting between any two charges is independent of presence of any other charge.

Q.3 (1)
$-eE = mg$

$$\vec{E} = -\frac{9.1\times10^{-31}\times10}{1.6\times10^{-19}} = -5.6\times10^{-11}\,N/C$$

Q.4 (2) $F_{net} = \sqrt{F^2+F^2+2F^2\cos60^\circ} = \sqrt{3}F$

Q.5 (1)
Let the side lenght of square be 'a' then potential at centre O is



$$V = \frac{k(-Q)}{\left(\frac{a}{\sqrt{2}}\right)} + \frac{k(-q)}{\frac{a}{\sqrt{2}}} + \frac{k(2Q)}{\frac{a}{\sqrt{2}}} = 0$$

$= -Q - q + 2q + 2Q = 0$

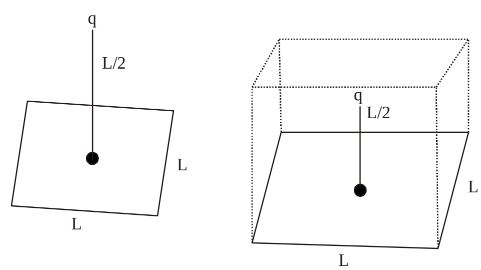
$\Rightarrow Q + q = 0$ (Given)

Q= –q

Q.6 **(3)**
The charged sphere is a conductor. therefore the field inside is zero and outside it is proportional to $1/r^2$

Q.7 (4)

Q.8 (2)
Q.9 (2)
Q.10 (2)
Q.11 (3)
Q.12 (1)
Q.13 (4)
Q.14 (1)
Q.15 (1)
Q.16 (3)
Q.17 (3)
Q.18 (1)
Q.19 (3)
Q.20 (3)
Q.21 (1)
Q.22 (1)
Q.23 (2)
Q.24 (3)



The given square of side L may be considered as one of the faces of a cube with edge L. Then given charge q will be considered to be placed at the centre of the cube. Then according to Gauss's theorem, the magnitude of the electric flux through the faces (six) of the cube is given be

$$\phi = \frac{q}{\varepsilon_0}$$

Hence, electric flux through one face of the cube for the given square will be

$$\phi' = \frac{1}{6}\phi = \frac{q}{6\varepsilon_0}$$

Q.25 (3) Electric field inside the uniformly charged sphere varies linearly, $E = \frac{kQ}{R^3}.r,(r \le R)$, while outside the sphere, it varies as inverse square of distance, $E = \frac{kQ}{r^3}; (r \geq R)$ which is correctly represented in option (3).

Q.26 (3) $\phi = E(ds)\cos\theta = E(2\pi r^2)\cos 0° = 2\pi r^2 E$.

Q.27 (1) For, $r < r_A$, $E = 0$

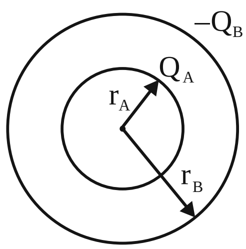
$r = r_A$, $$E = \frac{1}{4\pi\epsilon_0}\frac{Q_A}{r_A^2}$$

$r_A < r < r_g$, $$E = -\frac{1}{4\pi\epsilon_0}\frac{Q_A}{r^2}$$

$r = r_B$, $$E = \frac{1}{4\pi\epsilon_0}\left(\frac{Q_A - Q_B}{r_B^2}\right)$$

$$= \frac{1}{4\pi\epsilon_0}\left(\frac{Q_B - Q_A}{r_B^2}\right)$$

These values are correctly represent in option (1).



Q.28 (4)
Q.29 (3)
Q.30 (4)
Q.31 (1)
Q.32 (3)
Q.33 (4)

EXERCISE-II (NEET LEVEL)

Q.1 (1) $Q = ne = 10^{14} \times 1.6 \times 10^{-19} \Rightarrow Q = 1.6 \times 10^{-5}\,C = 16\,\mu C$
Electrons are removed, so chare will be positive.

Q.2 (2) The same force will act on both bodies although their directions will be different.

Q.3 (2) $F_a = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$, $F_b = \frac{q_1 q_2}{K 4\pi\varepsilon_0 r^2} \Rightarrow F_a : F_b = K : 1$

Q.4 (4) $Q_1 + Q_2 = Q$ ......(i)

and $F = k\frac{Q_1 Q_2}{r^2}$ ....(ii)

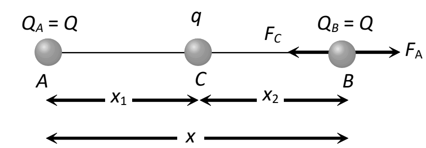
From (i) and (ii)

$$F = \frac{kQ_1(Q - Q_1)}{r^2}$$

For F to be maximum $\frac{dF}{dQ_1} = 0 \Rightarrow Q_1 = Q_2 = \frac{Q}{2}$

Q.5 (2) Suppose in the following figure, equilibrium of charge B is considered. Hence for it's equilibrium $|F_A| = |F_C|$

$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{4x^2} = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{x^2} \Rightarrow q = \frac{-Q}{4}$$



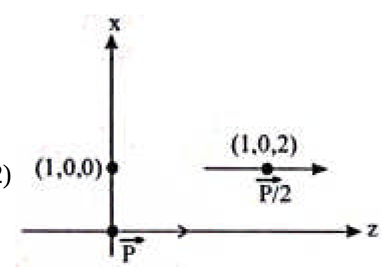
Short Trick : For such type of problem the magnitude of middle charge can be determined if either of the extreme charge is in equilibrium by using the following formula.

If charge A is in equilibrium then $q = -Q_B\left(\frac{x_1}{x}\right)^2$

If charge B is in equilibrium then $q = -Q_A\left(\frac{x_2}{x}\right)^2$

If the whole system is in equilibrium then use either of the above formula.

Q.6 (2)



The given point is at axis of $\frac{\vec{P}}{2}$ dipole and at equatorial line of $\vec{P}$ dipole so that field at given point.

Q.7 (1)

Q.8 (2)

Q.9 (1)

Q.10 (3)

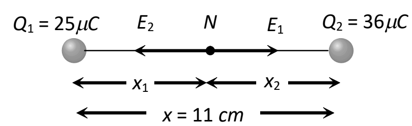
Q.11 (4)

Q.12 (2) According to the question, $eE = mg \Rightarrow E = \frac{mg}{e}$

Q.13 (3) $a = \frac{qE}{m} \Rightarrow \frac{a_e}{a_p} = \frac{m_p}{m_e}$

Q.14 (3) $K = \frac{E_{\text{without dielectric}}}{E_{\text{with dielectric}}} = \frac{2\times10^5}{1\times10^5} = 2$

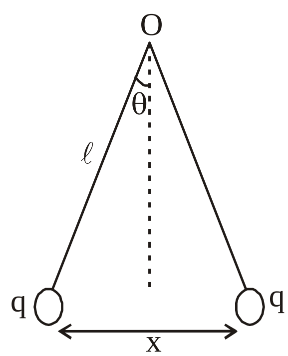
Q.15 (1) Suppose electric field is zero at point N in the figure then



At N $|E_1| = |E_2|$

Q.16 (2) Because E points along the tangent to the lines of force. If initial velocity is zero, then due to the force, it always moves in the direction of E. Hence will always move on some lines of force.

Q.17 (3) For figure $\tan\theta = \frac{F_e}{mg} \simeq \theta$



$$\frac{kq^2}{x^2 mg} = \frac{x}{2\ell}$$

or $x^3 \propto q^2 ...(1)$

or $x^{3/2} \propto q ...(2)$

Differentiating eq. (1) w.r.t. time

$3x^2 \frac{dx}{dt} \propto 2q \frac{dq}{dt}$ but $\frac{dq}{dt}$ is constant

so $x^2 (v) \propto q$ Replace from eq. (2)

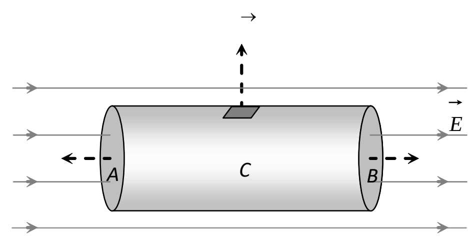
Q.18 (2) For balance $mg = eE \Rightarrow E = \frac{mg}{e}$

Also $m = \frac{4}{3}\pi r^3 d = \frac{4}{3}\times\frac{22}{7}\times(10^{-7})^3\times1000$ kg

$$\Rightarrow E = \frac{\frac{4}{3}\times\frac{22}{7}\times(10^{-7})^3\times1000\times10}{1.6\times10^{-19}} = 260 \text{ N/C}$$

Q.19 (3) At A and C, electric lines are equally spaced and dense that's why $E_A = E_C > E_B$

Q.20 (4) Flux through surface A, $\phi_A = E \times \pi R^2$ and $\phi_B = -E \times \pi R^2$



Flux through curved surface $C = \int \vec{E}.\vec{ds} = \int E ds \cos 90° = 0$

$\therefore$ Total flux through cylinder $= \phi_A + \phi_B + \phi_C = 0$

Q.21 (3) $E = \sigma/(2\varepsilon_0)$

Q.22 (1) Total flux through the cubical surface.

$$\phi = \frac{q_{in}}{\epsilon_0}$$

$$= \left[\frac{3+2+(-7)}{\epsilon_0}\right]C = -\frac{2C}{\epsilon_0}$$

Q.23 (1) By Gauss's theorem. $\phi_{cube} = \frac{1\times q}{\varepsilon_0}$, due to symmetry

$\rightarrow \phi_{face} = \frac{\phi_{cube}}{6}$

Q.24 (3) Entering flux = leaving flux

Q.25 (1) Entering electric flux = Leaving electric flux

Q.26 (2) By using $\int \vec{E}.\vec{dA} = \frac{1}{\varepsilon_0}(Q_{enc})$

Q.27 (2) $\phi_{net} = \frac{1}{\varepsilon_0}\times Q_{enc} \Rightarrow Q_{enc} = (\phi_2 - \phi_1)\,\varepsilon_0$

Q.28 (3) The electric field is due to all charges present whether inside or outside the given surface.

Q.29 (3) In electric dipole, the flux coming out from positive charge is equal to the flux coming in at negative charge i.e. total charge on sphere = 0. From Gauss law, total flux passing through the sphere = 0.

Q.30 (2) According to Gauss's applications.

Q.31 (3) Using Gauss's law. we have

$$\oint \vec{E}.d\vec{A} = \frac{1}{\epsilon_0}\int(\rho dv) = \frac{1}{\epsilon_0}\int_0^R kr^a \times 4\pi r^2 dr$$

or $\vec{E} \times 4\pi R^2 = \left(\frac{4\pi k}{\epsilon_0}\right)\frac{R^{(a+3)}}{a+3}$

$$\therefore E_1 = \frac{kR^{(a+1)}}{\epsilon_0{}^{(a+3)}}$$

For $r = \frac{R}{2}$. $E_2 = \frac{k\left(\frac{R}{2}\right)^{a+1}}{\epsilon_0\ (a+3)}$

Given, $E_2 = \frac{E_1}{8}$

or $\frac{E\left(\frac{R}{2}\right)^{a+1}}{\epsilon_0\ (a+3)} - \frac{1kR^{(a+1)}}{S\epsilon_0\ (a+3)}$

$$\therefore \frac{1}{2^{a+1}} = \frac{1}{S}$$

or a = 2.

Q.32 (3) Electric field inside a conductor is always zero.

Q.33 (3) Electric field outside of the sphere $E_{out} = \frac{kQ}{r^2}$ ...(i)

Electric field inside the dielectric sphere $E_{in} = \frac{kQx}{R^3}$ ...(ii)

From (i) and (ii),

$$E_{in} = E_{out} \times \frac{r^2 x}{R^3}$$

At 3 cm,

$$E = 100 \times \frac{3(20)^2}{10^3} = 120\ V/m$$

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (2)

Q.2 (4)

Q.3 (4) $F = \frac{Kq_1q_2}{r^2}$

$$F_1 = \frac{Kq_1q_2}{(r/2)^2} = \frac{4.Kq_1q_2}{r^2} = 4F$$

Q.4 (3) Attraction is possible between a charged and a neutral object.

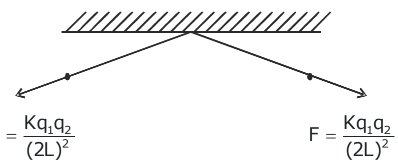
Q.5 (1) $F = \frac{Kq_1q_2}{r^2} = \frac{Kq_1q_2}{\varepsilon r r_1^2}$

$$\frac{1}{(20cm)^2} = \frac{1}{5r_1^2}$$

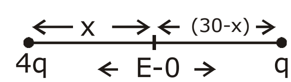
$$r_1^2 = \frac{20 \times 20 \times 10^{-4}}{5} = 80 \times 10^{-4}$$

$$r_1 = 8.94 \times 10^{-2} m$$

Q.6 (3)



Q.7 (1)

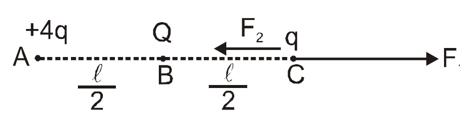


$$\frac{K(4q)}{x^2} = \frac{Kq}{(30-x)^2}$$

x = 20 cm from 4q

10 cm away from q

Q.8 (1)



Charges are placed as shown on line AC.

For net force on q to be zero, Q must be of –ve sign. If F_1 is force on q due ot 4q & F_2 due to Q

Then, $F_1 = F_2$ (magnitudewise)

or $\frac{k4q \cdot q}{\ell^2} = \frac{kQq}{\left(\frac{\ell}{2}\right)^2}$

$\therefore$ 4q = 4Q

or Q = q (in magnitude)

$\therefore$ Q = –q (with sign)

Q.9 (3) Initially, $F = \frac{k q_1 q_2}{r^2}$ ....(1)

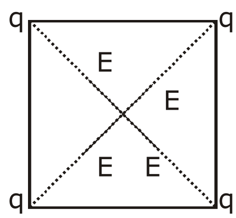
Finally, $4F = \frac{k q_1 q_2}{16 R^2}$ ....(2)

$\Rightarrow \frac{4kq_1q_2}{r^2} = \frac{4kq_1q_2}{16R^2}$ or $R = \frac{r}{8}$

Q.10 (2) F= qE

$E = \frac{100}{2} = 50 N/C$

Q.11 (1)



$E_{Net} = 0$

Q.12 (2) $a = \frac{qE}{m}$

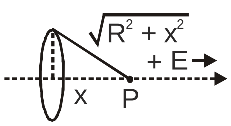
After time t

$v = \frac{qE}{m} t$

$KE = \frac{1}{2} mv^2 = \frac{E^2 q^2 t^2}{2m}$

Q.13 (4) $W = Fr \cos\theta \Rightarrow \therefore 4 = (0.2)\, E\, (2) \cos 60^\circ \Rightarrow \therefore E = 20$ N/C.

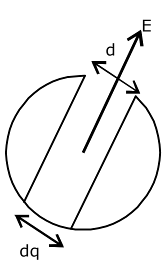
Q.14 (3) At point P on axis, $E = \frac{kqx}{(R^2 + x^2)^{3/2}}$



For max E, $\frac{dE}{dx} = 0 \Rightarrow$ or $x = \frac{R}{\sqrt{2}}$

$\therefore$ Putting x in (i)$E_{max} = \frac{2kq}{3\sqrt{3}R^2}$

Q.15 (1) $E = \frac{Kdq}{R^2}$



$dq = \frac{d}{2\pi R} .d$

$E = \frac{K\phi}{2\pi R^3} .d \Rightarrow E \times \frac{1}{R^3}$

Q.16 (1) a & b can't be both +ve or both – ve otherwise field would have been zero at their mid point.
b can't be positive even, otherwise the field would have been in –ve direction to the right of mid point answer is (1)

Q.17 (1) By definition

Q.18 (4)

Q.19 (3)

Q.20 (3) $\vec{A} = 100\hat{k}$, $\vec{E} = \hat{i} + \sqrt{2}\,\hat{j} + \sqrt{3}\,\hat{k}$

$\phi = \vec{E} \bullet \vec{A}$

$\phi = 100\sqrt{3}$

Q.21 (4)
Incoming flux = Outgoing flux

Q.22 (1) $\phi = \int \vec{E}\, d\vec{s}$, $= \pi R^2 E$

Q.23 (3) Net flux $= \phi_2 - \phi_1 = \frac{q_{in}}{\varepsilon_0}$ $q_{in} = \varepsilon_0 (\phi_2 - \phi_1)$

Q.24 (1)
Since same no of field lines are passing through both spherical surfaces, so flux has same value for both.

Q.25 (4) $q_{in} = 0$
$\phi = 0$

EXERCISE-IV

Q.1 [0191]

Q.2 [0208]

Q.3 [2.5]

Q.4 [0.5] $\tan\theta = \frac{E_y}{E_x} = \frac{\frac{2k\lambda}{y}}{\frac{2k\lambda}{x}} = \frac{x}{y} = \frac{1}{2} = 0.5$

Q.5 (4)

Q.6 (4)
If both Assertion & Reason are false

Q.7 (1)

Q.8 (2)

Q.9 (1)

Q.10 (4)

PREVIOUS YEAR'S

MHT CET

Q.1 (4)	**Q.2** (2)	**Q.3** (4)	**Q.4** (2)	**Q.5** (1)
Q.6 (3)	**Q.7** (3)	**Q.8** (4)	**Q.9** (1)	**Q.10** (3)
Q.11 (1)	**Q.12** (3)	**Q.13** (2)	**Q.14** (2)	**Q.15** (3)

Q.16 (1)

Given, charge on particle, q = 3e

Mass, m'= 2m

Force on charged particle in electric field

F = qE = 3eE

$\therefore$ Acceleration imparted to charged particle,

$$a = \frac{F}{m'} = \frac{3eE}{2m}$$

Q.17 (1)

From the principle of superposition, we have

$$F_{net} = \frac{1}{4\pi\varepsilon_0}\frac{Q\times q}{\left(\frac{d}{2}\right)^2} + \frac{1}{4\pi\varepsilon_0 (d)^2}$$

Since, $F_{net} = 0$

$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{Q\times q}{\left(\frac{d}{2}\right)^2} = -\frac{1\times Q\times Q}{4\pi\varepsilon_0 (d)^2} \Rightarrow q = -\frac{Q}{4}$$

Q.18 (4)

Net charge of one dipole = -e+ e = 0

Net charge of 8 dipoles = 8 × 0 = 0

$\therefore$ Net charge inside cube, q= 0

By Gauss's law

Total flux emerging out from surface = $\frac{q}{\varepsilon_0} = 0$

Q.19 (1)

The cube is a symmetrical body with 6 faces and the point charge is at its centre, so electric flux linked with each face will be

$$\phi' = \frac{\phi_{total}}{6} = \frac{Q}{6\varepsilon_0}$$

Q.20 (1)

The force on a charged particle in uniform electric field is given by

$F = qE \Rightarrow ma = qE$

or $a = \frac{qE}{m}$

$$\therefore \frac{a_e}{a_p} = \frac{eE}{m_e}\times\frac{m_p}{eE} = \frac{m_p}{m_e}$$

Q.21 (1)

Force on a charged particle in a uniform electric field E is given by

$F = qE = ma$

where, a is acceleration of charged particle.

$$\Rightarrow a = \frac{qE}{m}$$

From third equation of motion

$$v^2 = u^2 + 2as = 0 + 2\times\frac{qE}{m}\ y = \frac{2qEy}{m}$$

$\therefore$ Kinetic energy of particle, $KE = \frac{1}{2}mv^2$

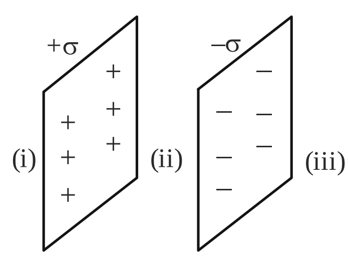
$$= \frac{1}{2}m\left(\frac{2qEy}{m}\right) = qEy$$

Q.22 (4)

Option (2) is not possible because it is not obeying the fact that number of lines of force has to be proportional to magnitude of charge and option (3) is not possible, because it is violating the fact electric lines of forces can never intersect.

Q.23 (3)

Between the plates, i.e., in the region II as shown in the figure, electric field is given by



$$E = \frac{1}{2\varepsilon_0}(\sigma_1 - \sigma_2) = \frac{1}{2\varepsilon_0}(2\sigma)$$

$\because \sigma_1 = \sigma_2$ and $\sigma_2 = -\sigma = \frac{\sigma}{\varepsilon_0}$ V / m

Q.24 (2)

The force between two charges in air,

$$F_1 = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^2} \quad ....(i)$$

Similarly, force between them in medium of dielectric constant K

$$F_2 = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1q_2}{r^2} \quad ....(ii)$$

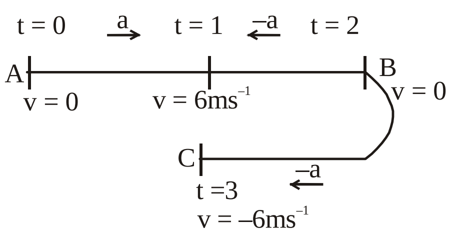
From Eqs. (i) and (ii), we get

$F_1/F_2 = K$

$F_1 : F_2 = K : 1$

NEET/AIPMT

Q.1 (2)



Acceleration $a = \frac{6-0}{1} = 6ms^{-2}$

For t = 0 to t = 1 s,

$$S_1 = \frac{1}{2}\times 6(1)^2 = 3m \quad ....(i)$$

For t = 1 s to t = 2 s,

$$S_2 = 6.1 - \frac{1}{2}\times 6(1)^2 = 3m \quad ....(ii)$$

For t = 2 s to t = 3 s,

$$S_3 = 0 - \frac{1}{2}\times 6(1)^2 = -3m \quad ....(iii)$$

Total displacement $S = S_1 + S_2 + S_3 = 3m$

Average velocity $= \frac{3}{3} = 1ms^{-1}$

Total distance travelled = 9m

Average speed $= \frac{9}{3} = 3ms^{-1}$

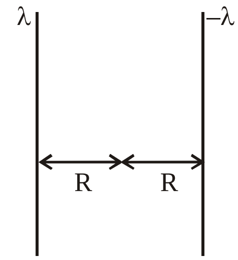
Q.2 (2)

For hollow conducting sphere

For r < R, E = 0

For $r > R \Rightarrow E = \frac{Kq}{r^2}$ so E decreases

Q.3 (3)



$\vec{E}$ due to infinite line charge $= \frac{2k\lambda}{R}$

λ = charge density

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = \frac{2k\lambda}{R} + \frac{2k\lambda}{R} = \frac{\lambda}{\pi\varepsilon_0 R} N/C$$

Q.4 (1)

Q.5 (1)

Q.6 (1)

It is electric dipole at large distance electric field intensity

$$E = \frac{KP}{R^3}\sqrt{1+3\cos^2\theta}$$

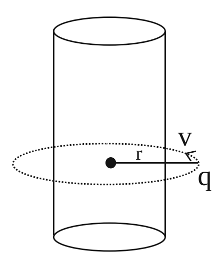
$$\therefore E \propto \frac{1}{R^3}$$

Q.7 (2)

Electric field is always perpendcular to EPS.

JEE MAIN

Q.1 (1)



$$qE = \frac{mv^2}{r} \quad ..... (i)$$

For E we use gauss law

$$E.2\pi r\ell = \frac{Q_{in}}{\varepsilon_0} = \frac{\rho\pi R^2\ell}{\varepsilon_0}$$

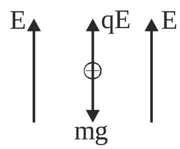
$$E = \frac{\rho R^2}{2\varepsilon_0 r} \qquad \text{Put in (i)}$$

$$\frac{q\rho R^2}{2\varepsilon_0 r} = \frac{mv^2}{r}$$

$$\frac{q\rho R^2}{4\varepsilon_0} = \frac{1}{2}mv^2 = K.E.$$

$$K.E. = \frac{\rho q R^2}{4\varepsilon_0}$$

Q.2 (2)

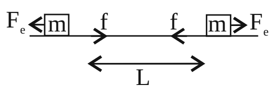


$qE = mg$

$$q = \frac{mg}{E} = \frac{0.1\times10^{-3}\times9.8}{4.9\times10^{5}}$$

$= 2 \times 10^{-9}$ C

Q.3 (1)



Fe = f (Max. friction)

$$\frac{kq^2}{L^2} = \mu mg$$

$$L_2 = \frac{kq^2}{\mu mg} = \frac{9\times10^9\times(2\times10^{-7})^2}{0.25\times10\times10^{-3}\times10}$$

$L^2 = 9 \times 16 \times 10^{-4}$

$L = 3 \times 4 \times 10^{-2}$ meter

L = 12 cm

Q.4 (3)

Electric field due to uniformly charged large surface is $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$. This is independent of the distance from the surface.

Thus, $E_1 = E_2 = \frac{\sigma}{2\varepsilon_0}$

Q.5 (2)

Let R = radius of combined drop

r = radius of smaller drop

Volume will remain same

$$\frac{4}{3}\pi R^3 \qquad \frac{4}{3}\pi R^3$$

R = 4r ; Q = 64q;

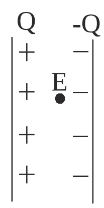
q : charge of smaller drop

Q : Charge of combined drop

$$\frac{\sigma_{bigger}}{\sigma_{smaller}} = \frac{\frac{Q}{4\pi R^2}}{4\pi r^2} = \frac{Q}{q}\cdot\frac{r^2}{R^2}$$

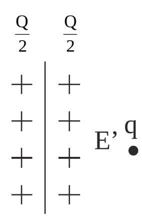
$$64\frac{r^2}{16r^2} = 4 \Rightarrow \frac{\sigma_{bigger}}{\sigma_{smaller}} = \frac{4}{1}$$

Q.6 (1)



$$F = qE = q\left(\frac{Q}{A\in_0}\right) = \frac{qQ}{A\in_0} = 10N$$

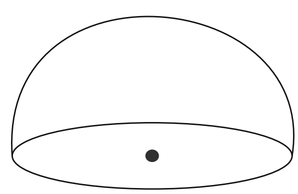
Now, when one plate is removed.



$$E' = \frac{Q}{2A\in_0}$$

$$F = qE' = \frac{Qq}{2AE\in_0} = 5N$$

Q. 7 (2)



Total flux through complete spherical surface is $\frac{q}{\varepsilon_0}$.

So the flux through curved surface will be $\frac{q}{2\varepsilon_0}$

The flux through flat surface will be zero.

Remark : Electric flux through flat surface is zero but no option is given, option is available for electric flux passing through curved surface.

Q. 8 (4)

$$F = \frac{k(2)(2)}{(1)^2}$$

(F = Force between two charges)

F = 4k

$$F_{net} = 2F\cos 30^o = 2.F.\frac{\sqrt{3}}{2} = F\sqrt{3}$$

(F_{net} = Net electrostatic force on one charged ball)

$$\frac{F_{net}}{F} = \frac{\sqrt{3}F}{F} = \left(\sqrt{3}\right)$$

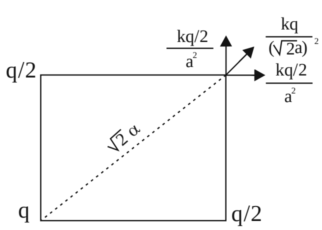
Remark : Net force on any one of the ball is zero. But not option given in options.

Q.9 (3)

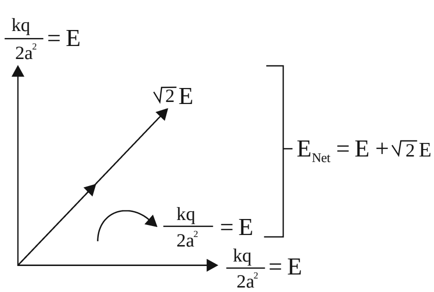
If the electric field is in the positive direction and the positive charge is to the left of that point then the electric field will increase. But to the left of the positive charge the electric field would decrease.

If the dipole is kept at the point where the electric field is maximum then the force on it will be zero.

Q.10 (1)



$$E_{over} = E + \sqrt{2}E$$

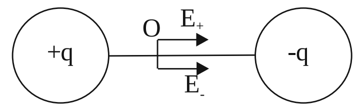


$$= E(1+\sqrt{2})$$

$$= \frac{kq}{2a^2}(1+\sqrt{2})$$

$$= \frac{kq}{a^2}\left(\frac{1}{2}+\frac{1}{\sqrt{2}}\right) \Rightarrow E_{net} = \frac{q}{4\pi\varepsilon_0 a^2}\left(\frac{1}{\sqrt{2}}+\frac{1}{2}\right)$$

Q.11 (2)



$$\Rightarrow E_0 = 2\times\frac{Kq}{(d/2)^2}$$

$$\Rightarrow E_0 = 8\frac{Kq}{d^2}$$

$$\Rightarrow d^2 = \frac{8\times9\times10^9\times8\times10^{-6}}{6.4\times10^4}$$

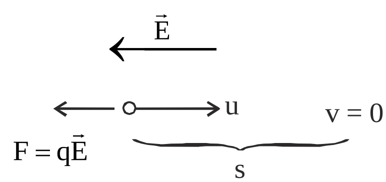
d = 3 m

Q.12 (4)

u = 200 m/s, $q = 40 \times 10^{-6}$ C

$E = 1 \times 10^5 \frac{N}{C}$

m = 100 mg = 0.1 kg



$$\therefore a = \frac{F}{m} = \frac{qE}{m}$$

III equation of motion

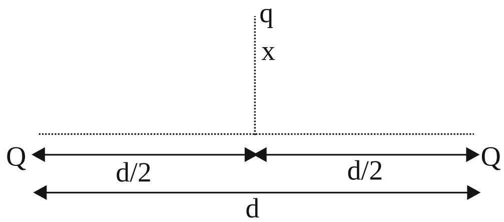
$v^2 = u^2 + 2as$ $\quad\therefore -u^2 = -2as$

$u^2 = 2as$

$$\therefore s = \frac{u^2}{2a} = \frac{u^2}{\frac{2qE}{m}} = \frac{u^2m}{2qE}$$

$$s = \frac{(200\times200)\times0.1}{2\times40\times10^{-6}\times10^5} = 0.5m$$

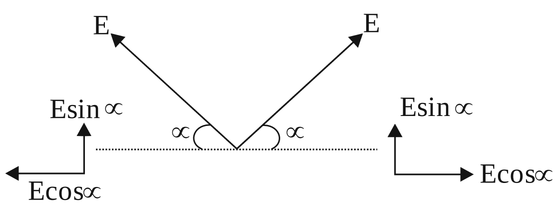
Q.13 (4)



Point charge q will experience maximum force at point where electric filed due to both charges Q and Q is maximum.
So we will first find expression of electric filled and then we will use concept of maxima & minima.

Let at point P $\vec{E}_1$ and $\vec{E}_2$ are electric fields due to the charges By symmetry, magnitudes of $\vec{E}_1$ and $\vec{E}_2$ will be same Let $\left|\vec{E}_1\right| = \left|\vec{E}_2\right| = E$

$$= \frac{KQ}{\left(\frac{d^2}{4} + x^2\right)}$$



Clearly net electric filled will be 2 Esin∝ in vertical direction.
$E_{net} = 2\,E\sin\propto$

$$\sin\propto = \frac{x}{\sqrt{\frac{d^2}{4} + x^2}}$$

$$E_{net} = 2\frac{KQx}{\left(\frac{d^2}{4} + x^2\right)^{3/2}}$$

Now for E_{net} to be maximum

$$\frac{d}{dx}E_{net} = 0$$

$$\Rightarrow \frac{d}{dx}2KQ\frac{x}{\left(\frac{d^2}{4} + x^2\right)^{3/2}} = 0$$

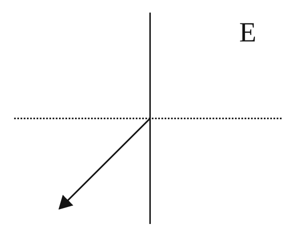
$$\Rightarrow \left(\frac{d^2}{4} + x^2\right)^{-3/2}\frac{d}{dx}x + x\frac{d}{dx}\left(\frac{d^2}{4} + x^2\right)^{-3/2} = 0$$

$$\Rightarrow \left(\frac{d^2}{4} + x^2\right)^{-3/2} + x\left(-\frac{3}{2}\right)\left(\frac{d^2}{4} + x^2\right)^{-5/2}(2x) = 0$$

$$\Rightarrow \frac{1}{\left(\frac{d^2}{4} + x^2\right)^{3/2}} = \frac{3x^2}{\left(\frac{d^2}{4} + x^2\right)^{5/2}}$$

$$\Rightarrow \frac{d^2}{4} + x^2 = 3x^2$$

$$\Rightarrow \frac{d^2}{4} = 2x^2 \Rightarrow x^2 \Rightarrow \frac{d^2}{8} \Rightarrow x = \frac{d}{2\sqrt{2}}$$



Q.14 (C)
Electric force on a positive charge is along electric field and that on negative charge is opposite ot electric field wherease direction of magnetic force is perpendicular to both velocity and magnetic field. Hence statement I is correct and statement II is incorrect.

Q.15 (4)
We know that potential V (x, y, z) is given then electric field is :

$$\vec{E} = \frac{-\partial V}{\partial x}\hat{i} - \frac{\partial v}{\partial y}\hat{j} - \frac{\partial v}{\partial x}\hat{k}$$

$$\vec{E}- = -\frac{d}{dx}3x^2\,\hat{i}$$

$$\vec{E}- = -6x\hat{i}$$

at (1, 0, 3)

$$\vec{E}- = -6\hat{i}\ V/m$$

Q.16 [45]
Electric field at surface

$E = \frac{kQ}{R^2}$

$E = \frac{\rho R}{3\epsilon_0}\left\{Q = \rho\frac{4}{3}\pi R^3\right\}$

Number of lines per unit area $\alpha\ |\vec{E}|$

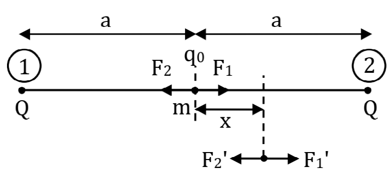
Number using proportionality constant = 1

of lines per unit area = $|\vec{E}|$

$= \frac{\rho R}{3\epsilon_0}$

$= \frac{\frac{2\times10^{-6}}{10^{-6}}\times 6}{3\times 8.85\times10^{-12}} = 45\times 10^{10}\frac{N}{C}$

Q.17 (1)



$F'_1 < F'_2$

$F_{net} = F'_2 - F'_1 = \frac{Kq_0Q}{(a+x)^2} - \frac{Kq_0Q}{(a-x)^2}$

$= kq_0Q\left[\frac{(a-x)^2-(a+x)^2}{(a^2-x^2)^2}\right]$

$F_{net} = \frac{kq_0Q[-4ax]}{(a^2-x^2)^2}$ a >> x

$F_{net} = \frac{-kq_0Q4ax}{a^4} = \frac{-4q_0Qx}{a^3}\cdot\frac{1}{4\pi\epsilon_0} = -\left(\frac{q_0Q}{\pi\epsilon_0 ma^3}\right)x$

$\text{ma cc.} = \frac{-aQx}{(\pi\epsilon_0 a^3)} \Rightarrow \text{acc.} = -\left(\frac{q_0Q}{\pi\epsilon_0 ma^3}\right)x$

$T = 2\pi\sqrt{\frac{\pi\epsilon_0 ma^3}{q_0Q}} = \sqrt{\frac{4\pi^2 ma^3\epsilon_0}{q_0Q}}$

Q.18 [1]

$\oint \vec{E}.d\vec{s} = \frac{q}{\epsilon_0}$

$E(2\pi xL) = \frac{\rho(\pi x^2.L)}{\epsilon_0}$

$E = \frac{\rho x}{2\varepsilon_0}$

at $x = \frac{2\epsilon_0}{\rho}$

$E = \frac{\rho}{2\epsilon_0}\cdot\frac{2\epsilon_0}{\rho}$

$\boxed{E = 1}$

Q.19 (2)

Let Q = 4

Now q is another part then

force between them

$F = \frac{K(Q-q)q}{r^2}$

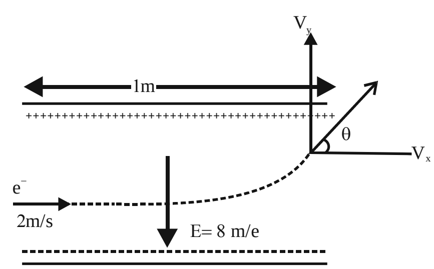
For F_{max} $\frac{dF}{dq} = 0$

Or Q – 2q = 0

$q = \frac{Q}{2}$

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

Q.20 (2)



$u_x = 2m/$

s $\quad a_x = 0 \quad s_x = u_x t + \frac{1}{2}a_x t^2$

$v_x = u_x + a_2 t \quad 1 = 2x\,t + 0$

Vx = ux = 2m/s $\quad$ t = 0.5 sec.

$u_y = 0 \quad a_y = \frac{eE}{m} = \frac{e}{m}\left(\frac{8m}{e}\right) = 8m/s^2$

$v_y = u_y + a_y t = 0 + 8x\ 0.5 = 4$ m/s

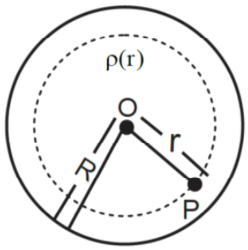
$\tan\theta = \frac{v_y}{v_x} \Rightarrow \theta = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

$= \tan^{-1}\left(\frac{4}{2}\right)$

$\theta = \tan^{-1}(2)$

Q.21 (3)

By Gauss law



$$\oint \vec{E}\cdot d\vec{S} = \frac{Q_{in}}{\varepsilon_0}$$

$$E\cdot 4\pi r^2 = \frac{\int_0^r \rho_0\left(\frac{3}{4}-\frac{r}{R}\right)4\pi r^2 dr}{\varepsilon_0}$$

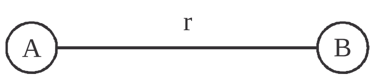
$$E\cdot 4\pi r^2 = \frac{\rho_0 4\pi}{\varepsilon_0}\left(\frac{3}{4}\frac{r^3}{3}-\frac{r^4}{4R}\right)$$

$$Er^2 = \frac{\rho_0 r^3}{4\varepsilon_0}\left\{1-\frac{r}{R}\right\}$$

$$E = \frac{\rho_0 r}{4\varepsilon_0}\left\{1-\frac{r}{R}\right\}$$

Q.22 (2)

Let $q_A = q_B = q$



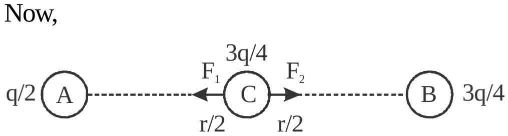
$$F = \frac{Kq^2}{r^2}$$

When C is placed in contact with A, charge on A and C will be q/2

Now, C is placed in contact with B, charge on B and C

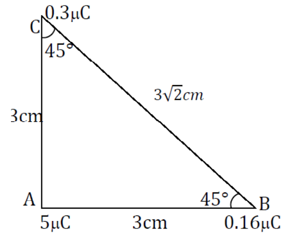
will be $= \dfrac{q+\frac{q}{2}}{2} = \dfrac{3q}{4}$

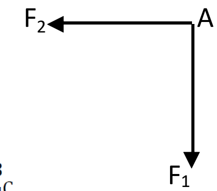
Now,



$$F' = F_2 - F_1 = \frac{\left(K\frac{3q}{4} - K\frac{q}{2}\right)}{\frac{r^2}{4}}.\frac{3q}{4} = \frac{3Kq^2}{4r^2} = \frac{3F}{4}$$

Q.23 [17]





$$F_1 = \frac{k\times 0.3\times 5\times 10^{-12}}{9\times 10^{-4}}$$

$$\frac{9\times 10^9\times 1.5\times 10^{-8}}{9} = 15$$

$$F_2 = \frac{9\times 10^9\times 0.8\times 10^{-8}}{9}$$

$$F_{net} = \sqrt{225+64} = \sqrt{289} = 17$$

ELECTROSTATIC POTENTIAL AND CAPACITANCE

EXERCISE-I (MHT CET LEVEL)

Q.1 (2)

$$\frac{kx}{1cm}=\frac{k(Q-x)}{3cm}$$

$$3x=Q-x\Rightarrow 4x=Q$$

$$x=\frac{Q}{4}=\frac{4\times10^{-2}}{4}C=1\times10^{-2}$$

$$Q'=Q-x=3\times10^{-2}C$$

Q.2 (2)
Potential at any point inside the sphere = potential at the surface of the sphere = 10V.

Q.3 (1)
Initial potential energy of the system

$$=\frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{a}+\frac{q^2}{a}+\frac{q^2}{a}\right]=\frac{1}{4\pi\varepsilon_0}\left(\frac{3q^2}{a}\right)$$

$$=9\times10^9\left(3\times\frac{(0.1)^{2.}}{1}\right)=27\times10^7\text{ J}$$

Let charge at A is moved to mid-point O, Then final potential energy of thhe system

$$U_f=\frac{1}{4\pi\varepsilon_0}\left[\frac{2q^2}{(a/2)}+\frac{q^2}{a}\right]$$

$$=5\times\frac{1}{4\pi\varepsilon_0}\left(\frac{q^2}{a^2}\right)=45\times10^7\text{ J}$$

Woek done = $U_f-U_i=18\times10^7$ J
Also, energy supplied per sec = 1000 J (given)
Time required to move one of the mid-point of the line joining the other two

$$t=\frac{18\times10^7}{1000}=18\times10^4 s=50h$$

Q.4 (3)
Q.5 (1)
Q.6 (1)
Q.7 (3)
Q.8 (1)
Q.9 (1)
When charge is given to inner cylinder, an electric field will be in between the cylinders. So there is potential difference between the cylinders.

Q.10 (2)
Q.11 (4)
Q.12 (4)
Q.13 (2)
Q.14 (3)

Q.15 (4) $\vec{E}=\frac{\partial V}{\partial x}\hat{i}-\frac{\partial V}{\partial y}\hat{j}-\frac{\partial V}{\partial z}\hat{k}$

$$=-\left[(6-8y)\hat{i}+(-8x-8+6z)\hat{j}+(6y)\hat{k}\right]$$

$$\text{At }(1,1,1),\vec{E}=2\hat{i}+10\hat{j}-6\hat{k}$$

$$\Rightarrow(\vec{E})=\sqrt{2^2+10^2+6^2}=\sqrt{140}=2\sqrt{35}$$

$$\therefore F=q\vec{E}=2\times2\sqrt{35}=4\sqrt{35}$$

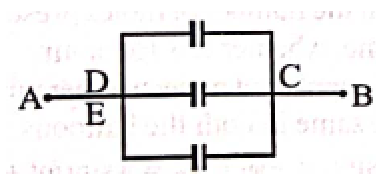
Q.16 (3)
Q.17 (2)
Q.18 (2)
Q.19 (4)
Q.20 (3)
Q.21 (2)
Q.22 (2)
Q.23 (3)
Q.24 (4)

For a parallel plate capacitor C= $\frac{\varepsilon_0 A}{d}$

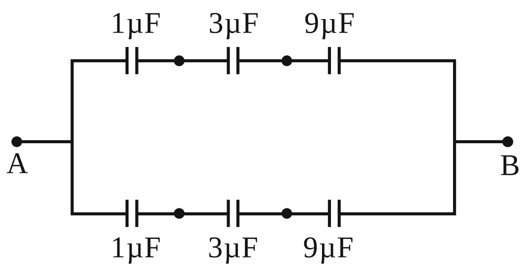
$$\therefore A=\frac{Cd}{\varepsilon_0}=\frac{1\times10^{-3}}{8.85\times10^{-12}}$$
$$=1.13\times10^8 m^2$$

This corresponds to area of square of side 10.6 km which shows that one farad is very large unit of capacitance.

Q.25 (4)
$C_{eq}=(1+2+3)\,\mu F=6\,\mu F$



Q.26 (2)
The effuective circuit is shown in figure.



The capacitance of upper series,

$$\frac{1}{C}=\frac{1}{1}+\frac{1}{3}+\frac{1}{9}+\frac{1}{27}+------\infty$$

$$\therefore\ C=\frac{2}{3}\mu C$$

Q.27 (1)
Q.28 (3)
Q.30 (1)
Q.29 (1)
Q.31 (3)
Q.32 (1) C = equivalent capacitance

$$\therefore \frac{1}{C}=\frac{1}{2}+\frac{1}{3}+\frac{1}{6}\Rightarrow C=1\mu F$$

Charge on each capacitor in series circuit will be same.
$\therefore$ q = CV = $(1\times10^{-6})\times10$ = 10 μC
$\therefore$ Charge across 3 μF capacitor will be 10μC.
Q.33 (4)
Q.34 (3)
Q.35 (1)
Q.36 (3)
Q.37 (4)
Q.38 (3)
Q.39 (3)
Q.40 (3)
Q.41 (4)
Q.42 (3)
Q.43 (3)
Capacitance of capacitor

$$(C)=6\mu F=6\times10^{-6}F$$

Initial potential $(V_1)=10V$ and final potential

$(V_2)=20V$.

The increases in energy (ΔU)

$$=\frac{1}{2}C\left(V_2^2-V_1^2\right)$$

$$=\frac{1}{2}\times\left(6\times10^{-6}\right)\times\left[(20)^2-(10)^2\right]$$

$$=\left(3\times10^{-6}\right)\times300=9\times10^{-4}J$$

Q.44 (3)
Initial energy of combined system

$$U_1=\frac{1}{2}CV_1^2+\frac{1}{2}CV_2^2$$

Final common potential, $V=\frac{V_1+V_2}{2}$

Final energy of system,

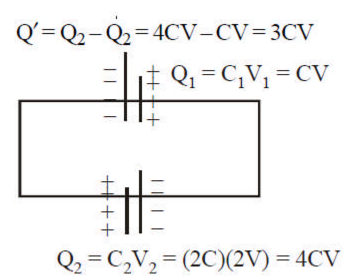
$$U_2=2\times\frac{1}{2}C\left(\frac{V_1+V_2}{2}\right)^2$$

Hence loss of energy

$$=U_1-U_2$$

$$=\frac{1}{4}C\left(V_1-V_2\right)^2$$

Q.45 (2)
From the figure.



The net charge shared between the two capacitors
Q' = $Q_2 - Q_2$ = 4CV–CV = 3CV

The two capacitors will have some potential, say V'.
The net capacitance of the parallel combination of the two capacitors
C' = $C_1 + C_2$ = C + 2C + 3C
The potential of the capacitors

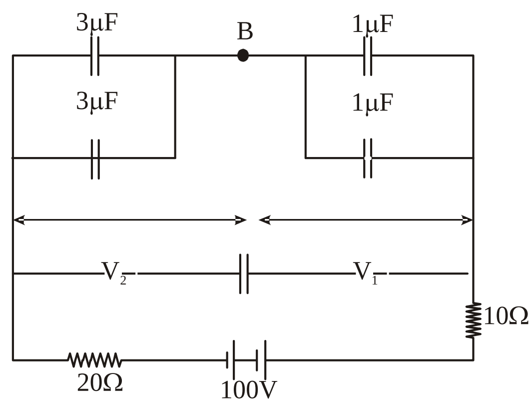
$$V'=\frac{Q'}{C'}=\frac{3CV}{3C}=V$$

The electrostatic energy of the capacitors

$$E'=\frac{1}{2}C'V'^2=\frac{1}{2}(3C)V^2=\frac{3}{3}CV^2$$

Q.46 (3)

The equilvalent circuit is shown in figure. $V_1+V_2 = 100$ and $2V_1 = 6V_2$



On solving above equations, we get

$V_1 = 75V, V_2 = 25V$

Q.47 (3)

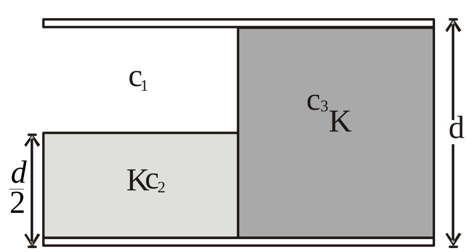
Q.48 (2)

Q.49 (3)

Q.50 (4)

Q.51 (4)

Q.52 (4)



$$c_1 = \frac{(A/2)\varepsilon_0}{d} = \frac{A\varepsilon_0}{d}, c_2 = K\frac{A\varepsilon_0}{d} c_3 = K\frac{A\varepsilon_0}{2d}$$

$$\therefore c_{eq} = \frac{c_1 \times c_2}{c_1 + c_2} + c_3 = \frac{(3+K)\,KA\,\varepsilon_0}{2d(K+1)}$$

($\therefore$ C_1 and C_2 are in series and resultant of these two in parallel with C_3)

Q.53 (1)

Q.54 (2)

EXERCISE-II (NEET LEVEL)

Q.1 (2)

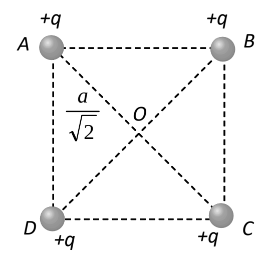
Since potential inside the hollow sphere is same as that on the surface.

Q.2 (2)

Potential at the centre O,

$$V = 4 \times \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{a/\sqrt{2}}$$

where $Q = \frac{10}{3} \times 10^{-9} C$ and $a = 8 \text{ cm} = 8 \times 10^{-2}$ m



$$\text{So } V = 5 \times 9 \times 10^9 \times \frac{\frac{10}{3} \times 10^{-9}}{\frac{8 \times 10^{-2}}{\sqrt{2}}} = 1500\sqrt{2} \text{ volt}$$

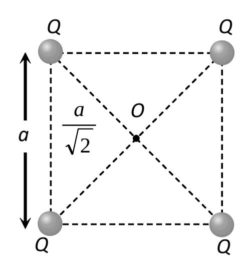
Q.3 (2)

Electrostatic energy density $\frac{dU}{dV} = \frac{1}{2}K\varepsilon_0 E^2$

$$\therefore \frac{dU}{dV} \propto E^2$$

Q.4 (3)

Potential at centre O of the square



$$V_0 = 4\left(\frac{Q}{4\pi\varepsilon_0\left(a/\sqrt{2}\right)}\right)$$

Work done in shifting (– Q) charge from centre to infinity

$$W = -Q(V_\infty - V_O) = QV_0 = \frac{4\sqrt{2}Q^2}{4\pi\varepsilon_0 a} = \frac{\sqrt{2}Q^2}{\pi\varepsilon_0 a}$$

Q.5 (2)

Using $v = \sqrt{\frac{2QV}{m}} \Rightarrow$ $v \propto \sqrt{Q} \Rightarrow$

$$\frac{v_A}{v_B} = \sqrt{\frac{Q_A}{Q_B}} = \sqrt{\frac{q}{4q}} = \frac{1}{2}$$

Q.6 (1)

Potential at the centre of square

$$V = 4\times\left(\frac{9\times10^9 \times 50\times10^{-6}}{2/\sqrt{2}}\right) = 90\sqrt{2}\times10^4\,V$$

Work done in bringing a charge (q = 50 mC) from ∞ to centre (O) of the square is $W = q\,(V_0 - V_\infty) = qV_0$

$$\Rightarrow W = 50\times10^{-6}\times90\sqrt{2}\times10^4 = 64\text{ J}$$

Q.7 (2) In balance condition

$$\Rightarrow QE = mg \Rightarrow Q\frac{V}{d} = \left(\frac{4}{3}\pi r^3\rho\right)g$$

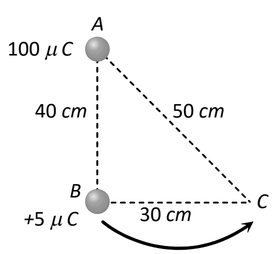
$$\Rightarrow Q \propto \frac{r^3}{V} \Rightarrow \frac{Q_1}{Q_2} = \left(\frac{r_1}{r_2}\right)^3 \times \frac{V_2}{V_1}$$

$$\Rightarrow \frac{Q}{Q_2} = \left(\frac{r}{r/2}\right)^3 \times \frac{600}{2400} = 2$$

$$\Rightarrow Q_2 = Q/2$$

Q.8 (4)

Work done in displacing charge of 5 μC from B to C is $W = 5 \times 10^{-6}\,(V_C - V_B)$ where



$$V_B = 9\times10^9\times\frac{100\times10^{-6}}{0.4} = \frac{9}{4}\times10^6\,V$$

and $$V_C = 9\times10^9\times\frac{100\times10^{-6}}{0.5} = \frac{9}{5}\times10^6\,V$$

So $$W = 5\times10^{-6}\times\left(\frac{9}{5}\times10^6 - \frac{9}{4}\times10^6\right) = -\frac{9}{4}\,J$$

Q.9 (3)

Kinetic energy $K = \frac{1}{2}mv^2 = eV \Rightarrow v = \sqrt{\frac{2eV}{m}}$

Q.10 (3)

For non-conducting sphere $E_{in} = \frac{k.Qr}{R^3} = \frac{\rho r}{3\varepsilon_0}$

Q.11 (2)

Potential V any where inside the hollow sphere, including the centre is $V = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{R}$

Q.12 (2)

$$V_{inside} = \frac{Q}{4\pi\varepsilon_0 R} \quad \text{for } r \le R \quad ....(i)$$

and $$V_{out} = \frac{Q}{4\pi\varepsilon_0 r} \quad \text{for } r \ge R \quad ....(ii)$$

i.e. potential inside the hollow spherical shell is constant and outside varies according to $V \propto \frac{1}{r}$.

Q.13 (1)

The electric potential $V(x, y, z) = 4x^2$ volt

Now $\vec{E} = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

Now $\frac{\partial V}{\partial x} = 8x$, $\frac{\partial V}{\partial y} = 0$ and $\frac{\partial V}{\partial z} = 0$

Hence $\vec{E} = -8x\hat{i}$, so at point (1m, 0, 2m)

$\vec{E} = -8\hat{i}$ volt / metre or 8 along negative X-axis.

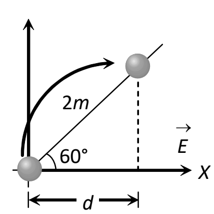
Q.14 (2)

$$\because \quad E = -\frac{dV}{dX} \Rightarrow V_x = -xE_0$$

Q.15 (2)

$$E = \frac{V}{d} = \frac{10}{2\times10^{-2}} = 500\text{ N/C}$$

Q.16 (4)



$W = qV = qE.d$

$\Rightarrow 4 = 0.2 \times E \times (2\cos 60^o)$

$= 0.2\,E \times (2 \times 0.5)$

$\therefore \quad E = \frac{4}{0.2} = 20\ NC^{-1}$

Q.17 (1)

$F = QE = \frac{QV}{d} \Rightarrow 5000 = \frac{5 \times V}{10^{-2}} \Rightarrow V = 10$ volt

Q.18 (2)
In the direction of electric field potential decreases.

Q.19 (3)
Potential energy = – pE cosθ
When θ = 0. Potential energy = – pE (minimum)

Q.20 (4)
Potential energy of dipole in electric field U = –PE cos θ; where θ is the angle between electric field and dipole.

Q.21 (2)

$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2p}{r^3}$

Q.22 (2)

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

Q.23 (1)

$V = \frac{kp\cos\theta}{r^2}$, Here $\theta = 90°$

Q.24 (4)
Potential due to dipole in general position is given by

$V = \frac{k.p\cos\theta}{r^2} \Rightarrow V = \frac{k.p\cos\theta r}{r^3} = \frac{k\cdot(\vec{p}\cdot\vec{r})}{r^3}$

Q.25 (1)
Electric field inside a conductor is zero.

Q.26 (3)
Electric field near the conductor surface is given by $\frac{\sigma}{\varepsilon_0}$ and it is perpendicular to surface.

Q.27 (4)

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

Q.28 (2)
By using $V_{big} = n^{2/3} v_{small}$

$\Rightarrow \frac{V_{big}}{v_{small}} = (8)^{2/3} = \frac{4}{1}$

Q.29 (4)
If the drops are conducting, then

$\frac{4}{3}\pi R^3 = N\left(\frac{4}{3}\pi r^3\right)$

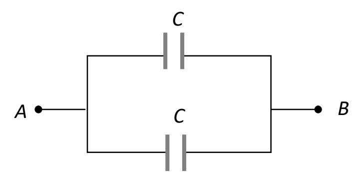
$\Rightarrow R = N^{1/3} r$. Final charge Q = Nq

So final potential $V = \frac{Q}{R} = \frac{Nq}{N^{1/3} r} = V \times N^{2/3}$

Q.30 (1)
Equivalent $C = C_1 + C_2$

Q.31 (1)

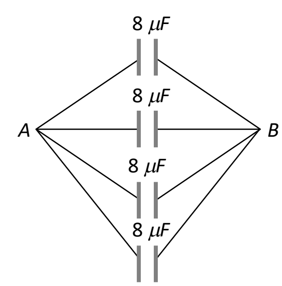
Q.32 (1)
The given circuit is equivalent to a parallel combination two identical capacitors



Hence equivalent capacitance between A and B is

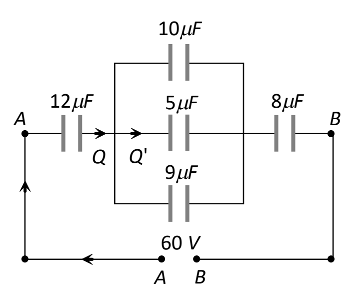
$C = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$

Q.33 (1)
Given circuit can be drawn as



Equivalent capacitance = 4 × 8 = 32μF

Q.34 (4)
The given circuit can be redrawn as follows



Equivalent capacitance of the circuit $C_{AB} = 4\ \mu F$
Charge given by the battery $Q = C_{eq} V = 4 \times 60 = 240\ \mu C$
Charge in 5μF capacitor

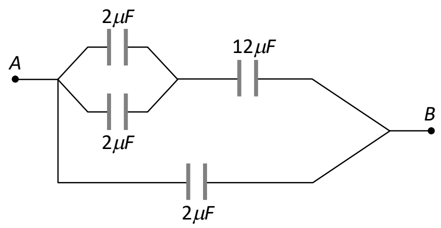
$Q' = \frac{5}{(10+5+9)} \times 240 = 50\ \mu C$

Q.35 (2)

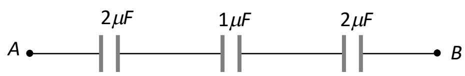
The given arrangement is equivalent to the parallel combination of three identical capacitors. Hence equivalent capacitance = 3C = $\dfrac{3\varepsilon_0 A}{d}$

Q.36 (4) Minimum when connected in series and maximum when connected in parallel

Q.37 (3) The circuit can be rearranged as



Q.38 (4)



$$\frac{1}{C} = \frac{1}{2} + \frac{1}{1} + \frac{1}{2} = \frac{1+2+1}{2} = \frac{4}{2} = 2$$

$\Rightarrow C_{AB} = 0.5\ \mu F$

Q.39 (2) Charge flows to second capacitor until the potential is same i.e. V/2. So new charge = CV/ 2

Q.40 (2) $\dfrac{1}{C} = \dfrac{1}{3} + \dfrac{1}{6} \Rightarrow C = 2\text{ pF}$

Total charge = $2 \times 10^{-12} \times 5000 = 10^{-8}$ C

The new potential when the capacitors are connected in parallel is

$$V = \frac{2\times 10^{-8}}{(3+6)\times 10^{-12}} = 2222\text{ V}$$

Q.41 (3) $\dfrac{1}{C_{eq}} = \dfrac{1}{3} + \dfrac{1}{10} + \dfrac{1}{15} \Rightarrow C_{eq} = 2\ \mu F$

Charge on each capacitor

$Q = C_{eq} \times V \Rightarrow 2 \times 100 = 200\ \mu C$

Q.42 (3) $\dfrac{1}{C_{eq}} = \dfrac{1}{1} + \dfrac{1}{2} + \dfrac{1}{8} \Rightarrow C_{eq} = \dfrac{8}{13}\mu F$

Total charge $Q = C_{eq} V = \dfrac{8}{13} \times 13 = 8\ \mu C$

Potential difference across 2μF capacitor = $\dfrac{8}{2} = 4V$

Total charge $Q = C_{eq} V = \dfrac{8}{13} \times 13 = 8\ \mu C$

Potential difference across 2μF capacitor = $\dfrac{8}{2} = 4V$

Q.43 (3) Given circuit can be reduced as follows

In series combination charge on each capacitor remain same. So using Q = CV

$\Rightarrow C_1V_1 = C_2V_2 \Rightarrow 3(1200 - V_p) = 6(V_P - V_B)$

$\Rightarrow 1200 - V_p = 2V_p \qquad (\because V_B = 0)$

$\Rightarrow 3V_p = 1200 \Rightarrow V_p = 400$ volt

Q.44 (4) $U = \dfrac{1}{2}CV^2 = \dfrac{1}{2} \times 2 \times 10^{-6} \times (50)^2 = 25 \times 10^{-4}$ J

Q.45 (4) $U = \dfrac{1}{2}CV^2 = \dfrac{1}{2} \times 6 \times 10^{-6} \times (100)^2 = 0.03$ J

Q.46 (1)

Let $E = \dfrac{1}{2}C_0V_0^2$ then, $E_1 = 2E$ and $E_2 = \dfrac{E}{2}$

So $\dfrac{E_1}{E_2} = \dfrac{4}{1}$

Q.47 (2) Power = $\dfrac{\frac{1}{2}CV^2}{t} = \dfrac{1 \times 40 \times 10^{-6} \times (3000)^2}{2 \times 2 \times 10^{-3}} = 90$ kW

Q.48 (2) $U = \dfrac{Q^2}{2C}$; in given case C increases so U will decrease

Q.49 (4) $C = \dfrac{\varepsilon_0 A}{d}$ ......(i)

$C' = \dfrac{\varepsilon_0 KA}{2d}$ ......(ii)

From equation (i) and (ii)

$$\frac{C'}{C} = \frac{K}{2}$$

$\Rightarrow 2 = \dfrac{K}{2} \Rightarrow K = 4$

Q.50 (2) In steady state potential difference across capacitor

V_2=potential difference across resistance

$R_2 = \left(\dfrac{R_2}{R_1 + R_2}\right)V$

Hence V_2 depends upon R_2 and R_1

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (4)
By M.E. conservation between initial & final point :
$U_i + K_i = U_f + K_f$
$\therefore$ Answer is (4)

Q.2 (2)

Q.3 (2)

$\therefore \quad \frac{1}{2}mV_A^2 = qV, \ \frac{1}{2}mV_B^2 = 4\,qV \Rightarrow \therefore \quad \frac{V_A^2}{V_B^2} = \frac{1}{4} \Rightarrow$

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

Q.4 (1)

$\because V_C = \frac{kQ}{r} \ \therefore \ V_C = \frac{9\times10^9 \times 1.5\times10^{-9}}{(0.5)} = 27\,V.$

Q.5 (2)

Q.6 (3)
PE = q ($V_{final} - V_{initial}$)
PE = qΔV PE decreases if q is +ve increases if q is –ve.

Q.7 (3)
PE may increase may decrease depending on sign of charges.

Q.8 (2)

$E = \frac{Kq}{r^2}$; $V = \frac{Kq(n-1)}{r} \quad \Rightarrow$

$\frac{V}{E} = r(n-1)$

Q.9 (4)

$q_1 \longleftarrow d \longrightarrow q_2$

Seperation increase then

$U = \frac{Kq_1q_2}{d} \downarrow$

But

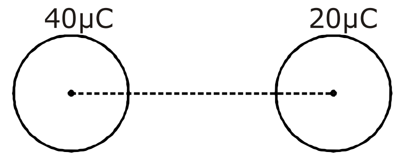
$q_1 \longleftarrow d \longrightarrow -q_2$

if d $\uparrow$ then $U = \frac{-kq_1q_2}{d} \uparrow$

Q.10 (2)

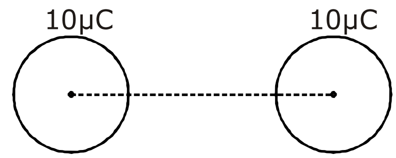
$\frac{1}{2}mv^2 = eV \therefore v = \sqrt{\frac{2eV}{m}}$

Q.11 (1)



$F_1 = \frac{k(40)(20)}{d^2}$

After touching the charge on sphere = 10μC

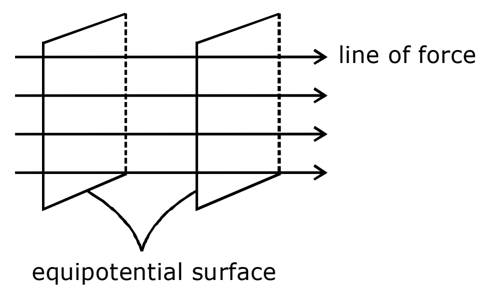


$F_2 = \frac{k(10)(10)}{d^2}$

$F_1 : F_2 = 8 : 1$

Q.12 (1)
$\Delta V = E.R$
$\Delta V = 1000 \times 1 \times 10^{-2} = 10$Volt

Q.13 (4)



Angle between both = 90°

Q.14 (1)

Q.15 (4)

At origin, $E = -\frac{dV}{dr} = -2.5$ V/cm $= -250$ V/m

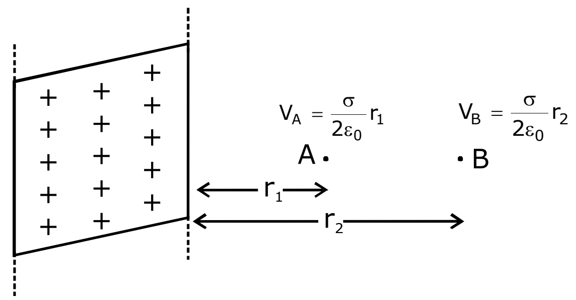
$\therefore$ F = force on 2C = q E = 2 × (– 250) N = – 500 N.

Q.16 (1)

$E = -\frac{dV}{dx} = -10x - 10$

$\therefore \ E_{(x=1m)} - 10(1) - 10 = -20$ V/m

Q.17 (2)



Given $V_B - V_A = 5$ V

$$\frac{\sigma}{2\varepsilon_0}(r_2 - r_1) = 5V$$

$r_2 - r_1 = 0.88$ mm

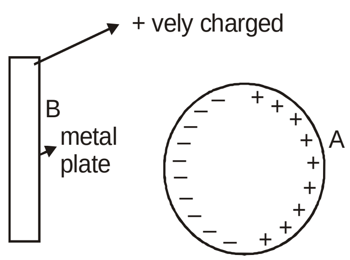
Q.18 (3)

Q.19 (3)
P = qd
$1 \times 10^{-6} \times 2 \times 10^{-2} = 2\times10^{-8}$
Maximum torque
$\tau = PE = 2 \times 10^{-2}$Nm

Q.20 (1)

Q.21 (3)
max PE $\Rightarrow$ position of unstable equilibrium $\Rightarrow \theta = \pi$.

Q.22 (2)



The given diagram shows induction on sphere (metallic) due to metal plate.
Since distance between plate and –ve charge is less than that between plate and +ve charge. electric force acts on object towards plate.

Q.23 (1)
Car (A conductor) behaves as electric field shield in which a person remains free from shock.

Q.24 (2)
Depends on body either conductor or non-conducting.

Q.25 (1)
$Q_t = Q_1 + Q_2 = 150\mu C$

$$\frac{Q_1'}{Q_2'} = \frac{C_1}{C_2} = \frac{1}{2} \Rightarrow Q_1' = 50\mu C$$

$Q_2' = 100\mu C$
25μC charge will flow from smaller to bigger sphere .

Q.26 (1)
$C = 4\pi\varepsilon_o R$

$$R = \frac{C}{4\pi \epsilon_0} = 1 \times 10^{-6} \times 9 \times 10^{9} = 9 \text{ km}$$

Q.27 (4)
Charge / Current flows from higher to lower potential or Q/C ratio.

Q.28 (4)

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

where k = dielectric constant of medium between the plates
A = Area, d = distance between the plates

Q.29 (3)
$Q_1 = 900\mu C$ $Q_2 = 2500\mu C$
When the two capacitors are connected together let the common potential is V.

$$900 + 2500 = (3 + 5)V$$

$$V = \frac{3400}{8} = 425V$$

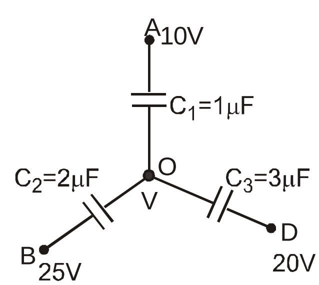
Q.30 (1)

$$E = \frac{1}{2}\varepsilon_o E^2$$

$$2.2 \times 10^{-10} = \frac{1}{2}\ 8.8 \times 10^{-12} E^2$$

$E = 7$ NC^{-1}

Q.31 (1)



From junction law
$(V - 10)1 + (V - 20)3 + (V + 25)2 = 0$
$6V = 120$
$V = 20$ Volt

Q.32 (1)

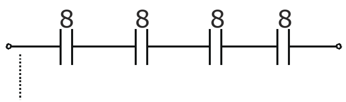
$$V_1 : V_2 = \frac{1}{C_1} : \frac{1}{C_2} = C_1 : C_2$$

$$\frac{V_1}{V_2} = \frac{C_1}{C_2} = \frac{1}{4}$$

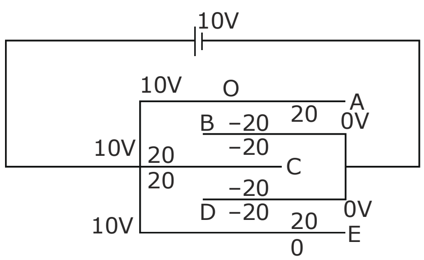
Q.33 (4)

To form a composite of 1000 V we need 4 capacitance in series.

4 capacitance in series means in each branch capacitance is 2 μF. So 8 branches are needed in parallel. So a total of 8 × 4 = 32 capacitors are required.



Q.34 (2)



Total charge on plate C = 40 μC

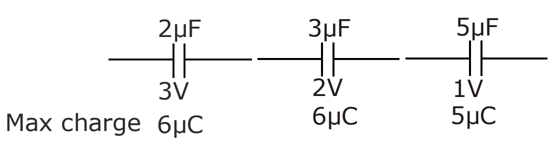
Q.35 (1)

Maximum charge on first capacitor $q_{1_{max}}$ = 160μC

Maximum charge on second capacitor $q_{2_{max}}$ = 1280 μC.

As capacitors are connected in series. Hence maximum charge they can store is 160μC.

Q.36 (2)



Hence maximum charge that the series can with stand is 5 μC. So break down voltage $= 5 \times \frac{31}{30} = \frac{31}{6}$ volt

Q.37 (2)

Force between the plates is given by

$$\frac{\sigma^2 A}{2 \epsilon_0} \text{ or}$$

$$F = q\frac{E}{2} = \frac{1 \times 10^{-6} \times 10^5}{2}$$

[$\frac{E}{2}$ as electric field is due to charges on a single plate is to be written] $\frac{0.1}{2} N = 0.05 Nt$

Q.38 (3)

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

$$= \frac{1}{2} \times 4 \times 10^{-6} \times (1 \times 10^3)^2$$

= 2 Joules.

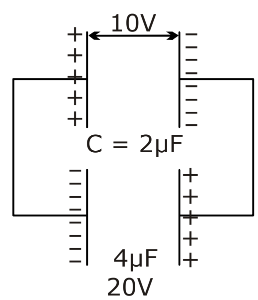
Q.39 (2)

$$W = U_f - U_i = \frac{1}{2}CV_f^2 - \frac{1}{2}CV_i^2 = \frac{1}{2} C(40^2 - 20^2)$$

W = 600 C

$$W_1 = \frac{1}{2} C(50^2 - 40^2) = \frac{900}{2} C \qquad W_1 = \frac{900}{2} \cdot \frac{W}{600} = \frac{3}{4} W$$

Q.40 (2)



Before connection

$Q_1 = 2 \times 10 = 20$, $Q_2 = 4 \times 20 = 80$

$$U_i = \frac{1}{2} 2(10)^2 + \frac{1}{2} 4(20)^2 = 900 \text{ J}$$

Since connected as shown

After $Q_{net} = -20 + 80$

Connection =60

$$V = \frac{60}{2+4} = 10 \text{ Volt}$$

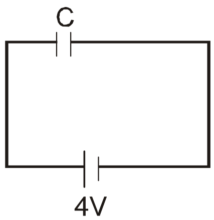
$$U_f = \frac{1}{2} 6(10)^2 = 300 \text{ J}$$

Heat generated $= -U_f + U_i = 600$ J

Q.41 (2)

$$C' = \frac{\epsilon_0 A}{d/2} = \frac{2\epsilon_0 A}{d} = 2C.$$

Q.42 (3)



Here, Potential difference on the capacitor will depend on emf of battery i.e., 4V

Q.43 (1) $U_0 = \frac{1}{2}CV^2$ (given)

Now energy = $U' = \frac{1}{2}C'V^2$

$C' = CK$

$U' = \frac{1}{2}CV^2K = U_oK$

Q.44 (3) Now, charge remains same on the plates.

$U_0 = \frac{Q^2}{2C}$ (given)

Now energy $= U' = \frac{Q^2}{2C'} = \frac{Q^2}{2CK} = \frac{U_0}{K}$

Q.45 (3) For metal $k = \infty$
Hence from formula.

$C_{eq} = \frac{\epsilon_0 A}{d - t + t/k}$

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

Q.46 (3) $V_i = E_i d = \frac{\sigma}{\epsilon_0} d = 3000$

$V_f = E_f d = \frac{\sigma}{\epsilon} d = 1000$

$\Rightarrow \frac{\epsilon}{\epsilon_0} = 3 \Rightarrow \epsilon = 3\epsilon_0 = 27 \times 10^{-12}\ C^2/Nm^2$

Q.47 (1) $V_{max} = E_{max} d_{max} = 4000$

$d = \frac{4000}{18 \times 10^6}$

Now, $C = \frac{\epsilon_0 KA_{min}}{d_{max}} = 7 \times 10^{-2}$ μf

$A = \frac{7 \times 10^{-2} \times 10^{-6} \times 4000}{8.85 \times 10^{-12} \times 2.8 \times 18 \times 10^6} = 0.63\ m^2$

Q.48 (2) Initially $C_{eq} = \frac{C}{2}$

So, $Q_1 = C_{eq} V = \frac{C}{2} E$

Finally $C_{eq} = \frac{C(KC)}{C + CK} = \frac{KC}{1 + K}$

So, $Q_2 = C'_{eq} E = \frac{KCE}{1 + K}$

So, change flow throw battery = $Q_2 - Q_1$

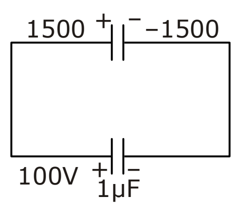
$\Delta q = CE\left[\frac{K}{1 + K} - \frac{1}{2}\right]$

$\Delta q = \frac{CE(K - 1)}{2(1 + K)}$

Q.49 (2) Charge on 15 μF capacitor A = 1500 μC.
Charge on capacitor B = 100 μC.
When they are connected with dielectric removed from A the capacitor.
Capacitance of A now becomes 1 μF.

$C_i = \frac{\varepsilon_0 A.15}{d} = 15C = 15\mu F,$

$C_f = \frac{\varepsilon_0 A}{d}$ $C = 1\mu F$



Q remains constant
$Q_{net} = C_{eq} \times V_{common}$
$1500 + 100 = 2V$
$V = 800$ Volt

Q.50 (i) (1)

$i_0 = \frac{V}{R} = \frac{6}{24} = 0.25$ A

(ii) (2)
$i = i_0 e^{-t/RC}$
$= 0.25\ e^{-1}$

$= \frac{0.25}{e} = 0.09$ A.

EXERCISE-IV

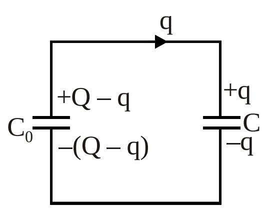
Q.1 [0002]
Q.2 [0024]
Q.3 [2.55]
Q.4 [0006]
Q.5 [– 9.6]
Q.6 [5.2]

Q.7 [0012] $\frac{1}{2}\times\frac{4\times 9}{4+9}=26^2=\frac{1}{2}\times(4+9)\,v^2$

$v = 26\times\frac{6}{13}=12$

Q.8 [0030] $\frac{q}{C}=\frac{Q-q}{C_0}\quad\Rightarrow q\left(\frac{C+C_0}{CC_0}\right)$

$=\frac{Q}{C_0}$



$\therefore \frac{q}{C}=\frac{Q}{C+C_0}=\frac{C_0V_0}{C+C_0}\Rightarrow\frac{10}{C+10}\times 12=3$

$\therefore C=30$

Q.9 [0025] $F=\frac{Q^2}{2A\in_0}=\frac{c^2v^2}{2A\in_0}=\frac{\in_0 A}{2d^2}v^2$

$=\frac{8.85\times10^{-12}\times17.7\times10^{-4}\times500^2}{2\times(8.85\times10^{-3})^2}$

$=\frac{10^{-16}\times25\times10^4}{10^{-6}}=25\mu N$

Q.10 [0119] $Q=CV$

$V=-\int_{-3}^{4}E\,dx=-20\int_{-3}^{4}\left(x^2+\frac{4}{3}\right)dx$

$V=-2Q\left[\frac{x^3}{3}+\frac{4x}{3}\Big|_{-3}^{4}\right]$

$V=-2Q\left[\frac{1}{3}[64+27]+\frac{4}{3}[7]\right]$

$\frac{Q}{C}=3Q\left[\frac{119}{3}\right]$

$\frac{1}{C}=119\ F^{-1}$

Q.11 (1)
Statement-I is **T**. Statement-II is **T**

Q.12 (1)
Statement-I is **T**. Statement-II is **T**

Q.13 (2)
Q.14 (3)
Q.15 (1)
Q.16 (3)

PREVIOUS YEAR'S

MHT CET

Q.1 (3)
Q.2 (1)
Q.3 (4)
Q.4 (1)
Q.5 (2)
Q.6 (4)

Given, mass of both particle = m
charge of particle, A = +q
charge of particle, B = +4q
Potential difference = V
Kinetic energy is given by

$K=\frac{1}{2}mv^2$ ....(i)

This energy is equal to electrostatic potential energy is k=V×Q ....(ii)

From Eqs. (i) and (ii), we have

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

For particle A,

$qV=\frac{1}{2}mv_A^2$ ....(iii)

For particle B,

$4qV=\frac{1}{2}mv_B^2$ ....(iv)

Dividing Eq. (iii) by Eq. (iv), we get

$$\frac{1}{4}=\frac{v_A^2}{v_B^2}$$

$$\Rightarrow \frac{v_A}{v_B}=\frac{1}{2}$$

Hence, the ratio of their speed $\frac{v_A}{v_B}=\frac{1}{2}$

Q.7 (4)

$$E=-\frac{\partial V}{\partial x}\hat{i}-\frac{\partial V}{\partial y}\hat{j}-\frac{\partial V}{\partial z}\hat{k}$$

$$\Rightarrow \mathbf{E_x}= -\frac{\partial V}{\partial x}=\frac{d}{dx}\left[\frac{20}{x^2-4}\right]=\frac{40x}{(x^2-4)^2}$$

$$\Rightarrow E_x = \text{at } x = 4\ \mu m = \frac{10}{9} V/\mu m$$

and is along + ve x - direction.

Q.8 (4) Electric field intensity due to a charged spherical shell is given by

$$E=\frac{q}{4\pi\varepsilon_0 r^2}\Rightarrow E\propto\frac{1}{r^2}$$

Electric potential due to a point charge is given by

$$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r}\Rightarrow V\propto\frac{1}{r}$$

Q.9 (3) Electric field, $E=-\frac{d\phi}{dt}=\frac{-d}{dt}\left(ar^2+b\right)=-2ar$

By Gauss's theorem, $E\left(4\pi r^2\right)=\frac{q}{\varepsilon_0}$

$\Rightarrow \quad q=-8\pi\varepsilon_0 ar^2$

$\therefore$ Charge density,

$$\rho=\frac{dq}{dV}=\frac{dq}{dr}\times\frac{dr}{dV}=\left(-24\pi\varepsilon_0 ar^2\right)\times\frac{1}{4\pi r^2}$$

$\Rightarrow \rho=-6\varepsilon_0 a$

Q.10 (4) Given, $V=2xy+3zx-yz$

$\therefore$ Electric field, $E=-\frac{dV}{dx}\hat{i}-\frac{dV}{dy}\hat{j}-\frac{dV}{dz}\hat{k}$

$$=(-2y-3z)\hat{i}-(2x-z)\hat{j}-(3x-y)\hat{k}$$

$$E_{at(0,1,1)}=(-2-3)\hat{i}-(0-1)\hat{j}-(0-1)\hat{k}$$

$$=-5\hat{i}+\hat{j}+\hat{k}$$

Q.11 (4)	**Q.12** (4)	**Q.13** (1)	**Q.14** (4)	**Q.15** (3)
Q.16 (1)	**Q.17** (1)	**Q.18** (1)	**Q.19** (2)	**Q.20** (4)
Q.21 (2)	**Q.22** (2)	**Q.23** (4)	**Q.24** (2)	**Q.25** (1)
Q.26 (1)	**Q.27** (2)	**Q.28** (1)	**Q.29** (1)	**Q.30** (4)
Q.31 (4)	**Q.32** (1)	**Q.33** (4)	**Q.34** (4)	

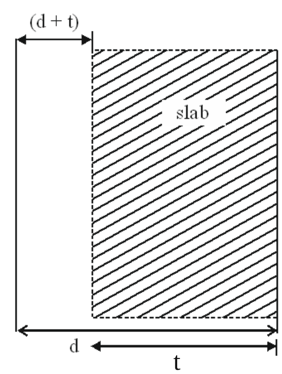
Q.35 (3)

The given situation can be shown as

The capacitance of a parallel plate capacitor is given by

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

The above circuit can be considered to be combination of two series capacitors as



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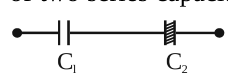


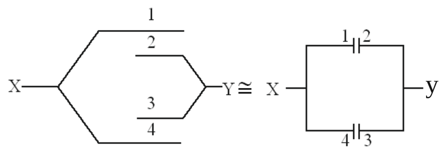
$$\therefore \frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}=\frac{(d-t)}{\varepsilon_0 A}+\frac{1}{k\varepsilon_0 A}$$

$$=\frac{k(d-t)+t}{\varepsilon_0 A}\ \frac{R_c}{4}$$

$$\Rightarrow C=\frac{\varepsilon_0 A}{d-t\left(1-\frac{1}{k}\right)}$$

Q.36 (2)

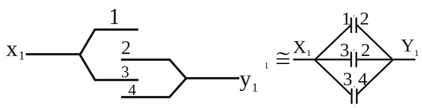
Let X(1,4) be positive plate and Y (2,3) be negative plates.



The equivalent capacitance is just a parallel combination of two capacitors, therefore,

$$C_1 = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$$

Now,



the equivalent capacitance is just a parallel combination of three capacitors. Therefore,

$$C_2 = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{3\varepsilon_0 A}{d}$$

Therefore, $\frac{C_1}{C_2} = \frac{2}{3}$

Q.37 (3) For air capacitor, $C_0 = \frac{\varepsilon_0 A}{d} = 18\mu F$ ....(i)

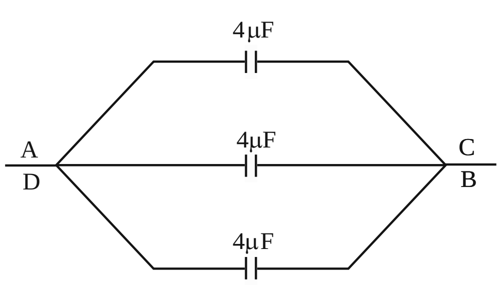
When dielectric slab is introduced between plates and distances in tripled, then

$$C_0 = \frac{K\varepsilon_0 A}{3d} = 72\mu F \quad .....(ii)$$

Dividing Eq. (ii) by Eq. (i), we get

$$\frac{K}{3} = \frac{72}{18} \Rightarrow K = 12$$

Q.38 (4) The given circuit diagram is drawn as



Hence, given capacitors are in parallel combination.

$\therefore C_{AB} = 4 + 4 + 4 = 12\mu F$

Q.39 (4) Since, two capacitors in the middle are in parallel, so their equivalent capacitance,

$$C' = 2 + 2 = 4\mu F$$

Now, C′ and remaining two capacitors are in series, so their equivalent capacitance,

$$\frac{1}{C''} = \frac{1}{2} + \frac{1}{2} + \frac{1}{4} = \frac{5}{4}$$

$$\Rightarrow C'' \text{ or } C_{AB} = \frac{4}{5}\mu F = \frac{4}{5} \times 10^{-6} F$$

$$\therefore \text{ Energy stored, } U = \frac{1}{2} C_{AB} V_{AB}^2$$

$$= \frac{1}{2} \times \frac{4}{5} \times (10)^2 \times 10^{-6}$$

$$= 40 \times 10^{-6} J = 400 \times 10^{-7} J$$

Q.40 (2) Since, two capacitors are in parallel, so area of each plate = A/2

Also, capacitance, $C = \frac{\varepsilon_0 A}{d}$

$$\Rightarrow C_1 = \frac{\varepsilon_0 A}{2d} \text{ and } C_2 = \frac{\varepsilon_0 A}{2(d+b)}$$

$\therefore$ Equivalent capacitance or capacity of the combination will be

$$C_{eq} = C_1 + C_2 = \frac{\varepsilon_0 A}{2d} + \frac{\varepsilon_0 A}{2(d+b)}$$

$$= \frac{\varepsilon_0 A}{2}\left[\frac{1}{d} + \frac{1}{(d+b)}\right] = \frac{\varepsilon_0 A}{2}\left[\frac{d+b+d}{d(d+b)}\right]$$

$$= = \frac{\varepsilon_0 A}{2d}\left[\frac{2d+b}{d+b}\right]$$

Q.41 (4) Heat = Energy loss = $\frac{1}{2}\frac{C_1 C_2}{C_1 + C_2}(V_1 - V_2)^2$

Here, $V_1 = 100$ V and $V_2 = -100$ V

(– ve sign signifies that the capacitor is connected in opposite manner)

$$\therefore \text{Loss} = \frac{1}{2} \times \left(\frac{2 \times 3}{2+3}\right) \times 10^{-6} \times [100 - (-100)]^2$$

Loss = 24×10^{-3}J = 24 mJ

Q.42 (4) Given, C = 5μF

Potential of a capacitor without dielectric,

$$V = \frac{Q}{C} = \frac{Qd}{A\varepsilon_0}$$

Potential of capacitor with dielectric,

$$V' = \frac{Q}{C'} = \frac{Qd}{KA\varepsilon_0} = \frac{V}{K}$$

Given, $V' = V/8$, so on comparing, we get
$\Rightarrow K = 8$

NEET/AIPMT

Q.1 (2)

$$Q_1 = Q - \frac{Q}{4},\ Q_2 = -Q + \frac{Q}{4}$$

$$F_1 = \frac{kQ^2}{r^2};\ F_2 = \frac{k\left(\frac{3}{4}Q\right)\left(\frac{3}{4}Q\right)}{r^2}$$

$$\frac{F_2}{F_1} = \frac{9}{16}$$

Q.2 (4)

Q.3 **(1)**

Q.4 (1)

Q.5 (3)

Q.6 (3)

Q.7 **(1)**

$$V = \frac{1}{4\pi \epsilon_0}.\frac{Q}{R}$$

$$\frac{1}{4\pi \epsilon_0} = \text{constatnt}$$

Q = same (Given)

$$\therefore V \propto \frac{1}{R}$$

$\therefore$ Potential is more on smaller sphere.

Q.8 (2)
Q = CV

$$\frac{dQ}{dt} = i = C\frac{dv}{dt} = 20\ \mu F \times \frac{3V}{s}$$

$= 60\ \mu A$
For circuit to be completed displacement current should be equal to conduction current.

Q.9 **(2)**

Q.10 **(2)**

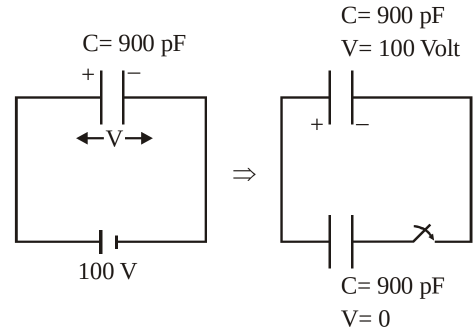
Q.11 **(1)**

Q.12 (1)

Q.13 (1)

Q.14 (2)

Q.15 (2)



Common potential

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

$$= \frac{C \times 100 + C \times 0}{C + C}$$

= 50 Volt
Electrostatic energy stored

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

$= 900 \times 10^{-12} \times 50 \times 50$
$= 225 \times 10^{-8}$ J
$= 2.25 \times 10^{-6}$ J

JEE MAIN

Q.1 (3)

Q.2 **(198)**

Q.3 (1)
(Properties of conductor)
Statement-I : True as body of conductor acts as equipotential surface.
Statement-II : True, as conductor is equipotential. Tangential component of electric field should be zero. Therefore electric field should be perpendicular to surface.

Q.4 (3)

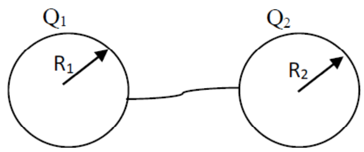
Electric field between plates $E = \frac{q_1 - q_2}{2A \epsilon_0}$

$$V = Ed = \frac{q_1 - q_2}{2A \epsilon_0}d$$

$$V = \frac{q_1 - q_2}{2C}$$

Q.5 (2)

At equilibrium, their potential will be same as they are connected by a conducting wire.



Given: $R_1 = 5$mm and $R_2 = 10$ mm.
Let at equilibrium, charge on both the spheres be Q_1 and Q_2 respectively. Then,
$V_1 = V_2$

$$\Rightarrow \frac{KQ_1}{R_1} = \frac{KQ_2}{R_2}$$

$$\Rightarrow \frac{Q_1}{R_1} = \frac{Q_2}{R_2}$$

$$\Rightarrow \frac{Q_1}{Q_2} = \frac{R_1}{R_2} = \frac{5}{10} = \frac{1}{2}$$

Now, electric field on surface of spherical conductor is given by $E = \frac{KQ}{R^2}$.

$$\therefore \frac{E_1}{E_2} = \frac{\frac{KQ_1}{R_1^2}}{\frac{KQ_2}{R_2^2}} = \frac{Q_1}{Q_2} \times \frac{R_2^2}{R_1^2}$$

$$= \frac{E_1}{E_2} = \frac{1}{2} \times \left(\frac{10}{5}\right)^2 = 2 \quad \therefore \frac{E_1}{E_2} = \frac{2}{1}$$

Q.6 (6)

$|\tau|_{max} = PE$

$$\frac{\tau_1}{\tau_2} = \frac{P_1E_1}{P_2E_2} = \frac{1.2 \times 10^{-30} \times 5 \times 10^4}{2.4 \times 10^{-30} \times 15 \times 10^4} = \frac{1}{6}$$

Hence x = 6

Q.7 (4)

Given that
Area of each plate = 30 π cm^2 or 30π × $(10^{-2})^2$ m^2
Dielectric strength E = 3.6 × 10^7 V/m
Maximum charge stored is Q = 7 × 10^{-6} C
To avoid the dielectric breakdown
Dielectric strength (E) = E_0
....(1)
where E_0 electric field between the plate

$$E_0 = \frac{\sigma}{K\varepsilon_0} \quad ....(2)$$

$$\left[\sigma = \frac{Q}{A}\right]$$

Equation (1) and (2) to

$$E = \frac{Q}{KA\varepsilon_0}$$

$$3.6 \times 10^7 = \frac{7 \times 10^{-6}}{K \times 30\pi(10^{-2})^2 \times 8.85 \times 10^{-12}}$$

$K = 0.0023 \times 10^3$
$K = 2.33$

Q.8 (1)

$Q_1 = Q$
$Q_2 = Q + 2$

$$U_1 = \frac{Q^2}{2C}$$

$U_2 = U_1 + U_1 \times 44\%$ ......(given)
$U_2 = 1.44\ U_1$

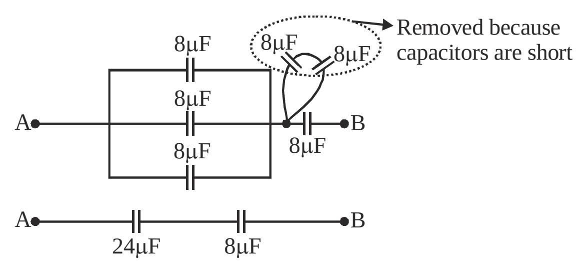
$$\frac{(Q+2)^2}{2C} = 1.44 \times \frac{Q^2}{2C}$$

$$\left(\frac{Q+2}{Q}\right)^2 = 1.44$$

$$\frac{Q+2}{Q} = 1.2$$

$Q + 2 = 1.2Q$
$0.2Q = 2$
$Q = 10C$

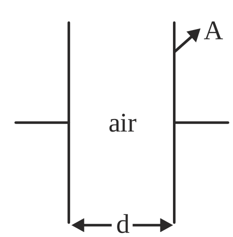
Q.9 **[6]**



Equivalent capacitance

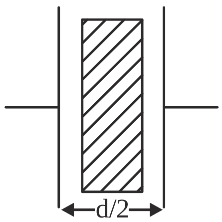
$$= \frac{24 \times 8}{24 + 8} = \frac{24 \times 8}{32} = 6\mu F$$

Q.10 (1)



$C = \frac{\varepsilon_0 A}{d}$ ...(1)

When metal sheet of d/2 width is placed inside the capacitor-



dielectric constant for metal $\rightarrow \infty$

$$C' = \frac{\varepsilon_0 A}{\left(\frac{t_1}{k_1} + \frac{t_2}{k_2} + ...\right)}$$

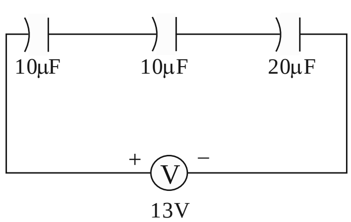
$$C' = \frac{\varepsilon_0 A}{\frac{d/2}{1} + \frac{d/2}{\infty}} = \frac{\varepsilon_0 A}{d/2}$$

$$C' = 2\frac{\varepsilon_0 A}{d} \quad ...(2)$$

$$\frac{C'}{C} = \frac{\left(2\frac{\varepsilon_0 A}{d}\right)}{\frac{\varepsilon_0 A}{d}} = \frac{2}{1} \Rightarrow \boxed{\frac{C'}{C} = \frac{2}{1}}$$

Q.11 (A)

Q.12 **(1)**



$$\frac{1}{C_{eq}} = \frac{1}{10} + \frac{1}{15} + \frac{1}{20} = \frac{12+8+6}{120} = \frac{26}{120}$$

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

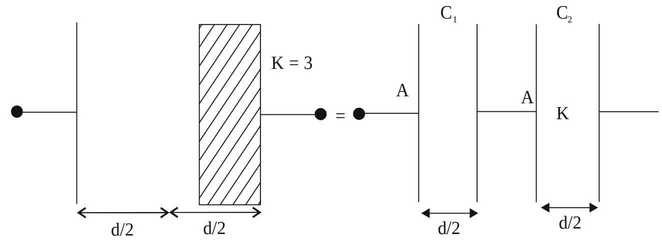
$$Q = \frac{13 \times 60}{13} = 60\mu C$$

Charge on each capacitor is same

$\because$ they are in series.

Q.13 **(3)**

$$C_{original} = \frac{A\varepsilon_0}{f}$$



$$C_1 = \frac{A\varepsilon_0}{d/2} = \frac{2A\varepsilon_0}{d} = C$$

$$C_2 = \frac{KA\varepsilon_0}{d/2} = \frac{2KA\varepsilon_0}{d} = \frac{6A\varepsilon_0}{d} = 3C$$

C_1 & C_2 are in series

$$C_{new} = \frac{C_1C_2}{C_1 + C_2} \quad \frac{C \times 3C}{C + 3C} = \frac{3C}{4} = \frac{3}{4} = \frac{2A\varepsilon_0}{d} = \frac{3}{2} \times \frac{A\varepsilon_0}{d}$$

$$C_{new} = \frac{3}{2}C_{original}$$

$$= \frac{3}{2} \times 4 = 6\mu F$$

Q.14 **(125)**

$$\text{Energy loss} = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$$

$$= \frac{1}{2}\frac{50 \times 50 \times 10^{-12} \times 10^{-12}}{(50+50)10^{-12}}(100-0)^2 = 125nJ$$

Q. 15 (23)

Parallel combination

$$C_{eq} = \varepsilon_0 A\left[\frac{1}{5b} + \frac{1}{3b} + \frac{1}{b}\right] = \frac{23}{15}\frac{\varepsilon_0 A}{b}$$

Q.16 (A)

$K_1 = 10$ $K_2 = 15$

$U_i = \frac{1}{2}(K_1C)V^2$ $U_f = \left(\frac{1}{2}K_2C\right)V^2$

$U_i = \frac{1}{2}10CV^2$ $U_f = \frac{1}{2}15CV^2$

$\frac{\Delta U}{U_i} = \frac{U_f - U_i}{U_i} = \frac{5}{10}$ $\frac{\Delta U}{U_i} \times 100 = \frac{5}{10} \times 100$

$\therefore$ 50% increases

Q.17 (1)

Charge Q is 0 to 5C steadily

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

$V_{max} = \frac{5}{2\times10^{-6}} \Rightarrow V_{max} = 2.5\times10^{6}$ volt

$V \propto Q$

$\{Q \text{ is steadily so } V \text{ is also steadily}\}$

Q.18 (1)

$C = 4\pi\varepsilon_0 R_1$

$C' = \frac{4\pi\varepsilon_0 R_1 R_2}{R_2 - R_1}$

C' = nC

$\frac{4\pi\varepsilon_0 R_1 R_2}{R_2 - R_1} = n.4\pi\varepsilon_0 R_1$

$\frac{R_2}{R_2 - R_1} = n$

$\frac{R_2/R_1}{R_2/R_1 - 1} = n$

$\frac{x}{x-1} = n$

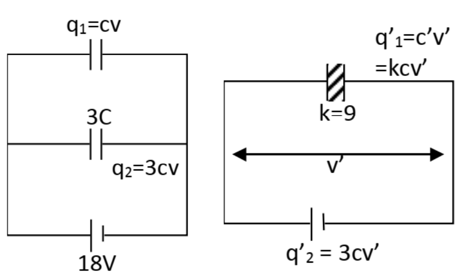
$x = nx - n$

$n = nx - x$

$n = (n-1)\,x$

$x = \frac{n}{n-1}$

Q.19 [6]



due to charge conservation

$q_1 + q_2 = q'_1 + q'_2$

$cv + 3cv = c'v' + 3cv'$

$4cv = v'(kc + 3c),\ k = 9$

$4cv = v'(12c)$

$v' = \frac{v}{3}$

$v' = \frac{18}{3} = 6$

Q.20 (1)

$C_{eq} = C_1 + C_2 + C_3 + C_4 = 1 + 2 + 3 + 4 = 10\ \mu F$

$q = C_{eq} V = 10\mu F \times 20 = 200\mu C$

Q.21 [60]

$C_1 = \frac{\epsilon_0\, kA}{t_1}$

$C_2 = \frac{\epsilon_0\, kA}{t_2}$

$$V_2 = \frac{C_1 \times 100}{C_1 + C_2} = \frac{\frac{\epsilon_0 k_1 A}{t_1}\times 100}{\frac{\epsilon_0 k_1 A}{t_1} + \frac{\epsilon_0 k_2 A}{t_2}}$$

$$= \frac{\frac{k_1}{t_1}\times 100}{\frac{k_1}{t_1} + \frac{k_2}{t_2}} = \frac{\frac{3}{0.5}\times 100}{\frac{3}{0.5} + \frac{4}{1}} = \frac{300}{5} = 60$$

$\boxed{V_2 = 60\text{volt}}$

Q.22 (3)

In case I, when the switch was closed and dielectric was not inserted :-

$E_1 = \frac{1}{2}(2C)V^2 = CV^2$

In case II, when the switch was open and dielectric was inserted :-

$E_2 = \frac{1}{2}(5C)V^2 + \frac{1}{2}\frac{Q^2}{5C}$

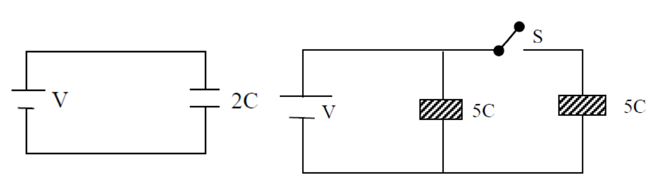
$\Rightarrow E_2 = \frac{1}{2}(5C)V^2 + \frac{1}{2}\frac{(CV)^2}{5C}$

$\Rightarrow E_2 = \frac{1}{2}(5C)V^2 + \frac{1}{10}CV^2$

$\Rightarrow E_2 = \left(\frac{5}{2} + \frac{1}{10}\right)CV^2 = \frac{26}{10}CV^2$

$\therefore E_2 = \frac{13}{5}CV^2$

Now, $\frac{E_1}{E_2} = \frac{5}{13}$



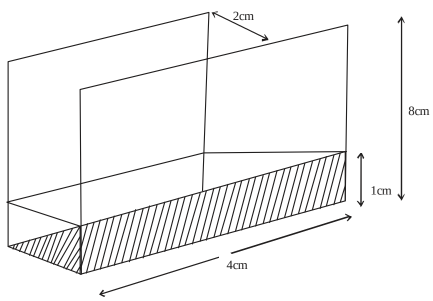
Q.23 [240]

$$v = \frac{1}{2}(C_{eq}V^2)$$

$$V = \frac{1}{2}\frac{\epsilon_0}{d}\left(KA_1 + A_2\right)V^2$$

$$V = \frac{\epsilon_0}{2}2\times10^{-3}\left(\frac{5\times1\times4}{100\times100}\right)$$

$$\left(\frac{7\times4}{100\times100}\right)(20)^2$$



$$= \frac{\epsilon_0}{2}\frac{48}{2\times10^{-3}}\times\frac{20\times20}{100\times100} = 240\ \epsilon_0$$

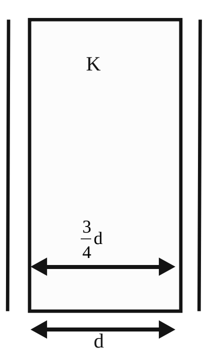
Q.24 (1)

$$C_{eq} = \frac{C(KC)}{C+KC} = \frac{KC}{K+1}$$

$$24 = \frac{K40}{K+1}$$

$[K = 1.5]$

Q.25 (1)



$$C_0 = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{\varepsilon_0 A}{\frac{d}{4}+\frac{3d}{4k}}$$

$$= \frac{4k\varepsilon_0 A}{(k+3)d}$$

$$c = \frac{4k}{3+k}\ C_0$$

CURRENT ELECTRICITY

EXERCISE-I (MHT CET LEVEL)

Q.1 (3) $R_G = 60.00\Omega$, shunt resistance, $r_s = 0.02\Omega$

Total resistance in the circuit is $R_G + 3 = 63\Omega$

Henc, I = 3/63= 0.048A

Resistance of the galvanometer converted to an ammeter is

$$\frac{R_G r_s}{R_G + r_s} = \frac{60\Omega \times 0.01\Omega}{(60+0.02)\Omega} = 0.02\Omega$$

Total resistance in the circuit = 0.02+3 = 3.02Ω

Q.2 (4) Number of electrons per kg of silver

$$= \frac{6.023\times10^{26}}{108}$$

Number of electrons per unit volume of silver

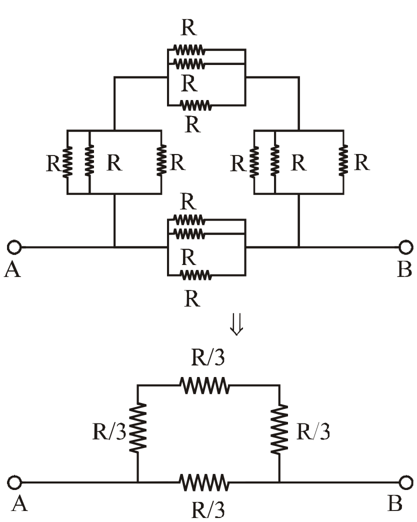
$$n = \frac{6.023\times10^{26}}{108} \times 10.5\times10^3 \quad v_d = \frac{I}{neA}$$

$$= \frac{20}{6.023\times10^{26}\times10.5\times10^3\times1.6\times10^{-19}\times3.14\times10^{-6}}\times108$$

Q.3 (2) Drift velocity
so $v_d \propto V$

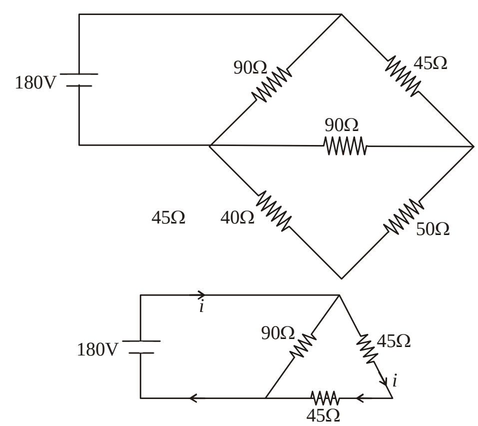
Q.4 (4) **Q.5** (3) **Q.6** (2) **Q.7** (2) **Q.8** (1)
Q.9 (4) **Q.10** (4) **Q.11** (4) **Q.12** (3) **Q.13** (4)
Q.14 (2) **Q.15** (4) **Q.16** (2) **Q.17** (2) **Q.18** (1)
Q.19 (1)

Q.20 (4) Redraw the given circuit,



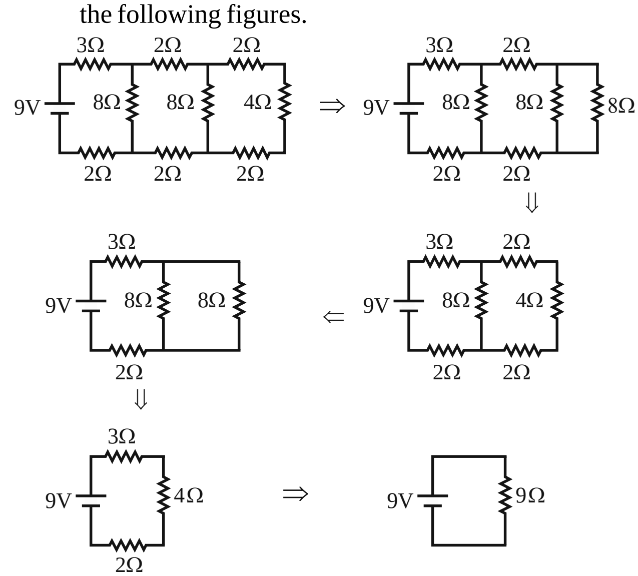
between
where, R = 16Ω
$R_{net} = 4\Omega$

Q.21 (2)
Q.22 (1)
Q.23 (3)
Q.24 (1)
Q.25 (3)
Q.26 (1)
Q.27 (3)



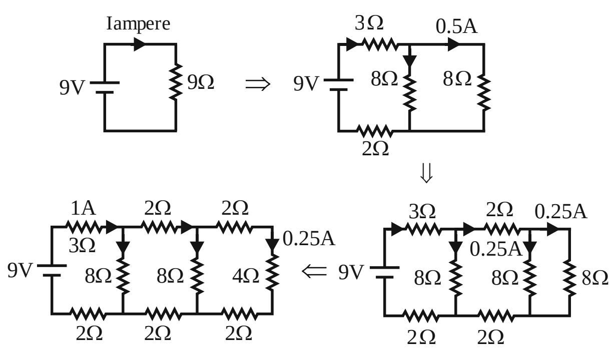
$$i\frac{180}{90} = 2A$$

Q.28 (4) The net resistance of the circuit is 9Ω as shown in the following figures.



$$I=\frac{V}{R}=\frac{9V}{9\Omega}=1.0A$$

The flow of current in the circuit is as follows.



The current divides into two equal if passes through two equal resistances in parallel.
Thus current through 4Ω resistor is 0.25 A.

Q.29 (2)
Q.30 (4)
Q.31 (4)
Q.32 (2)
Q.33 (2)
Q.34 (1)
Q.35 (4)
Q.36 (2)
Q.37 (2)
Q.38 (3)
Q.39 (4)

Q.40 (3) $P=\frac{V^2}{R_{eq}}$ ...(i)

$$\frac{1}{R_{eq}}=\frac{1}{R}+\frac{1}{5}=\frac{5+R}{5R}\quad R_{eq}=\left(\frac{5R}{5+R}\right)\quad P=30W$$

Substituting the values in equation (i)

$$30=\frac{(10)^2}{\left(\frac{5R}{5+R}\right)}\Rightarrow R=10\Omega$$

Q.41 (2) $\therefore 4i_1+2(i_1+i_2)-3+4i_1=16V$ .....(i)

Using Kirchhoff's second lawin the closed loop we have

. $9-i_2-2(i_1+i_2)=0$ ....(ii)

Solving equations (i) and (ii), we get $i_1=1.5A$ and

$i_2=2A$

$\therefore$ current through 2Ω resistor $=2+1.5=3.5A$

Q.42 (2)
Q.43 (4)
Q.44 (1)
Q.45 (4)
Q.46 (4)
Q.47 (2)

Q.48 (2) The heat produced is given by

$$H=\frac{V^2}{R} and R=\frac{r\ell}{\pi r^2}$$

$$\therefore\ H=V^2\left(\frac{\pi r^2}{r\ell}\right)$$

or $H=\left(\frac{\pi V^2}{\rho}\right)\frac{r^2}{\ell}$

Thus heat (H) is doubled if both length (ℓ) and radius (r) are doubled.

Q.49 (3)
Q.50 (4)
Q.51 (2)
Q.52 (2)

Q.53 (2) Potential gradient in the first case= $\frac{E_0}{l}$

$$E=\left(\frac{l}{3}\right).\left(\frac{E_0}{l}\right)=\frac{E_0}{3}\ \ldots\text{(i)}$$

Potential gradient in second case

$$\frac{E_0}{3}=\left(\frac{2E_0}{3l}\right)\times\Rightarrow\times=\frac{l}{2}$$

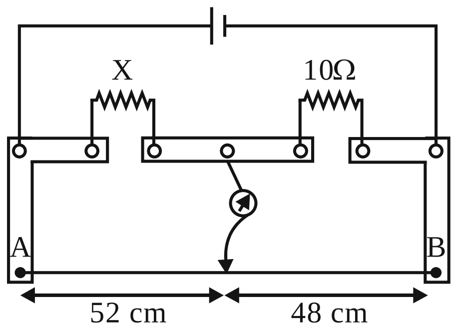
Q.54 (4) $(I-I_g)S=I_g\times G$
$(10-1)S=0.81$

$\boxed{S=0.09\Omega}$

Q.55 (4) Only number of free electrons is constant, other factors are temperature dependent.

Q.56 (4) Fuse wire should be such that it melts immediatley when strong current flows through the circuit. The same is possible if its melting point is low and resistivity is high.

Q.57 (2) At Null point



$$\frac{X}{\ell} = \frac{10}{\ell_2}$$

Here $\ell_1 = 52$ + End correction

$= 52 + 1 = 53$ cm

$\ell_2 = 48$ + End correction $= 48 + 2 = 50$ cm

$$\therefore \quad \frac{X}{53} = \frac{10}{50}$$

$$\therefore \quad X = \frac{53}{5} = 10.6\Omega$$

Q.58 (3) As the two cells oppose each other hence, the effective emf in closed circuit is 15–10=5 V and net resistance is 1+0.6=1.6Ω (because in the closed circuit the internal resistance of two cells are in series.

Current in the circuit, $I = \frac{\text{effective emf}}{\text{total resistance}} = \frac{5}{1.6}A$

The potential difference across voltmeter will be same as the terminal voltage of either cell. Since the current is drawn from the cell of 15V

$$\therefore V_1 = E_1 - Ir_1 = 15 - \frac{5}{1.6} \times 0.6 = 13.1V$$

Q.59 (1)
Q.60 (2)
Q.61 (1)
Q.62 (4)
Q.63 (1)
Q.64 (3)
Q.65 (1)
Q.66 (2)
Q.67 (2)
Q.68 (1)

EXERCISE-II (NEET LEVEL)

Q.1 (2) Density of Cu = 9×10^3 kg/m^3 (mass of 1 m^3 of Cu)

$\because$ 6.0×10^{23} atoms has a mass $= 63 \times 10^{-3}$ *kg*

$\therefore$ Number of electrons per m^3 are

$$= \frac{6.0 \times 10^{23}}{63 \times 10^{-3}} \times 9 \times 10^3 = 8.5 \times 10^{28}$$

Now drift velocity $= v_d = \frac{i}{neA}$

$$= \frac{1.1}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times \pi \times (0.5 \times 10^{-3})^2} = 0.1 \times 10^{-3} \text{ m/sec}$$

Q.2 (4) In case of stretching of wire $R \propto l^2$

$\Rightarrow$ If length becomes 3 times so Resistance becomes 9 times i.e. $R' = 9 \times 20 = 180\Omega$

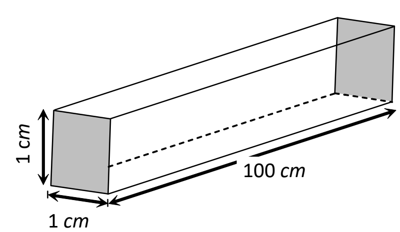
Q.3 (2) $R = \frac{\rho L}{A} \Rightarrow 0.7 = \frac{\rho \times 1}{\frac{22}{7}(1 \times 10^{-3})^2}$

$\rho = 2.2 \times 10^{-6}$ ohm-m.

Q.4 (2) $R \propto \frac{1}{A} \Rightarrow R \propto \frac{1}{A^2} \propto \frac{1}{d^2}$ [d = diameter of wire]

Q.5 (2) In the absence of external electric field mean velocity of free electron (V_{rms}) is given by $V_{rms} = \sqrt{\frac{3KT}{m}} \Rightarrow V_{rms} \propto \sqrt{T}$.

Q.6 (4) Length $l = 1$ cm $= 10^{-2}$ m



Area of cross-section A = 1 cm × 1 cm

$= 10^{-4}$ m^2

Resistance $R = \frac{\rho \ell}{A} = 3 \times 10^{-3}$

Q.7 (2) $R = \frac{\rho l}{a}$ for first wire and $R' = \frac{\rho l}{4a} = \frac{R}{4}$ for second wire.

Q.8 (1) $R = \rho\frac{l}{A} = \frac{m}{ne^2\tau}.\frac{l}{A}$

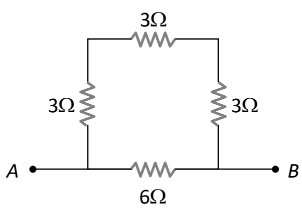
Q.9 (4) $R = 91 \times 10^2 \approx 9.1\ k\Omega$.

Q.10 (1)

Significant figures		Multiplier
Brown	Black	Brown
1	0	10^1

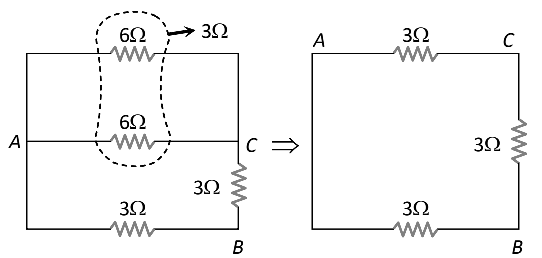
$\therefore R = 10 \times 10^1 = 100\ \Omega$

Q.11 (4) The circuit reduces to



$$R_{AB} = \frac{9\times 6}{9+6} = \frac{9\times 6}{15} = \frac{18}{5} = 3.6\Omega$$

Q.12 (2) Given circuit is equivalent to



So the equivalent resistance between points A and B

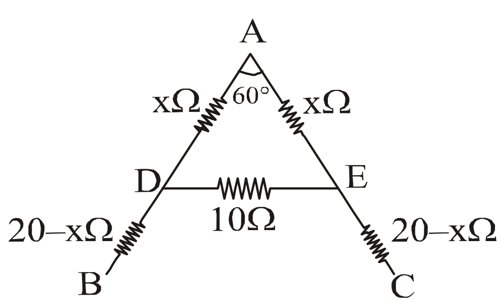
is equal to $R = \frac{6\times 3}{6+3} = 2\Omega$.

Q.13 (3) Equivalent resistance

$$= (5+10+15)\,||\,(10+20+30)$$

So, $R_{eq} = \frac{30\times 60}{30+60} = 20\Omega$

Q.14 (4)



For ADE $\frac{1}{R'} = \frac{1}{2x} + \frac{1}{10}$ or $R' = \frac{20x}{10+2x}$

$R_{BC} = \frac{20x}{10+2x} + 20 - x + 20 - x$ .... (i)

or $\frac{20x}{10+2x} + 40 = 2x$

Solving we get

$x = 10\Omega$

Putting the value of $x = 10\Omega$ in equation (i)

We get

$$R_{BC} = \frac{20\times 10}{10+2\times 10} + 20 - 10 + 20 - 10$$

$$\frac{80}{3} = 26.7\Omega$$

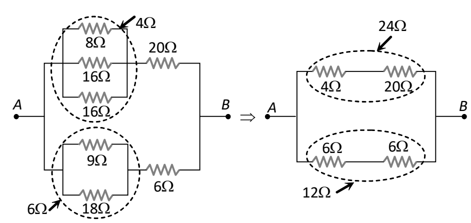
Q.15 (4) $R_1 = R_0(1+\alpha_1 t) + R_0(1+\alpha_2 t)$

$= 2R_0\left(1+\frac{\alpha_1+\alpha_2}{2}t\right)$ Comparing with

$R = R_0(1+\alpha t)$ $\alpha = \frac{\alpha_1+\alpha_2}{2}$

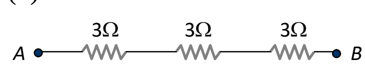
Q.16 (2)

Q.17 (2)



$$R_{AB} = \frac{24\times 12}{(24+12)} = 8\Omega$$

Q.18 (4) The network can be redrawn as follows



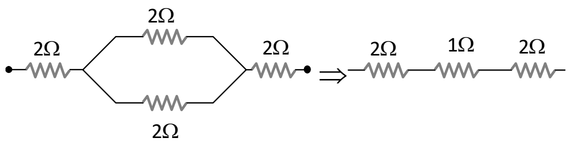
$\Rightarrow R_{eq} = 9\Omega$.

Q.19 (4) Three resistances are in parallel.

$\therefore \frac{1}{R'} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$

The equivalent resistance $R' = \frac{R}{3}\Omega$.

Q.20 (3) The given circuit can be redrawn as follows

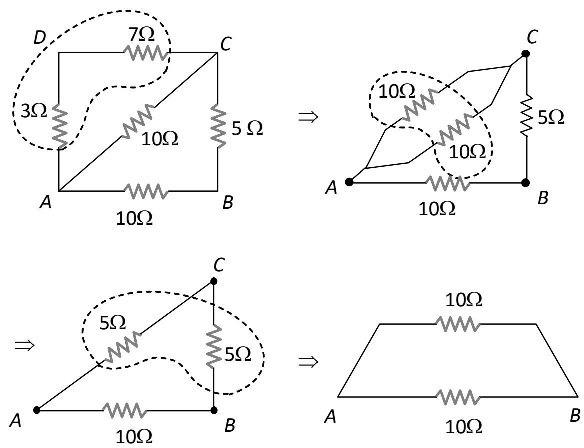


$\Rightarrow R_{eq} = 5\Omega.$

Q.21 (2) $R_{AB} = R_1 + \dfrac{R_2R_3}{R_2+R_3} + R_4 = 2 + \dfrac{4\times4}{4+4} + 2 = 6\Omega.$

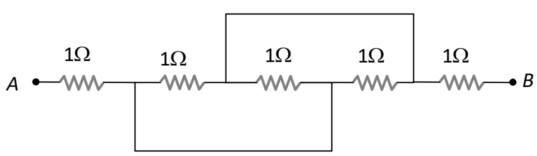
Q.22 (4) $R_{AB} = \dfrac{R}{3} + R = \dfrac{2}{3} + 2 = \dfrac{8}{3} = 2\dfrac{2}{3}\Omega.$

Q.23 (2) The figure can be drawn as follows



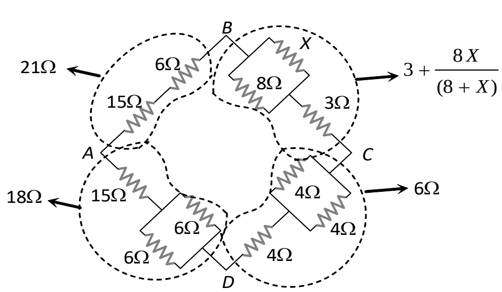
$\Rightarrow R_{AB} = 5\Omega.$

Q.24 (3)



$R_{AB} = 2 + \dfrac{1}{3} = 2\dfrac{1}{3}\Omega.$

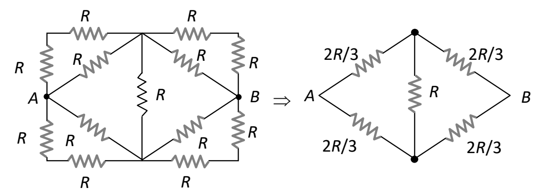
Q.25 (3) Potential difference between *B* and *D* is zero, it means Wheatstone bridge is in balanced condition



So $\dfrac{P}{Q} = \dfrac{R}{S}$

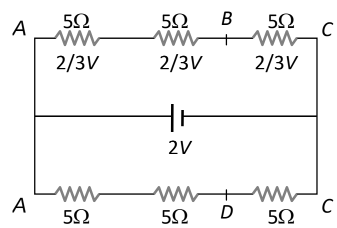
$\Rightarrow \dfrac{21}{3 + \dfrac{8X}{(8+X)}} = \dfrac{18}{6} \Rightarrow X = 8\Omega.$

Q.26 (3)



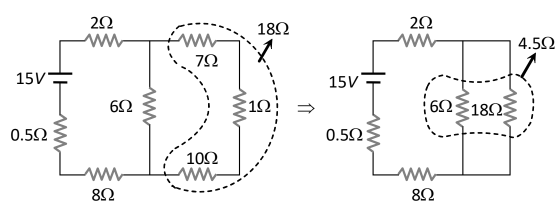
Hence $R_{eq} = \dfrac{2R}{3}.$

Q.27 (3) The given circuit can be redrawn as follows



For identical resistances, potential difference distributes equally among all. Hence potential difference across each resistance is $\dfrac{2}{3}$V and potential difference between *A* and *B* is $\dfrac{4}{3}$V.

Q.28 (1) The given circuit can be simplified as follows



On further solving equivalent resistance R = 15Ω

Hence current from the battery $i = \dfrac{15}{15} = 1A.$

Q.29 (4) Equivalent external resistance of the given circuit $R_{eq} = 4\Omega$

Current given by the cell $i = \dfrac{E}{R_{eq}+r} = \dfrac{10}{(4+1)} = 2A$

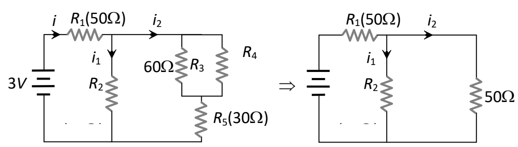
Hence, $(V_A - V_B) = \dfrac{i}{2} \times (R_2 - R_1) = \dfrac{2}{2}(2-4) = -2V.$

Q.30 (1) Equivalent resistance of the circuit $R = \frac{3}{2}\Omega$

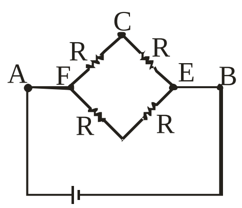
$\therefore$ Current through the circuit $i = \frac{V}{R} = \frac{3}{3/2} = 2A$.

Q.31 (3) Current through 6Ω resistance in parallel with 3Ω resistance = 0.4 *A*
So total current = 0.8 + 0.4 = 1.2 *A*
Potential drop across $4\Omega = 1.2 \times 4 = 4.8V$.

Q.32 (1) Equivalent resistance of the given network $R_{eq} = 75\,\Omega$.

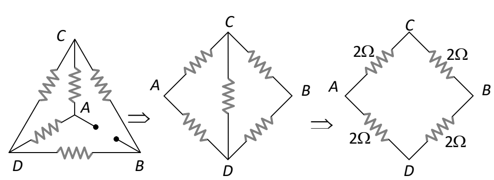


Q.33 (3) Equivalent diagram is



$I = \frac{V}{2R}$

Q.34 (4) The equivalent circuits are as shown below



Clearly, the circuit is a balanced Wheatstone bridge. So effective resistance between *A* and *B* is 2Ω.

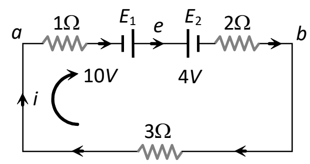
Q.35 (2) For no current through galvanometer, we have

$$\left(\frac{E_1}{500+X}\right)X = E \Rightarrow \left(\frac{12}{500+X}\right)X = 2 \Rightarrow X = 100\,\Omega.$$

Q.36 (3)

Q.37 (3)

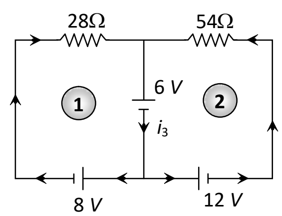
Q.38 (4) Since $E_1(10\,V) > E_2(4V)$
So current in the circuit will be clockwise.
Applying Kirchoff's voltage law
$-1 \times i + 10 - 4 - 2 \times i - 3i = 0$



$\Rightarrow i = 1A$(a to b via e)

$\therefore$ Current $= \frac{V}{R} = \frac{10-4}{6} = 1.0$ ampere

Q.39 (4) Suppose current through different paths of the circuit is as follows.



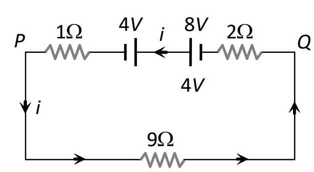
After applying KVL for loop (1) and loop (2)

We get $28i_1 = -6-8 \Rightarrow i_1 = -\frac{1}{2}A$

and $54i_2 = -6-12 \Rightarrow i_2 = -\frac{1}{3}A$

Hence $i_3 = i_1 + i_2 = -\frac{5}{6}A$.

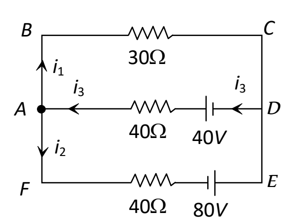
Q.40 (1) Applying Kirchoff's voltage law in the given loop.



$-2i + 8 - 4 - 1 \times 9i = 0$ $-2i + 8 - 4 - 1 \times i - 9i = 0 \Rightarrow i = \frac{1}{3}A$

Potential difference across PQ $= \frac{1}{3} \times 9 = 3V$.

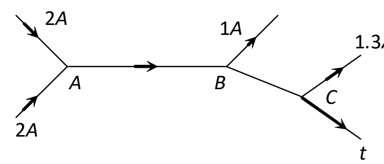
Q.41 (2) The circuit can be simplified as follows



Applying KCL at junction A
$\mathbf{i_3 = i_1 + i_2}$ .....(i)
Applying Kirchoff's voltage law for the loop ABCDA

$-30\,i_1 - 40i_3 + 40 = 0$
$\Rightarrow -30i_1 - 40(i_1 + i_2) + 40 = 0$
$\Rightarrow 7i_1 + 4i_2 = 4$ .....(ii)
Applying Kirchoff's voltage law for the loop ADEFA.
$-40i_2 - 40i_3 + 80 + 40 = 0$
$\Rightarrow -40i_2 - 40(i_1 + i_2) = -120$
$\Rightarrow i_1 + 2i_2 = 3$ ....(iii)
On solving equation (ii) and (iii) $i_1 = -0.4$ A

Q.42 (1) According to Kirchhoff's first law
At junction *A*, $i_{AB} = 2 + 2 = 4A$



At junction *B*,
At junction *C*, $i = i_{BC} - 1.3 = 3 - 1.3 = 1.7$ amp.

Q.43 (1) $i = \frac{12}{(4+2)} = 2A$

Energy loss inside the source $= i^2r = (2)^2 \times 2 = 8W$.

Q.44 (4) When the wire is bent in the form of a square and connected between M and N as shown in fig. (2), the effective resistance between M and N decreases to one fourth of the value in fig. (1). The current increases four times the initial value according to the relation V = IR. Since H = I^2 Rt, the decrease in the value of resistance is more than compensated by the increases in the value of current. Hence heat produced increases. Percentage loss in energy during the collision ≃ 56%.

Q.45 (1) $P = \frac{V^2}{R_{eq}}$; for P to be maximum R_{eq} should be less.

Hence option (1) is correct.

Q.46 (1) Potential gradient $= \frac{e}{(R + R_h + r)} \cdot \frac{R}{L}$

$$= \frac{2}{(15+5+0)} \times \frac{5}{1} = 0.5\frac{V}{m} = 0.005\frac{V}{cm}.$$

Q.47 (2)

Q.48 (2)

Q.49 (1)

Q.50 (3) $S = \frac{i_g G}{(i - i_g)} = \frac{1 \times 0.018}{10 - 1} = \frac{0.018}{9} = 0.002\Omega$.

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (3)

Given that $V_{d_1} = v$, $V_{d_2} = ?$
We know that
$I = neAv_d$

$$\Rightarrow \quad V_d \propto \frac{1}{A} \propto \frac{1}{\frac{\pi d^2}{4}} \propto \frac{1}{d^2}$$

$$\frac{V_{d_1}}{V_{d_2}} = \frac{(d/2)^2}{d^2} = \frac{1}{4} \quad V_{d_2} = 4V$$

Q.2 (2)
Given that l = 5 m, d = 10 cm. = 0.1 m.

$$R = \frac{\rho l}{A} = \frac{17 \times 10^{-8} \times 5}{\frac{\pi \times 0.095^2}{4}} = 5.7 \times 10^{-5}\Omega$$

Q.3 (4)

We know that $R = \frac{\rho l}{A}$

$$\left.\begin{aligned} x &= \frac{\rho 4a}{2a^2} = \frac{2\rho}{a} \\ y &= \frac{\rho a}{8a^2} = \frac{\rho}{8a} \\ z &= \frac{\rho(2a)}{4a^2} = \frac{\rho}{2a} \end{aligned}\right\} \text{From } R = \frac{\rho \ell}{A}$$

$x > z > y$

Q.4 (3)
Given that $l_1 = 20$ cm, $R_1 = 5\,\Omega$,
$l_2 = 40$ cm, $R_2 = ?$
During stretching volume of wire is constant
$20A = 40A' \Rightarrow A' = A/2$

We know that $R = \frac{\rho l}{A}$

$$\frac{R_2}{R_1} = \frac{l_2}{l_1} \times \frac{A}{A'} = \frac{40}{20} \times \frac{A}{\frac{A}{2}}$$

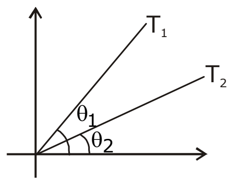
$R_2 = 20\Omega$

Q.5 (3)
$y : \rho = \rho_0(1 + \alpha\Delta T)$
α is –ve for semi conductor
z : temp ↑ τ ↓ Hence rate of collision ↑

Q.6 (4)
$i_1 = neAV$, $i_2 = n(2e)\,Av/4$

$i = i_1 + i_2 = \frac{3neAV}{2}$

Q.7 (2)



$R = \frac{V}{I} \Rightarrow \frac{I}{V} = \frac{1}{R}$

$\tan\theta = 1/R = w + \theta$

$\because\ \theta_1 > \theta_2$

$\Rightarrow\ R_1 < R_2 \Rightarrow T_1 < T_2$

$\because\ T\uparrow R\uparrow$

Q.8 (1)

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

$R_{square} = \frac{3.5\times10^{-5}\times50\times10^{-2}}{(10^{-2})^2}$

$= \frac{35}{2}\times10^{-2}\Omega$

$R_{rectangle} = \frac{3.5\times10^{-5}\times2[1\times10^{-2}]}{(50\times10^{-4})}$

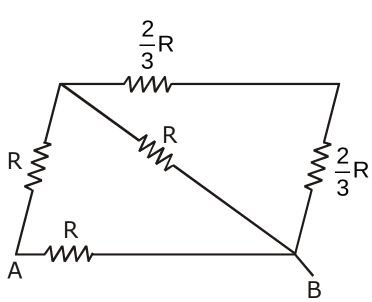
$= 7\times10^{-5}$

Q.9 (1)

$\frac{1}{R_{eq}} = \frac{10}{R} + \frac{10}{R} + ...10\text{times}$

$R_{eq} = R/100$

Q.10 (4)



Req. $= \frac{11R}{18}$

Q.11 (1)

From V : IR

When S_1 is closed $V_1 = \left(\frac{E}{4R}\right)3R = \frac{3E}{4} = 0.75E$

When S_2 is closed $V_2 = \frac{E}{7R}.6R = \frac{6E}{7} = 0.85E$

When both S_1 & S_2 are closed

$V_3 = \frac{E}{3R}\times2R = \frac{2E}{3} = 0.6E$

$V_2 > V_1 > V_3$

Q.12 (4)

All resistances are parallel so potential is same

$V = 0.3\times20 = 6V$

$i_1 : i_1 : i_3 = \frac{1}{R_1} : \frac{1}{20} : \frac{1}{15} = 60 : 3R_1 : 4R_1$

$\Rightarrow\ 0.3 = \frac{3R_1}{60+7R_1}\times(0.8)$

$\Rightarrow\ R_1 = 60\,\Omega$

Q.13 (1)

$R_{eq} = 2 + \frac{4}{2} + \frac{15}{3} + R_A = 9 + R_A$

$I = \frac{V}{R_{eq}} \Rightarrow 1 = \frac{10}{9+R_A} \Rightarrow R_A = 1\Omega$

if 4Ω replace by 2Ω resistance then

$R_{eq} = 2 + \frac{2}{2} + \frac{15}{3} + 1 = 9\Omega$

$I = \frac{10}{9}$ amp

Q.14 (2)

In an electric circuit containing a battery, the positive charge inside the battery may go from the positive terminal to the negative terminal

Q.15 (2)

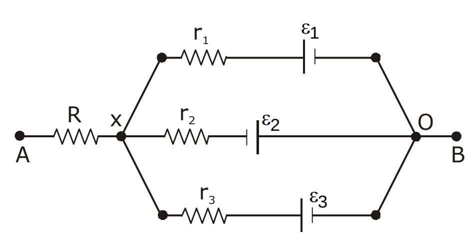
(a) $V = E - ir, V < E$ (b) $V = E + ir, V > E$

(c) $V = E$ (d) $V = E$

Q.16 (3) $i = \frac{4}{4} = 1$ Amp

$V = E + ir = 2 + 1\times3 = 5V$

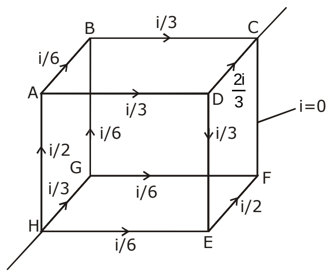
Q.17 (2)



$\frac{x-\varepsilon_1}{r_1} + \frac{x-\varepsilon_2}{r_2} + \frac{x-\varepsilon_3}{r_3} = 0$

$x = 2$ volt

Q.18 (2)



Q.19 (1) $R_{2.5\,W} = \frac{(110)^2}{2.5}\ \Omega$, $R_{100W} = \frac{(110)^2}{100} \Rightarrow R_{2.5} > R_{100}$.

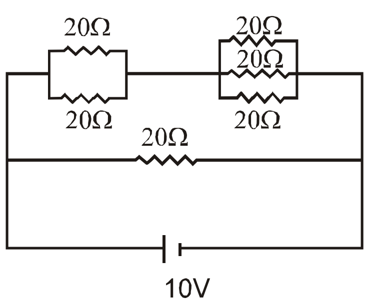
In series current passes through both bulb are same

$P_{2.5} = i^2 R_{2.5}$, $P_{100} = i^2 R_{100}$

$P_{2.5} > P_{100}$ due to $R_{2.5} > R_{100}$ & $\because P_{2.5} > 2.5W$ & $P_{100} < 100$ W (can be verified)

Therefore 2.5 W bulb will fuse

Q.20 (3)



$$R_{eq} = \frac{\left(\frac{20}{2} + \frac{20}{3}\right) \times 20}{\frac{20}{2} + \frac{20}{3} + 20} = \frac{50 \times 20}{110}$$

$$R_{eq} = \frac{100}{11}\ \Omega$$

$$P = \frac{V^2}{R} = \frac{(10)^2}{100/11} = 11\text{ W}.$$

Q.21 (1)

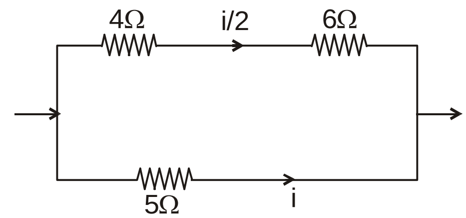
$$R = \frac{(220)^2}{100}$$

$$R_{eq} = \frac{R}{3} + R = \frac{4R}{3} = \frac{4(220)^2}{300}$$

$$P = \frac{V^2}{R_{eq}} = \frac{(220)^2 \times 300}{4(220)^2} = \frac{300}{4} = 75\text{ W}$$

Q.22 (2)

Since,resistance in upper branch of the circuit is twice the resistance in lower branch. Hence, current there will be half.



Now, $P_4 = (i/2)^2 (4)$ $(P = i^2R)$

$P_5 = (i)^2 (5)$

or $\frac{P_4}{P_5} = \frac{1}{5}$

$\therefore\ P_4 = \frac{P_5}{5} = \frac{10}{5} = 2$ cal/s.

Q.23 (2)

$H = \frac{V^2}{R}\Delta t$, & $R = \frac{\rho\ell}{A}$

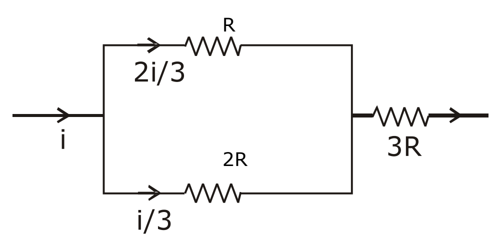
$$H = \frac{AV^2}{\rho\ell}\Delta t$$

$$H \propto \frac{A}{\ell}$$

$$H \propto \frac{r^2}{\ell}$$

Heat is doubled only when r, ℓ doubled

Q.24 (4)

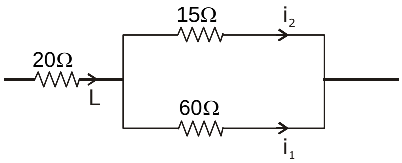


$$P_1 = \frac{V^2}{R} = I^2R = \frac{4I^2R}{9}$$

$$P_2 = I^2 \times 3R$$

$$\frac{P_1}{P_2} = \frac{4}{27}$$

Q.25 (2)



Given $\frac{15\times i}{75} = 0.75$

Now $i_2 = \frac{60\times i}{75} = \left[\frac{60\times 0.75\times 75}{15}\right] = 3A$

Q.26 (3)

Case – I $I_g = \frac{E_1+E_2}{R_g+R+2r} \Rightarrow 1 = \frac{3}{R_g+R+2r} \Rightarrow R_g +$ $R + 2r = 3$ .... (1)

Case – II $E_{eq} = E = 1.5$ V

$I_g = \frac{E_{eq}}{R_g+R+\frac{r}{2}} \Rightarrow 0.6 = \frac{1.5}{R_g+R+\frac{r}{2}} \Rightarrow R_g + R + \frac{r}{2} =$

$\frac{1.5}{0.6} = 2.5$ ....(2)

from eq (1) and (2)

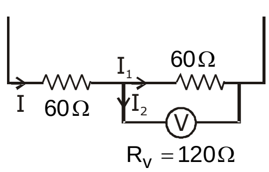
$\frac{3r}{2} = 0.5 \Rightarrow r = \frac{1}{3}\Omega$

Q.27 (4)

$\frac{6}{R} = \frac{\ell}{x-\ell}$

$\frac{6}{R} = \frac{30}{20} \Rightarrow R = 4\Omega$

Q.28 (1)



Net current

$I = \frac{120}{60+40} = 1.2A$

$I_1 : I_2 = \frac{1}{60} : \frac{1}{120} = 2 : 1$

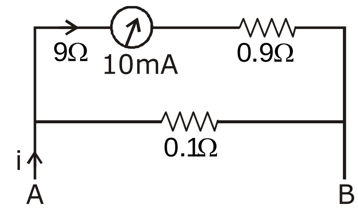
$I_1 = \frac{2}{3}\times 1.2 = 0.8$ Amp.

hence Reading V = 0.8 × 60 = 48 V

Q.29 (3)

Given for ammeter $i = 10^{-3}A$, $R = 9\Omega$

for given condition circuit shown like



$10\times 10^{-3} = \frac{0.1}{10}\times i \Rightarrow i = 1$ Ampere

Q.30 (1)

Potential gradient $x = \frac{6}{1}$

$6\ell = 4 \Rightarrow \ell = \frac{2}{3}$ m

EXERCISE-IV

Q.1 [0003]

Along z axis $\vec{E}\cdot d\vec{A} = 0$

Along x axis $\vec{E}$ = cont.

$\therefore \phi_x = 0$

for y = 0

$$\int \vec{E}\cdot d\vec{A} = \int 3(0+2)\hat{j}\cdot dA(-\hat{j}) = 6\int dA = -6$$

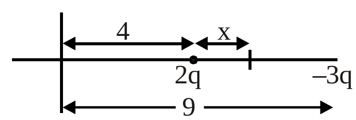
for y = 1

$$\int \vec{E}\cdot d\vec{A} = \int 3(1+2)\hat{j}\cdot dA(\hat{j}) = 9\int dA = 9$$

$\therefore \phi_{net} = +3\epsilon_0$

Q.2 [0012]

v = 0 at a point between both charges and to left of 2q.

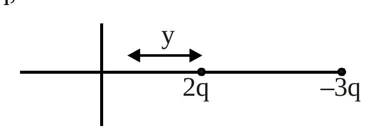


$$\frac{k\times 2q}{x} - \frac{-3kq}{5-x} = 0$$

$10 - 2x = 3x$

$x = 2$

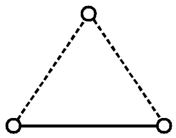
to left of 2q,



$$\frac{k\times 2q}{y} - \frac{3kq}{5+y} = 0$$

$10 + 2y = 3y$
$y = 10 \quad \Rightarrow$ distance = 12 m

Q.3 [0003]
$W_{ext} = \Delta U$



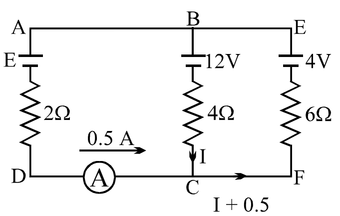
$$= \frac{kQ_1Q_3}{0.03} + \frac{kQ_2Q_3}{0.03}$$

$$= \frac{9\times10^9 \times -5\times10^{-6}}{0.03\times10^{-2}}[7-5]$$

= 3 J

Q.4 [6600]
For the mesh BCFEB,

$$-12 - 4I - 6\left(I + \frac{1}{2}\right) + 4 = 0$$

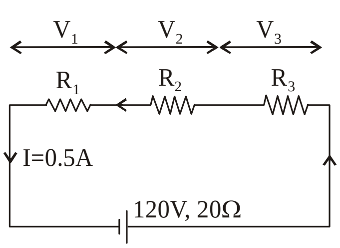


$\Rightarrow -8 - 10I - 3 = 0$
$\Rightarrow I = -1.1A$
For the mesh ABCDA,

$$-12 - 4I + 2\left(\frac{1}{2}\right) + E = 0$$

$\therefore\ -12 + 4.4 + I + \varepsilon = 0$
$\therefore\ E = 6.6\,V = 6600\,mV$

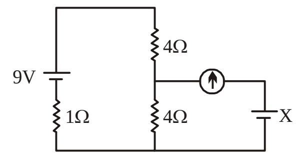
Q.5 [0080]
$V_1 + V_2 + V_3 = 120 - 20\,(0.5)$
$\Rightarrow\ V_1 + V_2 + V_3 = 110\,V$ .... (1)



Also $\quad V_1 + V_2 = 60 \Rightarrow V_3 = 110 - 60 = 50V$
Now $\quad V_2 + V_3 = 90 \Rightarrow V_2 = 40V$

$$\therefore\ R_2 = \frac{40}{0.5} = 80\Omega$$

Q.6 [0004]



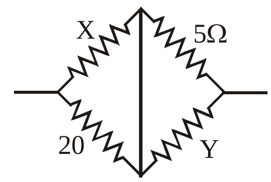
x =

P.d. across 4Ω = 4V

Q.7 [25]

As bridge is balanced, $\frac{x}{20} = \frac{5}{Y}$ or $Y = \frac{100}{X}$

and Pea of



should be $\frac{40}{3}\Omega$

Making equation and solving we get X = 25Ω

Q.8 [0020]
All the elements of circuit are in parallel arrangement

$$\frac{1}{R_{eq}} = \frac{1}{40}\times\frac{1}{40}\times\frac{1}{40}\times\frac{1}{40}\times\frac{1}{20}\times\frac{1}{20}$$

$$= \frac{4}{40}\times\frac{2}{40}$$

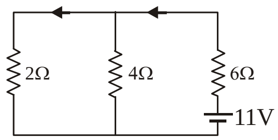
$R_{eq} = 5\Omega$
Power = V^2/R = 20 W

Q.9 [400Ω] $R_0 = \frac{\rho\ell_0}{A_0} = 100\,\Omega$ ....
(i)
$A_0 l_0 = A(2l_0)$

$\therefore A = \frac{A_0}{2}$ .... (ii)

$$R = \frac{\rho(2l_0)}{A_0/2} = 400\,\Omega$$

Q.10 [0001] More the resistance less will be power dissipated.
∴ One should connecte the battery is 6Ω resistor.



Q.11 (1)
Statement I & II both correct

Q.12 (2)
Statement-I is ture, Statement-II false.

Q.13 (1)

Q.14 (3)

Q.15 (1)

Q.16 (1)

PREVIOUS YEAR'S

MHT CET

Q.1 (1)	**Q.2** (3)	**Q.3** (1)	**Q.4** (2)	**Q.5** (1)
Q.6 (4)	**Q.7** (4)	**Q.8** (3)	**Q.9** (1)	**Q.10** (1)
Q.11 (2)	**Q.12** (3)	**Q.13** (3)	**Q.14** (1)	**Q.15** (1)
Q.16 (Bonus)	**Q.17** (2)	**Q.18** (4)	**Q.19** (1)	**Q.20** (1)
Q.21 (1)	**Q.22** (3)	**Q.23** (3)	**Q.24** (2)	**Q.25** (2)
Q.26 (3)	**Q.27** (1)	**Q.28** (4)	**Q.29** (2)	**Q.30** (3)
Q.31 (2)	**Q.32** (4)	**Q.33** (1)	**Q.34** (2)	**Q.35** (1)
Q.36 (4)	**Q.37** (2)	**Q.38** (2)	**Q.39** (2)	**Q.40** (1)
Q.41 (3)	**Q.42** (4)			

Q.43 (4)
At balanced condition

$$\frac{P}{Q}=\frac{S}{R}\Rightarrow\frac{22}{200}=\frac{30}{300}$$

So, it can be balanced again by increasing the resistance S by 3Ω or by increasing Q by 20Ω

Q.44 (3)
Given, length of wire, AB = L
Resistance of wire, AB = 12r
emf of cell D = ε, internal resistance of D= r

emf of cell C = $\frac{\varepsilon}{2}$, internal resistance of C= 3r

Current in potentiometer wire (i) = $\frac{\text{Total emf}}{\text{Total resistance}}$

$$i=\frac{\varepsilon}{r+12r}=\frac{\varepsilon}{13r}$$

Potential drop across the balance length AJ of potentiometer wire is $V_{AJ} = i \times R_{AJ}$

$\Rightarrow V_{AJ}$ = i (resistance per unit length × length AJ)

$$V_{AJ}=i\left(\frac{12r}{L}\times x\right)$$

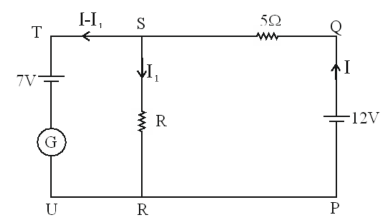
where, x is the balance length AJ.
As null point occurs at J, so potential drop across balance length,
AJ = emf of cell C

$$V_{AJ}=\frac{\varepsilon}{2}\Rightarrow i\left(\frac{12r}{L}\times x\right)=\frac{\varepsilon}{2}$$

$$\Rightarrow\frac{\varepsilon}{13r}\times\frac{12r}{L}\times x=\frac{\varepsilon}{2}$$

$$\Rightarrow x=\frac{13}{24}L$$

Q.45 (4) The current distribution in the circuit is shown below



Applying KVL in loop PQSRP, we get
$-5I - RI_1 + 12 = 0$-------- (i)
Similary, for loop SRUTS, we get
$-I_1R + 7 = 0$
$\Rightarrow I_2R = 7$-----------(ii)
As per question, $I - I_1 = 0 \Rightarrow I = I_1$ ---------- (iii)
Solving Eqs. (i), (ii) and (iii), we get
$-5I - 7 + 12 = 0 \Rightarrow I = 1A$
Form Eq. (ii),
R = 7Ω

Q.46 (3) Given, l_1 = 120 cm, l_2 = 100 cm
R = 10Ω, r = ?

$$\therefore\quad r=\left(\frac{l_1}{l_2}-1\right)R$$

$$=\left(\frac{120}{100}-1\right)\times10=\frac{20}{100}\times10=2\Omega$$

Q.47 (3) Balanced condition in meter bridge is given by

$$\frac{P}{Q}=\frac{l}{100-l}$$

Here, P = 20 Ω

$$\Rightarrow\quad\frac{20}{Q}=\frac{l}{100-l}\qquad .....(i)$$

When resistances are interchanged, $l' = l + 20$

$$\Rightarrow \quad \frac{Q}{20} = \frac{l'}{100 - l'} = \frac{l + 20}{100 - (l + 20)}$$

.....(ii)

Multiplying Eqs. (i) and (ii), we get

$$1 = \left(\frac{l}{100 - l}\right)\frac{(l + 20)}{(80 - l)}$$

$$\Rightarrow 100 \times 80 - 100l - 80l + l^2 = l^2 + 20l$$

$$\Rightarrow \quad l = \frac{100 \times 80}{200} = 40\,\text{cm}$$

From Eq. (i), we get

$$Q = \frac{60}{40} \times 20 = 30\,\Omega$$

Q.48 (3) Given, I = 2A, I_{max} = 10A

Since, shunt resistance, $S = \frac{IR}{I_{max} - I}$

$$= \frac{2R}{10 - 2} = \frac{2}{8}R = \frac{1}{4}R$$

Q.49 (4) Given, ℓ = 10m, $\frac{R}{\ell} = 2\,\Omega/\text{m}$

$\Rightarrow R = 2\ell = 2 \times 10 = 20\,\Omega$

Emf of cell, $\varepsilon = 3\,\text{V}$

Series resistance, $R_s = 10\,\Omega$

Potential across wire, $V = IR = \frac{\varepsilon \times R}{R + R_s}$

$$= \frac{3 \times 20}{(20 + 10)} = 2\,\text{V}$$

Potential gradient, $K = \frac{V}{\ell} = \frac{2}{10} = 0.2\,\text{V/m}$

Q.50 (1) Given, resistances 10 Ω and 2.5 Ω are in parallel,

$$R_1 = \frac{10 \times 2.5}{10 + 25} = 2\,\Omega$$

Now, 2 Ω and 10 Ω are in series,

$R_2 = 10 + 2 = 12\,\Omega$

R_2 and 12Ω are in parallel,

$$\frac{1}{R_3} = \frac{1}{12} + \frac{1}{12}$$

$\Rightarrow R_3 = 6\,\Omega$

Now, R_3 and 10 Ω are in series, $R_4 = 6 + 10 = 16\,\Omega$

Now, R_4 and 16 Ω are in parallel

$$\frac{1}{R} = \frac{1}{16} + \frac{1}{16} \Rightarrow R = \frac{16}{2} = 8\,\Omega$$

$\therefore$ Net equivalent resistance across the point A and B is 8 Ω

NEET/AIPMT

Q.1 (3)

$$I = \frac{E}{nR + R} \quad \text{......(i)}$$

$$10\,I = \frac{E}{\frac{R}{n} + R} \quad \text{......(ii)}$$

Dividing (ii) by (i),

$$10 = \frac{(n + 1)R}{\left(\frac{1}{n} + 1\right)R}$$

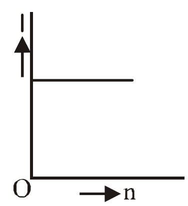
After solving the equation, n = 10

Q.2 (3)

$$I = \frac{n\varepsilon}{nr} = \frac{\varepsilon}{r}$$

So, I is independent of n and I is constant.

$\therefore$



Q.3 (2)

Q.4 (3)

Resistance for ideal voltmeter = ∞

Resistance for ideal ammeter = 0

For I[st] circuit

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{\infty}$$

$$\frac{1}{R_{eq}} = \frac{1}{10} + 0$$

$R_{eq} = 10\,\Omega$

$$i_i = \frac{V}{R} = \frac{10}{10} = 1\,\text{A}$$

$V_1 = 10\,\text{V}$

In II[nd] circuit

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}}=\frac{1}{10}+\frac{1}{10+\infty}$$

$$\frac{1}{R_{eq}}=\frac{1}{10}+0$$

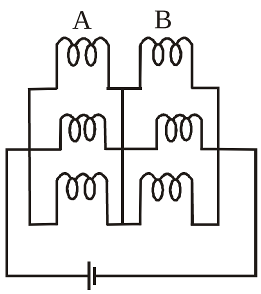
$$R_{eq}=10\Omega$$

$$i_2=\frac{10}{10}=1A$$

$$V_2=10\,V$$

Q.5 (2)

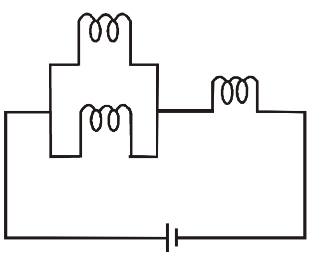
(i)



; $R_{eq}=\frac{2R}{3}$; P_{eq}

$$=\frac{V^2}{R_{eq}}=\frac{3V^2}{2R}$$

(ii)



; $R_{eq}=\frac{3R}{2}$;

$$P_{eq}=\frac{V^2}{R_{eq}}=\frac{2V^2}{3R}$$

$$\frac{(P_{eq})_1}{(P_{eq})_2}=\frac{3}{2}\times\frac{3}{2}=\frac{9}{4}$$

Q.6 (4)
Fuse is used as a circuit protector

Q.7 (3)
Q.8 (3)
Q.9 (2)
Q.10 (1)
Q.11 (4)
Q.12 (3)
Q.13 (4)
Q.14 (1)
Q.15 (1)

Resistance of P & Q should be approx. equal as it decreases error in experiment.

Q.16 (3)

Radius of wire = $\frac{10^{-2}}{\sqrt{\pi}}$

Cross sectional area A = $\pi r^2 = 10^{-4}\,m^2$

$$j=\frac{i}{A}=\left(\frac{V}{R}\right).\frac{1}{A}=\frac{E\ell}{RA} \qquad R=\frac{\rho\ell}{A}$$

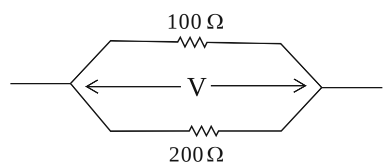
$$j=\frac{10\times10}{10\times10^{-4}}=10^5\,A/m^2$$

or

$$J=\sigma E\Rightarrow\frac{E}{\rho}=\frac{E\ell}{RA}=\frac{10\times10\times\pi}{10\times10^{-4}\times\pi}$$

$$\Rightarrow 10^5\,A/m^2$$

Q.17 (1)



As both resistors are in parallel combination so potential drop (V) across both are same.

$$P=\frac{V^2}{R}\Rightarrow P\propto\frac{1}{R}$$

$$\frac{P_1}{P_2}=\frac{R_2}{R_1}=\frac{200}{100}=\frac{2}{1}$$

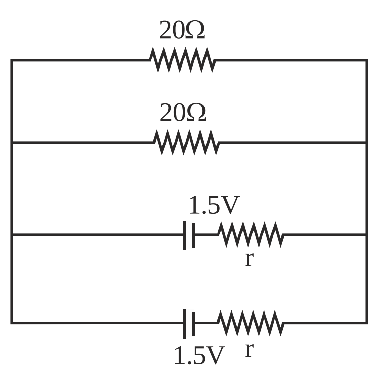
$= 2 : 1$

Q.18 (2)
For conductors α is (+)ve
For semiconductors & Insulators α is (–) ve

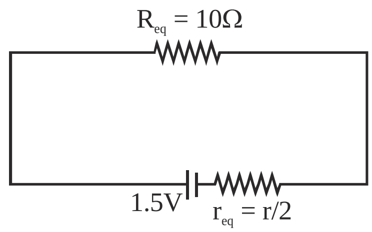
Q.19 (4)
$E = P\times t = 100\times10^3\times3600$
$= 36\times10^7\,J$

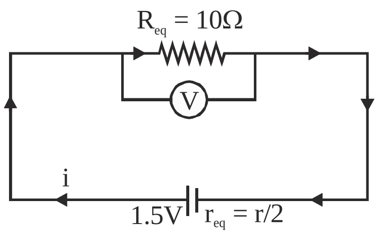
JEE MAIN

Q.1 (3)



equivalent Circuit





$$i = \frac{1.5}{10+\frac{r}{2}}$$

$V = I\,(R_{eq})$

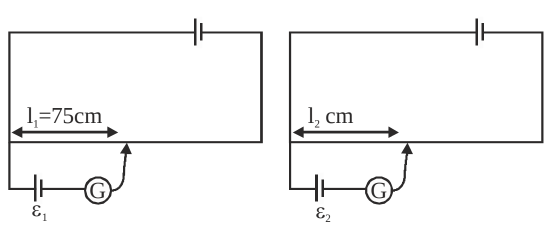
$$1.2 = \frac{1.5(10)}{\left(10+\frac{r}{2}\right)}$$

$$10+\frac{r}{2} = \frac{15}{12}\times 10$$

$$\frac{r}{2} = \frac{5}{4}\times 10 - 10$$

$$r = \frac{10}{4}\times 2 = 5\Omega$$

Q.2 (25)



$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

$$\frac{3}{2} = \frac{75}{l_2}$$

$$l_2 = \frac{2\times 75}{3} = 50\,\text{cm}$$

The difference in the balancing length of the potentiometer wire in above two cases is 75 – 50 = 25.

Q.3 (2)

A = 2Ω

B = 4Ω

C = 6Ω

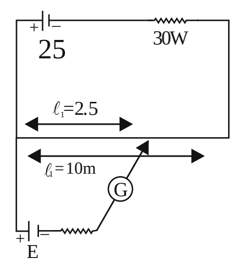
For Equivalent Resistance $= \frac{22}{3}\Omega$

$\therefore$ 2Ω & 4Ω will be in parallel and in series with 6Ω

$$R_{eq.} = \frac{2\times 4}{2+4} + 6$$

$$= \frac{8}{6}+6 \quad \Rightarrow = \frac{4}{3}+6 \quad \Rightarrow = \frac{22}{3}\Omega$$

Q.4 (25)



$$V = \frac{25\times 20}{20+30}$$

V = 10 volt

$$k = \frac{\upsilon}{\ell} = \frac{10}{10} = 1 \text{ volt / meter}$$

$E = k\ell_1$

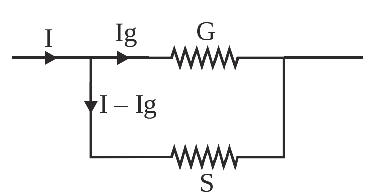
$= 1 \times 2.5$

$= 2.5$

$$= \frac{25}{10}$$

So x = 25 V

Q.5 (2)



$\Rightarrow (I - I_g)\,S = I_g G$

(Potential difference across galvanometer and shunt is same)

$$\frac{Ig}{I}=\frac{S}{S+G}$$

$\left\{I_g=\frac{1}{3}\right\}$ (when there is only galvanometer the current was I. After shunting it becomes $\frac{I}{3}$.)

$$\Rightarrow \frac{1}{3}=\frac{S}{S+G} \Rightarrow S+G=3S \Rightarrow G=2S$$

Q.6 [450]

Thermal energy developed

$H=i^2Rt$

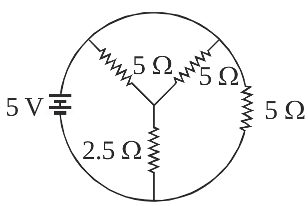
$300=2^2\times R\times 15$

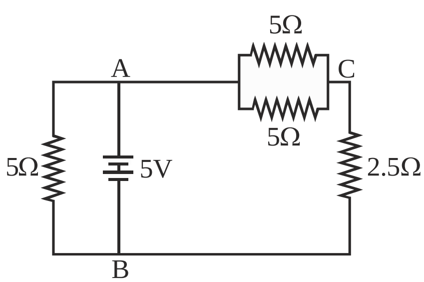
$$\Rightarrow R=\frac{300}{60}=5\Omega$$

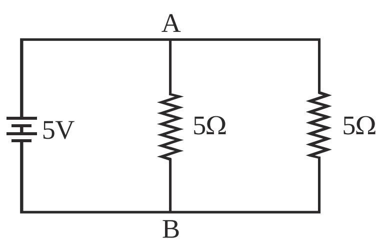
For I = 3A, t = 10s, R = 5Ω

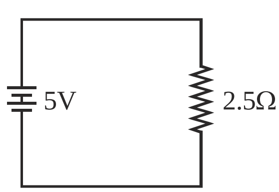
$H=3^2\times 5\times 10=450$ J

Q.7 [2]





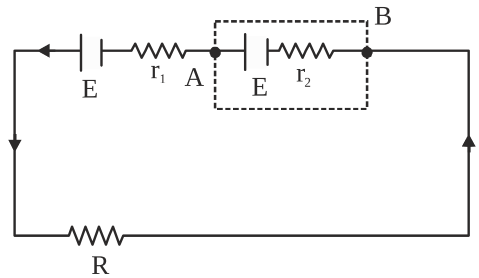




Current supplied by 5V battery

$$=\frac{5V}{2.5\Omega}=2A$$

Q.8 (1)



$$I=\frac{2E}{r_1+r_2+R} \quad ...(1)$$

Potential difference across the 2nd call is $V_{AB}=0$ then

$V_{AB}=E-Ir_2$

$$0=E-\frac{2Er_2}{(r_1+r_2+R)}$$

$$E=\frac{2Er_2}{r_1+r_2+R}$$

$\Rightarrow r_1+r_2+R=2r_2$

$\boxed{R=r_2-r_1}$

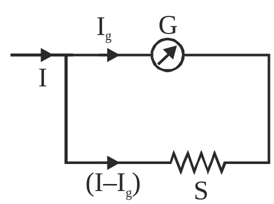
Q.9 (4)

Figure of merit $=\frac{\text{current}}{\text{division}}=K=\frac{I_g}{n}$

Total no. of division = n

$I_g=nk$ ...(1)

Total current = I



Now

$I_g.G=(I-I_g)s$

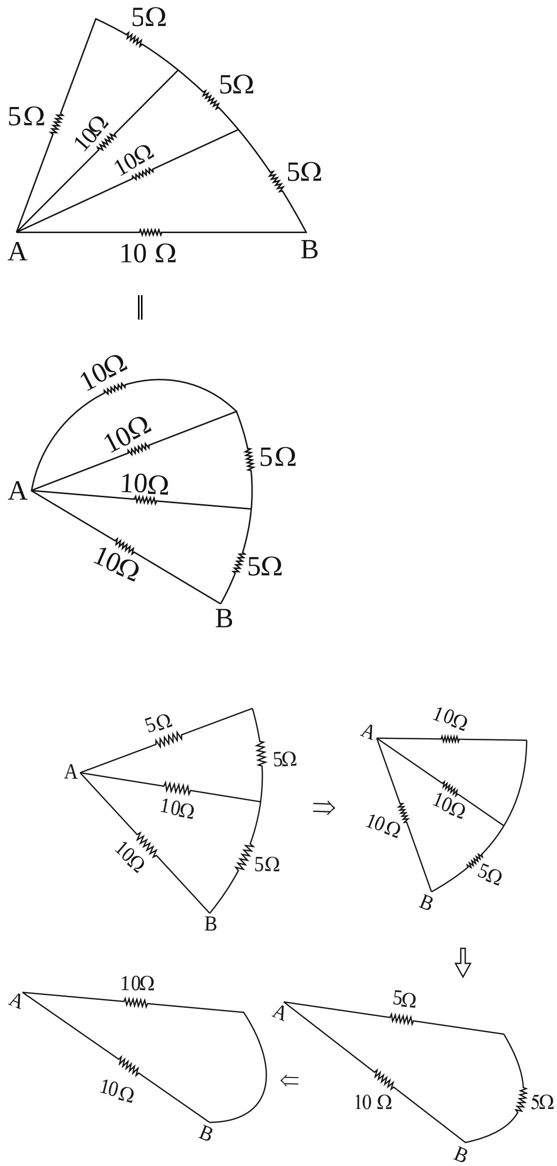
$$I_g(G+S)=IS \Rightarrow I=I_g\frac{(G+S)}{S}$$

$$\boxed{I=(\frac{G+S}{S}).nK}$$

Q.10 (300)

Q.11 (1)

Q.12 (3)



$R_{AB} = 5\Omega$

Q.13 (2)

$$S = \frac{R_G}{\frac{I}{I_g} - 1}$$

$$8 = \frac{72}{\frac{I}{I_g} - 1}$$

$$\frac{I}{I_g} - 1 = 9$$

$$\frac{I}{I_g} = 10 \Rightarrow \frac{I_g}{I} = \frac{1}{10}, \%I = \frac{I_g}{I} \times 100 = 10\%$$

Q.14 (975)

$P = Vi$

$5 = 25i$

$$i = \frac{1}{5}$$

$V_R = iR$

$$(220 - 25) = \frac{1}{5}R$$

$R = 195 \times 5 = 975\,\Omega$

Q.15 (8)

$$\frac{V_1}{V_2} = \frac{3}{2} = \frac{E - i_1 r}{E - i_2 r}$$

$$= \frac{E - \frac{E}{8+r} \times r}{E - \frac{E}{4+r} \times r}$$

$$\frac{3}{2} = \frac{8(4+r)}{4(8+r)}$$

$24 + 3r = 16 + 4r$

$r = 8\Omega$

Q.16 (48)

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

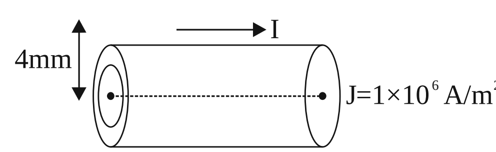
$I = JA$

$$= 4 \times 10^6 \times \left[\pi R^2 - \pi\left(\frac{R}{2}\right)^2\right]$$

$$= 4 \times 10^6 \times \pi R^2 \times \frac{3}{4}$$

$$= 4 \times 10^6 \times \pi \times (4 \times 10^{-3})^2 \times \frac{3}{4} = 48\pi A$$

Q. 17 (12)



$$I = \int J dA$$

$$I = \int 10^6 \times 2xsdx$$

$$= 10^6 \times 2\pi . x \frac{x^2}{2}\Big]_{r/2}^{r}$$

$$= \pi \times 10^6 \left[r^2 - \frac{r^2}{4} \right] = 12\pi$$

$x = 12$

29-Current Electricity

Q. 18 (3)

$$R = \left(\frac{ma}{3}\right) + \left(\frac{a}{2m}\right)$$

$$\frac{dR}{dm} = \frac{a}{3} - \frac{a}{2m^2} = 0$$

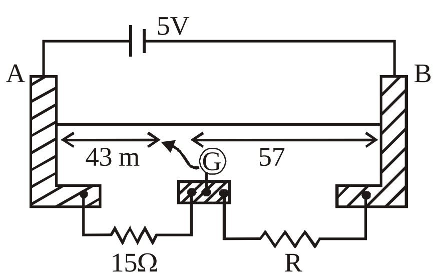
$$\frac{a}{3} = \frac{a}{2m^2}$$

$$m^2 = \frac{3}{2}$$

$$m = \sqrt{\frac{3}{2}}$$

$x = 3$

Q.19 (19)



End correction for A = 2 cm

$$\frac{2+43}{57} = \frac{15}{R}$$

$\Rightarrow R = 19\Omega$

Q.20 (1)

$R = R_0(1 + \alpha\Delta T)$

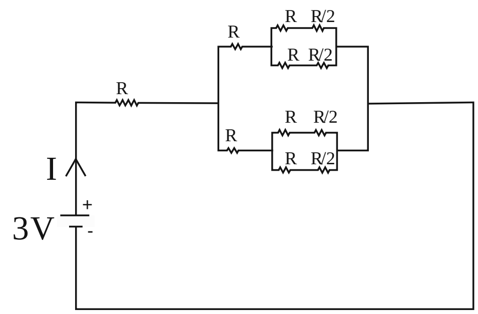
$3 = R_0(1 + \alpha(30-0))$

$2 = R_0(1 + \alpha(10-0))$

$$\frac{3}{2} = \frac{1+30\alpha}{1+10\alpha}$$

$$\alpha = \frac{1}{30} = 0.033$$

Q.21 (8)

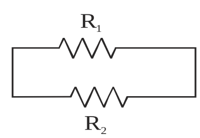


$$R_{eq} = \frac{15R}{8} = \frac{15}{8}\Omega$$

$$I = \frac{3}{\frac{15}{8}} = \frac{8}{5}A \qquad \therefore a = 8$$

Q.22 (15)

$$H = P \times t = \frac{v^2}{R_1} \times 60 \qquad H = \frac{v^2}{R_2} \times 20$$



Same heat produced

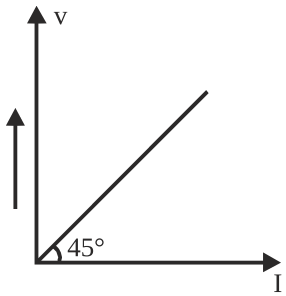
$$\frac{V^2}{R^{net}} \times t = H$$

$$H = \left(\frac{v^2}{R_1} + \frac{v^2}{R_2}\right)t$$

$$H = \left(\frac{H}{60} + \frac{H}{20}\right)t$$

$$\frac{60 \times 20}{80} = t \qquad t = 15 \text{ min}$$

Q.23 (144)



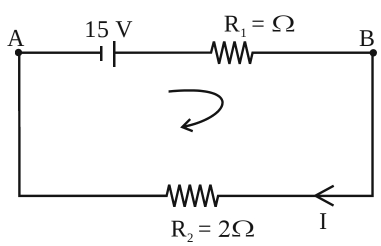
Diameter = 2.4 cm
Radius = 1.2 cm
ℓ = 31.4. cm
$\rho = x \times 10^{-3}\ \Omega - cm$
$\tan\theta$ = slope = resistance
$R = 1\ \Omega$

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

$$\therefore \rho = \frac{RA}{\ell} = \frac{1\times3.14\times(1.2)^2\times10^{-4}}{31.4\times10^{-2}} = \frac{144\times10^{-2}}{10\times100}$$

$\rho = 144 \times 10^{-5}\ \Omega m$
$= 144 \times 10^{-3}\ \Omega m$
$\therefore x = 144$

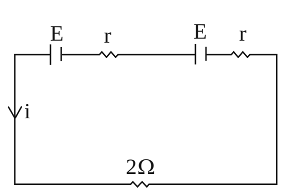
Q.24 (10)



$$I = \frac{E}{R_1 + R_2} \quad \therefore I = \frac{15}{2+1} = 5A$$

Applying KVL
$V_A + 15V - IR_1 - V_B = 0$
$V_A + 15 - 5(1) - V_B = 0,\ V_A - V_B = -10$
$\therefore \boxed{V_B - V_A = 10V}$

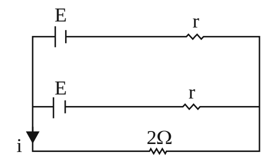
Q.25 (1)
When cells are connected in series.



Equivalent EMF = 2E
Equivalent resistance = 2r

$$i = \frac{2E}{2r+2}$$

When cell are connected in parallel then



Equivalent Emf = E

Equivalent resistance $= \frac{r}{2}$

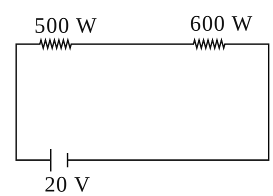
$$i = \frac{E}{\frac{r}{2}+2}$$

Both currents are equal

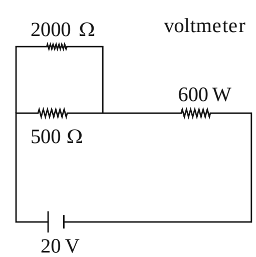
$$\Rightarrow \frac{2E}{2r+2} = \frac{E}{\frac{r}{2}+2}$$

$\Rightarrow r + 4 = 2r + 2$
$\Rightarrow r = 2\Omega$

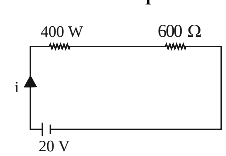
Q.26 (8)



Resistance of volt meter
$= 2000\ \Omega$



Reading of voltmeter will be same as the voltage drop across the equivalent of voltmeter and 500 Ω



$$i = \frac{20}{600+400}$$

$$= \frac{20}{1000}$$

$= \frac{1}{50}$ A

Reading = iR

$= \frac{1}{50} \times 400 = 8V$

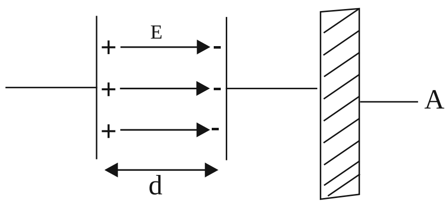
= 8

Q.27 (x = 8)

Displacement current = 4.425 μA

Rate of change of voltage = 10^6 vs^{-1}

Area of plate = 40 cm



We know that

$I_d = \varepsilon_0 \frac{d\phi_E}{dt}$

$\phi_E \rightarrow$ electric flux

$\phi_E = \frac{\sigma}{\varepsilon_0} A = EA$

$\phi_E = \frac{v}{d} A$

$\Rightarrow \frac{d\phi_E}{dt} = \frac{dv}{dt}\left(\frac{A}{d}\right) \Rightarrow I_C = \varepsilon_0 . \frac{d\phi_E}{dt}$

$I_C = \varepsilon_0 \frac{A}{d}\left(\frac{dV}{dt}\right)$

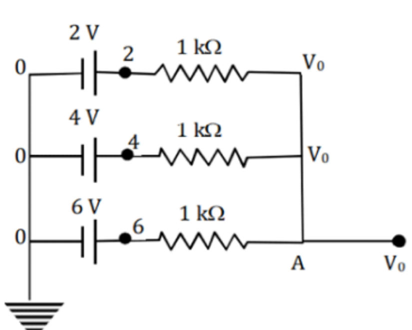
$\Rightarrow 4.425 \times 10^{-6} = 8.85 \times 10^{-12} \times \frac{40 \times 10^{-4}}{d} \times 10$

$\Rightarrow 1 = 2 \times 40 \times \frac{10^{-4}}{d} \Rightarrow d = 80 \times 10^{-4} m$

$d = 8 \times 10^{-3}$ m

x = 8

Q.28 [4]



using KCL at A junction

$\frac{v_0 - 2}{1} + \frac{v_0 - 4}{1} + \frac{v_0 - 6}{1} = 0$

$3 V_0 = 12$

$V_0 = 4$ Volt

Q.29 [4]

For each copper wire $r = \frac{4\rho\ell}{\pi d^2}$

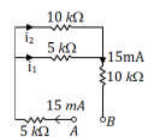
$R = \frac{r}{8} \Rightarrow R \frac{4\rho\ell}{8\pi d^2}$

$R = \frac{\rho\ell}{2\pi d^2}$

Single wire $R = \frac{4\rho(2\ell)}{\pi D^2}$

$\frac{\rho\ell}{2\pi d^2} = \frac{8\rho\ell}{\pi D^2} \Rightarrow D = 4d$

Q.30 (4)



$\frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{10}{5} = \frac{2}{1}$

$i_1 = \frac{2}{3} \times 15mA = 10mA$

$V_A - 15 \times 5 - 10 \times 5 - 15 \times 10 = V_B$

$V_A - V_B = 275$ V

Q.31 [18]

$E_1 \propto l_1$

$E_2 \propto l_2$

(assumed balanced point at length of wire)

$\frac{E_1}{E_2} = \frac{l_1}{l_2}$

$\frac{1.20}{1.80} = \frac{36}{l_2}$ cm

$\Rightarrow l_2 = 36 \times \frac{1.80}{1.12} = 54$ cm

$l_2 - l_1 = 54 - 36 = 18$ cm

Q.32 (1)

By WSB, $Req = \frac{8 \times 8}{8 + 8} = 4\Omega$

$$I = \frac{V}{Req} = \frac{40}{4} = 10A$$

Q.33 [20]

At null point

$4 \times 60 = Q \times 40$

$\boxed{Q = 6\Omega}$

Now $P = (4 + x)$

$(4 + x) \times 20 = 6 \times 80$

$4 + x = 24$

$\boxed{x = 20\Omega}$

Q.34 (1)

Given circuit is a balance Wheatstone bridge.

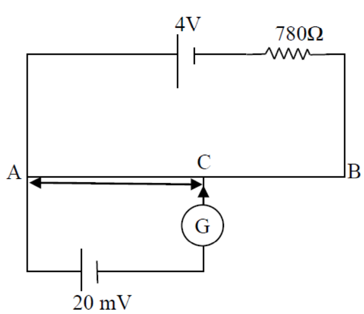
So, there will be no current in 5Ω resistance.

$$R_1 = \frac{6 \times 12}{6 + 12} = 4\Omega$$

$$R_{eq} = 4 + 2 = 6\Omega$$

$$\therefore I = \frac{V}{R_{eq}} = \frac{6}{6} = 1A$$

Q.35 [20]



Given, AB = 3m = 300 cm

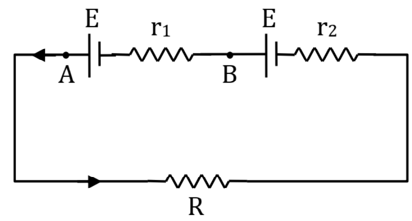
AC = 60 cm

For null deflection,

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{R_1}{R_2}$$

$$\frac{4}{20 \times 10^{-3}} = \frac{780 + R}{\frac{60}{300}R} \Rightarrow R = 20$$

Q.36 (1)



$r_1 > r_2$

$$I = \frac{E + E}{r_1 + r_2 + R} = \frac{2E}{r_1 + r_2 + R}$$

Potential difference across cell of r_1 resistance is zero

So, $V_{AB} = 0 = E - Ir_1$

$E = Ir_1$

$$E = \frac{2E \cdot r_1}{r_1 + r_2 + R} \Rightarrow r_1 + r_2 + R = 2r_1$$

$R = r_1 - r_2$

Q.37 (2)

For D.C. current

$R_1 = 3\Omega$ $I_1 = 4A$

And for A.C. current $\rightarrow I_2 = 4A$ (Peak value)

$$(I_2)_{rms} = \frac{4A}{\sqrt{2}} = \sqrt{2}A$$

$$\frac{H_1}{H_2} = \frac{I_1^2 R_1 t}{(I_2)_{rms}^2 R_2 t} = \frac{(4)^2(3)}{(2\sqrt{2})^2 \cdot 2} = \frac{16 \times 3}{8 \times 2} = 3:1$$

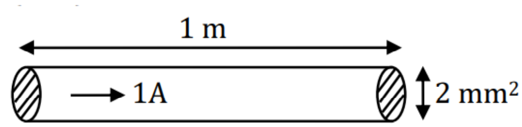
Q.38 [2400]

$$\frac{s}{30\,cm} = \frac{R}{70\,cm}$$

$$\frac{S}{3} = \frac{5.6k\Omega}{7}$$

$$S = \frac{3}{7} \times 5.6k\Omega = 2.4k\Omega$$

Q.39 [136]



$$R = \frac{pl}{A} = \frac{1.7 \times 10^{-8} \times 1}{2 \times 10^{-6}} = \frac{1.7 \times 10^{-8}}{2}\Omega$$

$$V = IR = 1 \times \frac{1.7}{2} \times 10^{-2} = \frac{1.7}{2} \times 10^{-2}\,\text{Volt}$$

$$E = \frac{V}{l} = \frac{1.7}{2} \times 10^{-2}\,\frac{N}{C}$$

$F = qE$

$$F = 1.6\times10^{-19}\times\frac{1.7}{2}\times10^{-2} = 1.36\times10^{-21} = 136\times10^{-23}$$

Ans - 136

Q.40 (2)
By Theory

Q.41 [40]
Potential gradient

$x = \frac{e}{l}$ does not depends on cross sectional area

Hence, balancing point will be same x = 40 cm

Q.42 (1)

$$R_1 = \rho\frac{L_1}{A_1}$$

$$R_2 = \rho\left(\frac{3L_1}{A_1/3}\right) = 9\rho\left(\frac{L_1}{A_1}\right)$$

$$\therefore \frac{R_2}{R_1} = 9$$

Q.43 (4)

$$i = \left(\frac{K}{NAB}\right)\theta \qquad \therefore \frac{d\theta}{di} = \frac{NAB}{K}$$

Q.44 (780)

$$E = \frac{AC}{AB}(V_A - V_B)$$

$$\therefore 20\times10^{-3} = \frac{60}{300}\times\frac{4\times20}{R+20}$$

$$\therefore R = 780\,\Omega$$

Q.45 (3)
Statement I : - 80 Ω is cut in 4 parts so resistance of each part = 20 Ω if they are in parallel

$$\frac{1}{R_{eq}} = \frac{1}{20}+\frac{1}{20}+\frac{1}{20}+\frac{1}{20} = \frac{4}{20}$$

$R_{eq} = 5\,\Omega$
Statement- 2 : 2R & 3R in parallel
So, thermal energy developed

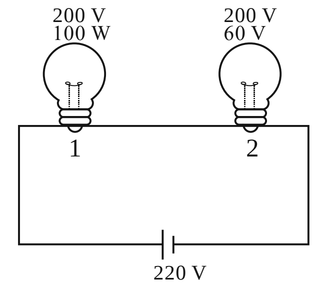
$$E = \frac{v^2}{R}t \quad E \propto \frac{1}{R}$$

$$\frac{E_1}{E_2} = \frac{2R}{3R} = 2:3$$

Statement I is correct and statement II is incorrect.

Q.46 [14]

$$R_1 = \frac{v^2}{p} = \frac{220^2}{100}$$



$$R_2 = \frac{220^2}{60}$$

$$R_{eq.} = R_1 + R_2$$

$$= 220^2\left(\frac{1}{100}+\frac{1}{60}\right)$$

$$= 220^2\left(\frac{6+10}{600}\right)$$

$$= \frac{(220)^2\times16}{600}$$

i in each bulb

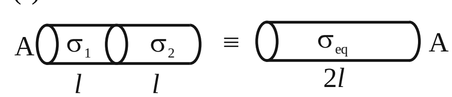
$$i = \frac{v}{R_{eq.}} = \frac{220\times600}{(220)^2\times16} = \frac{600}{220\times16}$$

Power consumed by 100 W
$P = L^2R_1$

$$\left(\frac{600}{220\times16}\right)^2\times\frac{(220)^2}{100}$$

$$= \frac{600\times600}{16\times16\times100} = 14.06 \text{ watt} \approx 14 \text{ watt}$$

Q.47 (2)



Let length of wire be '*l*'
Area of wire as 'A'
For equivalent wire length = 2*l* & area will be A
Thermal resistance
$R_{eq} = R_1 + R_2$

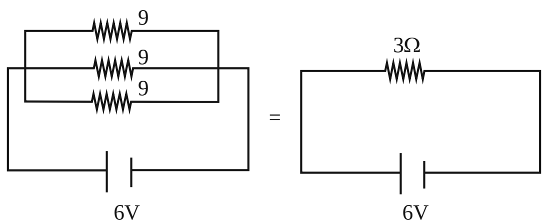
$$\frac{2l}{\sigma_{eq}A} = \frac{l}{\sigma_1 A}+\frac{l}{\sigma_2 A}$$

$$\frac{2l}{\sigma_{eq}} = \frac{l}{\sigma_1}+\frac{l}{\sigma_2}$$

$$\Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

Q.48 (2)

Equivalent circuit

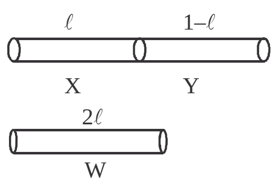


$I = \frac{6}{3} = 2A$

Q.49 (1)

Theory based

Q.50 (2)



$$\frac{R_x}{R_y} = \frac{\ell_x}{\ell_Y}$$

When wire is stretched to double of its length, then resistance becomes 4 times

$R_W = 4\,R_x = 2R_Y$

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

So, $\frac{\ell_X}{\ell_Y} = \frac{1}{2}$