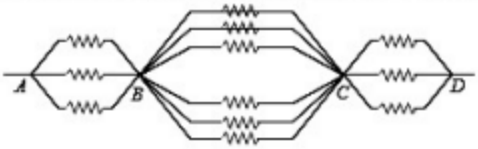
CHAPTER - 13

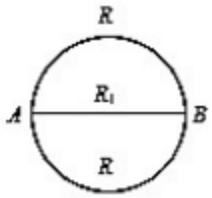
CURRENT ELECTRICITY & CAPACITANCE

1. 3 The given circuit can be simplified as follows



$\therefore R_{AD} = \frac{5R}{6}$

2. 3 Resistance across $AB = \frac{1}{R'} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R_1}$



$R_1 = 2 \times 10^{-6}\Omega$ and $R = \pi \times 1 \times 10^{-6}\Omega$

On solving, $R' = 0.88 \times 10^{-6}\Omega$

3. 4 Current in the bulb $= \frac{P}{V} = \frac{4.5}{1.5} = 3A$

Current in 1 Ω resistance $= \frac{1.5}{1} = 1.5A$

Hence total current from the cell $i = 3 + 1.5 = 4.5A$

By using $E = V + ir \Rightarrow E = 1.5 + 4.5 \times (2.67) = 13.5V$

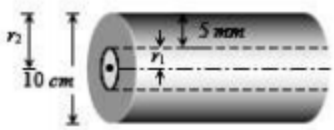
4. 1 Balancing length is independent of the cross sectional area of the wire.

5. 1 In series $P_{Consumed} \propto$ Brightness $\propto \frac{1}{P_{Rated}}$

6. 1 By using $R = \rho.\frac{l}{A}$; here $A = \pi(r_2^2 - r_1^2)$

Outer radius $r_2 = 5cm$

Inner radius $r_1 = 5 - 0.5 = 4.5\ cm$



So $R = 1.7 \times 10^{-8} \times \frac{5}{\pi\{(5 \times 10^{-2})^2 - (4.5 \times 10^{-2})^2\}} = 5.6 \times 10^{-5}\Omega$

7. 3

$R_{t_1} = R_1(1+\alpha_1 t)$ and $R_{t_2} = R_2(1+\alpha_2 t)$

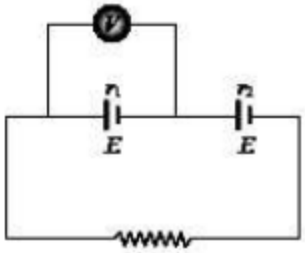
Also $R_{eq} = R_{t_1} + R_{t_2} \Rightarrow R_{eq} = R_1 + R_2 + (R_1\alpha_1 + R_2\alpha_2)t$

$\Rightarrow R_{eq} = (R_1 + R_2)\left\{1 + \left(\frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}\right)t\right\}$

So $\alpha_{eff} = \frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}$.

8. 2

Let the voltage across any one cell is V, then



$V = E - ir = E - r_1\left(\frac{2E}{r_1 + r_2 + R}\right)$

But $V = 0$

$\Rightarrow E - \frac{2Er_1}{r_1 + r_2 + R} = 0$

$\Rightarrow r_1 + r_2 + R = 2r_1$

$\Rightarrow R = r_1 - r_2$

9. 2

In series : Potential difference $\propto R$

When only S_1 is closed $V_1 = \frac{3}{4}E = 0.75E$

When only S_2 is closed $V_2 = \frac{6}{7}E = 0.86E$

and when both S_1 and S_2 are closed combined resistance of $6R$ and $3R$ is $2R$

$\therefore V_3 = \left(\frac{2}{3}\right)E = 0.67E \Rightarrow V_2 > V_1 > V_3$

10. 2

Here, $E = 2V$, $1 = \frac{2}{2} = 1A$ and $r = 1\Omega$

Therefore, $V = E - ir = 2 - 1\times 1 = 1V$

11. 2

12. 2

SECTION II (NUMERICAL)

13. 10

$H = \frac{V^2}{R}t$

Since supply voltage is same and equal amount of heat will produce, therefore

$\frac{R_1}{t_1} = \frac{R_2}{t_2}$ or $\frac{R_1}{R_2} = \frac{t_1}{t_2}$ .....(i)

But $R \propto l \Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2}$ .....(ii)

By (i) and (ii), $\frac{l_1}{l_2} = \frac{t_1}{t_2}$ .....(iii)

Now $l_2 = \frac{2}{3}l_1 \Rightarrow \frac{l_1}{l_2} = \frac{3}{2}$

$\therefore$ By equation (iii), $\frac{3}{2} = \frac{15}{t_2} \Rightarrow t_2 = 10$ *minutes*

14. 10

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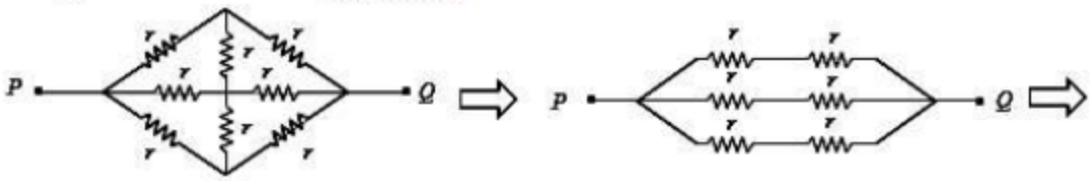
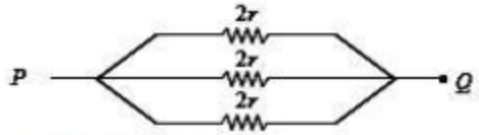
15. 1

The given circuit can be simplifies as follows





$R' = \frac{2r}{3} = \frac{2}{3} \times \frac{3}{2} = 1\Omega$.

16. 4 If two resistances are R_1 and R_2 then $S = R_1 + R_2$ and $P = \frac{R_1 R_2}{(R_1 + R_2)}$

From given condition $S = nP$ *i.e.* $(R_1 + R_2) = n\left(\frac{R_1 R_2}{R_1 + R_2}\right)$

$\Rightarrow (R_1 + R_2)^2 = n\ R_1 R_2 \Rightarrow (R_1 - R_2)^2 + 4R_1 R_2 = nR_1 R_2$

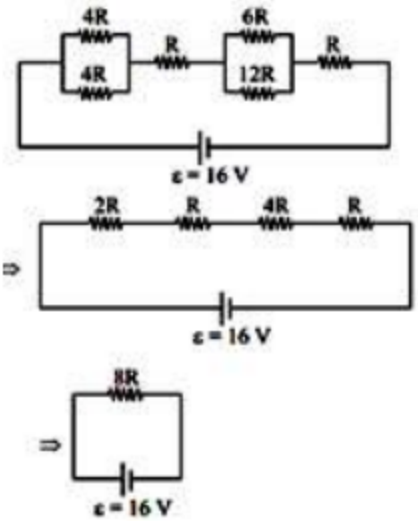
So $n = 4 + \frac{(R_1 - R_2)^2}{R_1 R_2}$. Hence minimum value of n is 4.

17. 4 Total current through the circuit

$$i = \frac{10}{\frac{1000}{3} + 500} = \frac{3}{250}\ A$$

Now voltmeter reading $= i_V \times R_V = \frac{2}{3} \times \frac{3}{250} \times 500 = 4V.$

18. 8



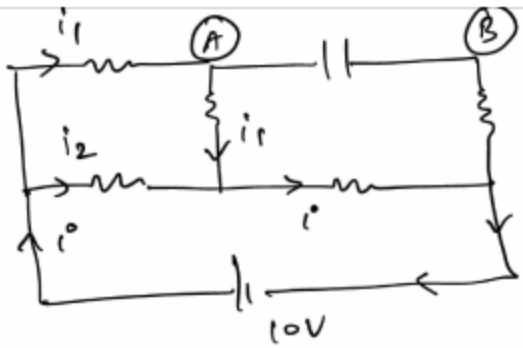
$$P = \frac{16^2}{8R} = 4$$

$\therefore\ R = 8\Omega$.

JEE ADVANCED LEVEL

SECTION III

19. B



find i_1 and i°, Apply KVL between A and B.

20. A

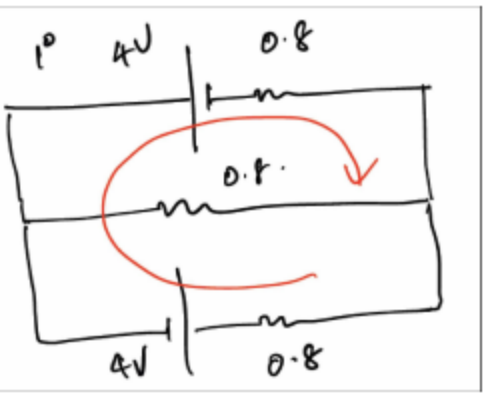
wheat stone application.

21. A

use $P = i^2R$. , $\downarrow i^\circ = \frac{\varepsilon}{\uparrow R+r}$.

$\therefore P \downarrow$

22. C



Apply KVL in outside loop, $i^\circ = \frac{8}{1.6} = \frac{10}{2} = 5A$

$V = \varepsilon - i^\circ r \Rightarrow 1 - 0.2 \times 5 = 0$ V.

23. A

$V = kl$. $\quad k = \frac{V}{l} = \frac{\varepsilon R}{(R+r)l}$

24. D

$q = q_0(1 - e^{-t/RC})$

$12.6 = 20(1 - e^{-t/RC})$

$.63 = 1 - e^{-t/RC}$

$0.37 = e^{-t/RC}$ (Solve).

$q = CV$.

$20\mu = 5 \cdot C$

$C = 4\mu F$

SECTION IV (More than one correct)

25. A,D

$P = neAv_d$.

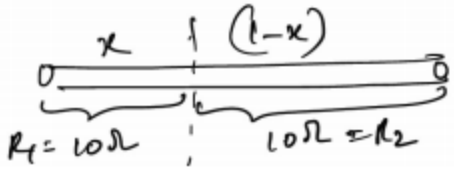
Av_d = constant.

26. A,B

radius. $r' = r + \left(\frac{2r - r}{l}\right)x$

x - distance from one end.

$\therefore r' = r + rx - r(1+x)$.



$R = \rho\frac{l}{A} = \rho\int\frac{dx}{A} = \rho\int\frac{dx}{\pi r^2(1+x)^2}$

$$R_1 = \rho \int_0^x \frac{dx}{\pi x^2 (1+x)^2} \cdot \int \frac{dx}{(1+x)^2}$$

$$= (1+x)^{-1} \Big|_0^x$$

$$R_1 \propto \left(1 - \frac{1}{1+x}\right)$$

$$R_2 \propto \left(\frac{1}{(1+x)} - \frac{1}{2}\right)$$

$$\frac{2}{1+x} = \frac{3}{2} \qquad 1+x = \frac{4}{3}$$

$$x = \frac{1}{3}$$

27. A,B,C,D

at $t = 0$, C will offer zero opposition. $\therefore$ R_3 will be shorted

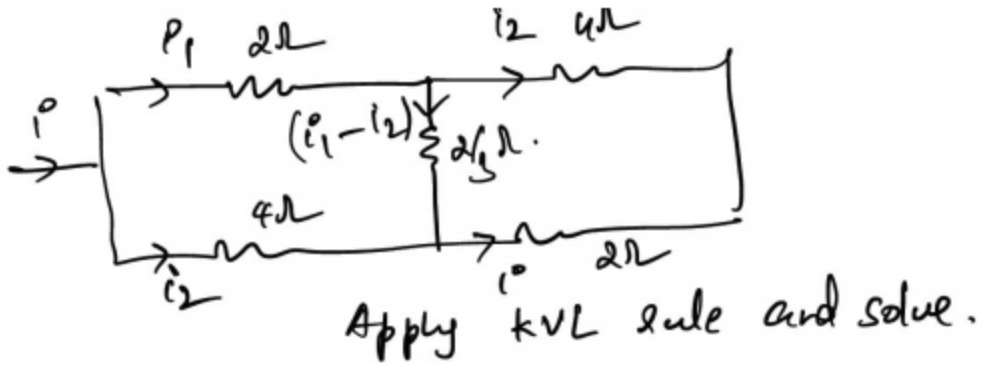
SECTION V - (Numerical type)

28. 20

29. 11

Find i^0 in the circuit, apply KVL Rule

30. 1



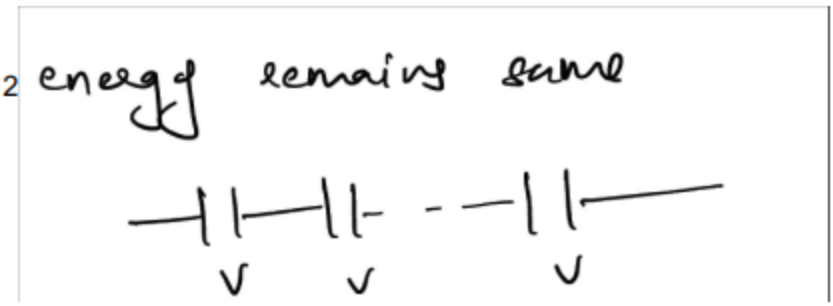
SECTION VI - (Matrix match type)

31. A-q, B-p, C-p

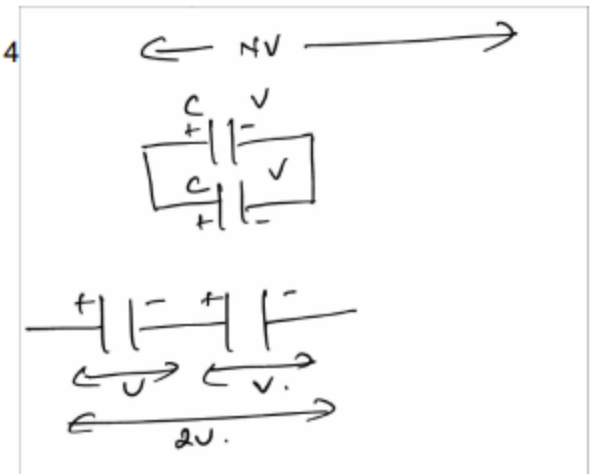
CAPACITANCE

SECTION - I

1. 2



2. 4



3. 4

$$C = C_1 + C_2$$

$$C = \frac{\varepsilon_0\left(\frac{2A}{3}\right)}{d} + 2\frac{\varepsilon_0\left(\frac{A}{3}\right)}{d} = \frac{4\varepsilon_0 A}{3d.}$$

$$c' = \frac{\varepsilon_0 A}{d\cdot} \therefore C = \frac{4}{3}C^1$$

$$c^1 = \frac{3}{4}c\cdot$$

4. 1

$$\frac{C_1}{C_2} = \frac{k_1\varepsilon_0 A/d_1}{k_2\varepsilon_0 A/d_2}$$

5. 1

$V = \frac{q}{C}$ $\quad V \propto \frac{1}{C}$.

$\therefore \quad C_1 = C_2$

$C_1 = \frac{\varepsilon_0 A}{d}$, $\quad \frac{1}{C_2} = \frac{d}{K\varepsilon_0 A} + \frac{t}{\varepsilon_0 A}$.

SECTION II (NUMERICAL)

6. 0

7. 2μF,18μF

PART II - (JEE ADVANCED LEVEL)

SECTION - III (One correct answer)

8. D

On bringing them in contact, V becomes same

$$\frac{k(Q_1 - q)}{R_1} = \frac{k(Q_2 + q)}{R_2}$$

$q = \_\_\_\_$.

$Q_1' = Q_1 - q$

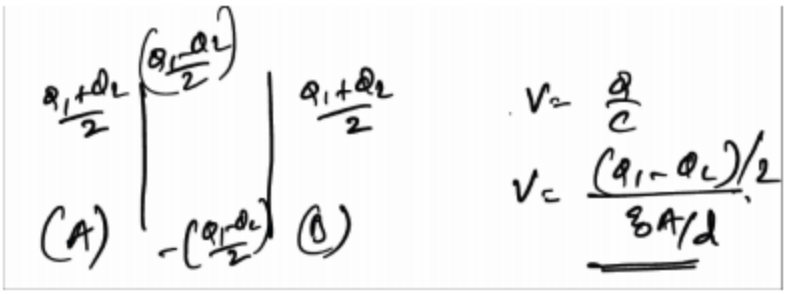
$Q_2' = Q_2 + q$

$\Delta U = U_{final} - U_{initial}$

9. A $\frac{Q_1 + Q_2 + Q_3}{3}$, using the notion $E = 0$ inside a conductor.

SECTION - IV (More than one correct answer)

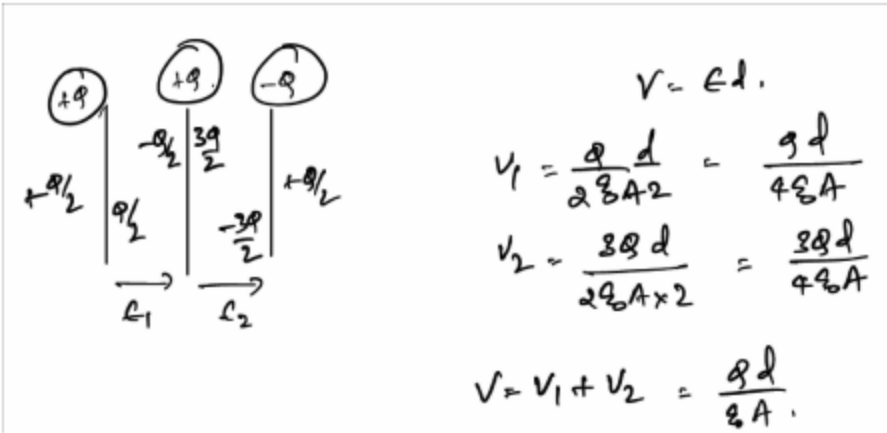
10. A,C



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

$V = \frac{(Q_1 - Q_2)/2}{\varepsilon_0 A/d}$

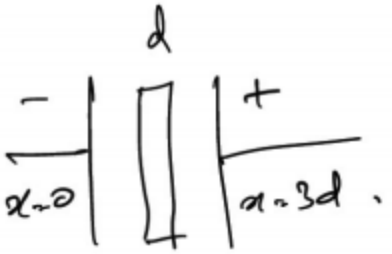
11. A,B,C,D



12. B,C,D

find charge on 7MF
same is the charge on 2MF.
find voltage across 3MF. Then
add voltage across 2MF ad 7MF
which will be same as V across 3.9MF
so on...

13. B,C



$\vec{E}$ direction is same but magnitude changes inside dielectric $\vec{E}$ decreases.

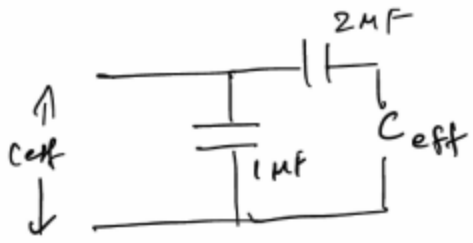
SECTION - V (Numerical Type - Upto two decimal place)

14. 3

$$C_{eff} = \frac{C_1 C_2}{C_1 + C_2}$$

$$C_1 = \frac{k_1 \varepsilon_0 A}{d_1}, \quad C_2 = \frac{k_2 \varepsilon_0 A}{d_2}$$

15. 2



$$\frac{2C_{eff}}{2 + C_{eff}} + 1 = C_{eff} \quad \text{(solve)}.$$

16. 5 similar to Q. no. 5.

SECTION - VI (Matrix Matching)

17. A-p, B-r,s, C-p, D-r