17

Current Electricity

TOPIC 1
Ohm's Law and Resistance

01 **Column I** Gives certain physical terms associated with flow of current through a metallic conductor.
Column II Gives some mathematical relations involving electrical quantities. Match Column I and Column II with appropriate relations. **[NEET 2021]**

Column I		Column II
A. Drift velocity	1.	$\frac{m}{ne^2\rho}$
B. Electrical resistivity	2.	nev_d
C. Relaxation period	3.	$\frac{eE}{m}\tau$
D. Current density	4.	$\frac{E}{J}$

Codes

	A	B	C	D
(a)	3	4	1	2
(b)	3	4	2	1
(c)	3	1	4	2
(d)	3	2	4	1

Ans. *(a)*
As we know that, the expression of the drift velocity,

$$v_d = \frac{eE}{m}\tau$$

Here, e is the electric charge,
E is the electric field,
m is the mass of an electron,
τ is the relaxation time.
Consider the conductor having length l, area of the cross-section A and the charge density n.

Electrical resistivity, $\rho = \frac{m}{ne^2\tau}$

Rearranging the above expression,

Relaxation period, $\tau = \frac{m}{ne^2\rho}$

As we know that, the expression of current density,

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

Again, $\frac{E}{J} = \frac{E}{\sigma E} = \frac{1}{\sigma} = \rho$

$\therefore$ Electrical resistivity, $\rho = \frac{E}{J}$

The correct match is A$\rightarrow$3, B$\rightarrow$4, C$\rightarrow$1, D$\rightarrow$2.

02 The effective resistance of a parallel connection that consists of four wires of equal length, equal area of cross-section and same material is 0.25 Ω. What will be the effective resistance if they are connected in series? **[NEET 2021]**

(a) 0.25 Ω (b) 0.5 Ω
(c) 1 Ω (d) 4 Ω

Ans. *(d)*
The four resistances have equal length, equal cross-sectional area and same material.

So, $R_1 = R_2 = R_3 = R_4 = R$ (say)

Given, the effective resistance,

$R_{eq} = 0.25\,\Omega$

For parallel arrangement,

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$$

$$\Rightarrow \frac{1}{0.25\,\Omega} = \frac{4}{R}$$

$$\Rightarrow R = 1\,\Omega$$

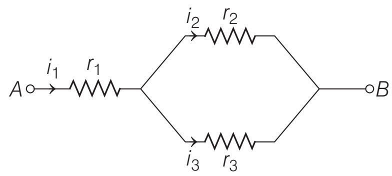
For series combination,

$R_{eq} = R_1 + R_2 + R_3 + R_4$

$\Rightarrow R_{eq} = R + R + R + R$

$\Rightarrow R_{eq} = 4R \Rightarrow R_{eq} = 4(1) = 4\,\Omega$

03 Three resistors having resistances r_1, r_2 and r_3 are connected as shown in the given circuit. The ratio $\frac{i_3}{i_1}$ of currents in terms of resistances used in the circuit is **[NEET 2021]**



(a) $\frac{r_1}{r_2 + r_3}$ (b) $\frac{r_2}{r_2 + r_3}$
(c) $\frac{r_1}{r_1 + r_2}$ (d) $\frac{r_2}{r_1 + r_3}$

Ans. *(b)*
According to the given circuit diagram in question,

$$i_1 = i_2 + i_3 \quad \text{...(i)}$$

In parallel arrangement of the electrical circuit,
the voltage remains same.

$\therefore$ $V = ir$ (using Ohm's law)

$\Rightarrow$ $i_2 r_2 = i_3 r_3$

$\Rightarrow$ $i_2 = \frac{i_3 r_3}{r_2}$

Substituting the values in the Eq. (i), we get

$$i_1 = \frac{i_3 r_3}{r_2} + i_3 \Rightarrow \frac{i_1}{i_3} = \frac{r_3}{r_2} + 1$$

$$\Rightarrow \frac{i_1}{i_3} = \frac{r_3 + r_2}{r_2} \Rightarrow \frac{i_3}{i_1} = \frac{r_2}{r_3 + r_2}$$

04 Two solid conductors are made up of same material, have same length and same resistance. One of them has a circular cross-section of area A_1 and the other one has a square cross-section of area A_2. The ratio A_1 / A_2 is **[NEET (Oct.) 2020]**

(a) 1.5 (b) 1 (c) 0.8 (d) 2

Ans. ***(b)***

Given, $R_1 = R_2, l_1 = l_2$

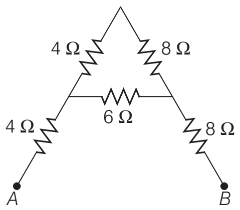
Since, resistance, $R = \rho \cdot \frac{l}{A}$

$$\Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2} \cdot \frac{A_2}{A_1} \Rightarrow \frac{R_1}{R_1} = \frac{l_1}{l_1} \cdot \frac{A_2}{A_1}$$

$$\Rightarrow 1 = \frac{A_2}{A_1} \qquad [\because R_1 = R_2]$$

$$\Rightarrow \frac{A_1}{A_2} = 1$$

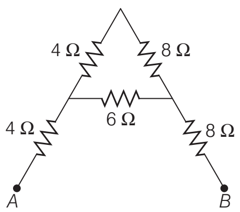
05 The equivalent resistance between A and B for the mesh shown in the figure is **[NEET (Oct.) 2020]**



(a) 7.2 Ω (b) 16 Ω (c) 30 Ω (d) 4.8 Ω

Ans. ***(b)***

Equivalent resistance between points A and B is given as



$$R_{AB} = [(4+8) \| 6] + 4 + 8 = [12 \| 6] + 12$$
$$= \left[\frac{12 \times 6}{12 + 6}\right] + 12 = [4] + 12 = 16\Omega$$

06 A charged particle having drift velocity of 7.5×10^{-4} ms^{-1} in an electric field of 3×10^{-10} Vm^{-1}, has a mobility (in $m^2V^{-1}s^{-1}$) of **[NEET (Sep.) 2020]**

(a) 2.5×10^6 (b) 2.5×10^{-6}
(c) 2.25×10^{-15} (d) 2.25×10^{15}

Ans. ***(a)***

Given, drift velocity, $v_d = 7.5 \times 10^{-4}$ m/s

Electric field, $E = 3 \times 10^{-10}$ V-m

Mobility, $\mu = ?$

As, $$\mu = \frac{v_d}{E} = \frac{7.5 \times 10^{-4}}{3 \times 10^{-10}}$$
$$= 2.5 \times 10^6 \, m^2V^{-1}s^{-1}$$

Hence, correct option is (a).

07 The color code of a resistance is given below **[NEET (Sep.) 2020]**

The values of resistance and tolerance respectively, are

(a) 47 kΩ, 10% (b) 4.7 kΩ, 5%
(c) 470 Ω, 5% (d) 470 kΩ, 5%

Ans. ***(c)***

According to the carbon colour code for resistors,

Code of yellow = 4

Code of violet = 7

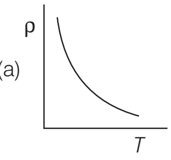
Code of brown, i.e. multiplier = 10^1

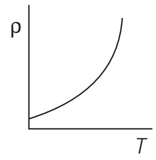
Code of gold, i.e. tolerance = ± 5%

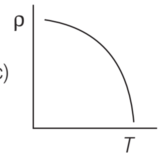
Hence, resistance of resistor
$= 47 \times 10^1 \Omega$, 5%
$= 470 \Omega$, 5%

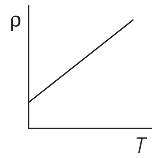
Hence, correct option is (c).

08 Which of the following graph represents the variation of resistivity (ρ) with temperature (T) for copper? **[NEET (Sep.) 2020]**

(a)


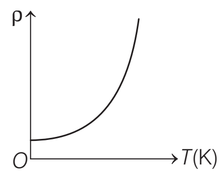
(b)


(c)


(d)


Ans. ***(b)***

Resistivity of copper (a metal) as a function of temperature increases with the increase in temperature as shown below,



For copper at 0K, value of resistivity is 1.7×10^{-8} Ω-m.

Hence, correct option is (b).

09 Which of the following acts as a circuit protection device? **[NEET (National) 2019]**

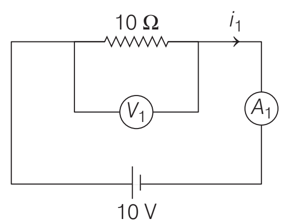
(a) Inductor (b) Switch
(c) Fuse (d) Conductor

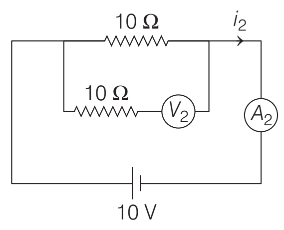
Ans. ***(c)***

Among given devices fuse is used in electric circuit as a protective device.

It helps in preventing excessive amount of current to flow in the circuit or from short circuiting. It has low melting point and low resistivity, so when excess amount of current flow in the circuit, it melts and break the circuit.

10 In the circuits shown below, the readings of voltmeters and the ammeters will be **[NEET (National) 2019]**

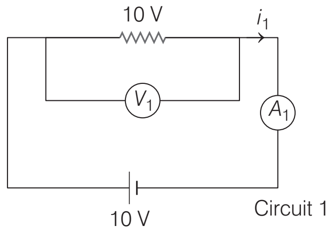




(a) $V_1 = V_2$ and $i_1 > i_2$ (b) $V_1 = V_2$ and $i_i = i_2$
(c) $V_2 > V_1$ and $i_1 > i_2$ (d) $V_2 > V_1$ and $i_1 = i_2$

Ans. ***(b)***

For an ideal voltmeter, the resistance is infinite and for an ideal ammeter, the resistance is zero.



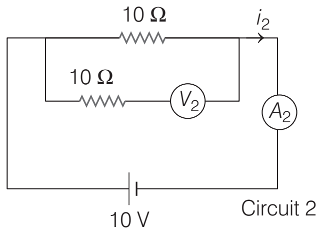
So, the current in circuit 1 is

$$R \times i = V \quad \text{or} \quad 10\, i_1 = 10$$

$$\Rightarrow \quad i_1 = \frac{10}{10} = 1\,\text{A}$$

$$\therefore \quad V_1 = i_1 \times R = 1 \times 10 = 10\,\text{V}$$

Similarly, for circuit 2, the addition of $10\,\Omega$ to voltmeter does not affect the current and hence



$$10\, i_2 = 10 \Rightarrow i_2 = \frac{10}{10} = 1\,\text{A}$$

$$V_2 = i_2 R = 1 \times 10 = 10\,\text{V}$$

$$\therefore \quad V_1 = V_2 \text{ and } i_1 = i_2$$

11 A carbon resistor of $(47 \pm 4.7)\ \text{k}\Omega$ is to be marked with rings of different colours for its identification. The colour code sequence will be **[NEET 2018]**

(a) Yellow - Green - Violet - Gold
(b) Yellow - Violet - Orange - Silver
(c) Violet - Yellow - Orange - Silver
(d) Green - Orange - Violet - Gold

Ans. ***(b)***

Given, $R = (47 \pm 4.7)\,\text{k}\Omega$

$$= 47 \times 10^3 \pm 10\%\ \Omega$$

As per the colour code for carbon resistors, the colour assigned to numbers.

4 – Yellow
7 – Violet
3 – Orange

For ±10% accuracy, the colour is silver. Hence, the bands of colours on carbon resistor in sequence are yellow, violet, orange and silver.

Note To remember the colour code sequence for carbon resistor, the following sentence should be kept in memory. B B Roy of Great Britain has a Very Good Wife.

12 The resistance of a wire is R ohm. If it is melted and stretched to n times its original length, its new resistance will be **[NEET 2017]**

(a) nR (b) $\frac{R}{n}$ (c) $n^2 R$ (d) $\frac{R}{n^2}$

Ans. ***(c)***

Thinking Process Volume of material remains same in stretching.

As volume remains same, $A_1 l_1 = A_2 l_2$

Now, given $l_2 = n l_1$

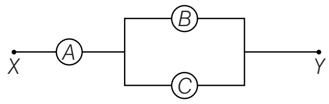
$\therefore$ New area $A_2 = \frac{A_1 l_1}{l_2} = \frac{A_1}{n}$

Resistance of wire after stretching

$$R_2 = \rho \frac{l_2}{A_2} = \rho \cdot \frac{n l_1}{A_1 / n}$$

$$= \left(\rho \frac{l_1}{A_1}\right) \cdot n^2 = n^2 \cdot R \left[\because R = \left(\rho \frac{l_1}{A_1}\right)\right]$$

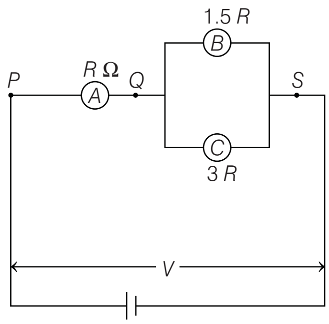
13 A, B and C are voltmeters of resistance R, $1.5\,R$ and $3R$ respectively as shown in the figure. When some potential difference is applied between X and Y, the voltmeter readings are V_A, V_B and V_C respectively. Then, **[CBSE AIPMT 2015]**



(a) $V_A = V_B = V_C$ (b) $V_A \neq V_B = V_C$
(c) $V_A = V_B \neq V_C$ (d) $V_A \neq V_B \neq V_C$

Ans. ***(a)***

The equivalent resistance between Q and S is given by



$$\frac{1}{R'} = \frac{1}{1.5R} + \frac{1}{3R} = \frac{2+1}{3R}$$

$$\Rightarrow \quad R' = R$$

Now, $V_{PQ} = V_A = IR$

Also $V_{QS} = V_B = V_C = IR$

Hence, $V_A = V_B = V_C$

14 Across a metallic conductor of non-uniform cross-section, a constant potential difference is applied. The quantity which remain constant along the conductor is **[CBSE AIPMT 2015]**

(a) current density (b) current
(c) drift velocity (d) electric field

Ans. ***(b)***

As the cross-sectional area of the conductor is non-uniform so current density will be different.

As $\quad I = JA \quad$ ...(i)

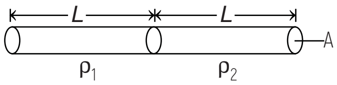
It is clear from Eq. (i), when area increases the current density decreases so the number of flow of electrons will be same and thus the current will be constant.

15 Two metal wires of identical dimensions are connected in series. If σ_1 and σ_2 are the conductivities of the metal wires respectively, the effective conductivity of the combination is **[CBSE AIPMT 2015]**

(a) $\frac{2\,\sigma_1 \sigma_2}{\sigma_1 + \sigma_2}$ (b) $\frac{\sigma_1 + \sigma_2}{2\,\sigma_1 \sigma_2}$
(c) $\frac{\sigma_1 + \sigma_2}{\sigma_1 \sigma_2}$ (d) $\frac{\sigma_1 \sigma_2}{\sigma_1 + \sigma_2}$

Ans. ***(a)***

Net resistance of a metal wire having resistivity ρ, we have



$$R_1 = \rho_1 \frac{L}{A}$$

Similarly, $\quad R_2 = \rho_2 \frac{L}{A}$

Then, net effective resistance of two metal wires,

$$R_{eq} = R_1 + R_2 \Rightarrow \rho \frac{2L}{A} = \rho_1 \frac{L}{A} + \rho_2 \frac{L}{A}$$

$$\Rightarrow \quad 2\rho = \rho_1 + \rho_2$$

As, conductivity $\sigma = \frac{1}{\rho}$, we have

$$\frac{2}{\sigma} = \frac{1}{\sigma_1} + \frac{1}{\sigma_2} \Rightarrow \frac{2}{\sigma} = \frac{\sigma_1 + \sigma_2}{\sigma_1 \sigma_2}$$

$\Rightarrow$ Net effective conductivity of combined wires,

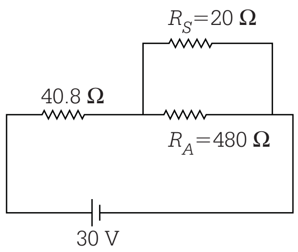
$$\sigma = \frac{2\sigma_1 \sigma_2}{\sigma_1 + \sigma_2}$$

16 A circuit contains an ammeter, a battery of 30 V and a resistance 40.8 Ω all connected in series. If the ammeter has a coil of resistance 480 Ω and a shunt of 20 Ω, then reading in the ammeter will be **[CBSE AIPMT 2015]**

(a) 0.5 A (b) 0.25 A
(c) 2 A (d) 1 A

Ans. *(a)*

Effective resistance of a circuit,



$$R_{eff} = 40.8 + \frac{480 \times 20}{480 + 20}$$

$$= 40.8 + 19.2 = 60\ \Omega$$

So, current flowing across ammeter,

$$I = \frac{V}{R} = \frac{30}{60} = \frac{1}{2} = 0.5\text{ A}$$

Hence, reading of ammeter = 0.5 A

17 A wire of resistance 4Ω is stretched to twice its original length. The resistance of stretched wire would be **[NEET 2013]**

(a) 2 Ω (b) 4 Ω (c) 8 Ω (d) 16 Ω

Ans. *(d)*

As the resistance of stretched wire to length n times of original length is

$R' = n^2 R = 2^2 \times 4 = 4 \times 4 = 16\ \Omega$

where, R = original resistance

R' = final resistance

18 The mean free path of electrons in a metal is 4×10^{-8} m. The electric field which can give on an average 2 eV energy to an electron in the metal will be in unit of Vm^{-1} **[CBSE AIPMT 2009]**

(a) 8×10^7 (b) 5×10^{-11}
(c) 8×10^{-11} (d) 5×10^7

Ans. *(d)*

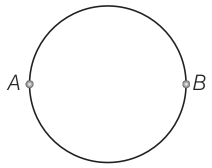
Energy = 2eV

$eV_0 = 2\text{ eV} \Rightarrow V_0 = 2$

So, electric field, $\mathbf{E} = \dfrac{2}{4 \times 10^{-8}}$

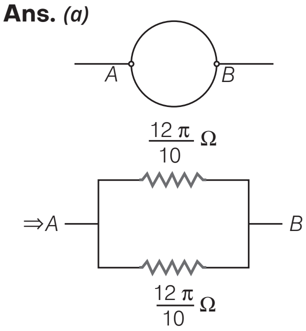
$$= 0.5 \times 10^8$$
$$= 5 \times 10^7\text{ V/m}$$

19 A wire of resistance $12\ \Omega\text{ m}^{-1}$ is bent to form a complete circle of radius 10 cm. The resistance between its two diametrically opposite points A and B as shown in the figure is **[CBSE AIPMT 2009]**



(a) 0.6 $\pi\ \Omega$ (b) 3 Ω
(c) 6 $\pi\ \Omega$ (d) 6 Ω

Ans. *(a)*



Circumference of circle $= 2\pi r = 2 \times \pi \dfrac{10}{100}$

$$= \frac{2\pi}{10} = \frac{\pi}{5}$$

Resistance of wire $= 12 \times \dfrac{\pi}{5} = \dfrac{12\pi}{5}$

Resistance of each section $= \dfrac{12\pi}{10}\ \Omega$

$\therefore$ Equivalent resistance

$$= \frac{\frac{12\pi}{10} \times \frac{12\pi}{10}}{\frac{12\pi}{10} + \frac{12\pi}{10}}$$

$$\Rightarrow \quad = \frac{6\pi}{10} = 0.6\ \pi\ \Omega$$

20 A wire of a certain material is stretched slowly by 10 percent. Its new resistance and specific resistance become respectively **[CBSE AIPMT 2008]**

(a) 1.2 times, 1.1 times
(b) 1.21 times, same
(c) Both remain the same
(d) 1.1 times, 1.1 times

Ans. *(b)*

After stretching, specific resistance (ρ) will remain same.

Original resistance of wire, $R = \dfrac{\rho l}{A}$

Ratio of resistance before and after streching,

$$\frac{R_2}{R_1} = \frac{l_2}{l_1} \times \frac{A_1}{A_2} = \left[\frac{l_2}{l_1}\right]^2$$

$$\frac{R_2}{R_1} = \frac{(l + 10\% l)^2}{l^2}$$

$$\frac{R_2}{R_1} = \frac{\left(\frac{11}{10} l\right)^2}{l^2}$$

$$R_2 = 1.21 R_1$$

21 When a wire of uniform cross-section a, length l and resistance R is bent into a complete circle, resistance between two of diametrically opposite points will be **[CBSE AIPMT 2005]**

(a) $\dfrac{R}{4}$ (b) $\dfrac{R}{8}$ (c) $4R$ (d) $\dfrac{R}{2}$

Ans. *(a)*

When wire is bent to form a complete circle, then

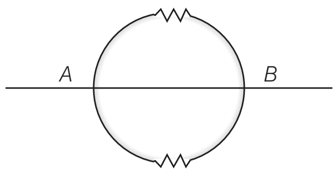
Total circumference,

$$2\pi r = \text{Total length, } R$$

$$\Rightarrow \quad r = \frac{R}{2\pi}$$

Resistance of each semicircle $= \pi r$

$$= \frac{\pi R}{2\pi} = \frac{R}{2}$$



Thus, net resistance in parallel combination of two semicircular resistances

$$R' = \frac{\frac{R}{2} \times \frac{R}{2}}{\frac{R}{2} + \frac{R}{2}} = \frac{\frac{R^2}{4}}{R} = \frac{R}{4}$$

22 n resistances each of r ohm, when connected in parallel give an equivalent resistance of R ohm. If these resistances were connected in series, the combination would have a resistance in ohms, equal to **[CBSE AIPMT 2004]**

(a) $n^2 R$ (b) $\dfrac{R}{n^2}$

(c) $\dfrac{R}{n}$ (d) nR

Ans. *(a)*

Equivalent resistance of n resistances each of r ohm in parallel is given by

$$\frac{1}{R} = \frac{1}{r} + \frac{1}{r} + \ldots + n \text{ times} = \frac{n}{r}$$

So, $r = nR$

When these resistances are connected in series, effective resistance is

$$R' = r + r + \ldots + n \text{ times} = nr$$

$\therefore \quad R' = n(nR) = n^2 R$

23 The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then **[CBSE AIPMT 2004]**

(a) the resistance will be doubled and the specific resistance will be halved
(b) the resistance will be halved and the specific resistance will remain unchanged
(c) the resistance will be halved and the specific resistance will be doubled
(d) the resistance and the specific resistance will both remain unchanged

Ans. *(b)*

The formula for resistance of wire is

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

where, ρ = specific resistance of the wire

$$\Rightarrow \quad R \propto \frac{l}{A}$$

$$\Rightarrow \quad R \propto \frac{l}{r^2} \quad (\because A = \pi r^2)$$

$$\therefore \quad \frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{r_2^2}{r_1^2} \quad \ldots\text{(i)}$$

Given, $l_1 = l, l_2 = 2l, r_1 = r, r_2 = 2r, R_1 = R$.

Substituting these values in Eq. (i), we have

$$\frac{R_1}{R_2} = \frac{l}{2l} \times \frac{(2r)^2}{r^2}$$

$$\frac{R_1}{R_2} = \frac{l}{2l} \times \frac{(2r)^2}{r^2}$$

$$\frac{R_1}{R_2} = 2 \Rightarrow R_2 = \frac{R}{2}$$

Therefore, resistance will be halved.

Now, the specific resistance of the wire does not depend on the geometry of the wire. Hence, it remains unchanged.

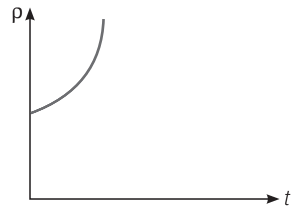
24 The specific resistance of a conductor increases with **[CBSE AIPMT 2002]**

(a) increase in temperature
(b) increase in cross-sectional area
(c) decrease in length
(d) decrease in cross-sectional area

Ans. *(a)*

The specific resistance (resistivity) of a metallic conductor nearly increases with increasing temperature as shown in figure. This is because, with the increase in temperature the ions of the conductors vibrate with greater amplitude and the collisions between electrons and ions become more frequent, over a small temperature range (upto 100°C). The resistivity of a metal can be represented approximately by the equation

$$\rho_t = \rho_0 (1 + \alpha t)$$



The factor α is called the temperature coefficient of resistivity.

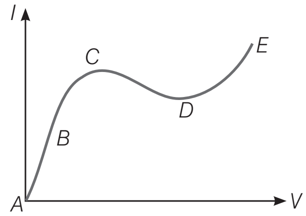
25 The resistance of a discharge tube is **[CBSE AIPMT 1999]**

(a) zero (b) ohmic
(c) non-ohmic (d) infinity

Ans. *(c)*

In discharge tube, the current is due to flow of positive ions and electrons. Moreover, secondary emission of electrons is also possible. So, V-I curve is non-linear, hence its resistance is non-ohmic.

26 From the graph between current I and voltage V shown in figure, identify the portion corresponding to negative resistance. **[CBSE AIPMT 1997]**



(a) DE (b) CD
(c) BC (d) AB

Ans. *(b)*

From Ohm's law, resistance $R = \frac{\Delta V}{\Delta I}$

Resistance is said to be negative if on increasing voltage or temperature, current decreases.

In V-I graph, for portion CD of graph, the current decreases with increasing voltage.

Thus, portion CD corresponds to negative resistance.

Alternative

We know that the slope of graph V-I will give the resistance, since slope of CD curve is negative.

So, it has negative resistance.

27 There are three copper wires of length and cross-sectional area (L, A), $(2L, A/2)$ $(L/2, 2A)$. In which case is the resistance minimum ? **[CBSE AIPMT 1997]**

(a) It is the same in all three cases
(b) Wire of cross-sectional area $2A$
(c) Wire of cross-sectional area A
(d) Wire of cross-sectional area $\frac{1}{2}A$

Ans. *(b)*

The relation between length and area is

$$R = \frac{\rho l}{A} \quad \ldots\text{(i)}$$

where, ρ being specific resistance is the proportionality constant and depends on nature of material.

(i) Length $= \frac{L}{2}$, area $= 2A$

Putting in Eq. (i), we have

$$R = \frac{\rho(L/2)}{2A} = \frac{\rho L}{4A}$$

(ii) Length $= L$, area $= A$

Putting in Eq. (i), we have

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

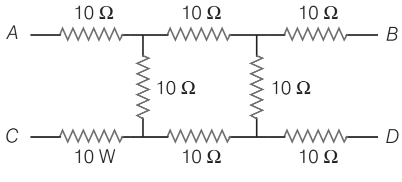
(iii) Length $= 2L$, area $= \frac{A}{2}$

Putting in Eq. (i), we have

$$R = \rho \frac{2L}{A/2} = \frac{4\rho L}{A}$$

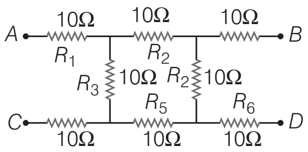
As it is understood from above, resistance is minimum only in option (b).

28 What will be the equivalent resistance of circuit shown in figure between two points A and D? **[CBSE AIPMT 1996]**



(a) 10 Ω (b) 20 Ω (c) 30 Ω (d) 40 Ω

Ans. *(c)*



Effective resistance of R_2 and R_4 in series,

$$R' = 10 + 10 = 20\ \Omega$$

Effective resistance of R_3 and R_5 in series,

$$R'' = 10 + 10 = 20\ \Omega$$

Net total resistance of R' and R'' in parallel is

$$R_p = \frac{20 \times 20}{20 + 20} = 10\ \Omega$$

$\therefore$ Total resistance between A and D

$$= 10 + 10 + 10$$
$$= 30\ \Omega$$

29 If a neglegibly small current is passed through a wire of length 15 m and of resistance $5\ \Omega$ having uniform cross-section of $6 \times 10^{-7}\ \text{m}^2$, then coefficient of resistivity of material, is **[CBSE AIPMT 1996]**

(a) $1 \times 10^{-7}\ \Omega$-m (b) $2 \times 10^{-7}\ \Omega$-m
(c) $3 \times 10^{-7}\ \Omega$-m (d) $4 \times 10^{-7}\ \Omega$-m

Ans. *(b)*

Resistance of a given conducting wire is given by

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

where, ρ is the specific resistance of the material of the conductor.

Here, $l = 15\ \text{m}$

$A = 6 \times 10^{-7}\ \text{m}^2$

$R = 5\ \Omega,\ \rho = ?$

$$\therefore \quad \rho = \frac{RA}{l}$$
$$= \frac{5 \times 6 \times 10^{-7}}{15}$$
$$= 2 \times 10^{-7}\ \Omega\text{-m}$$

30 If the resistance of a conductor is $5\ \Omega$ at $50°$C and $7\ \Omega$ at $100°$C, then the mean temperature coefficient of resistance (of the material) is **[CBSE AIPMT 1996]**

(a) 0.01/°C (b) 0.04/°C
(c) 0.06/°C (d) 0.08/°C.

Ans. *(a)*

Temperature coefficient of resistance is defined as the increase in resistance per unit original resistance per degree rise of temperature and is given by

$$\alpha = \frac{R_t - R_o}{R_o \times t} \quad \text{or} \quad R_t = R_o(1 + \alpha t)$$

R_t = Resistance at final temperature
R_o = Resistance at initial temperature
t = Change in temperature

Case **I** $\quad 5 = R_o[1 + \alpha(50)]$ ...(i)

Case **II** $\quad 7 = R_o[1 + \alpha(100)]$ ...(ii)

Dividing Eq. (i) by Eq. (ii)

$$\frac{5}{7} = \frac{1 + 50\alpha}{1 + 100\alpha}$$

$$\therefore \quad 5 + 500\alpha = 7 + 350\alpha$$

$$\therefore \quad \alpha = \frac{2}{150} = 0.01/°\text{C}$$

31 If a wire of resistance R is melted and recasted to half of its length, then the new resistance of the wire will be **[CBSE AIPMT 1995]**

(a) $\frac{R}{4}$ (b) $\frac{R}{2}$
(c) R (d) $2R$

Ans. *(a)*

Let initial resistance of wire be R, its initial length is l_1 and final length is l_2. According to problem $l_2 = 0.5\,l_1$, volume of the wire is $= lA$.

Since, the volume of wire remains the same after recasting, therefore

$$l_1 A_1 = l_2 A_2$$

$$\therefore \quad \frac{l_1}{l_2} = \frac{A_2}{A_1} \quad \text{or} \quad \frac{l_1}{0.5\,l_1} = \frac{A_2}{A_1}$$

$$\therefore \quad \frac{A_2}{A_1} = 2$$

As resistance of wire, $R \propto \frac{l}{A}$

$$\therefore \quad \frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \frac{l_1}{0.5\,l_1} \times 2 = 4$$

$$\text{or} \quad R_2 = \frac{R_1}{4} = \frac{R}{4}$$

Note

As we know the resistance R of wire of length l and area of cross-section, A is given by $R = \int l/A$

32 Two wires of the same metal have same length, but their cross-sections are in the ratio 3 : 1. They are joined in series. The resistance of thicker wire is $10\ \Omega$. The total resistance of the combination will be **[CBSE AIPMT 1995]**

(a) $10\ \Omega$ (b) $20\ \Omega$
(c) $40\ \Omega$ (d) $100\ \Omega$

Ans. *(c)*

For the same length and same material,

$$\frac{R_2}{R_1} = \frac{A_1}{A_2} = \frac{3}{1}$$

or $\quad R_2 = 3R_1$

The resistance of thick wire,

$$R_1 = 10\ \Omega$$

The resistance of thin wire

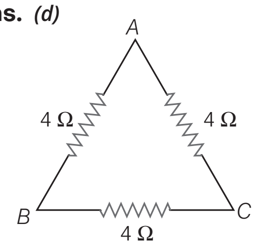
$= 3R_1 = 3 \times 10 = 30\ \Omega$

Total resistance $= 10 + 30 = 40\ \Omega$

33 Three resistances each of $4\ \Omega$ are connected to form a triangle. The resistance between any two terminals is **[CBSE AIPMT 1993]**

(a) $12\ \Omega$ (b) $2\ \Omega$
(c) $6\ \Omega$ (d) $\frac{8}{3}\ \Omega$

Ans. *(d)*



Between any two terminals, two resistors of two arms are in series i.e. between B and C, equivalent resistance is

$$\frac{1}{R_{BC}} = \frac{1}{4} + \frac{1}{8}$$

$$\frac{1}{R_{BC}} = \frac{2 + 1}{8}$$

$$\therefore \quad R_{BC} = \frac{8}{3}\ \Omega$$

34 The velocity of charge carriers of current (about 1 A) in a metal under normal conditions is of the order of **[CBSE AIPMT 1991]**

(a) a fraction of mm/s
(b) velocity of light
(c) several thousand m/s
(d) a few hundred m/s

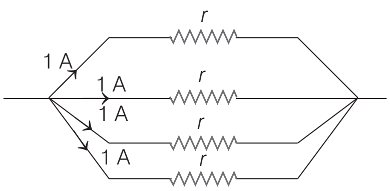
Ans. *(a)*

The charged particles whose flow in a definite direction constitutes the electric current are called current carriers. In metals the valence electrons of the atoms do not remain attached to individual atoms but are free to move throughout the volume of the conductor. Their velocity under normal conditions is of the order of a fraction of mm/s.

35 You are given several identical resistances each of value $R = 10\,\Omega$ and each capable of carrying a maximum current of 1A. It is required to make a suitable combination of these resistances of $5\,\Omega$ which can carry a current of 4 A. The minimum number of resistances of the type R that will be required for this job is **[CBSE AIPMT 1990]**

(a) 4 (b) 10
(c) 8 (d) 20

Ans. *(c)*



To carry a current of 4 A we need four path, each carrying a current of 1A. Let r be the resistance of each path. These resistances are connected in parallel. So, their equivalent resistance.

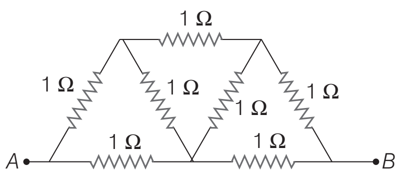
$$\frac{1}{r_p} = \frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \frac{1}{r} \quad \text{or} \quad r_p = \frac{r}{4}.$$

But, $\quad r_p = \frac{r}{4} = 5 \qquad$ (given)

$\therefore \quad r = 20\,\Omega$

For this purpose two resistances should be connected is series. There are four such combinations in parallel. Hence, the total number of resistances $= 4 \times 2 = 8$.

36 In the network shown in figure each resistance is 1Ω. The effective resistance between A and B is **[CBSE AIPMT 1990]**

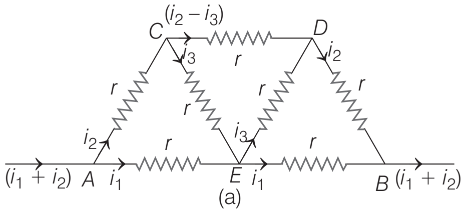


(a) $\frac{4}{3}\,\Omega$ (b) $\frac{3}{2}\,\Omega$

(c) $7\,\Omega$ (d) $\frac{8}{7}\,\Omega$

Ans. *(d)*

The distribution of currents in the circuit is shown in the Fig. (a). Due to symmetry, current in arm AE is equal to current in the arm EB. Since, current in the arm CE is equal to the current in the arm ED, therefore the resistance of network will not change, if the wires CED and AEB are disconnected at E, as shown in Fig. (b).



(a)

Now, resistance of path $AEB = r + r = 2r$

Resistance of path

$$ACDB = r + \frac{(2r) \times r}{(2r) + r} + r = \frac{8r}{3}$$

The paths AEB and $ACDB$ are in parallel, therefore the effective resistance between A and B will be

$$\frac{1}{R} = \frac{1}{2r} + \frac{3}{8r} = \frac{4+3}{8r} = \frac{7}{8r}$$

or $\quad R = \frac{8r}{7}$

But $\quad r = 1\,\Omega,$

Therefore, $\quad R = \frac{8 \times 1}{7} = \frac{8}{7}\,\Omega$

37 n equal resistors are first connected in series and then connected in parallel. What is the ratio of the maximum to the minimum resistance ? **[CBSE AIPMT 1989]**

(a) n (b) $1/n^2$ (c) n^2 (d) $1/n$

Ans. *(c)*

When resistors are connected in series, then effective resistance of series combination

$$R_S = R + R + \ldots + n \text{ terms}$$
$$= nR \qquad \ldots\text{(i)}$$

When resistors are connected in parallel, then effective resistance

$$\frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \ldots + n \text{ terms}$$

or $\quad \frac{1}{R_P} = \frac{n}{R} \qquad \ldots$(ii)

$$R_p = \frac{R}{n}$$

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

$$\frac{R_S}{R_P} = \frac{n^2}{1}$$

38 The masses of the three wires of copper are in the ratio of $1:3:5$ and their lengths are in the ratio of $5:3:1$. The ratio of their electrical resistance is **[CBSE AIPMT 1988]**

(a) 1 : 3 : 5 (b) 5 : 3 : 1
(c) 1 : 25 : 125 (d) 125 : 15 : 1

Ans. *(d)*

Let A_1, A_2, A_3 be the area of cross-section of three wires of copper of masses m_1, m_2, m_3 and length l_1, l_2, l_3 respectively. Given $m_1 = m, m_2 = 3m,$ $m_3 = 5m, l_1 = 5l, l_2 = 3l, l_3 = l$

Mass = volume × density,

So, $\quad m = A_1 \times 5l \times \rho \qquad \ldots$(i)

$3m = A_2 \times 3l \times \rho \qquad \ldots$(ii)

$5m = A_3 \times l \times \rho \qquad \ldots$(iii)

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

$$A_2 = 5A_1$$

From Eqs. (i) and (iii),

$$A_3 = 25A_1$$

$$\therefore \quad R_1 = \rho\frac{l_1}{A_1} = \rho\frac{5l}{A_1}$$

$$R_2 = \rho\frac{l_2}{A_2} = \rho \times \frac{3l}{5A_1} = \frac{3}{25}R_1$$

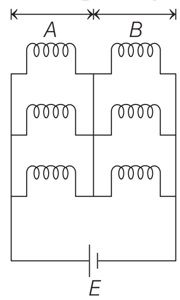
$$R_3 = \rho\frac{l_3}{A_3} = \frac{\rho \times l}{25A_1} = \frac{R_1}{125}$$

$$\therefore R_1 : R_2 : R_3 = R_1 : \frac{3}{25}R_1 : \frac{R_1}{125}$$

$$= 125 : 15 : 1$$

TOPIC 2
Heating Effect of Current

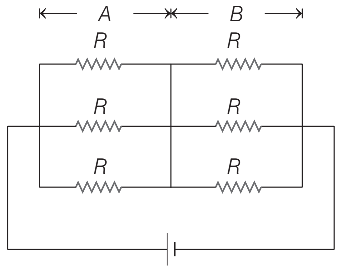
39 Six similar bulbs are connected as shown in the figure with a DC source of emf E and zero internal resistance.
The ratio of power consumption by the bulbs when (i) all are glowing and (ii) in the situation when two from section A and one from section B are glowing, will be **[NEET (National) 2019]**



(a) 9 : 4 (b) 1 : 2
(c) 2 : 1 (d) 4 : 9

Ans. *(a)*

Case I When all bulbs are glowing, then the circuit can be realised as shown in the figure below.



$\therefore$ The equivalent resistance of this circuit is

$$R_{eq} = R_A + R_B$$

As, section A has three parallel resistance, so equivalent resistance,

$$R_A = \frac{R}{3}$$

Similarly, for section B, equivalent resistance,

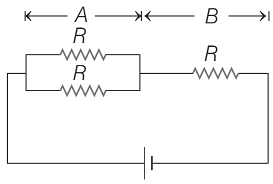
$$R_B = \frac{R}{3}$$

$$\therefore \quad R_{eq} = \frac{R}{3} + \frac{R}{3} = \frac{2R}{3} \quad \text{... (i)}$$

Thus, power consumed in this circuit,

$$P_1 = \frac{V^2}{R} = \frac{E^2}{R_{eq}} = \frac{3E^2}{2R} \text{ [using Eq. (i)]} \quad \text{...(ii)}$$

Case II When two from section A and one from section B glow, the circuit can be realised as shown in the figure below.



$\therefore$ Equivalent resistance of section A,

$$R_A = \frac{R}{2}$$

and of section B,

$$R_B = R$$

Thus, equivalent resistance of the entire circuit becomes

$$R_{eq} = R_A + R_B = \frac{R}{2} + R = \frac{3R}{2} \quad \text{... (iii)}$$

$\therefore$ Power consumed by this circuit,

$$P_2 = \frac{V^2}{R} = \frac{E^2}{R_{eq}} = \frac{2E^2}{3R}$$

[using Eq. (iii)]... (iv)

So, ratio of power of two cases is obtained from Eqs. (ii) and (iv), we get

$$\frac{P_1}{P_2} = \frac{3E^2}{2R} \times \frac{3R}{2E^2} = \frac{9}{4} \text{ or } 9:4$$

40 The charge following through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is **[NEET 2016]**

(a) $\frac{a^3R}{3b}$ (b) $\frac{a^3R}{2b}$ (c) $\frac{a^3R}{b}$ (d) $\frac{a^3R}{6b}$

Ans. *(d)*

Given, charge $Q = at - bt^2$ ...(i)

$\because$ We know that current, $I = \frac{d\theta}{dt}$

So, eq. (i) can be written as

$$I = \frac{d}{dt}(at - bt^2) \Rightarrow I = a - 2bt \quad \text{...(ii)}$$

For maximum value of t, till the current exist is given by

$$\Rightarrow \quad a - 2bt = 0$$

$$\therefore \quad t = \frac{a}{2b} \quad \text{...(iii)}$$

$\because$ The total heat produced (H) can be given as

$$H = \int_0^t I^2 R\, dt$$

$$= \int_0^{a/2b} (a - 2bt)^2 R\,.dt \quad \left\{\because t = \frac{a}{2b}\right\}$$

$$= \int_0^{a/2b} (a^2 + 4b^2t^2 - 4abt) R dt$$

$$H = \left[a^2t + 4b^2 \frac{t^3}{3} - \frac{4abt^2}{2}\right]_0^{a/2b} R$$

Solving above equation, we get

$$\Rightarrow \quad H = \frac{a^3R}{6b}$$

41 A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500 W. The value of R is **[NEET 2016]**

(a) 230 Ω (b) 46 Ω
(c) 26 Ω (d) 13 Ω

Ans. *(c)*

If a rated voltage and power are given, then $P_{rated} = \frac{V_{rated}^2}{R}$

$\therefore$ Current in the bulb, $i = \frac{P}{V}$ $(\because P = Vi)$

$$i = \frac{500}{100} = 5 \text{ A}$$

$\therefore$ Resistance of bulb,

$$R_b = \frac{100 \times 100}{500} = 20\,\Omega$$

$\because$ Resistance R is connected in series.

$$\therefore \quad \text{Current, } i = \frac{E}{R_{net}} = \frac{230}{R + R_b}$$

$$\Rightarrow \quad R + 20 = \frac{230}{5} = 46$$

$$\therefore \quad R = 26\,\Omega$$

42 Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 V and the average resistance per km is 0.5 Ω. The power loss in the wire is **[CBSE AIPMT 2014]**

(a) 19.2 W (b) 19.2 kW
(c) 19.2 J (d) 12.2 kW

Ans. *(b)*

Potential drop between two cities is

$$= 150 \times 8 = 1200 \text{ V}$$

Average resistance of total wire $= 0.5 \times 150 = 75\ \Omega$

So, power loss $P = \frac{V^2}{R}$

$$= \frac{1200 \times 1200}{75} = 19200 \text{ W}$$

$$= 19.2 \text{ kW}$$

43 If voltage across a bulb rated 220 V-100 W drops by 2.5% of its rated value, the percentage of the rated value by which the power would decrease is **[CBSE AIPMT 2012]**

(a) 20% (b) 2.5%
(c) 5% (d) 10%

Ans. *(c)*

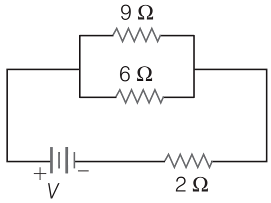
Power, $(P) = \frac{V^2}{R}$

For small variation,

$$\frac{\Delta P}{P} \times 100 = 2 \times \frac{\Delta V}{V} \times 100 = 2 \times 2.5 = 5\%$$

Therefore, power would decrease by 5%.

44 If power dissipated in the 9 Ω resistor in the circuit shown is 36W, the potential difference across the 2 Ω resistor is **[CBSE AIPMT 2011]**



(a) 8 V (b) 10 V (c) 2 V (d) 4 V

Ans. *(b)*

Electric power, $P = i^2 R$

$\therefore$ Current, $i = \sqrt{\dfrac{P}{R}}$

For resistance of 9 Ω,

$$i_1 = \sqrt{\frac{36}{9}} = \sqrt{4} = 2\text{ A}$$

$$i_2 = \frac{i_1 \times R}{6} = \frac{2 \times 9}{6} = 3\text{ A}$$

$$I = i_1 + i_2 = 2 + 3 = 5\text{ A}$$

So, $V_2 = IR_2 = 5 \times 2 = 10\text{ V}$

45 An electric kettle takes 4 A current at 220 V. How much time will it take to boil 1 kg of water from temperature 20°C? **[CBSE AIPMT 2008]**

(a) 6.3 min (b) 8.4 min
(c) 12.6 min
(d) 4.2 min

Ans. *(a)*

$$Vit = ms\,\Delta t$$

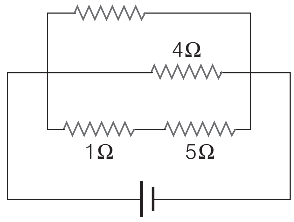
$$\Rightarrow \quad t = \frac{ms\,\Delta t}{Vi}$$

$$= \frac{1 \times 4200 \times 80}{220 \times 4}$$

$$= 381.82\text{ s}$$

$$= 6.3\text{ min}$$

46 A current of 3 A flows through the 2 Ω resistor shown in the circuit. The power dissipated in the 5 Ω resistor is **[CBSE AIPMT 2008]**



(a) 4 W (b) 2 W
(c) 1 W (d) 5 W

Ans. *(d)*

Voltage across 2 Ω,

$$= 3 \times 2 = 6\text{ V}$$

Voltage across 4 Ω and (5 Ω + 1 Ω) resistor is same.

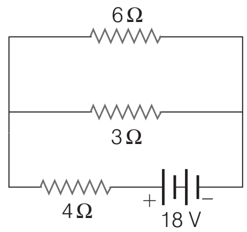
So, current across 5 $\Omega = \dfrac{6}{1+5} = 1\text{ A}$ $\left[i = \dfrac{V}{R}\right]$

Power across 5 $\Omega = P = i^2 R$

$$= (1)^2 \times 5$$

$$= 5\text{ W}$$

47 The total power dissipated in watts in the circuit shown here is **[CBSE AIPMT 2007]**



(a) 16 (b) 40 (c) 54 (d) 4

Ans. *(c)*

The resistance of 6 Ω and 3 Ω are in parallel in the given circuit, their equivalent resistance is

$$\frac{1}{R_1} = \frac{1}{6} + \frac{1}{3} = \frac{1+2}{6} = \frac{1}{2} \quad \text{or} \quad R_1 = 2\,\Omega$$

Again, R_1 is in series with 4 Ω resistance, hence

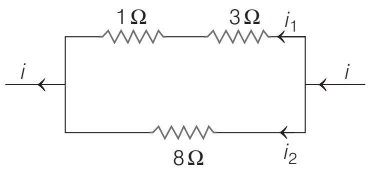
$$R = R_1 + 4 = 2 + 4 = 6\,\Omega$$

Thus, the total power dissipated in the circuit

$P = \dfrac{V^2}{R}$; Here, $V = 18\text{ V}, R = 6\,\Omega$

Thus, $P = \dfrac{(18)^2}{6} = 54\text{ W}$

48 Power dissipated across the 8 Ω resistor in the circuit shown here is 2 W. The power dissipated in watt units across the 3 Ω resistor is **[CBSE AIPMT 2006]**



(a) 2.0 (b) 1.0 (c) 0.5 (d) 3.0

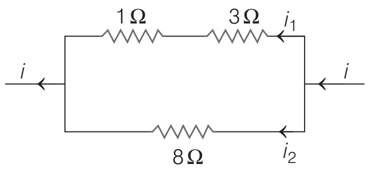
Ans. *(d)*

Problem Solving Strategy Find the equivalent resistance of the circuit and then calculate the power dissipated by the circuit.

Resistances 1 Ω and 3 Ω are connected in series, so, effective resistance

$$R' = 1 + 3 = 4\,\Omega$$

Now, R' and 8 Ω are in parallel. We know that potential difference across resistances in parallel is same.



So, from Kirchhoff's law, $V_1 = V_2$

$R' \times i_1 = 8i_2$ or $4 \times i_1 = 8i_2$

or $i_1 = \dfrac{8}{4} i_2 = 2i_2$

or $i_1 = 2i_2$ ...(i)

Power dissipated across 8 Ω resistance is

$i_2^2\,(8)\,t = 2\text{ W}$ $[\because P = iRt]$

or $i_2^2\,t = \dfrac{2}{8} = 0.25\text{ W}$ ...(ii)

Power dissipated across 3 Ω resistance is

$$H = i_1^2\,(3)\,t$$

$$= (2i_2)^2\,(3)\,t = 12\,i_2^2\,t$$

but $i_2^2\,t = 0.25\text{ W}$

$$H = 12 \times 0.25 = 3\text{ W}$$

49 A 5 A fuse wire can withstand a maximum power of 1 W in circuit. The resistance of the fuse wire is **[CBSE AIPMT 2005]**

(a) 0.2 Ω (b) 5 Ω
(c) 0.4 Ω (d) 0.04 Ω

Ans. *(d)*

As we know that,

Power $P = i^2 R$ $\left[\begin{array}{l}\text{where, } i = \text{current in circuit} \\ R = \text{resistance}\end{array}\right]$

$$R = \frac{p}{i^2}$$

Given, $P = 1\text{ W}, \; i = 5\text{ A}$

$$R = \frac{1}{(5)^2} = 0.04\,\Omega$$

50 In India, electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60 W bulb for use in India is R, the resistance of a 60 W bulb for use in USA will be **[CBSE AIPMT 2004]**

(a) R (b) $2R$ (c) $\dfrac{R}{4}$ (d) $\dfrac{R}{2}$

Ans. *(c)*

Since, power rating of bulb in both the countries India and USA is same, so

$$\frac{V_1^2}{R_1} = \frac{V_2^2}{R_2} \qquad \left[P = \frac{V^2}{R}\right]$$

$$\Rightarrow \frac{220 \times 220}{R_1} = \frac{110 \times 110}{R_2}$$

$$\Rightarrow \frac{R_2}{R_1} = \frac{110 \times 110}{220 \times 220}$$

$$\Rightarrow R_2 = \frac{R}{4} \qquad (\because R_1 = R)$$

51 When three identical bulbs of 60 W, 200 V rating are connected in series to a 200 V supply, the power drawn by them will be **[CBSE AIPMT 2004]**

(a) 60 W (b) 180 W (c) 10 W (d) 20 W

Ans. *(d)*

Let R_1, R_2 and R_3 are the resistances of three bulbs respectively.

In series order,

$$R = R_1 + R_2 + R_3$$

but, $R = \frac{V^2}{P}$ and supply voltage in series order is the same as the rated voltage.

$$\therefore \quad \frac{V^2}{P} = \frac{V^2}{P_1} + \frac{V^2}{P_2} + \frac{V^2}{P_3}$$

$$\text{or} \quad \frac{1}{P} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60}$$

$$\text{or} \quad P = \frac{60}{3} = 20 \text{ W}$$

Alternative

As three bulbs have same power and voltage so, they have equal resistance. So, power equivalent when connected in series is given by,

$$\frac{1}{P_{EQ}} = \frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3}$$

$$\frac{1}{P_{EQ}} = \frac{1}{P} + \frac{1}{P} + \frac{1}{P} \quad (\text{as } P_1 = P_2 = P_3 = P)$$

$$\text{So, } P_{EQ} = \frac{P}{3} \Rightarrow \frac{60}{3} = 20 \text{ W}$$

52 Two 220 V, 100 W bulbs are connected first in series and then in parallel. Each time the combination is connected to a 220 V AC supply line. The power drawn by the combination in each case respectively will be **[CBSE AIPMT 2003]**

(a) 200 W, 150 W (b) 50 W, 200 W
(c) 50 W, 100 W (d) 100 W, 50 W

Ans. *(b)*

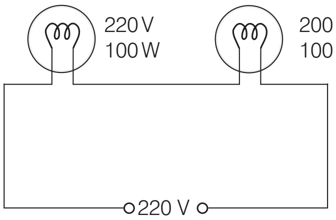
Power $P = 100$ W, Voltage, $V = 220$ V

$$P = \frac{V^2}{R}$$

$$\therefore \quad R = \frac{V^2}{P} = \frac{(220)^2}{100} = \frac{220 \times 220}{100} \, \Omega$$

As both the bulb have same voltage and power so, resistance of bulbs will also be same.

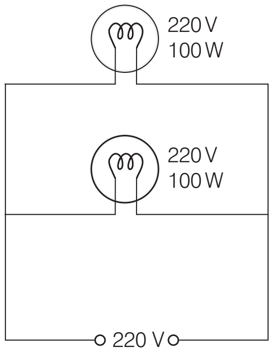
Case I When two bulbs are connected in series.



$$\text{In series, } R_{eq} = R_1 + R_2 = \left(\frac{220 \times 220}{100}\right) \times 2$$

$$\text{Hence, } P_{eq} = \frac{V^2}{R_{eq}} = \frac{220 \times 220}{\left(\frac{220 \times 220}{100} \times 2\right)} = \frac{100}{2} = 50 \text{ W}$$

Case II When two bulbs are connected in parallel.



$$\text{In parallel, } R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\left(\frac{220 \times 220}{100}\right)^2}{\frac{220 \times 220}{100} \times 2}$$

$$R_{eq} = \frac{220 \times 220}{100} \times \frac{1}{2}$$

$$\text{Hence, } P_{eq} = \frac{V^2}{R_{eq}} = \frac{220 \times 220}{\frac{220 \times 220}{100} \times \frac{1}{2}} = 200 \text{ W}$$

Alternative

$$\text{For series, } P_{eq} = \frac{P_1 P_2}{P_1 + P_2} = \frac{100 \times 100}{200} = 50 \text{ W}$$

$$\text{For parallel, } P_{eq} = P_1 + P_2 = 100 + 100 = 200 \text{ W}$$

Note Power equivalent of two or more resistance in series is given by $\frac{1}{P_{eq}} = \frac{1}{P_1} + \frac{1}{P_2}$ and for parallel combination $P_{eq} = P_1 + P_2$

53 An electric kettle has two heating coils. When one of the coils is connected to an AC source, the water in the kettle boils in 10 min. When the other coil is used the water boils in 40 min. If both the coils are connected in parallel, the time taken by the same quantity of water to boil will be **[CBSE AIPMT 2003]**

(a) 25 min (b) 15 min
(c) 8 min (d) 4 min

Ans. *(c)*

Let R_1 and R_2 be the resistances of the coils, V be the supply voltage, H be the heat required to boil the water.

$$\text{For first coil, } H = \frac{V^2 t_1}{R_1} \quad \text{...(i)}$$

$$\text{For second coil, } H = \frac{V^2 t_2}{R_2} \quad \text{...(ii)}$$

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

$$\frac{t_1}{R_1} = \frac{t_2}{R_2}$$

$$\text{i.e.} \quad \frac{R_2}{R_1} = \frac{t_2}{t_1} = \frac{40}{10} = 4 \quad \begin{bmatrix} t_1 = 10 \text{ min} \\ t_2 = 40 \text{ min} \end{bmatrix}$$

$$\Rightarrow \quad R_2 = 4R_1 \quad \text{...(iii)}$$

When the two heating coils are in parallel, equivalent resistance is given by

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{R_1 \times 4R_1}{R_1 + 4R_1} = \frac{4R_1}{5}$$

$$\text{and} \quad H = \frac{V^2 t}{R} \quad \text{...(iv)}$$

Comparing Eqs. (i) and (iv), we get

$$\frac{V^2 t_1}{R_1} = \frac{V^2 t}{R}$$

$$\Rightarrow \quad t = \frac{R}{R_1} \times t_1 \quad [t_1 = 10 \text{ min}]$$

$$\therefore \quad t = \frac{4}{5} \times 10 = 8 \text{ min}$$

54 Fuse wire is a wire of **[CBSE AIPMT 2003]**

(a) low resistance and low melting point
(b) low resistance and high melting point
(c) high resistance and high melting point
(d) high resistance and low melting point

Ans. *(d)*

The electric fuse is a device which is used to limit the current in an electric circuit. Thus, the use of fuse safeguards the circuit and the appliances connected in the circuit from being damaged. It is always connected with the live (or phase) wire. The fuse wire is a short piece of wire made of a material of high resistance and low melting point so that it may easily melt due to overheating when excessive current passes through it.

55 Two bulbs 25 W, 220 V and 100 W, 220 V are given. Which has higher resistance? **[CBSE AIPMT 2000]**

(a) 25 W bulb
(b) 100 W bulb
(c) Both bulbs will have equal resistance
(d) Resistance of bulbs cannot be compared

Ans. ***(a)***

Power of electric bulb, $P = \frac{V^2}{R}$

So, resistance of electric bulb, $R = \frac{V^2}{P}$

Given, $P_1 = 25$ W, $P_2 = 100$ W, $V_1 = V_2 = 220$ V

Therefore, for same potential difference V,

$$R \propto \frac{1}{P}$$

Thus, we observe that for minimum power, resistance will be maximum and *vice-versa*.

Hence, resistance of 25 W bulb is maximum and 100 W bulb is minimum.

56 A 5°C rise in temperature is observed in a conductor by passing a current. When the current is doubled the rise in temperature will be approximately **[CBSE AIPMT 1998]**

(a) 16°C (b) 10°C (c) 20°C (d) 12°C

Ans. ***(c)***

Energy loss in conductor, $Q = i^2 Rt$

where, i = current flowing through it

R = resistance of conductor

t = time for which current is passed

Heat developed $= ms\,\Delta\theta$

$\therefore \quad ms\,\Delta\theta = i^2\,Rt$

Since m, s, R, t remains constant.

So, $\quad \Delta\theta \propto i^2$

So, for two different cases

$$\frac{\Delta\theta_2}{\Delta\theta_1} = \frac{i_2^2}{i_1^2}$$

or $$\Delta\theta_2 = \left(\frac{i_2}{i_1}\right)^2 \Delta\theta_1 \quad \ldots \text{(i)}$$

Given, $i_2 = 2i_1$, $\Delta\theta_1 = 5°C$

So, from Eq. (i),

$$\therefore \quad \Delta\theta_2 = \left(\frac{2i_1}{i_1}\right)^2 \times 5 = 4 \times 5 = 20°C$$

57. Three equal resistors connected in series across a source of emf together dissipate 10 W of power. What will be the power dissipated in watt if the same resistors are connected in parallel across the same source of emf ? **[CBSE AIPMT 1998]**

(a) $\frac{10}{3}$ (b) 10
(c) 30 (d) 90

Ans. ***(d)***

Power, $P = \frac{\Delta U}{\Delta t} = V\frac{\Delta q}{\Delta t} = Vi$

or $\quad P = Vi = \frac{V^2}{R} \quad (\because V = iR)$

When resistors are in series, then

$$R_1 = R + R + R = 3R$$

$\therefore$ Power dissipated,

$$P_1 = \frac{V^2}{R_1} = \frac{V^2}{3R} \quad \ldots \text{(i)}$$

When resistors are in parallel, then

$$\frac{1}{R_2} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$$

$$\Rightarrow \quad R_2 = \frac{R}{3}$$

$$\therefore \quad P_2 = \frac{V^2}{R_2} = \frac{V^2}{R/3} = \frac{3V^2}{R} \quad \ldots \text{(ii)}$$

By taking ratio of Eqs. (i) and (ii)

$$\frac{P_2}{P_1} = \frac{3V^2}{R} \times \frac{3R}{V^2} = 9$$

$$P_2 = 9P_1 = 9 \times 10 = 90 \text{ W}$$

58. A 100 W 200 V bulb is connected to a 160 V power supply. The power consumption would be **[CBSE AIPMT 1997]**

(a) 125 W (b) 100 W
(c) 80 W (d) 64 W

Ans. ***(d)***

Power consumed, $P = \frac{V^2}{R}$

and $\quad P' = \frac{V'^2}{R}$ $\left(\begin{array}{l}\text{As resistance is same}\\ \text{for both the cases}\end{array}\right)$

Given, $V = 200$ V

$V' = 160$ V, $P = 100$ W

Comparing two different cases of voltage supplied

So, $$\frac{P'}{P} = \left(\frac{V'}{V}\right)^2 = \left(\frac{160}{200}\right)^2 = (0.8)^2$$

or $\quad P' = (0.8)^2\,P = 0.64 \times 100 = 64$ W

59 A heating coil is labelled 100 W, 220 V. The coil is cut in two equal halves and the two pieces are joined in parallel to the same source. The energy now liberated per second is **[CBSE AIPMT 1995]**

(a) 25 J (b) 50 J
(c) 200 J (d) 400 J

Ans. ***(d)***

When heating coil is cut into two equal parts and these parts are joined in parallel, then the resistance of the coil is reduced to $\frac{1}{4}$ of the previous value. As $\left(H \propto \frac{1}{R}\right)$, for constant voltage so, energy liberated per second becomes 4 times, i.e.

$$4 \times 100 = 400 \text{ J}.$$

60 A $4\mu F$ conductor is charged to 400 V and then its plates are joined through a resistance of $1k\Omega$. The heat produced in the resistance is **[CBSE AIPMT 1994]**

(a) 0.16 J (b) 1.28 J
(c) 0.64 J (d) 0.32 J

Ans. ***(d)***

The energy stored in the capacitor

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

This energy will be converted into heat in the resistor.

$$\therefore \quad H = \frac{1}{2}CV^2$$

where, C = capacitance of capcitor

V = voltage across the plate of capacitor

$$\Rightarrow \quad H = \frac{1}{2} \times 4 \times 10^{-6} \times (400)^2 = 0.32 \text{ J}$$

61 40 electric bulbs are connected in series across a 220 V supply. After one bulb is fused the remaining 39 are connected again in series across the same supply. The illumination will be **[CBSE AIPMT 1989]**

(a) more with 40 bulbs than with 39
(b) more with 39 bulbs than with 40
(c) equal in both the cases
(d) in the ratio $40^2 : 39^2$

Ans. *(b)*

As the voltage is same for both forty and thirty nine bulbs combination, therefore heat produced is given by $H = \frac{V^2 t}{R}$ and $H \propto \frac{1}{R}$. As equivalent resistance decreases, the combination of 39 bulbs will glow more.

62 A current of 2 A, passing through a conductor produces 80 J of heat in 10 s. The resistance of the conductor in ohm is **[CBSE AIPMT 1989]**

(a) 0.5 (b) 2
(c) 4 (d) 20

Ans. *(b)*

Amount of heat produced in a conductor is equal to work done in carrying a charge q from one end of conductor to other end of conductor having potential difference V.

$\therefore \quad H = W = Vq = Vit = i^2 Rt$ [as, $V = IR$]

$\therefore \quad H = i^2 Rt$ J

$\Rightarrow \quad R = \frac{H}{(i^2 t)}$

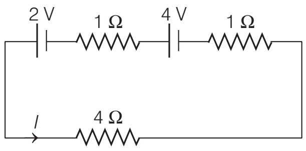
Given, $H = 80$ J, $i = 2$ A, $t = 10$ s,

So, $R = \frac{80}{(2)^2 \times 10} = 2\,\Omega$

TOPIC 3

Cells and its Combination and Kirchhoff's Rules

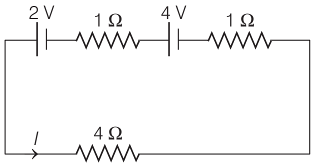
63 For the circuit shown in the figure, the current I will be **[NEET (Oct.) 2020]**



(a) 0.75 A (b) 1 A
(c) 1.5 A (d) 0.5 A

Ans. *(b)*

The circuit diagram is shown below



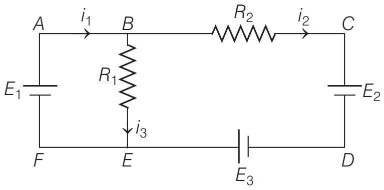
Applying KVL in the loop, we get

$4I + I \cdot 1 - 4 + I \cdot 1 - 2 = 0$

$\Rightarrow \quad 6I = 6$

$\Rightarrow \quad I = 1$ A

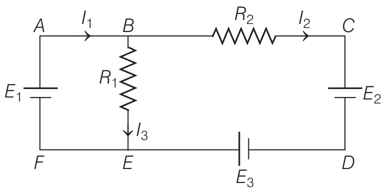
64 For the circuit given below, the Kirchhoff's loop rule for the loop *BCDEB* is given by the equation **[NEET (Oct.) 2020]**



(a) $-i_2R_2 + E_2 - E_3 + i_3R_1 = 0$
(b) $i_2R_2 + E_2 - E_3 - i_3R_1 = 0$
(c) $i_2R_2 + E_2 + E_3 + i_3R_1 = 0$
(d) $-i_2R_2 + E_2 + E_3 + i_3R_1 = 0$

Ans. *(b)*

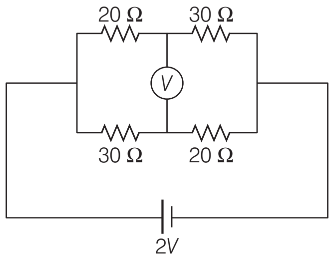
The circuit diagram is given below



Applying KVL rule in loop *BCDEB*,

$R_2I_2 + E_2 - E_3 - I_3R_1 = 0$

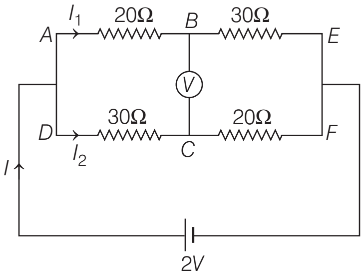
65 The reading of an ideal voltmeter in the circuit shown is **[NEET (Odisha) 2019]**



(a) 0.6 V (b) 0 V
(c) 0.5 V (d) 0.4 V

Ans. *(d)*

The given circuit diagram can be drawn as shown below



The equivalent resistance of circuit is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_{AE}} + \frac{1}{R_{DF}}$$

$$= \frac{1}{(20+30)} + \frac{1}{(30+20)}$$

$$= \frac{1}{50} + \frac{1}{50} = \frac{2}{50}$$

$\Rightarrow \quad R_{eq} = 25\,\Omega$

The current in circuit, $I = \frac{V}{R} = \frac{2}{25}$ A

As the resistance of two branches is same i.e. $50\,\Omega$.

So, the current $I_1 = I_2$

$\Rightarrow \quad I = I_1 + I_2$

$\frac{2}{25} = 2I_1 \Rightarrow I_2 = I_1 = \frac{1}{25}$ A

$\therefore$ The voltage across *AB*

$$V_1 = I_1R_1 = \frac{1}{25} \times 20$$

and voltage across *CD*

$$V_2 = I_2R_2 = \frac{1}{25} \times 30$$

$\therefore$ Voltmeter reading $= V_2 - V_1$

$$= \frac{30}{25} - \frac{20}{25} = \frac{10}{25} = 0.4\text{ V}$$

66 A set of 'n' equal resistors, of value 'R' each, are connected in series to a battery of emf 'E' and internal resistance 'R'. The current drawn is I. Now, the 'n' resistors are connected in parallel to the same battery. Then, the current drawn from battery becomes $10I$. The value of 'n' is **[NEET 2018]**

(a) 20 (b) 11 (c) 10 (d) 9

Ans. *(c)*

When n equal resistors of resistance R are connected in series, then the current drawn is given as

$$I = \frac{E}{nR + r}$$

where,

nR = equivalent resistance of n resistors in series and r = internal resistance of battery.

Given, $r = R$

$$\Rightarrow \quad I = \frac{E}{nR + R} = \frac{E}{R(n+1)} \quad \text{...(i)}$$

Similarly, when n equal resistors are connected in parallel, then the current drawn is given as

$$I' = \frac{E}{\frac{R}{n} + R}$$

where, $\frac{R}{n}$ = equivalent resistance of n resistors in parallel.

Given, $I' = 10I$

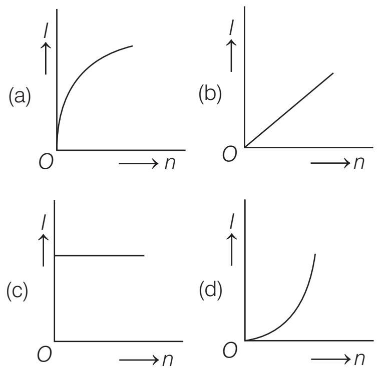
$$\Rightarrow \quad 10I = \frac{E}{\frac{R}{n} + R} = \frac{nE}{(n+1)R} \quad \text{...(ii)}$$

Substituting the value of I from Eq. (i) in Eq. (ii), we get

$$10\left(\frac{E}{R(n+1)}\right) = \frac{nE}{R(n+1)}$$

$$\Rightarrow \quad n = 10$$

67 A battery consists of a variable number 'n' of identical cells (having internal resistance 'r' each) which are connected in series. The terminals of the battery are short-circuited and the current I is measured. Which of the graphs shows the correct relationship between I and n? **[NEET 2018]**



Ans. ***(c)***

If n identical cells are connected in series, then

Equivalent emf of the combination,

$$E_{eq} = nE$$

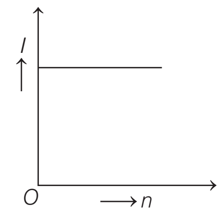
Equivalent internal resistance,

$$r_{eq} = nr$$

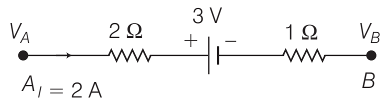
$$\therefore \text{ Current,} \quad I = \frac{E_{eq}}{r_{eq}} = \frac{nE}{nr}$$

$$\text{or} \quad I = \frac{E}{r} = \text{constant}$$

Thus, current (I) is independent of the number of cells (n) present in the circuit. Therefore, the graph showing the relationship between I and n would be as shown below.

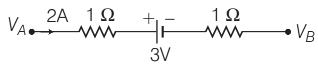


68 The potential difference $(V_A - V_B)$ between the points A and B in the given figure is **[NEET 2016]**



(a) –3 V (b) +3 V
(c) +6 V (d) +9 V

Ans. ***(d)***



Applying KVL,

$$V_A + \Sigma V = V_B + 2 \times 2 + 2 \times 1$$

$$V_A - V_B - 3 = 4 + 2; \; V_A - V_B = 9\text{ V}$$

69 The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is **[NEET 2013]**

(a) 0.2 Ω (b) 0.5 Ω
(c) 0.8 Ω (d) 1.0 Ω

Ans. ***(b)***

As, $I = \frac{E}{R + r}$

E = emf of cell

R = external resistance

r = internal resistance

I = current in circuit

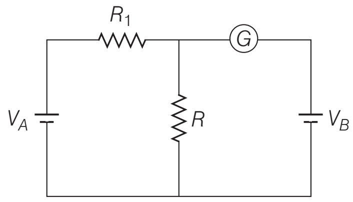
$$\text{or} \quad E = I(R + r),$$

$$2.1 = 0.2(10 + r)$$

$$10 + r = \frac{2.1}{2} \times 10$$

$$\therefore \quad r = 10.5 - 10 = 0.5\,\Omega$$

70 In the circuit shown, the cells A and B have negligible resistances. For $V_A = 12$ V, $R_1 = 500\,\Omega$ and $R = 100\,\Omega$ the galvanometer (G) shows no deflection. The value of V_B is **[CBSE AIPMT 2012]**



(a) 4 V (b) 2 V
(c) 12 V (d) 6 V

Ans. ***(b)***

Concept If potential difference across R Ω resistor is equal to potential difference of cell B, galvanometer shows no deflection.

Applying Kirchhoff's law,

$$500I + 100I = 12$$

$$\text{So,} \quad I = \frac{12 \times 10^{-2}}{6} = 2 \times 10^{-2}\text{ A}$$

$$\text{Hence,} \quad V_B = 100(2 \times 10^{-2}) = 2\text{ V}$$

71 A current of 2 A flows through a 2 Ω resistor when connected across a battery. The same battery supplies a current of 0.5 A when connected across a 9 Ω resistor. The internal resistance of the battery is **[CBSE AIPMT 2011]**

(a) 1/3 Ω (b) 1/4 Ω
(c) 1 Ω (d) 0.5 Ω

Ans. ***(a)***

Current in circuit connected with battery of emf E with internal resistance r is given by

$$\text{Current,} \quad i = \frac{E}{R + r}$$

$$\textbf{Case I} \quad 2 = \frac{E}{2 + r} \quad \text{...(i)}$$

$$\textbf{Case II} \quad 0.5 = \frac{E}{9 + r} \quad \text{...(ii)}$$

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

$$\frac{2}{0.5} = \frac{9 + r}{2 + r}$$

$$4 = \frac{9 + r}{2 + r}$$

$$\Rightarrow \quad 3r = 1$$

$$\Rightarrow \quad r = \frac{1}{3}\,\Omega$$

72 Consider the following two statements:

I. Kirchhoff's junction law follows from the conservation of charge.

II. Kirchhoff's loop law follows from the conservation of energy.

Which of the following is correct? **[CBSE AIPMT 2010]**

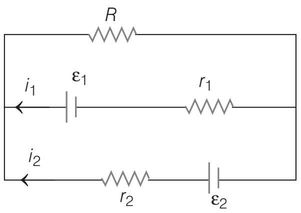
(a) Both I and II are wrong
(b) I is correct and II is wrong
(c) I is wrong and II is correct
(d) Both I and II are correct

Ans. ***(d)***

Kirchhoff's junction law follows from the conservation of charge.

Kirchhoff's loop law follows from the conservation of energy.

73 See the electrical circuit shown in this figure. Which of the following equations is a correct equation for it ? **[CBSE AIPMT 2009]**



(a) $\varepsilon_1 - (i_1 + i_2)R - i_1 r_1 = 0$
(b) $\varepsilon_2 - i_2 r_2 - \varepsilon_1 - i_1 r_1 = 0$
(c) $-\varepsilon_2 - (i_1 + i_2)R + i_2 r_2 = 0$
(d) $\varepsilon_1 - (i_1 + i_2)R + i_1 r_1 = 0$

Ans. ***(a)***

The algebraic sum of the changes in potential in complete transversal of a mesh (closed loop) is zero. i.e. $\Sigma V = 0$

So, $\varepsilon_1 - (i_1 + i_2)R - i_1 r_1 = 0$

74 A student measures the terminal potential difference (V) of a cell (of emf ε and internal resistance r) as a function of the current (I) flowing through it. The slope and intercept of the graph between V and I, respectively, equal to **[CBSE AIPMT 2009]**

(a) ε and $-r$ (b) $-r$ and ε
(c) r and $-\varepsilon$ (d) $-\varepsilon$ and r

Ans. ***(b)***

According to Ohm's law

$\frac{dV}{dI} = -r$ and $V = \varepsilon$ if $I = 0$

[As $V + Ir = \varepsilon$]

So, slope of the graph $= -r$ and intercept $= \varepsilon$

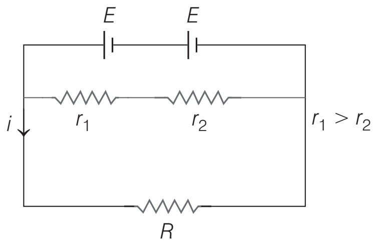
75 Two cells, having the same emf are connected in series through an external resistance R. Cells have internal resistances r_1 and r_2 ($r_1 > r_2$) respectively. When the circuit is closed, the potential difference across the first cell is zero. The value of R is **[CBSE AIPMT 2006]**

(a) $r_1 - r_2$ (b) $\frac{r_1 + r_2}{2}$
(c) $\frac{r_1 - r_2}{2}$ (d) $r_1 + r_2$

Ans. ***(a)***

Net resistance of the circuit $= r_1 + r_2 + R$

Net emf in series $= E + E = 2E$



Therefore, from Ohm's law, current in the circuit

$$i = \frac{\text{Net emf}}{\text{Net resistance}}$$

$$\Rightarrow \quad i = \frac{2E}{r_1 + r_2 + R} \quad \text{...(i)}$$

It is given that, as circuit is closed, potential difference across the first cell is zero.

i.e., $V = E - ir_1 = 0$

$$\Rightarrow \quad i = \frac{E}{r_1} \quad \text{...(ii)}$$

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

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

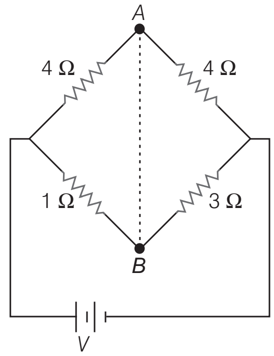
$\therefore$ $R =$ external resistance

$\Rightarrow$ $R = r_1 - r_2$

Note

The question is wrong as the statement is when the circuit is closed, the potential difference across the first cell is zero which implies that in a series circuit, one part cannot conduct current which is wrong, Kirchhoff 's law is violated. The question must have been modified.

76 In the circuit shown, if a conducting wire is connected between points A and B, the current in this wire will **[CBSE AIPMT 2006]**



(a) flow from A to B
(b) flow in the direction which will be decided by the value of V
(c) be zero
(d) flow from B to A

Ans. ***(d)***

Resistances 4 Ω and 4 Ω are connected in series, so their effective resistance is

$$R' = 4 + 4 = 8\,\Omega$$

Similarly, 1Ω and 3 Ω are in series

So, $R'' = 1 + 3 = 4\,\Omega$

Now R' and R'' will be in parallel, hence effective resistance

$$R = \frac{R' \times R''}{R' + R''}$$

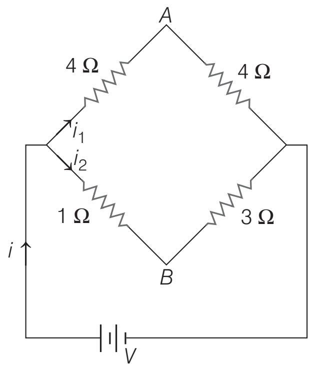
$$= \frac{8 \times 4}{8 + 4} = \frac{32}{12} = \frac{8}{3}\,\Omega$$

Current through the circuit, from Ohm's law

$$i = \frac{V}{R} = \frac{3V}{8}\text{ A}$$

Let currents i_1 and i_2 flow in the branches as shown. As voltage remains same in parallel combination

i.e. $V_1 = V_2$



$\therefore$ $8i_1 = 4i_2$

$\Rightarrow$ $i_2 = 2i_1$ ...(i)

Also, $i = i_1 + i_2$

$\Rightarrow$ $\frac{3V}{8} = i_1 + 2i_1$

$\Rightarrow$ $i_1 = \frac{V}{8}\text{ A}$ and $i_2 = \frac{V}{4}\text{ A}$

Potential drop at A,

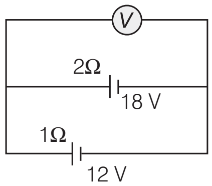
$$V_A = 4 \times i_1 = \frac{4V}{8} = \frac{V}{2}$$

Potential drop at B,

$$V_B = 1 \times i_2 = 1 \times \frac{V}{4} = \frac{V}{4}$$

Since, drop of potential is greater in $4\,\Omega$ resistance so, it will be at lower potential than B. Hence, on connecting wire between points A and B the current will flow from B to A.

77 Two batteries, one of emf 18V and internal resistance $2\,\Omega$ and the other of emf 12 V and internal resistance $1\,\Omega$, are connected as shown. The voltmeter V will record a reading of **[CBSE AIPMT 2005]**

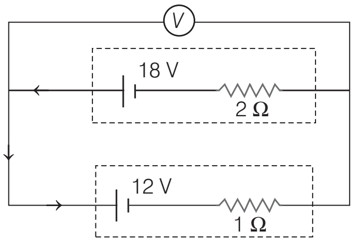


(a) 15 V (b) 30 V (c) 14 V (d) 18 V

Ans. *(c)*

It is clear that the two cells oppose each other hence, the effective emf in closed circuit is $18 - 12 = 6$ V and net resistance is $1 + 2 = 3\,\Omega$ (because in the closed circuit the internal resistances of two cells are in series).

The current in circuit will be in direction of arrow shown in figure.



$$I = \frac{\text{Effective emf}}{\text{Total resistance}} = \frac{6}{3} = 2\text{ A}$$

The potential difference across V will be same as the terminal voltage of either cell.

Since, current is drawn from the cell of 18 V, hence,

$$V_1 = E_1 - ir_1 = 18 - (2 \times 2) = 18 - 4 = 14\text{ V}$$

Similarly, current enters in the cell of 12 V, hence,

$$V_2 = E_2 + ir_2 = 12 + 2 \times 1 = 12 + 2 = 14\text{ V}$$

Hence, $V = 14$ V

78 A 6 V battery is connected to the terminals of a 3m long wire of uniform thickness and resistance of $100\,\Omega$. The difference of potential between two points on the wire separated by a distance of 50 cm will be **[CBSE AIPMT 2004]**

(a) 2 V (b) 3 V
(c) 1 V (d) 1.5 V

Ans. *(c)*

Total current drawn from the battery

$$i = \frac{E}{R + r} = \frac{6}{100 + 0} = 0.06\text{ A}$$

Resistance of 50 cm wire is

$$R' = \frac{\rho l'}{A} = \left(\frac{\rho}{A}\right) l' = \left(\frac{R}{l}\right) l' \quad \left(\because R = \frac{\rho l}{A}\right)$$

$$= \frac{100}{300} \times 50$$

So, $R' = \frac{50}{3}\,\Omega$

Hence, the potential difference between two points on the wire separated by a distance l' is given by Ohm's law

i.e. $V = iR'$

$$= 0.06 \times \frac{50}{3} = 1\text{ V}$$

79 A battery is charged at a potential of 15 V for 8 h when the current flowing is 10 A. The battery on discharge supplies a current of 5 A for 15 h. The mean terminal voltage during discharge is 14 V. The watt-hour efficiency of the battery is **[CBSE AIPMT 2004]**

(a) 82.5% (b) 80%
(c) 90% (d) 87.5%

Ans. *(d)*

Input energy when the battery is charged

$$E_{in} = Vit = 15 \times 10 \times 8 = 1200\text{ Wh}$$

Energy released when the battery is discharged

$$E_{out} = 14 \times 5 \times 15 = 1050\text{ Wh}$$

Hence, watt hour efficiency of battery is given by

$$= \frac{\text{Energy output}}{\text{Energy input}} = \frac{1050}{1200}$$

$$= 0.875 = 87.5\%$$

80 For a cell, the terminal potential difference is 2.2V when circuit is open and reduces to 1.8 V when cell is connected to a resistance $R = 5\,\Omega$, the internal resistance (r) of cell is **[CBSE AIPMT 2002]**

(a) $\frac{10}{9}\,\Omega$ (b) $\frac{9}{10}\,\Omega$
(c) $\frac{11}{9}\,\Omega$ (d) $\frac{5}{9}\,\Omega$

Ans. *(a)*

In an open circuit, emf of cell

$$E = 2.2\text{ V}$$

In a closed circuit, terminal potential difference

$$V = 1.8\text{ V}$$

External resistance, $R = 5\,\Omega$

Thus, internal resistance of cell is

$$r = \left(\frac{E}{V} - 1\right)R = \left(\frac{2.2}{1.8} - 1\right)5$$

$$= \left(\frac{11}{9} - 1\right)5 = \frac{2}{9} \times 5 = \frac{10}{9}\,\Omega$$

81 A cell has an emf 1.5 V. When connected across an external resistance of $2\,\Omega$, the terminal potential difference falls to 1.0 V. The internal resistance of the cell is **[CBSE AIPMT 2000]**

(a) $2\,\Omega$ (b) $1.5\,\Omega$
(c) $1.0\,\Omega$ (d) $0.5\,\Omega$

Ans. *(c)*

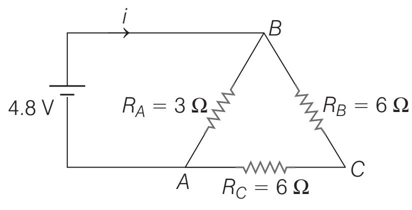
Internal resistance of the cell is given by

$$r = \left(\frac{E - V}{V}\right)R$$

Given, $E = 1.5$ V, $V = 1.0$ V, $R = 2\,\Omega$

$$\therefore \quad r = \left(\frac{1.5 - 1.0}{1.0}\right) \times 2 = \frac{0.5}{1.0} \times 2 = 1\,\Omega$$

82 The current (i) in the given circuit is **[CBSE AIPMT 1999]**



(a) 1.6 A (b) 2 A
(c) 0.32 A (d) 3.2 A

Ans. *(b)*

In the given circuit, resistances R_B and R_C are in series order, so their effective resistance,

$R' = R_B + R_C$

$= 6 + 6 = 12\,\Omega$

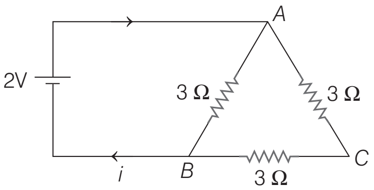
Now, R_A and R' are in parallel order, hence net resistance of the circuit

$$R = \frac{R' \times R_A}{R' + R_A} = \frac{12 \times 3}{12 + 3} = \frac{36}{15}\,\Omega$$

The current flowing in the circuit,

$$i = \frac{V}{R} = 4.8 \times \frac{15}{36} = 2\,\text{A}$$

83 The current in the following circuit is **[CBSE AIPMT 1997]**



(a) 1 A (b) $\frac{2}{3}$ A

(c) $\frac{2}{9}$ A (d) $\frac{1}{8}$ A

Ans. *(a)*

From the given figure, the resistances in the arms *AC* and *BC* are in series.

$\therefore \quad R' = R_{AC} + R_{BC}$

$= 3\,\Omega + 3\,\Omega = 6\,\Omega$

Now, R' is in parallel with the resistance in arm *AB*,

So, $\quad R = \frac{R' \times R_{AB}}{R' + R_{AB}}$

$= \frac{6\,\Omega \times 3\,\Omega}{6\,\Omega + 3\,\Omega} = 2\,\Omega$

Therefore, the Ohm's law can be stated as

$V = iR$ or current, $i = \frac{V}{R}$

Substituting the values, we get

$i = \frac{2}{2} = 1\text{A} \qquad (\because V = 2\,\text{V})$

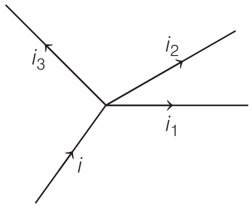
84 Kirchhoff's first law, i.e. $\Sigma i = 0$ at a junction, deals with the conservation of **[CBSE AIPMT 1997]**

(a) angular momentum
(b) linear momentum
(c) energy
(d) charge

Ans. *(d)*

Kirchhoff's law states that the algebraic sum of currents meeting at a point (say at a junction) is equals to zero i.e.,

$$\Sigma i = 0$$



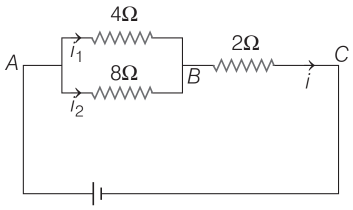
or $\quad i = i_1 + i_2 + i_3$

$$\frac{dQ}{dt} = \frac{dQ_1}{dt} + \frac{dQ_2}{dt} + \frac{dQ_3}{dt}$$

or, $\quad dQ = dQ_1 + dQ_2 + dQ_3$

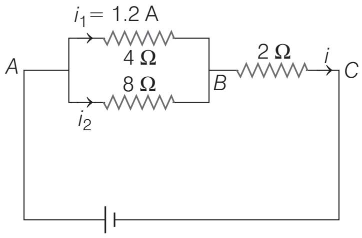
So, we can say that when a steady current flows through circuit, then neither accumulation of charges take place at the junction in the circuit nor any charge is removed from there. That's why Kirchhoff's first law deals with the conservation of charge.

85 In the circuit of figure, the current in 4 Ω resistance is 1.2 A, what is the potential difference between *B* and *C*? **[CBSE AIPMT 1994]**



(a) 3.6 V (b) 6.3 V
(c) 1.8 V (d) 2.4 V

Ans. *(a)*



The potential difference across 4 Ω resistance is given by Ohm's law

$= 4 \times i_1$

$= 4 \times 1.2 = 4.8\,\text{V} \qquad (\text{as } i_1 = 1.2\,\text{A})$

As resistances 4 Ω and 8 Ω are in parallel, so potential difference across 8 Ω resistance will also be 4.8 V.

$\therefore$ Current through 8 Ω resistance

$$i_2 = \frac{V}{R} = \frac{4.8}{8} = 0.6\,\text{A}$$

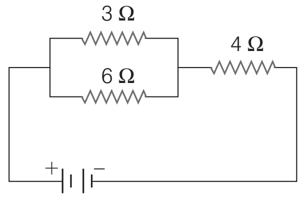
$\therefore \quad i = i_1 + i_2 = 1.2 + 0.6 = 1.8\,\text{A}$

$\therefore$ Potential difference across 2 Ω resistance

$V_{BC} = i \times 2$

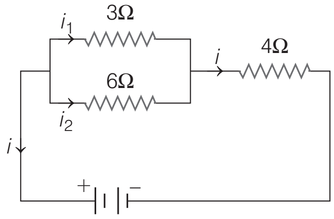
$= 1.8 \times 2 = 3.6\,\text{V}$

86 Current through 3 Ω resistor is 0.8 A, then potential drop through 4 Ω resistor is **[CBSE AIPMT 1993]**



(a) 9.6 V (b) 2.6 V
(c) 4.8 V (d) 1.2 V

Ans. *(c)*



Voltage across 3 Ω resistance is given by Ohm's law

i.e. $\quad V = IR = 3 \times i_1$

$= 3 \times 0.8 = 2.4\,\text{V} \qquad (\text{as } i_1 = 0.8\,\text{A})$

As 3 Ω and 6 Ω are in parallel, hence voltage across 6 Ω resistance will also be 2.4 V.

$\therefore$ Current through 6 Ω resistance

$$i_2 = \frac{V}{R} = \frac{2.4}{6} = 0.4\,\text{A}$$

$\therefore$ Total current in the circuit,

$i = i_1 + i_2 = 0.8 + 0.4 = 1.2\,\text{A}$

$\therefore$ Potential drop across 4 Ω resistance,

$= i \times 4 = 1.2 \times 4 = 4.8\,\text{V}$

87 Kirchhoff's first law of electricity follows **[CBSE AIPMT 1992]**

(a) only law of conservation of energy
(b) only law of conservation of charge
(c) law of conservation of both energy and charge
(d) sometimes law of conservation of energy and some other times law of conservation of charge

Ans. *(b)*

Kirchhoff's first law supports law of conservation of charge. This is because a point in a circuit cannot act as a source or sink of charge.

88 A battery of emf 10 V and internal resistance 0.5 Ω is connected across a variable resistance *R*. The value of *R* for which the power delivered in it is maximum, is given by **[CBSE AIPMT 1992]**

(a) $0.5\,\Omega$ (b) $1.0\,\Omega$
(c) $2.0\,\Omega$ (d) $0.25\,\Omega$

Ans. *(a)*

According to maximum power transfer theorem, the power output across load due to a cell or battery is maximum, if the load resistance is equal to the internal resistance of cell or battery. Hence, value of R will be $0.5\,\Omega$.

89 Two identical batteries each of emf 2 V and internal resistance 1Ω are available to produce heat in an external resistance by passing a current through it. The maximum power that can be developed across R using these batteries is **[CBSE AIPMT 1990]**

(a) 3.2 W (b) 2 W
(c) 1.28 W (d) $\frac{8}{9}$ W

Ans. *(b)*

To receive maximum current, the two batteries should be connected in series.

Given, $R = 1\Omega + 1\Omega = 2\,\Omega$.

Hence, power developed across the resistance R with the batteries in series is

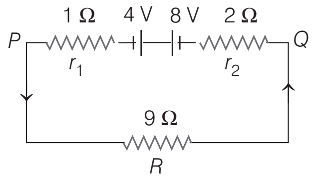
$$P = i^2 R = \left(\frac{2E}{R+2r}\right)^2 R \qquad \left[I = \frac{E}{R_{eq}}\right]$$

$$= \left(\frac{2\times 2}{2+2}\right)\times 2 = 2\text{ W} \qquad [\because r = 1\Omega]$$

Note

In case of batteries connected in series, equivalent emf is given by $E_{eq} = E_1 + E_2$

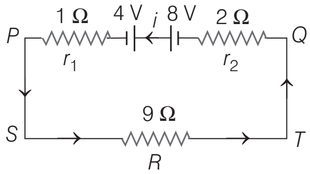
90 Two batteries of emf 4 V and 8 V with internal resistance 1Ω and $2\,\Omega$ are connected in a circuit with a resistance of $9\,\Omega$ as shown in figure. The current and potential difference between the points P and Q are **[CBSE AIPMT 1988]**



(a) $\frac{1}{3}$ A and 3 V (b) $\frac{1}{6}$ A and 4 V
(c) $\frac{1}{9}$ A and 9 V (d) $\frac{1}{12}$ A and 12 V

Ans. *(a)*

Applying Kirchhoff's voltage law in the given loop and going in direction of current $PSTQ$ total voltage is equal to zero



So, $-2i + 8 - 4 - 1\times i - 9i = 0$

$\therefore \qquad i = \frac{1}{3}$ A

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

$= 3$ V

TOPIC 4
Measuring Instruments

91 In a potentiometer circuit, a cell of emf 1.5 V gives balance point at 36 cm length of wire. If another cell of emf 2.5 V replaces the first cell, then at what length of the wire, the balance point occurs? **[NEET 2021]**

(a) 60 cm (b) 21.6 cm
(c) 64 cm (d) 62 cm

Ans. *(a)*

Given, length of balancing point, $L_1 = 36$ cm

$E_1 = 1.5$V

$E_2 = 2.5$V

We know that,

Potential gradient $= \frac{E}{L}$

$\because \qquad \frac{E_1}{L_1} = \frac{E_2}{L_2}$

where, L_2 is the length of the balancing point for cell of emf E_2.

Substituting the values in the above equation, we get

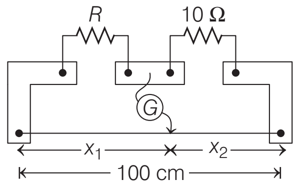
$$\frac{1.5}{36} = \frac{2.5}{L_2} \Rightarrow L_2 = 60\text{ cm}$$

92 A resistance wire connected in the left gap of a metre bridge balances a $10\,\Omega$ resistance in the right gap at a point which divides the bridge wire in the ratio 3 : 2. If the length of the resistance wire is 1.5 m, then the length of $1\,\Omega$ of the resistance wire is **[NEET (Sep.) 2020]**

(a) 1.0×10^{-1} m (b) 1.5×10^{-1} m
(c) 1.5×10^{-2} m (d) 1.0×10^{-2} m

Ans. *(a)*

According to the question, the metre bridge is shown below,



Given, $\frac{x_1}{x_2} = \frac{3}{2}$

At balance condition in metre bridge,

$$\frac{R}{10} = \frac{x_1}{x_2}$$

$$\Rightarrow \qquad R = \frac{x_1}{x_2}\times 10 = \frac{3}{2}\times 10 = 15\,\Omega$$

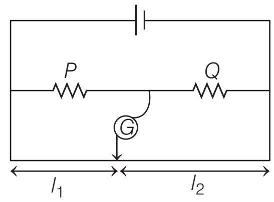
Now, length of given wire whose resistance $15\,\Omega$ is 1.5 m.

Therefore, length of 1Ω resistance wire is

$$= \frac{1.5}{15} = \frac{1}{10} = 0.1 = 1\times 10^{-1}\text{ m}$$

Hence, correct option is (a).

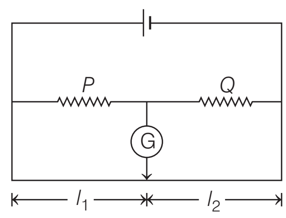
93 The meter bridge shown in the balance position with $\frac{P}{Q} = \frac{l_1}{l_2}$. If we now interchange the positions of galvanometer and cell, will the bridge work? If yes, that will be balanced condition? **[NEET (Odisha) 2019]**



(a) yes, $\frac{P}{Q} = \frac{l_2 - l_1}{l_2 + l_1}$ (b) no, no null point
(c) yes, $\frac{P}{Q} = \frac{l_2}{l_1}$ (d) yes, $\frac{P}{Q} = \frac{l_1}{l_2}$

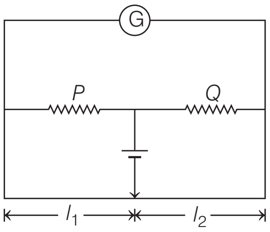
Ans. *(d)*

For balanced position in a meterbridge



$$\frac{P}{Q}=\frac{l_1}{l_2}$$

Now, if position of G and cell is interchanged,



The balance condition still remains the same if the jockey points as the same point as given in the initial condition, for which there is no deflection in the galvanometer or no current will be drawn from the cell. Thus, the bridge will work as usual and balance condition is same, $P/Q = l_1/l_2$

94 A potentiometer is an accurate and versatile device to make electrical measurement of EMF because the method involves **[NEET 2017]**

(a) cells
(b) potential gradients
(c) a condition of no current flow through the galvanometer
(d) a combination of cells, galvanometer and resistances

Ans. ***(c)***

When a cell is balanced against potential drop across a certain length of potentiometer wire, no current flows through the cell

∴ emf of cell = potential drop across balance length of potentiometer wire.

So, potentiometer is a more accurate device for measuring emf of a cell or no current flows through the cell during measurement of emf.

95 A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf is **[NEET 2016]**

(a) 5 : 4 (b) 3 : 4 (c) 3 : 2 (d) 5 : 1

Ans. ***(c)***

According to question, emf of the cell is directly proportional to the balancing length i.e.

$$E \propto l \quad \text{...(i)}$$

Now, in the first case, cells are connected in series to support one another i.e.

Net emf $= E_1 + E_2$

From Eq. (i), $E_1 + E_2 = 50$ cm(given) ...(ii)

Again cells are connected in series in opposite direction i.e.

Net emf $= E_1 - E_2$

From Eq. (i), $E_1 - E_2 = 10$ ...(iii)

From Eqs. (ii) and (iii)

$$\frac{E_1+E_2}{E_1-E_2}=\frac{50}{10} \Rightarrow \frac{E_1}{E_2}=\frac{5+1}{5-1}=\frac{6}{4}=\frac{3}{2}$$

96 A potentiometer wire has length 4 m and resistance 8Ω. The resistance that must be connected in series with the wire and an accumulator of emf 2V, so as to get a potential gradient 1 mV per cm on the wire is **[CBSE AIPMT 2015]**

(a) 32 Ω (b) 40 Ω (c) 44 Ω (d) 48 Ω

Ans. ***(a)***

Given, $l = 4$ m,

R = potentiometer wire resistance = 8 Ω

Potential gradient $= \frac{dV}{dr} = 1\,\text{mV/cm}$

So, for 400 cm, $\Delta V = 400 \times 1 \times 10^{-3} = 0.4$ V

Let a resistor R_S connected in series, so as

$$\Delta V = \frac{V}{R+R_S}\times R \Rightarrow 0.4 = \frac{2}{8+R}\times 8$$

$$\Rightarrow \quad 8 + R = \frac{16}{0.4} = 40 \Rightarrow R = 32\,\Omega$$

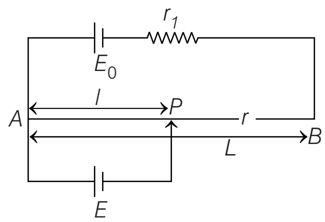
97 A potentiometer wire of length L and a resistance r are connected in series with a battery of e.m.f. E_0 and a resistance r_1. An unknown e.m.f. is balanced at a length l of the potentiometer wire. The e.m.f. E will be given by **[CBSE AIPMT 2015]**

(a) $\frac{LE_0 r}{l r_1}$ (b) $\frac{E_0 r}{(r+r_1)}\cdot\frac{l}{L}$

(c) $\frac{E_0 l}{L}$ (d) $\frac{LE_0 r}{(r+r_1) l}$

Ans. ***(b)***

Consider a potentiometer wire of length L and a resistance r are connected in series with a battery of emf E_0 and a resistance r_1 as shown in figure. Current in wire $AB = \frac{E_0}{r_1 + r}$



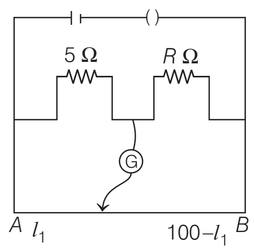
Potential gradient,

$$x = \frac{Ir}{L} = \left[\frac{E_0}{r_1 + r}\right]\frac{r}{L}$$

emf produced across E will be given by

$$E = x \cdot l = \left[\frac{E_0 r}{r_1 + r}\right]\frac{l}{L}$$

98 The resistances in the two arms of the meter bridge are 5 Ω and R Ω, respectively. When the resistance R is shunted with an equal resistance, the new balance point is at 1.6 l_1. The resistance R, is **[CBSE AIPMT 2014]**



(a) 10 Ω (b) 15 Ω (c) 20 Ω (d) 25 Ω

Ans. ***(b)***

For first case, balanced condition of meter bridge will be

$$\frac{5}{l_1} = \frac{R}{(100 - l_1)} \quad \text{...(i)}$$

Now, by shunting resistance R by an equal resistance R, new resistance in that arm become $\frac{R}{2}$.

So, new balanced condition will be

$$\frac{5}{1.6 l_1} = \frac{R/2}{(100 - 1.6 l_1)} \quad \text{...(ii)}$$

From Eqs. (i) and (ii),

$$\frac{1.6}{1} = \frac{(100 - 1.6 l_1)}{100 - l_1}\times 2$$

$$\Rightarrow 160 - 1.6 l_1 = 200 - 3.2 l_1$$

$$1.6 l_1 = 40$$

$$l_1 = \frac{40}{1.6} = 25\,\text{m}$$

$\Rightarrow$ From Eq. (i), $\frac{5}{25} = \frac{R}{75} \Rightarrow R = 15\,\Omega$

99 A potentiometer circuit has been set up for finding the internal resistance of a given cell. The main battery, used across the potentiometer wire, has an emf of 2.0 V and a negligible internal resistance. The potentiometer wire itself is 4 m long. When the resistance R, connected across the given cell, has values of (i) infinity, (ii) 9.5 Ω, the balancing lengths, on the potentiometer wire are found to be 3 m and 2.85 m, respectively.

The value of internal resistance of the cell is **[CBSE AIPMT 2014]**

(a) 0.25 Ω (b) 0.95 Ω
(c) 0.5 Ω (d) 0.75 Ω

Ans. *(c)*

Given, $e = 2\text{V}$ and $l = 4\,\text{m}$

Potential drop per unit length

$$\phi = \frac{e}{l} = \frac{2}{4} = 0.5\ \text{V/m}$$

Case **I**

$$e' = \phi l_1 \quad \text{...(i)}$$

(e' = emf of the given cell)

Case **II**

$$V = \phi l_2 \quad \text{...(ii)}$$

From Eqs. (i) and (ii),

$$e'/V = l_1/l_2$$

$$\therefore \quad e' = I(r+R)$$

and $V = IR$ for the second case

$$\frac{I(r+R)}{IR} = \frac{l_1}{l_2}$$

So, $$r = R\left(\frac{l_1}{l_2} - 1\right) = 9.5\left(\frac{3}{2.85} - 1\right)$$

$$= 9.5(1.05 - 1)$$

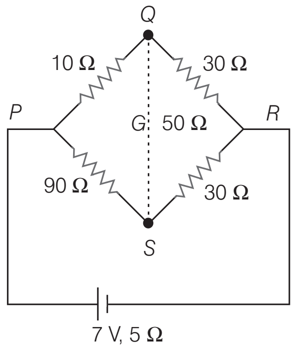
$$= 9.5 \times 0.05 = 0.475 \simeq 0.5\ \Omega$$

100 The resistances of the four arms P, Q, R and S in a Wheatstone bridge are 10 Ω, 30 Ω, 30 Ω and 90 Ω, respectively. The emf and internal resistance of the cell are 7 V and 5 Ω respectively. If the galvanometer resistance is 50 Ω, the current drawn from the cell will be **[NEET 2013]**

(a) 1.0 A
(b) 0.2 A
(c) 0.1 A
(d) 2.0 A

Ans. *(b)*

Effective resistance,



$$\frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{...(i)}$$

then, $R_1 = 10 + 30$

$R_1 = 40$

Now, $R_2 = 90 + 30 = 120$

$R_2 = 120$

By Eq. (i),

$$\frac{1}{R_{\text{eff}}} = \frac{1}{40} + \frac{1}{120}$$

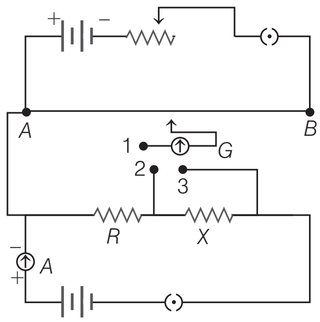
$$R_{\text{eff}} = \frac{40 \times 120}{120 + 40} = \frac{4800}{160} = 30\ \Omega$$

In the balancing condition,

$$\therefore \text{Current, } I = \frac{7}{(30+5)} = \frac{7}{35} = 0.2\ \text{A}$$

$$\left[\because I = \frac{E}{R+r}\right]$$

101 A potentiometer circuit is set up as shown. The potential gradient across the potentiometer wire, is k volt/cm and the ammeter, present in the circuit, reads 1.0 A when two way key is switched off. The balance points, when the key between the terminals (a) 1 and 2 (b) 1 and 3, is plugged in, are found to be at lengths l_1 cm and l_2 cm respectively. The magnitudes, of the resistors R and X in ohm, are then equal, respectively to **[CBSE AIPMT 2010]**



(a) $k(l_2 - l_1)$ and kl_2 (b) kl_1 and $k(l_2 - l_1)$
(c) $k(l_2 - l_1)$ and kl_1 (d) kl_1 and kl_2

Ans. *(c)*

The balancing length for R (when 1, 2 are connected) be l_1 and balancing length for $R + X$ (when 1, 3 is connected) is l_2.

Then, $iR = kl_1$ and $i(R + X) = kl_2$

Given, $i = 1\text{A}$

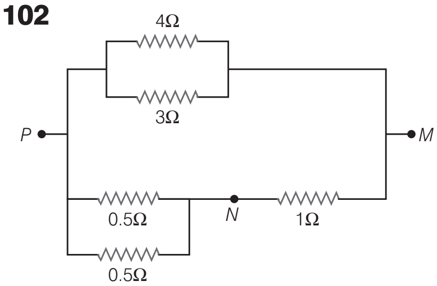
$$\therefore \quad R = kl_1 \quad \text{...(i)}$$

$$R + X = kl_2 \quad \text{...(ii)}$$

Also, subtracting Eq. (i) from Eq. (ii), we get

$$X = k(l_2 - l_1)$$

102



In the circuit shown, the current through the 4 Ω resistor is 1 A when the points P and M are connected to a DC voltage source. The potential difference between the points M and N is **[CBSE AIPMT 2008]**

(a) 1.5 V (b) 1.0 V (c) 0.5 V (d) 3.2 V

Ans. *(d)*

Potential across PM,

$$V_{PM} = 4 \times 1 = 4\ \text{V}$$

Now, equivalent resistance across PN

$$\frac{1}{R_{\text{eq}}} = \frac{1}{0.5} + \frac{1}{0.5}$$

$$R_{\text{eq}} = \frac{0.5}{2} = 0.25\ \Omega$$

Effective resistance between P and M

$$R_{PM} = 0.25 + 1 = 1.25\ \Omega$$

For balancing condition,

$$\frac{V_{MN}}{V_{PM}} = \frac{R_{MN}}{R_{PM}}$$

$$V_{MN} = \frac{V_{PN} \times R_{MN}}{R_{PM}} = \frac{1}{1.25} \times 4 = 3.2\ \text{V}$$

103. A cell can be balanced against 110 cm and 100 cm of potentiometer wire, respectively with and without being short circuited through a resistance of 10 Ω. Its internal resistance is **[CBSE AIPMT 2008]**

(a) 1.0 Ω (b) 0.5 Ω
(c) 2.0 Ω (d) zero

Ans. *(a)*

In potentiometer experiment in which we find internal resistance of a cell. Let E be the emf of the cell and V be the terminal potential difference, then

$$\frac{E}{V} = \frac{l_1}{l_2}$$

where, l_1 and l_2 are lengths of potentiometer wire with and without being short circuited through a resistance.

Since, $\frac{E}{V} = \frac{R + r}{R}$

$[\because E = I(R + r) \text{ and } V = IR]$

$\therefore \quad \frac{R + r}{R} = \frac{l_1}{l_2} \quad$ or $\quad 1 + \frac{r}{R} = \frac{110}{100}$

or $\quad \frac{r}{R} = \frac{10}{100}$ or $r = \frac{1}{10} \times 10 = 1\,\Omega$

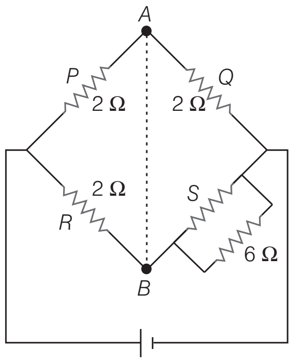
104 Three resistance P, Q, R each of $2\,\Omega$ and an unknown resistance S form the four arms of a Wheatstone bridge circuit. When a resistance of $6\,\Omega$ is connected in parallel to S the bridge gets balanced. What is the value of S? **[CBSE AIPMT 2007]**

(a) $2\,\Omega$ (b) $3\,\Omega$
(c) $6\,\Omega$ (d) $1\,\Omega$

Ans. *(b)*

Concept Balancing condition of Wheatstone bridge is used to calculate the value of unknown resistance.

The situation can be depicted as shown in figure.



As resistances S and $6\,\Omega$ are in parallel their effective resistance is

$$\frac{6S}{6 + S}\,\Omega$$

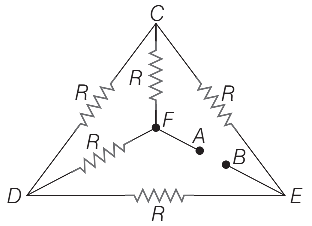
As the bridge is balanced, hence it is balanced Wheatstone bridge.

For balancing condition,

$\frac{P}{Q} = \frac{R}{\left(\frac{6S}{6+S}\right)}$ or $\frac{2}{2} = \frac{2(6 + S)}{6S}$

or $3S = 6 + S$ or $S = 3\,\Omega$

105 Five equal resistances each of resistance R are connected as shown in the figure. A battery of $4V$ volts is connected between A and B. The current flowing in $AFCEB$ will be **[CBSE AIPMT 2004]**

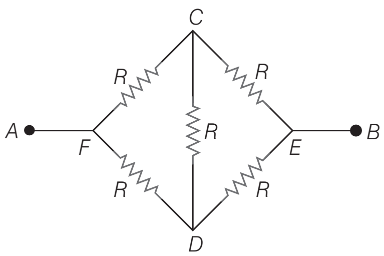


(a) $\frac{3V}{R}$ (b) $\frac{V}{R}$ (c) $\frac{V}{2R}$ (d) $\frac{2V}{R}$

Ans. *(c)*

The given circuit can be redrawn as shown.

From circuit, $\frac{FC}{CE} = \frac{FD}{DE} = 1$



Thus, it is balanced Wheatstone bridge, so, resistance in arm CD is ineffective and so no current flows in this arm.

Net resistance of the circuit is

$$\frac{1}{R'} = \frac{1}{(R + R)} + \frac{1}{(R + R)}$$

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

$\therefore \quad R' = R$

So, net current drawn from the battery is

$$i' = \frac{V}{R'} = \frac{V}{R}$$

As from symmetry, upper circuit $AFCEB$ is half of the whole circuit and is equal to $AFDEB$.

So, in both the halves half of the total current will flow.

Hence, in $AFCEB$, the current flowing is

$$i = \frac{i'}{2} = \frac{V}{2R}$$

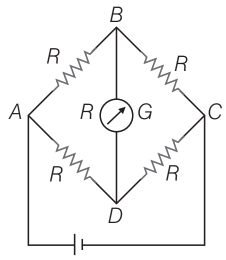
106 In a Wheatstone bridge, all the four arms have equal resistance R. If the resistance of the galvanometer arm is also R, the equivalent resistance of the combination as seen by the battery is **[CBSE AIPMT 2003]**

(a) R (b) $2R$
(c) $\frac{R}{4}$ (d) $\frac{R}{2}$

Ans. *(a)*

$$\frac{R_{AB}}{R_{BC}} = \frac{R_{AD}}{R_{DC}}$$

As bridge is in balanced condition, no current will flow through BD.



$R_1 = R_{AB} + R_{BC}$
$= R + R$
$= 2R$

$R_2 = R_{AD} + R_{CD}$
$= R + R = 2R$

R_1 and R_2 are in parallel combination.

Hence, equivalent resistance between A and C will be

$$\therefore \quad R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{4R^2}{4R} = R$$

107 Resistivity of potentiometer wire is $10^{-7}\ \Omega\text{-m}$ and its area of cross-section is $10^{-6}\ \text{m}^2$. When a current $i = 0.1\text{A}$ flows through the wire, its potential gradient is **[CBSE AIPMT 2001]**

(a) 10^{-2} V/m (b) 10^{-4} V/m
(c) 0.1 V/m (d) 10 V/m

Ans. *(a)*

Potential gradient

$= \text{Potential fall per unit length} = \frac{V}{l}$

$= \text{current} \times \text{resistance per unit length}$

$= i \times \frac{R}{l}$

but $\quad R = \frac{\rho l}{A} \Rightarrow \frac{R}{l} = \frac{\rho}{A}$

where, symbols have their usual meanings.

$\therefore$ Potential gradient $= i \times \frac{\rho}{A}$

Here $\rho = 10^{-7}\ \Omega\text{-m}$, $i = 0.1\,\text{A}$

and $A = 10^{-6}\ \text{m}^2$

Hence, potential gradient $= 0.1 \times \dfrac{10^{-7}}{10^{-6}}$

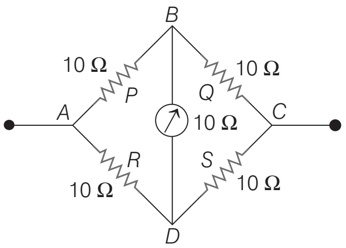
$$= \frac{0.1}{10} = 0.01 = 10^{-2} \text{ V/m}$$

108 In a Wheatstone bridge resistance of each of the four sides is $10\,\Omega$. If the resistance of the galvanometer is also $10\,\Omega$, then effective resistance of the bridge will be **[CBSE AIPMT 2001]**

(a) $10\,\Omega$ (b) $5\,\Omega$
(c) $20\,\Omega$ (d) $40\,\Omega$

Ans. *(a)*

The given circuit can be shown as,



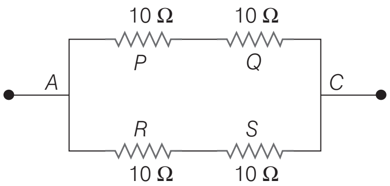
From figure, $\dfrac{P}{Q} = \dfrac{10}{10} = 1$

$$\frac{R}{S} = \frac{10}{10} = 1$$

$$\therefore \quad \frac{P}{Q} = \frac{R}{S}$$

Hence, Wheatstone bridge is balanced. Therefore, the galvanometer will be ineffective.

The above Wheatstone bridge can be redrawn as



Resistances P and Q are in series, so

$$R' = 10 + 10 = 20\,\Omega$$

Resistances R and S are in series, so

$$R'' = 10 + 10 = 20\,\Omega$$

Now, R' and R'' are in parallel hence, net resistance of the circuit

$$= \frac{R' \times R''}{R' + R''} = \frac{20 \times 20}{20 + 20} = 10\,\Omega$$

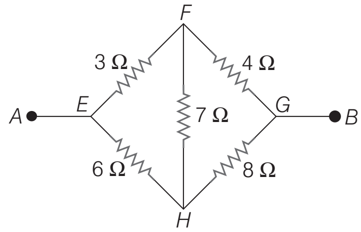
109 Potentiometer measures the potential difference more accurately than a voltmeter, because **[CBSE AIPMT 2000]**

(a) it has a wire of high resistance
(b) it has a wire of low resistance
(c) it does not draw current from external circuit
(d) it draws a heavy current from external circuit

Ans. *(c)*

When we measure the emf of a cell by the potentiometer then no current is drawn from the external circuit. Thus, in this condition the actual value of a cell is found. In this way potentiometer is equivalent to an ideal voltmeter of infinite resistance.

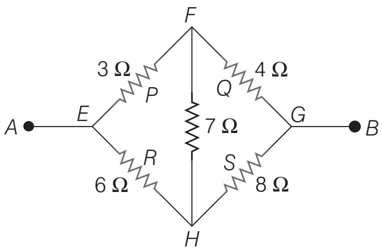
110 A bridge circuit is shown in figure. The equivalent resistance between A and B will be **[CBSE AIPMT 2000]**



(a) $21\,\Omega$ (b) $7\,\Omega$ (c) $\dfrac{252}{85}\,\Omega$ (d) $\dfrac{14}{3}\,\Omega$

Ans. *(d)*

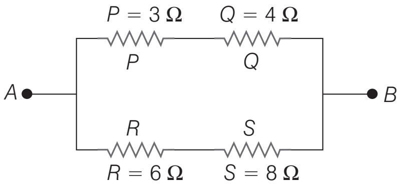
The bridge circuit can be shown as



The balanced condition of bridge circuit is given by

$$\frac{P}{Q} = \frac{3}{4}, \frac{R}{S} = \frac{6}{8} = \frac{3}{4} \Rightarrow \frac{P}{Q} = \frac{R}{S}$$

Thus, it is balanced Wheatstone bridge, so potential at F is equal to potential at H. Therefore, no current will flow through 7Ω resistance. So, circuit can be redrawn as



P and Q are in series, so their equivalent resistance $= 3 + 4 = 7\,\Omega$

R and S are also in series, so their equivalent resistance $= 6 + 8 = 14\,\Omega$

Now, $7\,\Omega$ and $14\,\Omega$ resistances are in parallel, so

$$R_{AB} = \frac{7 \times 14}{7 + 14} = \frac{7 \times 14}{21} = \frac{14}{3}\,\Omega$$

Note Normally, in Wheatstone bridge in middle arm galvanometer must be connected. In Wheatstone bridge, cell and galvanometer arms are interchangeable.
In both the cases, condition of balanced bridge is

$$\frac{P}{Q} = \frac{R}{S}$$

111 A potentiometer consists of a wire of length 4 m and resistance $10\,\Omega$. It is connected to a cell of emf 2 V. The potential gradient of the wire is **[CBSE AIPMT 1999]**

(a) 0.5 V/m b) 2 V/m
(c) 5 V/m (d) 10 V/m

Ans. *(a)*

Potential gradient $= \dfrac{\text{Potential applied}}{\text{Length of wire}}$

$$\therefore \quad k = \frac{V}{l}$$

Given, $V = 2$ V, $l = 4$ m

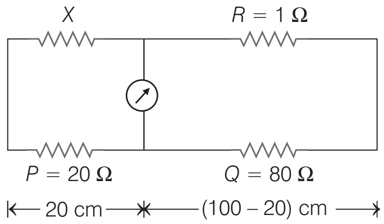
$$\therefore \quad k = \frac{2}{4} = 0.5 \text{ V/m}$$

112 In meter bridge, the balancing length from left is found to be 20 cm when standard resistance of 1Ω is in right gap. The value of unknown resistance is **[CBSE AIPMT 1999]**

(a) $0.25\,\Omega$ (b) $0.4\,\Omega$ (c) $0.5\,\Omega$ (d) $4\,\Omega$

Ans. *(a)*

Let unknown resistance be X.



Then condition of Wheatstone bridge gives, $\dfrac{X}{R} = \dfrac{20}{80}$

where, X = unknown resistance
R = known resistance

Hence, unknown resistance is

$$X = \frac{20}{80} \times R = \frac{1}{4} \times 1 \quad (\because R = 1\,\Omega)$$

$$= 0.25\,\Omega$$