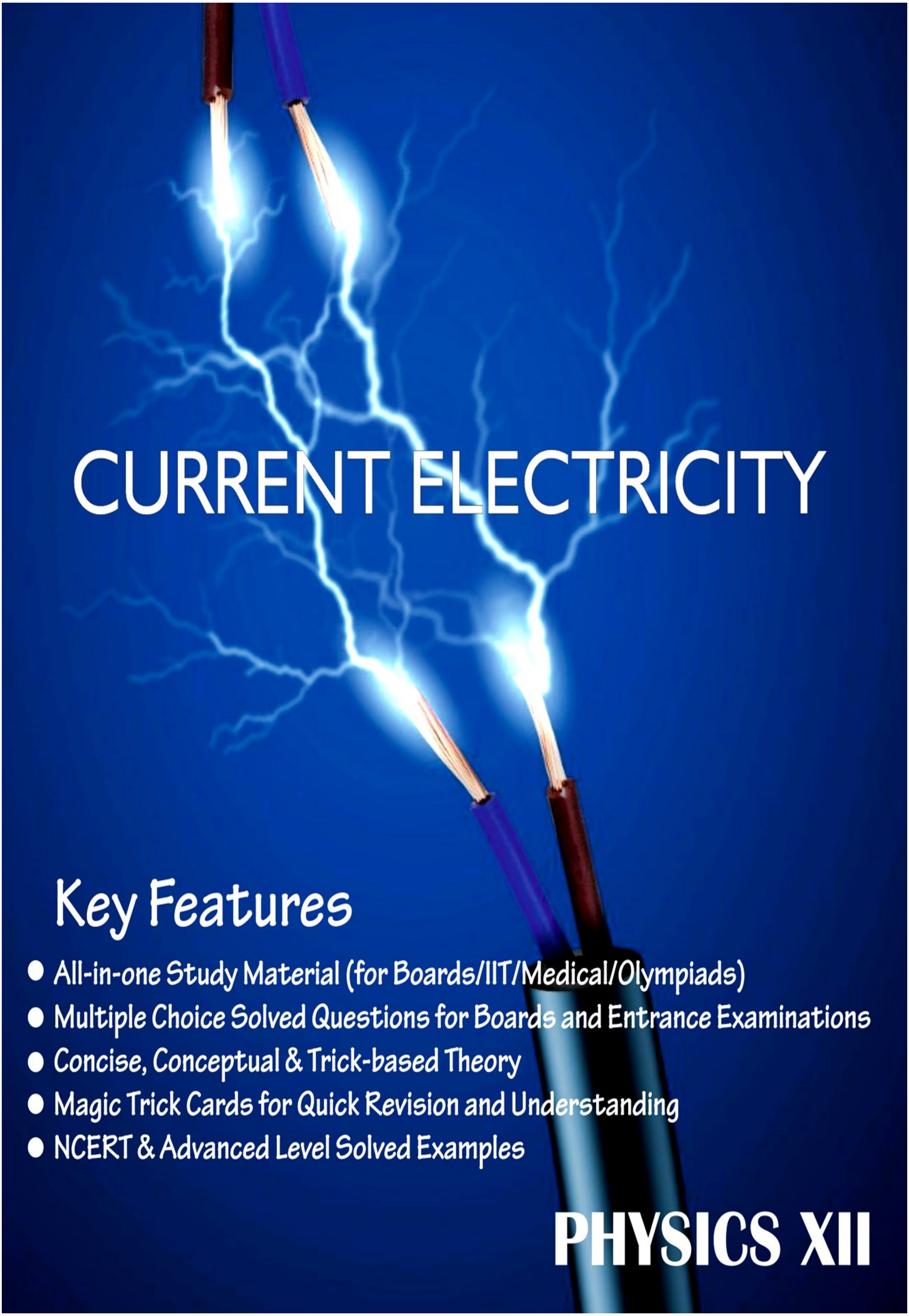

CURRENT ELECTRICITY

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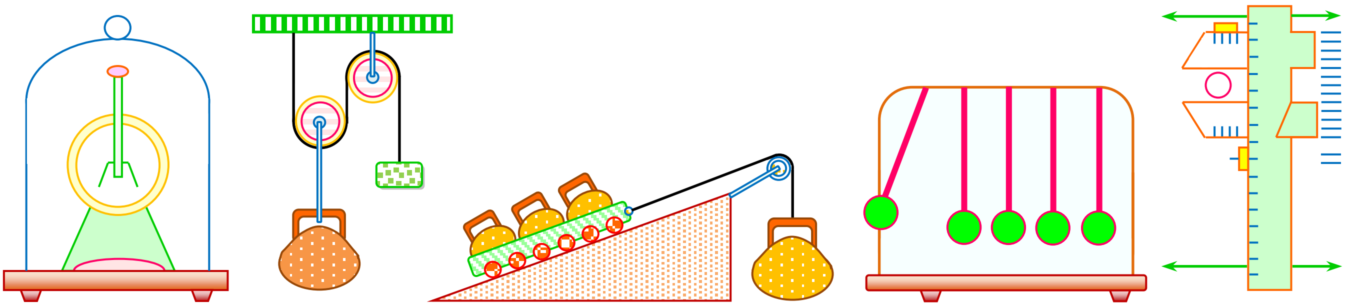

PHYSICS BOOKLET FOR JEE NEET & BOARDS

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CURRENT ELECTRICITY

1 ELECTRIC CHARGE AND CURRENT

Electric charges in motion constitute electric current. Metals such as gold, silver, copper, aluminum etc., called conductors, have large number of free electrons. These free electrons move around in all directions from atom to atom under normal conditions but when a potential difference is applied between two points (two ends preferably), the electrons move only in one direction. The electrons are negatively charged particles and the conventional current is considered as the flow of positive charges. Hence the direction of flow of electrons is opposite to the direction of conventional current, which takes place in a direction from a point of higher potential to a point of lower potential.

The strength of the current is the rate at which the electric charges are flowing. If a charge Q coulomb passes through a given cross-section of the conductor in t second, the current I through the conductor is given by

$$I = \frac{Q\ \text{coulomb}}{t\ \text{second}} = \frac{Q}{t} \qquad \text{... (1)}$$

The SI unit of current is 'ampere'(A)

Illustration 1

Question: **An electrical device sends out 78 coulombs of charge through a conductor in 6 seconds. Find the current flow.**

Solution: Given that charge flowing $Q = 78$ C,

time of flow $t = 6$ s

The current $I = \frac{Q}{t} = \frac{78\ \text{C}}{6\ \text{s}}$ = **13 A**

Illustration 2

Question: **What is the quantity of electricity required to provide a current of 1 A for one hour?**

Solution: Given that the current $I = 1$ A,

time of flow $t = 1$ hour = 3600 s

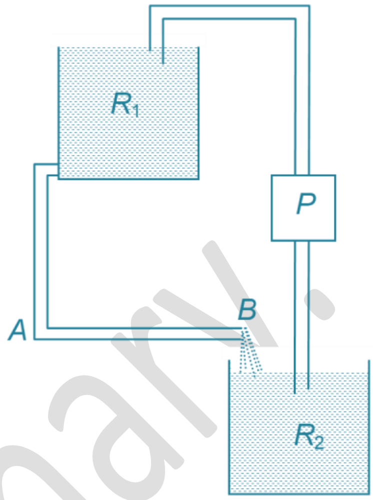
The quantity of electricity = the amount of charge flowing

$Q = It$

= (1 A)(3600 s) = **3600 C**

2 ELECTROMOTIVE FORCE AND VOLTAGE

Let us consider a water flow system as shown in the figure. Suppose in the horizontal tube *AB* we wish to maintain a steady flow of water. This requires a steady pressure difference between *A* and *B*. This is accomplished by maintaining the levels of water in the two reservoirs R_1 and R_2. An external source of energy (the pump *P*) serves the purpose. Water flows spontaneously from higher to lower pressure. The pump is meant to do the opposite – take water from lower pressure to higher pressure. For this, the pump will need to work at a steady rate. Water cannot flow at a constant rate in an isolated tube.



A steady electric current in a conductor is maintained in an analogous way. In a conductor, positive charge will flow from higher potential (*A*) to lower potential (*B*) i.e. in the direction of electric field. To maintain a steady electric current, the conductor cannot be isolated to transport the positive charge from *B* back to *A* i.e. from lower to higher potential and thus maintain a potential difference between *A* and *B*. The external device will need to do work for transporting positive charge from lower to higher potential.

Electromotive force is the maximum work done in taking a unit charge once around the closed circuit. The external device may be a cell, a battery, a generator or dynamo.

Emf of a cell is defined as the maximum potential difference between the two electrodes of the cell when no current is drawn from the cell.

The SI unit of emf of a cell is volt (V) or joule per coulomb. The emf of the cell is said to be 1 volt, if 1 Joule of energy is supplied by the cell to drive 1 coulomb of charge once around the whole circuit.

In current electricity, dry cells or secondary cells or generators are employed to create a potential difference in order to cause an electric current flow in closed circuits just as a water pump is used to create pressure difference in order to drive water in water pipes.

The unit of potential difference is **volt**. The volt is defined as that potential difference between two points of a conductor carrying a current of one ampere when the power dissipated between these points is equal to one watt.

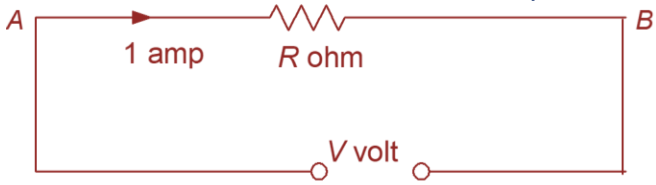
3 RESISTANCE

Electrical resistance may be defined as the property of a substance, which opposes the flow of an electric current through it.

The unit of resistance is **ohm**. Symbol is Ω. Ohm is that resistance between two points of a conductor when a potential difference of one volt is applied between these points produces in this conductor a current of one ampere.

4 OHM'S LAW

Ohm's law is the most fundamental of all the laws in electricity.



Statement: The current which flows in a conductor is proportional to the potential difference which causes its flow provided the temperature of the conductor is constant.

If a potential difference of V volt exists between the ends A and B of a conductor AB current of I ampere flows through the conductor and

$$V \propto I \quad \text{or} \quad V = IR \qquad \text{... (2)}$$

where the constant R is the resistance of the conductor. In this Ohm's law relation, V is in volts, I is in amperes and R is in ohms.

Illustration 3

Question: **The current in a conductor is 5 A when the voltage between the ends of the conductor is 12 V. What is the resistance (in mΩ) of the conductor?**

Solution: Given that $I = 5$ A; $V = 12$ V; R =?

$$R = \frac{V}{I} = \frac{12V}{5A} = \mathbf{2400\ m\Omega}$$

5 RESISTIVITY AND ORIGIN OF RESISTIVITY

The resistance of a resistor depends on its geometrical factors as also on the nature of the substance of which the resistor is made. For a conductor of length l and cross sectional area A, the resistance R is proportional to both l and R.

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

$$R = \rho \frac{l}{A} \qquad \text{... (3)}$$

where ρ is a constant of proportionality called resistivity. It depends only on the nature of the material of the resistor and its physical conditions such as temperature and pressure. The unit of resistivity is ohm m (Ωm). The inverse of ρ is called conductivity and is denoted by σ. The unit of σ is $(\Omega m)^{-1}$ or mho m^{-1} or siemen m^{-1}.

ORIGIN OF RESISTIVITY

At any temperature, the electrons in a metal have a certain distribution of velocities. When there is no external field, velocities in all directions are equally likely and there is no overall drift. In the presence of an external field each electron experiences an acceleration of $\frac{eE}{m}$ opposite to the field direction. The electrons are accelerated and they start gaining speed. In the motion of the electron the suffer frequent collisions against the metal ions. After a collision each electron makes a fresh start, accelerates only to be deflected randomly. The net result is that, in addition to their random motion, the electrons acquire a small velocity towards the end of the conductor. This average velocity is called drift velocity. Thus drift velocity is defined as the average velocity with which free electrons get drifted towards the positive electric field. If τ is the average time between two collisions the average drift speed of the electrons is given by

$$v_d = \frac{eE}{m}\tau \qquad \text{... (4)}$$

Resistivity is also the resistance of a cube of 1 m side measured between opposite faces of the cube.

6 RELATION BETWEEN CURRENT AND DRIFT VELOCITY

Let us consider a conductor of length l and of uniform area of cross section A. If n is the number of free electrons per unit volume of the conductor, then total number of free electrons in the conductor = Aln. Thus charge on all the free electrons in the conductor is $q = Alne$. If a constant potential difference V be applied across the ends of the conductor with the help of a battery, then electric field set up across the conductor is given by $E = \frac{V}{l}$, let v_d be the drift speed of the electrons.

Therefore the time taken by the free electrons to cross the conductor, $t = \frac{l}{V_d}$

Hence current $\Rightarrow I = \frac{q}{t} = \frac{Al\,ne}{l/v_d} = neAv_d$

or $\quad I = \frac{ne^2Av\tau}{lm} \quad$ or $\quad v = \frac{m}{ne^2\tau}\frac{l}{A}I = RI$

$\therefore \quad R = \frac{m}{ne^2\tau}\frac{l}{A}$

Resistivity of the material $\rho = \frac{m}{ne^2\tau}$

MOBILITY OF ELECTRON

Mobility of electron (μ_e) is defined as the drift velocity of electron per unit electric field applied.

$$\mu_e = \frac{v_d}{E} \Rightarrow v_d = \mu_e E$$

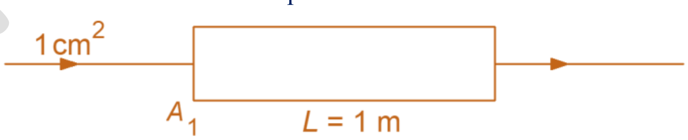
So, $\quad I = neA\mu_e E$

Illustration 4

Question: **A certain rectangular block has dimensions 100 cm × 1 cm × 1 cm. Find the resistance (in mΩ) of the block (across the square faces. The specific resistance of the material is 40 × 10^{-8} ohm-metre.**

Solution:

Resistance of the block across the square faces



$$R = \frac{\rho \times L}{A} = \frac{(40\times10^{-8}\,ohm\text{-}m)(1m)}{1\times10^{-4}\,m^2} = 4\ \text{m}\Omega$$

TEMPERATURE DEPENDENCE OF RESISTIVITY

In most metals an increase in temperature increases the amplitude of vibration of lattices ions of the metal. Due to it, the collision of free electrons with ions/atoms while drifting, becomes more frequent, resulting in a decreases in relaxation time τ.

The resistivity of all metallic conductors increases with temperature.

Resistivity of the material $\rho = \frac{m}{ne^2\tau}$

Over a limited temperature range that is not too large, the resistivity of a metallic conductor can often be represented approximately by a linear relation

$$\rho_T = \rho_0[1+\alpha(T-T_0)]$$

Where ρ_0 is the resistivity at a reference temperature T_0 and ρ_T its value at temperature T. The factor α is called the temperature coefficient of resistivity.

7 TEMPERATURE DEPENDENCE OF RESISTANCE

If R_0 and R be the resistances of a conductor at 0°C and θ°C, then it is found that

$$R = R_0(1+\alpha\theta) \quad \dots (6)$$

where α is a constant called the temperature coefficient of resistance.

$$\alpha = \frac{R-R_0}{R_0 \cdot \theta}$$ and the unit of α is K^{-1} or °C^{-1}.

If R_1 and R_2 be the resistances of a conductor at temperatures θ_1° C and θ_2° C, then

$$R_1 = R_0(1+\alpha\theta_1)$$

$$R_2 = R_0(1+\alpha\theta_2) \quad \text{and} \quad \alpha = \frac{R_2-R_1}{R_1\theta_2-R_2\theta_1}$$

Illustration 5

Question: **A metal wire of diameter 2 mm and of length 100 m has a resistance of 0.5475 ohm at 20°C and 0.805 ohm at 150°C. Find the value of its resistance at 0°C**

Solution:

If R_{20} and R_{150} be the resistances at temperatures 20°C and 150°C respectively and α be the temperature coefficient of resistance

$$R_{20} = 0.5475 = R_0(1+\alpha\times 20) \quad \dots (i)$$

$$R_{150} = 0.805 = R_0(1+\alpha\times 150) \quad \dots (ii)$$

Now, $\alpha = \dfrac{R_{150}-R_{20}}{R_{20}\times 150-R_{150}\times 20} = \dfrac{0.805-0.5475}{0.5475\times 150-0.805\times 20}$ or $\alpha = 3.9\times 10^{-3}$ °C^{-1}

Substituting this value of α in equation (i), R_0 **= 508 mΩ**

8 COLOUR CODE FOR CARBON RESISTORS

The resistance of a carbon resistance is indicated by means of colour code printed on it. There are two types of colour codes.

(a) In the first code, there is always a set of co-axial rings or strips printed on the resistor. In order to understand the significance of these rings, let us first understand the resistor colour code given in the following table.

Colour	Number	Multiplier	Colour	Tolerance
Black	0	10^0	Gold	± 5%
Brown	1	10^1	Silver	± 10%
Red	2	10^2	No colour	± 20%
Orange	3	10^3		
Yellow	4	10^4		
Green	5	10^5		
Blue	6	10^6		
Violet	7	10^7		
Grey	8	10^8		
White	9	10^9		

The multipliers in the case of gold and silver are 10^{-1} and 10^{-2} respectively.

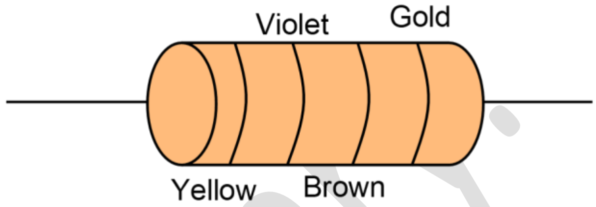
The first two rings or strips from the end give the first two significant figures or resistance in ohm. While the colour of the first ring on the extreme left represents the first significant figure, the second ring represents the second significant figure.

The third ring indicates the decimal multiplier i.e. the number of zeros that will follow the two significant figures.

The last ring indicates the tolerance in percentage about the indicated value i.e. it represent the percentage accuracy.

Illustration 6

Question: **Figure shows a colour –coded resistor. What is the resistance of this resistor?**



Solution: The number for yellow colour is 4. The number for violet colour is 7. Brown colour gives a multiplier of 10^1. Gold indicates a tolerance of 5%. So the resistance of the given resistor is $47 \times 10\Omega \pm 5\%$

(b) In the second code the body of the resistor one, end of a resistor and a dot on the body of the resistor carry specific colours.

The colour of the body gives the first significant figure.

The colour of the end gives the second significant figure.

The colour of the dot on the body of the resistor gives the decimal multiplier i.e., the number of zeros that will follow the two significant figures.

The colour of the ring *R* indicates the percentage accuracy of resistance or tolerance limits of the value of resistance.

9 NON – OHMIC CONDUCTORS

The conductor which do not obey Ohm's Law called non-ohmic conductors. In such conductors the relation of voltage to current may not be a direct proportion and it may be different for the two directions of current. One common semi conductivity device that has non linear. I versus *V* characteristics is the diode. The resistance of this device is small for currents in one direction and large for currents in the reverse direction. There are a number of commonly used circuit elements with one or more of the following prosperities;

(a) *V* depends on *I* non-linearly

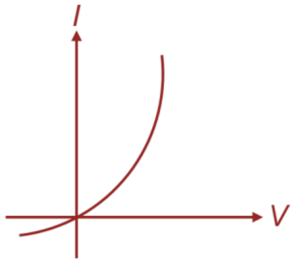
(b) The relation between *V* and I depends on the sign of *V* for the same absolute value of *V*.

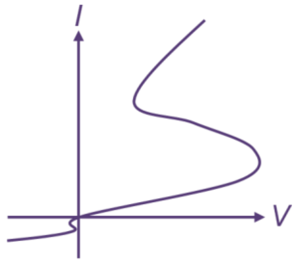
(c) The relation between *V* and *I* is non unique, i.e. for the same current *I*, there is more than one value of voltage *V*.

For example,

Vacuum tubes, semiconductor diodes liquid electrolyte, thyristor are all non-ohmic conductors

Characteristics of diode Characteristics of thyristor





10 SUPER CONDUCTIVITY

The electrical resistivity of many metals and alloys drops suddenly to zero when their specimen are cooled to a sufficiently low temperature called the critical temperature. This phenomenon is called superconductivity and the material showing such a behaviour is called super conductor. The phenomenon was first discovered by H. Kamerlingh Onnes in 1911 in mercury and the critical temperature of mercury was found out to be 4.2K

10.1 MEISSNER EFFECT

In 1933, Meissner and Ochsenfeld in 1933, found that if conductor is cooled in a magnetic field to below the transition temperature, then at the transition the lines of induction *B* are pushed out of the conductor.

The Meissner effect shows that a bulk superconductor behaves as if inside the specimen, the magnetic field is zero.

10.2 SOME SUPER CONDUCTORS

It was later found that lead, tin and indium also become superconductors at 7.2 K, 3.7 K and 3.4 K respectively. Certain alloys become super conductors at rather high temperatures. As an example, the compound Nb_3Sn becomes superconducting at 17.9 K

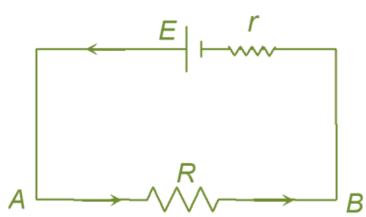
Critical temperature T_C (K) of some superconducting materials

Hg	4.2
Au_2Bi	1.7
$YBa_2Cu_3O_7$	90
$Tl_2Ba_2Ca_2Cu_3O_{10}$	120

Application of superconductor

1. Superconductor are used in making large electromagnets. This is because no heat is generated when a current flows through a superconductor.
2. Superconductor may be used for transmission of electric power without power losses.
3. Super conductors can be used for making high speed computers.

11 EMF OF A CELL AND ITS INTERNAL RESISTANCE



If a cell of emf *E* and internal resistance *r* be connected with a resistance *R* the total resistance in the circuit is $(R+r)$.

The current through the circuit $I=\dfrac{E}{R+r}$

Potential difference across the ends *A* and *B*

$$=IR=\frac{ER}{R+r}$$

Thus, although the emf of the cell is E, the effective potential difference it can deliver is less than E and it is given by

$$V_{AB} = E - Ir$$

The quantity V_{AB} is called the terminal potential difference of the cell and this is also the potential difference across the external resistance R.

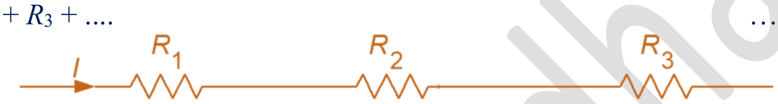
If $R \to \infty$, $V_{AB} \to E$, the emf of the cell.

12 GROUPING OF RESISTANCES

12.1 RESISTORS IN SERIES

The series circuit is one in which the same current flows in all the components of the circuit. If resistors R_1, R_2, R_3, ... are connected in series, the equivalent (or effective) resistance of the combination is the sum of the resistances so connected.

$$R = R_1 + R_2 + R_3 + ... \quad \ldots (7)$$



In a series combination of resistors

(i) the equivalent resistance is equal to the sum of the individual resistances,

(ii) the same current flows through all the components and

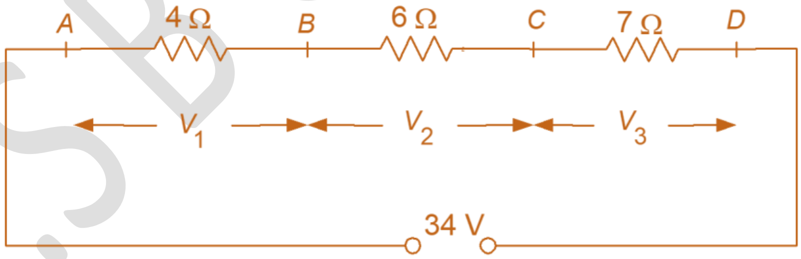
(iii) the sum of the separate voltage drops (IR drop) is equal to the applied voltage across the combination. If V be the applied voltage, V_1, V_2, V_3, ... be the IR drops across resistances R_1, R_2, R_3, ... respectively.

$$V = IR_1 + IR_2 + IR_3 + ... = V_1 + V_2 + V_3 + ...$$

Illustration 7

Question: **Three resistors of values 4 ohm, 6 ohm and 7 ohm are in series and a potential difference of 34 V is applied across the grouping. Find the potential drop across each resistor.**

***Solution*:**



The current through the circuit $= \dfrac{34V}{(4+6+7)ohm} = 2$ A

Potential difference across 4 ohm resistor = IR = 2 A × 4 ohm = **8 V**

Potential difference across 6 ohm resistor = 2A × 6 ohm = **12 V**

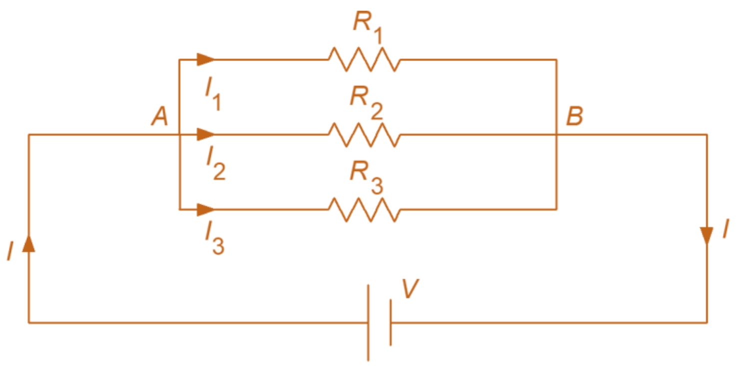
Potential difference across 7 ohm resistor = 2 A × 7 ohm = **14 V**

12.2 RESISTORS IN PARALLEL

A parallel circuit of resistors is one in which the same voltage is applied across all the components.

If resistors R_1, R_2, R_3, ... are connected in parallel then reciprocal of the equivalent resistance is the sum of the reciprocals of the resistance of separate components.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... \quad \ldots (8)$$



(i) the total current taken from the supply is equal to the sum of the currents in separate branches.

(ii) the potential difference across each resistor is the same V volt which is the applied voltage.

(iii) the branch currents I_1, I_2, I_3, ... are in the ratio,

$$\frac{1}{R_1}:\frac{1}{R_2}:\frac{1}{R_3}:\ldots$$

(iv) the equivalent resistance is smaller than the smallest of the resistances in parallel.

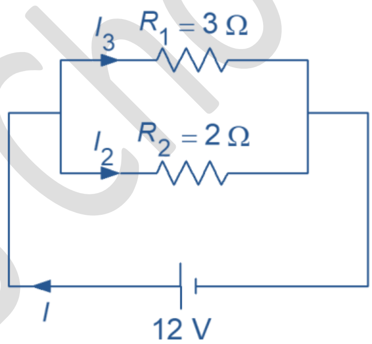
Illustration 8

Question: **Two resistances 3 ohm and 2 ohm are in parallel connection and a potential difference of 12 V is applied across them. Find**

(a) the circuit current and

(b) the branch currents.

Solution:



(a) The circuit current $= \frac{\text{Circuit voltage}}{\text{Circuit resistance}}$

$$= \frac{12V}{1.2\Omega} = \mathbf{10\ A}$$

(b) The current through 2 ohm resistor

$$I_2 = I\times\frac{3}{2+3} = 10\times\frac{3}{5} = \mathbf{6\ A}$$

The current through 3 ohm resistor

$$I_3 = I\times\frac{2}{2+3} = 10\times\frac{2}{5} = \mathbf{4\ A}$$

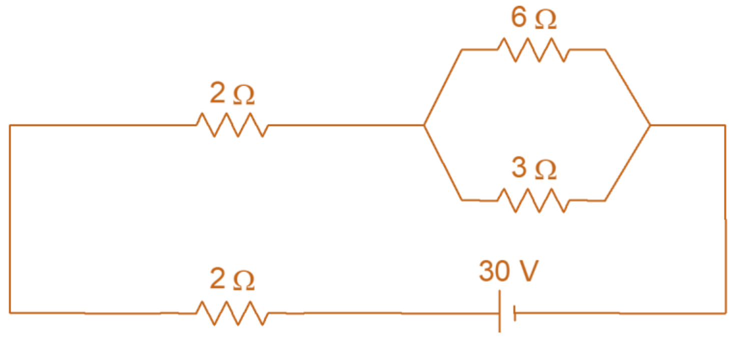
(Also $I_3 = I - I_2 = 10\text{ A} - 6\text{ A} = 4\text{ A}$)

12.3 SERIES-PARALLEL GROUPINGS

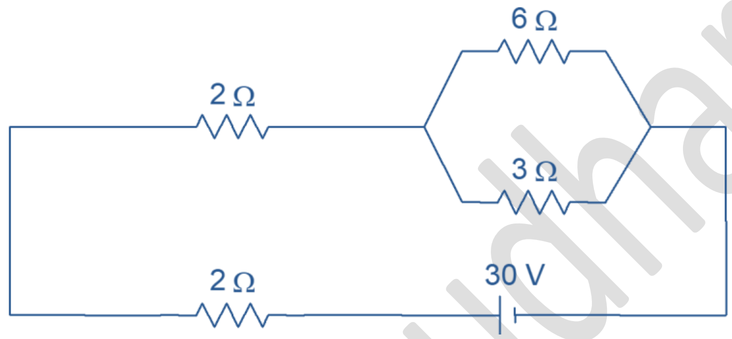
A series-parallel circuit is a combination of resistors in series as well as parallel connections. The following examples will illustrate the solutions of such problems.

Illustration 9

Questions: **Determine the current taken from the 30 *V* supply.**



Solution: As a first step to solution let us reduce the parallel combination of 6 ohm and 3 ohm into a single resistance.



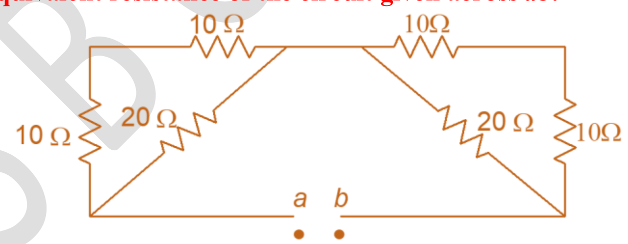
The parallel combination = $\frac{6\times3}{6+3}\Omega=2\Omega$

Now the circuit reduces to three resistors, each 2 ohm, in series to a 30 V supply.

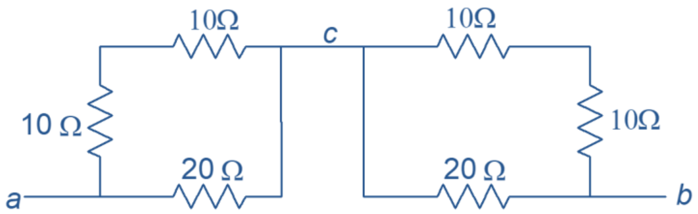
Hence the circuit current = $\frac{30V}{6\Omega}$ = **5 A**

Illustration 10

Questions: **Find the equivalent resistance of the circuit given across *ab*.**



Solution: As a first step the circuit may be redrawn as follows.



The left block is equivalent to 20 ohm and 20 ohm in parallel

i.e., $\frac{20\times20}{20+20}=10\,\Omega$

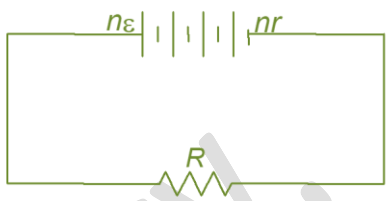
The right block is equivalent to 20 ohm and 20 ohm in parallel

i.e., $\frac{20\times20}{20+20}=\ 10\,\Omega$

The circuit now reduces as two resistors in series = **20 Ω**

13 GROUPING OF CELLS

13.1 CELLS IN SERIES

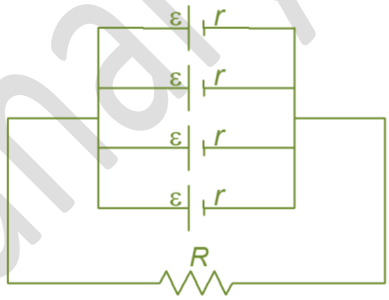


Let there be n cells each of emf ε, arranged in series. Let r be the internal resistance of each cell.

The total emf is $n\varepsilon$ and the total internal resistance is nr. If R be the external load, the current I through the circuit

$$I=\frac{n\varepsilon}{R+nr} \qquad \ldots (9)$$

13.2 CELLS IN PARALLEL



If m cells each of emf ε and internal resistance r be connected in parallel and if this combination be connected to an external resistance R, then the emf of the circuit = ε.

The internal resistance of the circuit = the resistance due to m resistances each of r in parallel $=\frac{r}{m}$.

Now the current through the external resistor $R=\frac{\varepsilon}{R+\frac{r}{m}}=\frac{m\varepsilon}{mR+r}$. … **(10)**

13.3 MIXED GROUPING OF CELLS

Let n identical cells be arranged in series and let m such rows be connected in parallel. Obviously the total number of cells is nm.

The emf of the system = $n\varepsilon$

The internal resistance of the system $=\frac{nr}{m}$

The current through the external resistance R

$$I=\frac{n\varepsilon}{R+\frac{nr}{m}}=\frac{mn\varepsilon}{mR+nr} \qquad \ldots (11)$$

Illustration 11

Questions: **Six cells are connected (a) in series, (b) in parallel and (c) in 2 rows each containing 3 cells. The emf of each cell is 1.08 V and its internal resistance is 1 ohm. Calculate the currents (in mA) that would flow through an external resistance of 5 ohm in the three cases.**

Solution: (a) The cells in series.

Given that ε = 1.08 V, n = 6, r = 1 ohm, R = 5 ohm

The total emf = $n\varepsilon$ = 6 × 1.08 V

The total internal resistance nr = 6 × 1 = 6 ohm

The current in the circuit $I_S=\frac{n\varepsilon}{R+nr}=\frac{6\times1.08}{5+6}=$ **589 mA**

(b) The cells in parallel.

Here ε = 1.08 V, m = 6, r = 1 ohm, R = 5 ohm

$I_p=\frac{m\varepsilon}{mR+r}=\frac{6\times1.08}{6\times5+1}=\frac{6.48}{31}=$ **209 mA**

(c) The cells in multiple arc with n = 3, m = 2

$$I = \frac{mn\varepsilon}{mR + nr} = \frac{6 \times 1.08}{(2 \times 5) + (3 \times 1)}$$

$$= \frac{6.48}{13} = \mathbf{498\ mA.}$$

14 ARRANGEMENT OF CELLS FOR MAXIMUM CURRENT

Considering the above case it is required to find the condition for maximum current if the product *mn* is given.

In this case the product *mn*, ε, *r* and *R* are constants and *m* and *n* alone can be varied to get *I* maximum.

For I_{max} denominator $(mR + nr)$ should be minimum in equation (9). This happens when $mR = nr$ or $R = \frac{nr}{m}$.

Hence the current through the external resistance *R* is a maximum when it is equal to internal resistance of the battery $\frac{nr}{m}$.

☞ If cells of different emf and internal resistance are in parallel there is no simple formula to give the total emf and the internal resistance and any calculations involving circuits in such cases can be done with the help of Kirchhoff's laws which will be discussed later.

Illustration 12

Question: **How would you arrange 20 cells each of emf 2 V and internal resistance 1 ohm to give the maximum current through an external resistance of 5 ohm? Also find this current.**

Solution: Let *n* cells be in series and let there be m such groups in parallel.
Total number of cells $mn = 20$
The external resistance $R = 5$ ohm
The internal resistance of each cell $r = 1$ ohm
The condition for maximum current is $R = \frac{nr}{m}$

or, $5 = \frac{n \times 1}{m} = \frac{n}{m}$

or $n = 5m$

Now $mn = m(5m) = 20$

or $m^2 = 4$

$m = 2$ $n = 10$

To get the maximum current the cells have to be arranged in 2 rows, each row consisting of 10 cells in series.

The maximum current $= \frac{mn\varepsilon}{mR + nr} = \frac{20 \times 2}{2 \times 5 + 10 \times 1} = \mathbf{2\ A}$

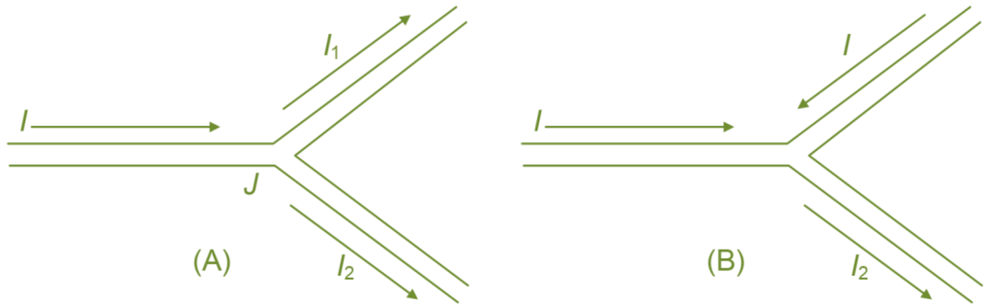
15 KIRCHHOFF'S LAW

KIRCHOFF'S LAWS: If several resistors and cells are connected such that they cannot be reduced to simple series and parallel arrangements, Ohm's law becomes insufficient to solved the problem.

1. FIRST LAW

According to it, "The algebraic sum of currents meeting at a junction is zero"

i.e. $\sum I = O$ **… (12)**



Treating the current to be positive if it is reaching a junction and negative if leaving it, we have

$$I - I_1 - I_2 = 0$$

or $\quad I = I_1 + I_2 \quad$ (for figure A)

For the figure (B), we have

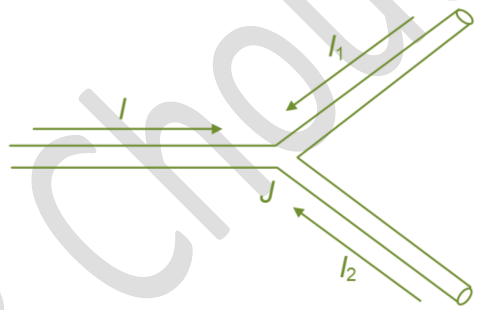
$$I + I_1 - I_2 = 0$$

or $\quad I + I_1 = I_2$

IMPORTANT POINTS REGARDING FIRST LAW

(i) This law implies that current reaching a junction is equal to the current leaving the junction

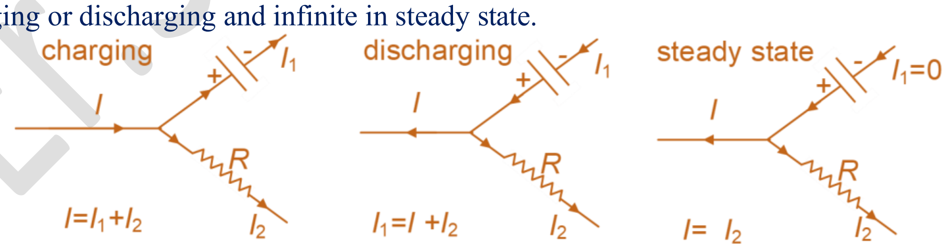
(ii) If a current comes out to be negative, actual direction of current at the junction is opposite to that assumed.



In the above diagram, $I + I_1 + I_2 = 0$ can be satisfied only if at least one current is negative i.e. leaving the junction.

(iii) This law is simply a statement of "conservation of charge". If current reaching a junction is not equal to the current leaving, charge will not be conserved.

(iv) This law is also applicable to a capacitor treating the resistance of capacitor to be zero during charging or discharging and infinite in steady state.



(v) This law is also known as junction rule or current law (KCL) or node theorem.

2. SECOND LAW

According to it " The algebraic sum of all potential differences in closed loop is zero" i.e

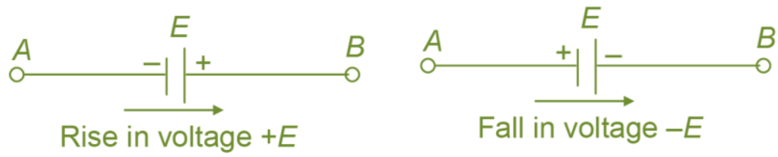
$$\sum V = 0 \quad \ldots (13)$$

IMPORTANT POINTS REGARDING SECOND LAW

1. Determination of sign

(a) Sign of Battery E.M.F

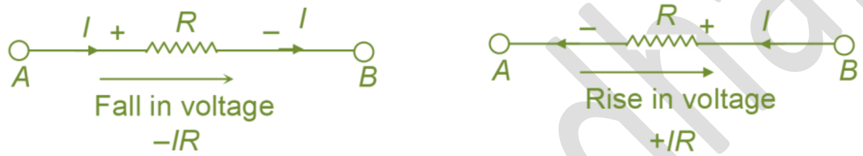
A rise in voltage should be given a +ve sign and a fall in voltage a –ve sign. Keeping this in mind, it is clear that as we go from the negative terminal of a battery to its positive terminal, these is a rise in potential, hence this voltage should be given a +ve sign. If, on the other hand, we go from +ve terminal to the –ve terminal, then these is a fall in potential, hence this voltage should be preceded by a negative sign.

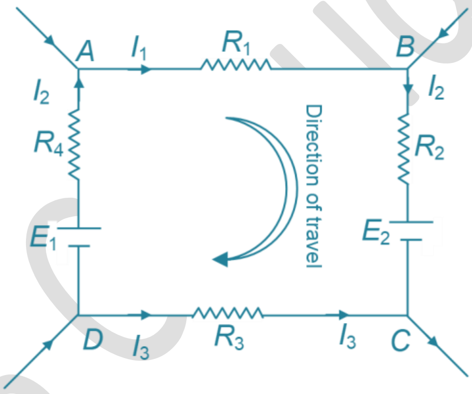


It is important to not that the sign of the battery emf is independent of the direction of the current through that branch.

(b) Sign of IR drop

If we go through a resistor in the same direction as the current, then there is a fall in potential because current flows from a higher to a lower potential. Hence, this voltage fall should be taken as negative. However, if we go in a direction opposite to that of the current, then there is a rise in voltage. Hence, this voltage rise should be given a positive sign.





Consider the closed path *ABCDA* (as shown the above figure). As we travel around the mesh in the clockwise direction, different voltage drops will have the following signs.

I_1R_1 is –ve (fall in potential)
I_2R_2 is –ve (fall in potential)
I_3R_3 is +ve (rise in potential)
I_4R_4 is –ve (fall in potential)
E_2 is –ve (fall in potential)
E_1 is +ve (rise in potential)

Using Kirchoff's voltage law, we get

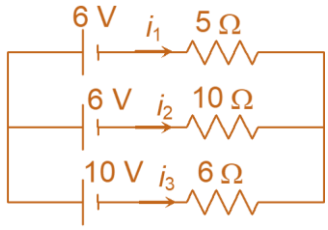
$$-I_1R_1 - I_2R_2 + I_3R_3 - I_4R_4 - E_2 + E_1 = 0$$

or $$I_1R_1 + I_2R_2 - I_3R_3 + I_4R_4 = E_1 - E_2$$

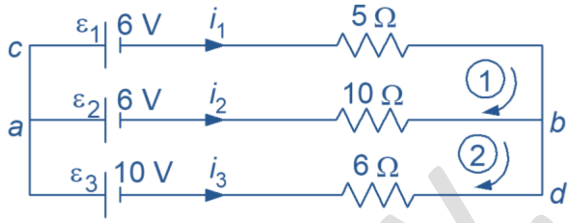
2. This law represents "conservation of energy". If the sum of potential changes around a closed loop is not zero, unlimited energy could be gained by repeatedly carrying a charge around a loop.

Illustration 13

Question: **Show that value of $i_1 + i_2 + i_3$ in the circuit given is zero. The internal resistances of the batteries are included in the external resistances.**



Solution: The circuit given can not be simplified further because it contains resistors not in simple series or parallel connection. Hence Kirchhoff's rules have to be applied. Since the currents have not been marked we have to do that first. No special care need be taken to indicate the exact current directions since those chosen incorrectly will simplify to give negative numerical values.



Applying the junction rule to junction a

$i_1 + i_2 + i_3 = 0$ … (i)

Taking the loop acba

IR drop across 5 Ω = $+5i_1$

IR drop across 10 Ω = $-10i_2$

emf of $\varepsilon_1 = +6$ V

emf of $\varepsilon_2 = -6$ V

Applying the loop rule

$5i_2 - 10i_2 = +6 - 6 = 0$ or $i_1 - 2i_2 = 0$ **… (ii)**

Considering the loop *abda*

$10i_2 - 6i_3 = 10 - 6$

$10i_2 - 6i_3 = 4$

$5i_2 - 3i_3 = 2$ **… (iii)**

To find the unknowns i_1, i_2 and i_3, solve the three equations (i), (ii) and (iii). We get

$i_1 = \frac{2}{7}A$, $i_2 = \frac{1}{7}A$

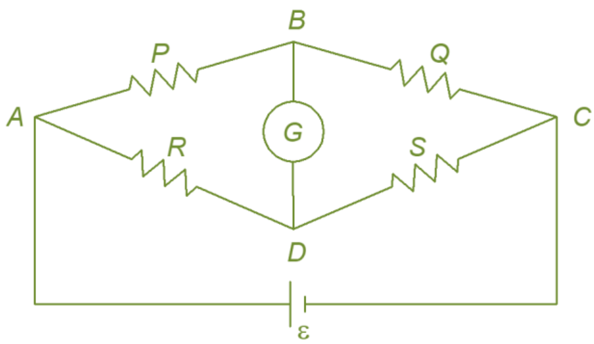
$i_3 = -\frac{3}{7}A$. The direction of flow of i_3 is opposite to that marked in the circuit.

$\therefore \quad i_1 + i_2 + i_3 = \mathbf{0}$

16 ELECTRICAL DEVICES

16.1 WHEATSTONE'S BRIDGE

For measurement of a resistance, a network made up of four resistance arms *P*, *Q*, *R* and *S* is arranged as shown. Arms *AB* and *BC* having resistances *P* and *Q* respectively are known as ratio arms.



A galvanometer G is connected across B and D. A battery is connected across A and C. When the values of resistances P, Q, R and S are such that no current flows through the galvanometer G the bridge is said to be balanced.

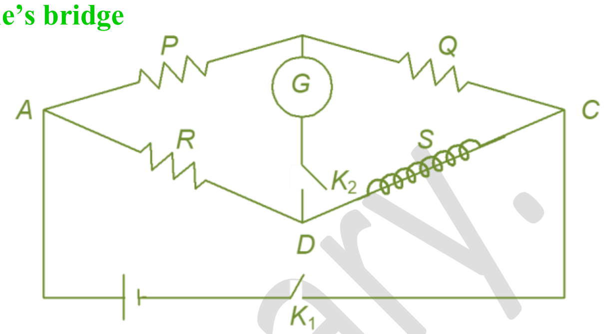
In that case B and D are at the same potential and we have the condition

$$\frac{P}{Q}=\frac{R}{S}$$

Usually S is an unknown resistance and P, Q and R are known.

Temperature measurement using wheatstone's bridge

A platinum wire about 50 cm in length is wound on a non-conducting rod with a non inductive winding. This platinum wire in connected in the arm CD of wheatstone bridge circuit as shown in the figure.



Working and Theory

1. Keeping the platinum wire S is ice at 0^0C the arms P and Q are made equal. The value of R is adjusted so that on closing key K_1 and K_2 the galvanometer shown no deflection. If R_0 is the resistance of platinum wire at 0^0C, then

$$R_0=\frac{RQ}{P} \qquad \ldots \text{(i)}$$

2. Keeping the platinum wire into steam at 100^0C and repeating the same procedure as in step 1, we get

$$R_{100}=\frac{R'Q}{P} \qquad \ldots \text{(ii)} \quad [\ R' = \text{resistance of arm } R]$$

3. Keeping the platinum wire into the bath whose temperature t^0C is to be determined and repeating the step -1, we get

$$R_t=\frac{R''Q}{P} \qquad \ldots \text{(iii)} \quad [\ R'' = \text{resistance of arm } R]$$

If α is the temperature coefficient of resistance of platinum wire at t^0C, then

$$R_{100}=R_0\left(1+\alpha\times 100\right)$$

$$\alpha=\frac{R_{100}-R_0}{R_0\times 100} \qquad \ldots \text{(iv)}$$

Also $R_t=R_0\left(1+\alpha t\right)$

$$\alpha=\frac{R_t-R_0}{R_0\times t} \qquad \ldots \text{(v)}$$

From (iv) and (v)

$$\frac{R_t-R_0}{R_0\times t}=\frac{R_{100}-R_0}{R_0\times 100}$$

$$t=\frac{R_t-R_0}{R_{100}-R_0}\times 100 \;=\frac{R''-R}{R'-R}\times 100$$

16.2 METER BRIDGE

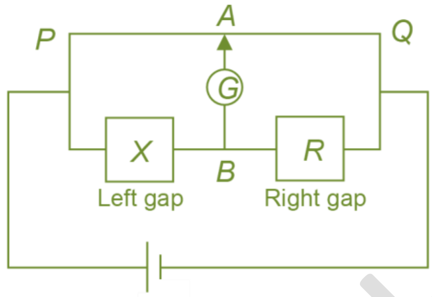
The wheatstone network is used to determine unknown resistances. The meter bridge is an instrument based on the balancing condition of wheatstone network.

The resistances R_1 and R_2 are two parts of a long wire PQ (usually 1 m long). The portion PA of the wire offers resistance R_1 and the portion QA offers resistance R_2. The sliding contact at A is adjusted so that galvanometer reads zero.

For no deflection $\frac{R_1}{R_2} = \frac{X}{R}$

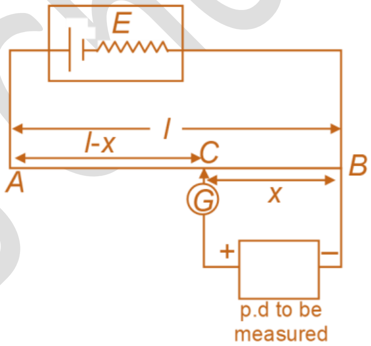
$$\Rightarrow \qquad X = R\left[\frac{R_1}{R_2}\right] = R\frac{l_1}{l_2} \qquad \text{... (14)}$$

If R is a known resistance, then X can be measured by measuring the length l_1 and l_2



16.3 POTENTIOMETER

We already know that when a voltmeter is used to measure potential difference, its finite resistance causes it to draw a current from the circuit. Hence the p.d. which was to be measured is changed due to the presence of the instrument. Potentiometer is an instrument which allows the measurement of p.d. without drawing current from the circuit. Hence it acts as an infinite-resistance voltmeter.



The resistance between A and B is a uniform wire of length l , with a sliding cont act C at a distance x from B. The sliding contact is adjusted until the galvanometer G reads zero. The no deflection condition of galvanometer ensures that there is no current through the branch containg G and the p.d. to be measured. The length x for no deflection is called as the balancing length.

$V_{CB} = V$ p.d. to be measured.

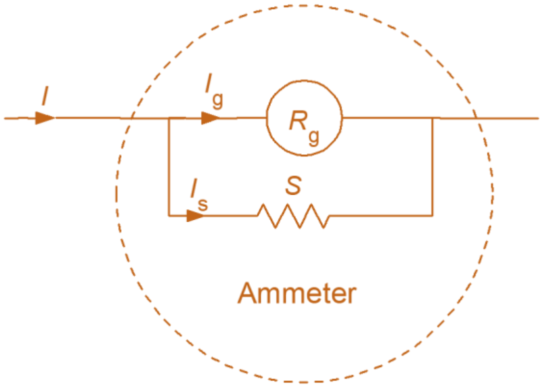
If λ is the resistance per unit length of AB.

$$V = V_{CB} = \frac{x}{l}V_{AB} = \left(\frac{V_{AB}}{l}\right)x \qquad \text{... (15)}$$

16.4 AMMETER

An ammeter is a modified form of suspended coil galvanometer. While galvanometers can permit only very small currents to pass through them, ammeters can allow, depending upon their construction, much heavy currents to flow through them.

A suitable shunt resistance *S* (of very small value compared to R_g) in parallel with that of galvanometer of resistance R_g achieves this objective.



If the ammeter is designed to measure a maximum current *I* (full scale deflection current), then the shunt *S* required for the purpose is given by $I_g \cdot R_g = (I - I_g)S$

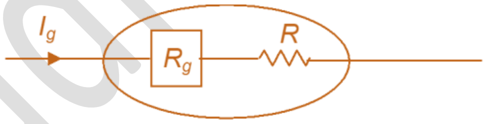
where I_g is the maximum permissible current through the galvanometer.

The resistance of ammeter is small (smaller than that of the shunt *S*) and for current measuring purposes it is included in series in a circuit. An ideal ammeter has zero resistance.

16.5 VOLTMETER

Voltmeter is also a modified form of a galvanometer. It is used to measure potential differences.

A suitable high resistance *R* is included in series with the galvanometer of resistance R_g to enable the instrument to measure voltages. If the maximum range of the voltmeter is V_0 and the maximum permissible current through the galvanometer is I_g, then the value of *R* is given by

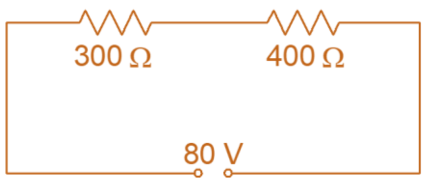


$$I_g = \frac{V_0}{R + R_g} \qquad \text{... (17)}$$

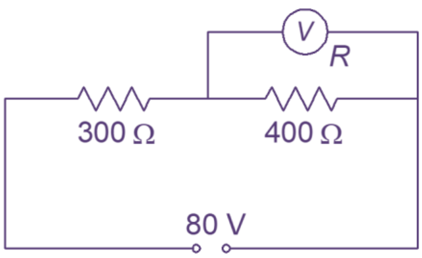
To measure the potential difference across two points in a circuit the voltmeter is connected in parallel with it. An ideal voltmeter has infinite resistance.

Illustration 14

Question: **In the circuit shown a voltmeter reads 30 volt when it is connected across the 400 ohm resistance. Calculate what the same voltmeter would read when it is connected across the 300 ohm resistance.**



Solution: The voltmeter is in parallel with 400 ohm resistance.
Let its resistance be *R* ohm.
It is clear that the resistances *R* and 400 ohm combining in parallel produce equivalent resistance of value of 300 ohm so that the potential drop across this equivalent resistance is half of 60 V.



$$\therefore \qquad \frac{R \times 400}{R + 400} = 300$$

$400R = 300R + 120000$
$100R = 120000$
$R = 1200\ \Omega$

Next the same voltmeter is connected across the 300 ohm resistance. Now the equivalent resistance of 300 ohm and 1200 ohm of voltmeter in parallel connection will be

$$\frac{300 \times 1200}{300 + 1200} = 240\Omega$$

The total circuit resistance $= 240 + 400 = 640$

Potential drop across 240 ohm $= \frac{240}{640} \times 80V$ $=$ **30 V**

Illustration 15

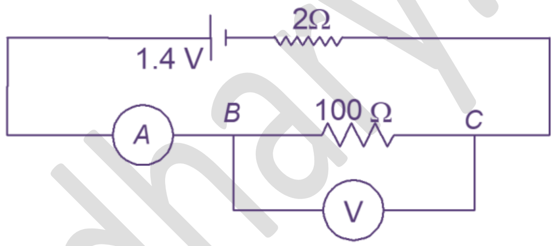
Question: **A battery of emf 1.4 V and internal resistance 2 ohm is connected to a resistor of 100 ohm resistance through an ammeter. The resistance of the ammeter is $\frac{4}{3}$ ohm. A voltmeter has also been connected to find the potential difference across the resistor.**

(i) Draw the circuit diagram.

(ii) The ammeter reads 0.02 A. What is the resistance of the voltmeter?

Solution:

(i) The circuit diagram is shown.



(ii) Let the resistance of the voltmeter be R ohm. The equivalent resistance of voltmeter (R ohm) and 100 ohm in parallel is $\frac{100 \times R}{100+R} = \frac{100R}{100+R}$

The resistance of the ammeter $= \frac{4}{3}\Omega$

The total resistance of the circuit $= \frac{100R}{100+R} + \frac{4}{3} + 2\Omega$

The current in the circuit as read by the ammeter = 0.02 A

Now, $$0.02 = \frac{1.4}{\frac{100R}{100+R} + \frac{4}{3} + 2}$$

or, $$\frac{100R}{100+R} + \frac{4}{3} + 2 = \frac{1.4}{0.02} = 70$$

$$\frac{100R}{100+R} = 70 - \frac{10}{3} = \frac{200}{3}$$

$300R = 200R + 20000$

$100R = 20000$

$R =$ **200 Ω**

Resistance of the voltmeter = **200 Ω**

17 HEATING EFFECT OF CURRENT

17.1 JOULE'S LAW OF ELECTRICAL HEATING

When an electric current flows through a conductor electrical energy is used in overcoming the resistance of the wire. If the potential difference across a conductor of resistance R is V volt and if a current of I ampere flows the energy expended in time t seconds is given by

$$W = VIt \text{ joule} \quad = I^2Rt \text{ joule} \quad = \frac{V^2}{R}t \text{ joule}$$

The electrical energy so expended is converted into heat energy and this conversion is called the heating effect of electric current.

The heat generated in joules when a current of I ampere flows through a resistance of R ohm for t seconds is given by

$$H = I^2Rt \text{ joule} \qquad \dots \textbf{(17)}$$

This relation is known as Joule's law of electrical heating.

17.2 ELECTRICAL POWER

The energy liberated per second in a device is called its power. The electrical power P delivered by an electrical device is given by

$$\left.\begin{aligned} P &= VI \text{ watt} \\ &= I^2R \text{ watt} \\ &= \frac{V^2}{R} \text{ watt} \end{aligned}\right\}$$

The power P is in watts when I is in amperes, R is in ohms and V is in volts.

The practical unit of power is 1 kW = 1000 W.

The formula for power $P = I^2R = VI = \frac{V^2}{R}$ is true only when all the electrical power is dissipated as heat and not converted into mechanical work, etc., simultaneously.

17.3 UNIT OF ELECTRICAL ENERGY CONSUMPTION

1 unit of electrical energy = 1 kilowatt-hour=1 kWh $= 36 \times 10^5$ J

Number of units consumed $= \frac{\text{watt} \times \text{hour}}{1000} = \text{kWh}$

Illustration 16

Question: **What is the resistance of the filament of a bulb rated at (100 W – 250 V)? What is the current (in mA) through it when connected to 250 V line? What will be power if it is connected to a 200 V line?**

Solution: Power $P = VI = \frac{V^2}{R}$

Resistance $R = \frac{V^2}{P} = \frac{250 \times 250}{100} = $ **625 Ω**

The current through the lamp $= \frac{P}{V} = \frac{100\ W}{250\ V}$

= **400 mA**

The power of the lamp when it is connected to a 200 V line is

$$P = \frac{V^2}{R} = \frac{200 \times 200}{625} = \textbf{64 W}$$

Illustration 17

Question: **Forty 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. In which case will there be more illumination and why?**

Solution: Let r be the resistance of each bulb and 40 bulbs in series will have a resistance of 40 r ohm. When connected across a supply voltage V, the power of the system with 40 bulbs will be

$$P_{40} = \frac{V^2}{40r}$$

When one of the bulbs is fused, the resistance of the remaining 39 bulbs in series = 39 *r* and the power of the system when connected to the same supply

$$P_{39} = \frac{V^2}{39r}$$

It is clear that $\frac{V^2}{39r} > \frac{V^2}{40r}$

∴ power of **39 bulbs** in series is greater.

18 CHEMICAL EFFECT OF CURRENT

The chemical effect current is one of the earliest effects of electric current known to mankind. The chemical effect of current was first studied by Faraday in 1833.

Pure metals do not decompose when an electric current is passed through them. Substances which decompose and show chemical reaction when an electric current is passed through them are known as electrolytes. Solutions of inorganic salts in water, dilute acids and bases are examples of electrolytes. An electrolyte in solution separates into free ions, positive and negative. This process of breaking up of molecules of electrolyte (salt) is called dissociation. When an electric field is applied between the two electrodes dipped in the solution, the positively charged ions called cations move toward the negative electrode called cathode while the negatively charged ions called anions move towards the positive electrode called anode and get discharged there.

This process of decomposition of a compound by the application of an electric field is called electrolysis or chemical effect of current. The vessel in which electrolysis is carried out is called voltameter or electrolytic cell.

18.1 THEORY OF IONIC DISSOCIATION

In 1887 Arrhenius explained the phenomenon of electrolysis by an ionic dissociation theory. The molecules of an electrolyte, say NaCl, arr compounds of equally charged positive and negative ions, Na^+ and Cl^-. In crystalline NaCl the ions are bound together under strong electrostatic attraction. When NaCl is dissolved in water (where dielectric constant is 81) its ionic binding reduces by a factor of 1/81. The ions, therefore dissociate from each other due to thermal agitation

$$NaCl \longrightarrow Na^+ + Cl^-$$

and move purely at random in the solution. Because at any instant, both the positive and negative ions are present every where in the solution, the solution remains electrically neutral.

Like NaCl, the substance like $CuSO_4$ and $AgNO_3$, when dissolved in water dissociate in the following way.

$$CuSO_4 \longrightarrow Cu^{2+} + SO_4^{2-}$$

$$AgNO_3 \longrightarrow Ag^+ + NO_3^-$$

18.2 COPPER VOLTAMETER

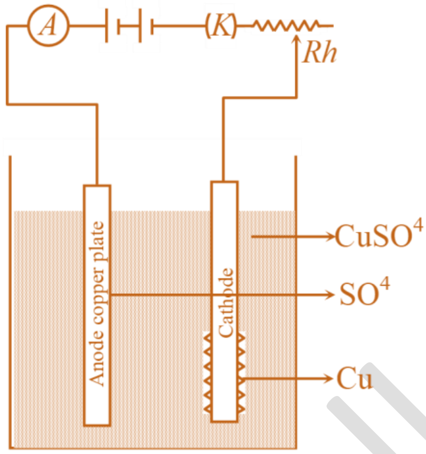
It consists of a glass vessel containing $CuSO_4$ solution as the electrolyte, and two copper plates as cathode and anode. The electrodes are connected across a battery along, with an ammeter (A) key (K) and rheostat (Rh) as shown in figure.

When the current is passed through the electrolyte, the Cu^{++} ions move to the cathode and get deposited on it. The SO_4^{--} ions are attracted by the anode and remove copper from the anode. The process continues but the concentration of the $CuSO_4$ in the solution remains constant.

Explanation: Before passing the current, some $CuSO_4$ molecules in the solution dissociate into its positive end negative ions, i.e.

$$CuSO_4 \longrightarrow Cu^{++} + SO_4^{--}$$

When the current is passed through $CuSO_4$ solution, Cu^{++} ions are attracted by the cathode and SO_4^{--} move towards the anode.



At the cathode: Each Cu^{++} ions takes two electrons and becomes neutral and gets deposited on the cathode.

$$Cu^{++} + 2e^{-} \longrightarrow Cu \text{ (reduction)}$$

At anode: Each SO_4^{--} ion loses its two electrons at the anode and becomes neutral. The electrons so released move towards the positive terminal of the battery through the external circuit. The neutral SO_4 ion combines with one copper atom of the anode and forms $CuSO_4$ when comes in the solution and gets dissolved.

$$SO_4^{--} \longrightarrow SO_4 + 2e^{-}$$

$$Cu + SO_4 \longrightarrow CuSO_4 \text{ and } CuSO_4 \longrightarrow Cu^{++} + SO_4^{--}$$

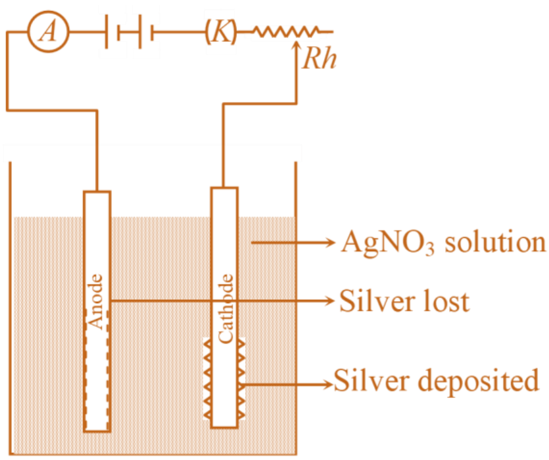
or $$Cu \longrightarrow Cu^{++} + 2e \text{ (oxidation)}$$

Thus, during electrolysis of $CuSO_4$, copper is lost by the anode and an equal amount of copper is deposited on the cathode. The concentration of the solution remains constant.

18.3 SILVER VOLTAMETER

It consists of a glass vessel containing an aqueous solution of $AgNO_3$ as the electrolyte and two silver plates as the electrodes. A battery along with an ammeter, key (*K*) and a rheostat (*Rh*), are connected as shown in the figure.

When a steady electric current is passed through the electrolyte, silver is deposited at the cathode and an equal amount of silver is lost by the anode. The amount of silver lost by the anode goes into the solution. Thus the concentration of the solution remains the same.



Explanation: Before passing the current $AgNO_3$ dissociates into Ag^+ and NO_3^- ions i.e.

$$AgNO_3 \longrightarrow Ag^+ + NO_3^-$$

On passing the current through the electrolytes., Ag^+ ions move to the cathode and NO_3^- ions to the anode.

At cathode: Each Ag^+ ion take one electron from the cathode end becomes neutral and gets deposited around the cathode.

$$Ag^+ + 1e^{-1} \longrightarrow Ag$$

At anode: Each incoming NO_3^- ion loses its electron and becomes neutral. The electron so released moves to the positive terminal of the battery through the external circuit and maintains the continuity of current.

The neutral NO_3 ion combines with a silver atom and forms $AgNO_3$ which then goes into the solution.

$$NO_3^- \longrightarrow NO_3 + 1e^{-1}$$

$$Ag^+ + NO_3^- \longrightarrow AgNO_3$$

$$AgNO_3 \longrightarrow Ag^+ + NO_3^-$$

or $$Ag \longrightarrow Ag^+ + 1e^-$$

Thus, during the electrolysis of $AgNO_3$, silver is lost by the anode and equal amount of silver gets deposited on the cathode.

18.4 FARADAY'S LAWS OF ELECTROLYSIS

On the basis of his experimental study, Faraday gave two laws to explain the quantitative aspects of electrolysis. These are

First law: It states that the mass of the substance liberated or deposited at the cathode during electrolysis is directly proportional to the amount of charge passed through the electrolyte.

Let m be the mass of the substance liberated at the cathode when a charge q is passed through the electrolyte. Then according to Faraday's first law.

$$m \propto q$$

or $$m = Z.q \qquad \text{… (i)}$$

when Z is a constant of proportionality and is called electro-chemical equivalent (ECE) of that substance.

Let charge q be the amount of charge that flows through the electrolyte due to the flow of a steady current I for time t seconds.

$$\therefore \quad q = It \qquad \text{… (ii)}$$

$\therefore \quad m = ZIt$

$\therefore$ From equation (i) and (ii), we get

$$Z = \frac{m}{q} = \frac{m}{It}$$

If $q = 1\,C$ or $I = 1A$ and $t = 1\sec$

Then, $Z = m$

Hence, the electro-chemical equivalent of a substance may be defined as the mass of the substance liberated during electrolysis when one coulomb of charge is passed through the electrolyte (or when a steady current of 1A flows through it for 1sec)

Electro-chemical equivalent of substance is generally expressed in gm/coulomb (gC^{-1}) and different substances have different values of ECE. For example, -

ECE of hydrogen = 1.05×10^{-5} gc^{-1} and ECE of copper = $3.2945 \times 10^{-5} gc^{-1}$.

Second law: If the same amount of charge is passed through different electrolytes (or same current is passed through them for the same time internal), the masses of the substances liberated are directly proportional to their chemical equivalents.

Let m_1 and m_2 be the masses of the two substances liberated when the same current is passed through the two electrolytes for the same time let E_1 and E_2 are the chemical equivalents of the substances. Therefore, according to Faraday's second law.

$$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$

Chemical equivalent of an element (E)
is defined as atomic mass per unit valency of the element, i.e.

$$E = \frac{\text{Atomic Mass}}{\text{Valency}} = \frac{M}{p}$$

Relationship between Electro-chemical Equivalent (Z) and Chemical Equivalent (E)

Suppose a steady current I flows for time t through two different voltameters connected in series. Let the masses of the substance liberated at their cathodes be m_1 and m_2 and E_1 and E_2 be their chemical equivalents.

Then, from Faraday's second law.

$$\frac{m_1}{m_2} = \frac{E_1}{E_2} \quad \text{... (i)}$$

From Faraday's law

$$\frac{m_1}{m_2} = \frac{Z_1 It}{Z_2 It} = \frac{Z_1}{Z_2} \quad \text{... (ii)}$$

From equation (i) and (ii) we get

$$\frac{E_1}{E_2} = \frac{Z_1}{Z_2} \text{ or } \frac{E_1}{Z_1} = \frac{E_2}{Z_2} = \text{constant}$$

$$\therefore \quad \frac{E}{Z} = \text{constant}$$

This is called Faraday constant and is denoted by F

$\therefore \quad \frac{E}{Z} = F$

or $\quad E = ZF$ ... (**18**)

18.5 FARADAY CONSTANT (F)

Consider one mole of an element liberated during electrolysis

$\therefore$ Let M be its atomic mass and p be the valency of the element.

$\therefore$ Charge required to liberate one atom of the element at the cathode = pe

$\therefore$ Charge required to liberated 1 mole, i.e., $q = Npe$

where N is Avogadro number

$\therefore$ From Faraday's first law,

$m = Zq$

or $\quad M = Z.pNe$

or $\quad \frac{M}{p} = Z.\,Ne$ but $\frac{M}{p} = E$

or $\quad E = Z.\,(Ne)$

But $\quad Ne = 6.023 \times 10^{23} \times 1.6 \times 10^{-19} = 96500$ c mole^{-1}

Comparing equation, we conclude

$$F = Ne = 96500 \text{ c mole}^{-1}$$

Thus Faraday constant (F) may be defined as the amount of charge required to liberate 1 mole of a substance during electrolysis.

Illustration 18

Question: **Calculate the value of current (in mA) required to deposit 0.72g of chromium in 4 second. If E.C.E of chromium is 0.00018 g C^{-1}.**

Solution: Here, $I = ?$, $m = 0.72$ g,

$t = 4$, $z = 0.00018$ g C^{-1}

As $m = zIt$

$$\therefore \quad I = \frac{m}{2t} = \frac{0.72}{0.00018 \times 4 \times 60 \times 60} = \mathbf{1000\ A}$$

Illustration 19

Question: **A metal plate of surface area 250 sq.cm is to be coated on both sides with a metal by electrolysis. How long will it take to deposit metal 0.01 cm in thickness if a current of 1.5 A is used. Given ECE of metal is 0.001 g C^{-1}, density of metal = 27 g cm^{-3}.**

Solution: Area, A = 2 × 250 cm^2 = 500 cm^2 , t = ?

thickness, d = 0.01 cm, z = 0.00033 g C^{-1}

density, ρ = 9 cm^{-3} , I = 1.5 A

Mass of metal deposited

= volume × density = A × d × ρ = 500 × 0.01 × 27 = 135 gram

$$\text{As } t = \frac{m}{zI} = \frac{135}{0.001 \times 60 \times 60 \times 1.5} = \mathbf{25\ hrs}$$

18.6 APPLICATION OF ELECTROLYSIS

It finds a variety of applications in industry. Some of them are as under

(i) Electroplating: It is the process in which a thin layer of a superior metal is coated over the surface of an inferior metal.

For example, gold coating over a silver ornament or silver coating over a copper vessel. The article to be coated is made the cathode and the metal to be coated is made the anode. The solution of a soluble salt of the superior metal is used as the electrolyte. When the current is passed, electrolysis takes place and the layer of the metal is deposited on the article. Apart from giving an attractive loop, it helps to protect the articles from corrosion.

(ii) Electrotyping: The process of obtaining the exact copy of a page composed of metallic type used in printing work by using electrolysis is called electrotyping.

The impression of the page is first obtained on a sheet of wax. It is, then, coated with graphite powder to make is conducting. It is, then, electroplated with copper in a copper voltameter. This is how we obtain the exact copy of the metallic typed page. Gramophone records are also manufactured using the same technique.

(iii) Purification of Metals: Metals can be extracted from the its ore or an impure sheet by electrolysis. The ore or the impure sheet is made the anode and a pure sheet of that metal is the cathode. The solution of a salt of that metal is taken as the electrolyte.

When a steady current is passed through the electrolyte, the atoms of the metal from the anode come into the electrolyte and then deposit on the cathode. Thus, the metal gets purified.

(iv) Manufacturing Chemicals: Caustic soda is manufactured by the electrolysis of sodium chloride solution. It is also used for commercially preparing hydrogen and oxygen. It is also employed for chemical analysis of compounds.

(v) Medical Applications: Electrolysis is used for local anaesthesia, nerve stimulation (especially for polio) and for removing unwanted hair from any part of the body.

18.7 ELECTRO-CHEMICAL CELLS

An electro-chemical cell is a device in which a chemical reaction proceeding at a steady rate converts chemical energy into electrical energy.

Electro-chemical cells are of the two types

(i) Primary cells
(ii) Secondary cells

Primary cell: The cell in which the chemical energy is converted into electrical energy due to an irreversible chemical reaction is called a primary cell.

Voltaic cell, Leclanche cell and Daniel cell are the examples of primary cells.

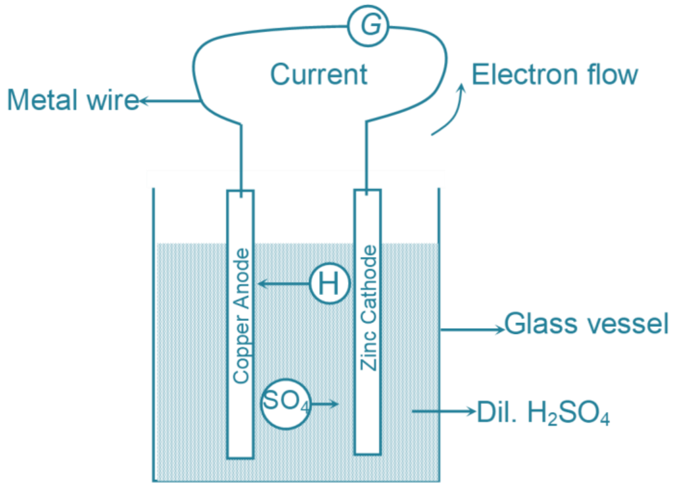
Secondary cell: The cell in which the chemical energy is converted into electrical energy due to a reversible chemical reaction is called a secondary cell. Such cells are therefore, rechargeable. They are also known as storage cell or accumulators. Edison's alkali cell, and lead acid cell are the two commonly used secondary cells.

18.8 PRIMARY CELLS

Simple Voltaic Cells

This cell was developed by Volta in 1800

It consists of a glass vessel containing dil H_2SO_4 which acts as electrolyte. Two rods, one of copper and the other of zinc are dipped in the acid. They act as the anode and cathode respectively.



Chemical Action of the Cell

Dil H_2SO_4 dissociates into positive hydrogen ions and negative sulphate ions. i.e

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

Some H^+ ions from the acid go to the copper plate, take free electrons from the copper rod and become neutral H atoms. The copper electrode on losing its free electrons becomes positively charged till it attains a potential of 0.46 V w.r.t. the acid.

Some zinc ions (Zn^{++}) from the zinc electrode go into the acid and in the process, gives up two electrons each on the electrode. Thus, the zinc electrode becomes negatively charged till it attains a potential of –0.62 V w.r.t. the acid.

$\therefore$ Potential difference between the two electrodes i.e. the emf of the cell
= 0.46 – (– 0.62)
= 1.08 V

Inside the electrolyte Zn^{++} ions combine with SO_4^{--} and from $ZnSO_4$. i.e.

$$Zn^{++} + SO_4^{--} \longrightarrow ZnSO_4$$

The chemical reactions which occur in the voltaic cell can be summarised as under

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

At anode $\quad 2H^+ + 2e^- \longrightarrow H_2$

At cathode $\quad Zn \longrightarrow Z_n^{++} + 2e^-$

In the electrolyte $\quad \longrightarrow Zn^{++} + SO_4^{--} \longrightarrow ZnSO_4$

$\therefore$ Chemical reaction in the cell $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

Hydrogen gas liberated is bubbled out

18.9 DEFECTS OF A VOLTAIC CELL

Voltaic cell suffers from the following two defects

(i) Local action

The zinc plate used in the cell contains the impurities such as iron, lead, carbon etc. The atoms of these impurities along with zinc come in contact with the electrolyte i.e. dil H_2SO_4 and constitute minute voltaic cells. As a consequence, a small local currents are set up in the zinc electrode. These local currents not only reduce the current in the external circuit but cause the wastage of zinc even when the cell is not used. This is called local action. This defect can be avoided by coating the zinc plate with mercury, i.e. by amalgamating it. The layer of mercury does not allow the impurities to come in contact with acid. Hence local action is eliminated.

(ii) Polarisation

In a voltaic cell (even in other primary cells) the positive hydrogen ions move to copper electrode from the electrolyte and give off their positive charges i.e. gain electron from copper rod and become neutral. These neutral hydrogen atom combine to form free hydrogen molecules and bubble out the electrolyte. But in the process hydrogen gas is partly deposited as a layer around the copper electrode. Due to this the current supplied by the cell falls to very low value. It is because

(i) Hydrogen being bad conductor increases the internal resistance of the cell.

(ii) The incoming H^+ ions cannot give up their positive charge to the copper electrode and are repelled back.

A back emf is thus set up in the cell. These two factors reduce the emf of the cell and hence the current supplied by it. This defect can be prevented either by

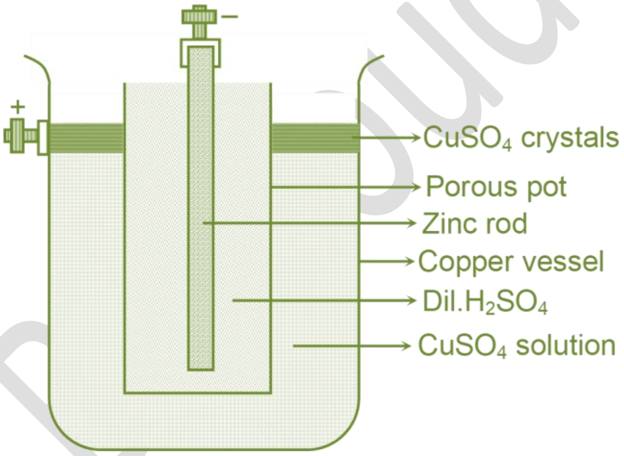
(a) Talking out the copper electrode from time to time and rub it with a brush to remove the hydrogen layer or

(b) By using depolarisers (oxidizing agents) such as MnO_2, HNO_3, $CuSO_4$ etc. to oxidise the hydrogen into water.

Daniel Cell

It consists of a copper vessel containing $CuSO_4$ solution. The copper vessel itself acts as anode.

A porous pot containing dil H_2SO_4 is placed in the copper vessel. An amalgamated zinc rod placed inside the porous pot acts as the cathode. Some $CuSO_4$ crystals are kept in the perforated shell near the top of the vessel. This is done to keep the concentration of $CuSO_4$ solution constant in the vessel.



Dil H_2SO_4 acts as the electrolyte and $CuSO_4$ as the depolariser.

Chemical reactions of the cell: $Zn \longrightarrow Zn^{++} + 2e^-$

In the porous pot: $H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$

$$Zn^{++} + SO_4^{--} \longrightarrow ZnSO_4$$

∴ The combined reaction is

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H^+ + 2e^-$$

The electrons released in such reactions are collected by the zinc electrode and thus it attains a negative potential.

The hydrogen ions (H^+) pass through the pores of the porous pot and enter $CuSO_4$ solution which contain the Cu^{++} and SO_4^{--} ions.

Here H^+ and SO_4^{--} ions combine and form H_2SO_4. i.e.

Inside copper vessel: $2H^+ + SO_4^{--} \longrightarrow H_2SO_4$

The positive ions of copper (Cu^{++}) move to the copper vessel where they give up their charge and deposit on the vessel.

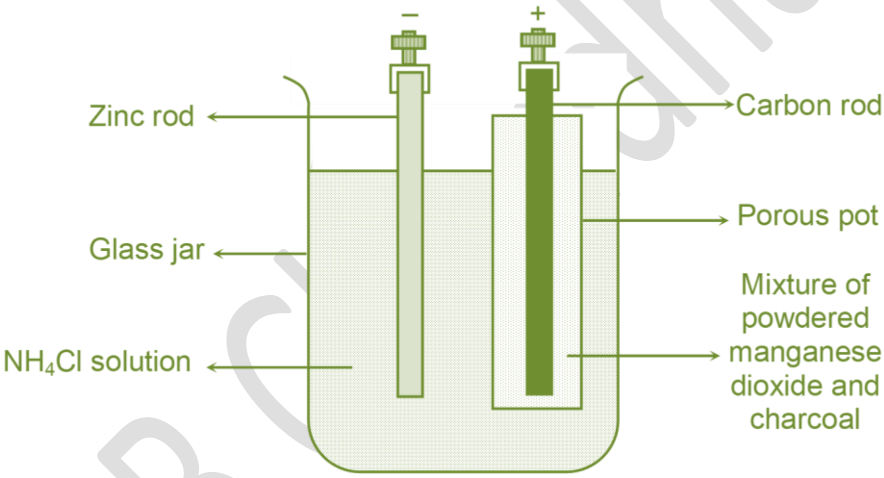
At anode $Cu^{++} + 2e^- \longrightarrow Cu$

The emf of Daniel cell is about 1.09 V and it can supply a steady current for reasonably long durations.

Leclanche Cell

It consists of glass vessel containing the saturated solution of NH_4Cl which acts as the electrolyte. An amalgamated zinc rod dipped in the solution acts as the cathode.

A porous pot consisting of a carbon rod and a mixture of powdered carbon and manganese dioxide is placed in the vessel. The carbon rod in the porous pot acts as the anode and MnO_2 as the depolariser. Powdered carbon (charcoal) reduces the internal resistance of the cell by making MnO_2 conducting.



Chemical reactions of the cell

$$Zn \longrightarrow Zn^{++} + 2e^-$$

$$2NH_4Cl \longrightarrow 2NH_3 + 2H^+ + 2Cl^-$$

$$Zn^{++} + 2Cl^- \longrightarrow ZnCl_2$$

$\therefore$ The combined reaction is

$$Zn + 2NH_4Cl \longrightarrow 2NH_3 + ZnCl_2 + 2H^+ + 2e^-$$

Ammonia gas liberated in the reaction escapes out. The electrons released in the reaction are collected by zinc rod. Due to which it attains a negative potential. H^+ ions pass through the pores of the porous pot and react with MnO_2 to form water i.e.

$$2H^+ + 2MnO_2 \longrightarrow Mn_2O_3 + H_2O + 2e^+$$

Here e^+ represents one unit of positive charge. The positive charge is given up to the carbon electrode. Due to which it attains positive potential w.r.t. the electrolyte.

The Mn_2O_3 is oxidised to MnO_2 by the atmospheric oxygen i.e.

$$2Mn_2O_3 + O_2 \longrightarrow 4MnO_2$$

Leclanche cell has one defect. It cannot supply a steady current for longer time intervals. It is because of slow depolarising action of MnO_2. It cannot oxidise the hydrogen as fast as it is formed. Hence some hydrogen is deposited around the carbon rod and the cell gets partially polarised. This can be prevented by allowing the cell to rest for some time. During this period, the deposited hydrogen gets oxidised into water and the cells regains its initial strength of emf.

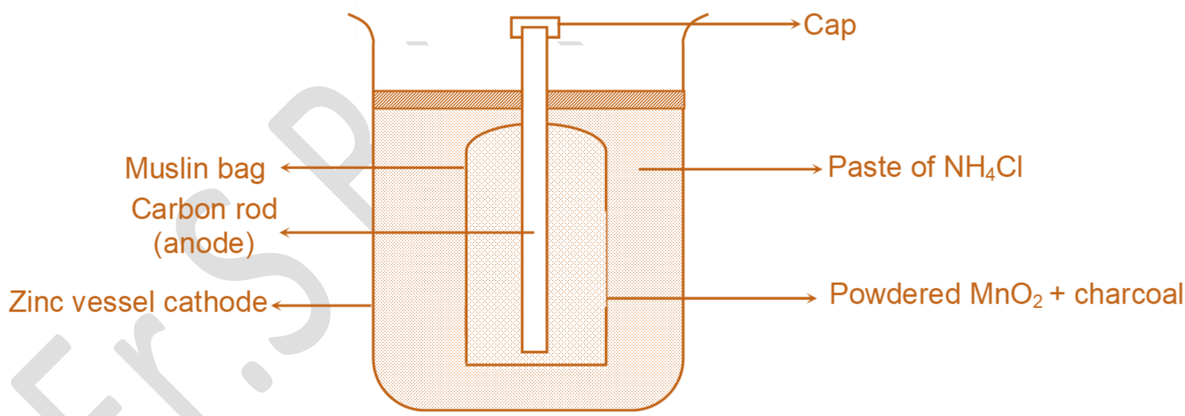
Hence, a Leclanche cell is suitable when intermittent current is required.

The emf of this cell is about 1.5 V.

18.10 DRY CELL

It is a portable form of Leclanche cell. It consists of a small zinc vessel which acts as the cathode. The vessel contains the moiste paste of ammonium chloride (NH_4Cl), Zinc chloride ($ZnCl_2$) and gum. NH_4Cl acts as the electrolyte and $ZnCl_2$ helps in maintaining the moisture of the paste. A carbon rod with a brass cap is placed at the centre of the vessel and acts as the anode of the cell.

The carbon rod is surrounded by a compressed mixture of MnO_2 and charcoal in powder form in a muslin bag. The vessel is sealed at the top with pitch or shellac to prevent evaporation. A small hole is, however provided at the top for allowing ammonia to escape out shown in the figure. The emf of a dry cell is about 1.5 V.



18.11 SECONDARY CELLS

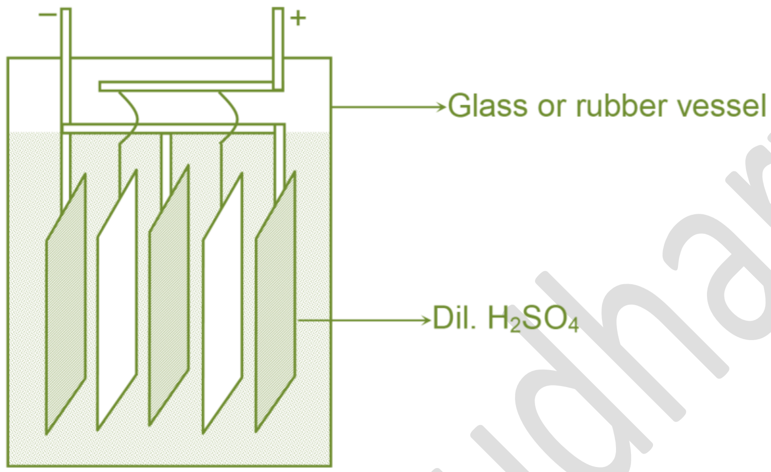
(i) Lead acid accumulator

It consists of two sets of perforated lead Plate arranged alternately parallel to each other and kept separated by thin strips of rubber, plastic or wood.

The perforations or holes in one set of alternative plates shown in the figure are filled with spongy lead (Pb) and connected together to a lead rod which acts as the negative terminal i.e. the cathode of the cell.

The plates of the other set coated with the paste of lead per oxide (PbO_2) are connected to another rod of lead which acts as the anode of the cell.

The entire arrangement is immersed in dil H_2SO_4 (electrolyte) contained in a glass or hard rubber vessel.



Working

(i) Charging process

The accumulator is first charged with the help of a dc charger battery such that its positive terminal is connected to the anode of the accumulator and the negative terminal to the cathode.

The electrolyte H_2SO_4 dissociates into its positive and negative ions, i.e.

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

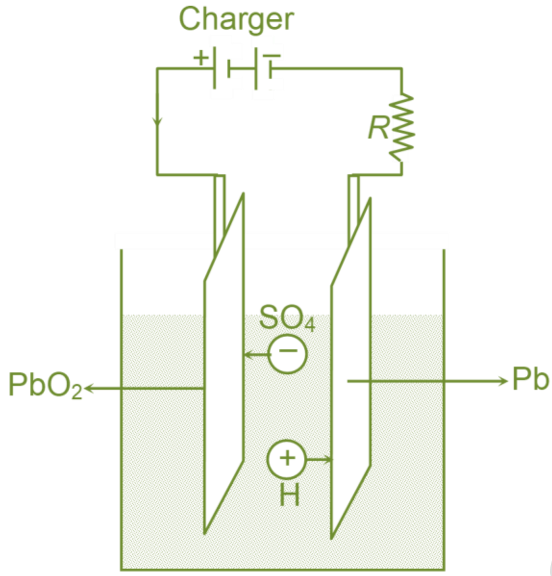
H^+ ions move the cathode and SO_4^{--} ions to the anode, as shown in figure. Consequently, the following reactions take place.

At cathode: $PbSO_4 + 2H^+ + 2e^{-1} \longrightarrow Pb + H_2SO_4$

At anode: $PbSO_4 + SO_4^{--} + 2H_2O - 2e^- \longrightarrow PbO_2 + 2H_2SO_4$

(Actually before charging both, the anode and cathode had the coating of $PbSO_4$ on them.)

Above reactions show that during the charging, the electrons move from the anode to the cathode and hence the potential difference between the electrodes (emf) of the accumulator increases. We also find that in the process H_2SO_4 is formed and water is consumed and the cathode and anode get deposited with spongy lead (Pb) and PbO_2 respectively.

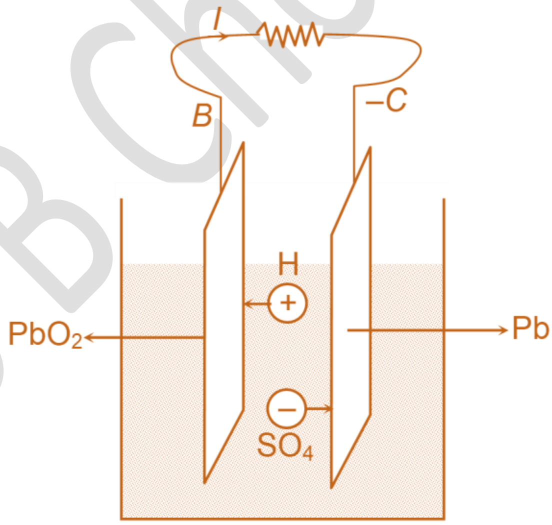


(ii) Discharging: When the two electrodes of the cell are connected to an external resistance, as shown in the figure, a current flows in the external circuit from the anode to the cathode.

The following chemical reaction occurs inside the cell

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

H^+ ions move to the anode and SO_4^{--} ions to the cathode. On reaching their electrodes, they give up their charges and forms lead sulphate ($PbSO_4$). Following reactions occur at the two electrodes



At cathode: $Pb + SO_4^{--} - 2e^- \longrightarrow PbSO_4$

At anode: $PbO_2 + 2H^- + 2e^- + H_2SO_4 \longrightarrow PbSO_4 + 2H_2O$

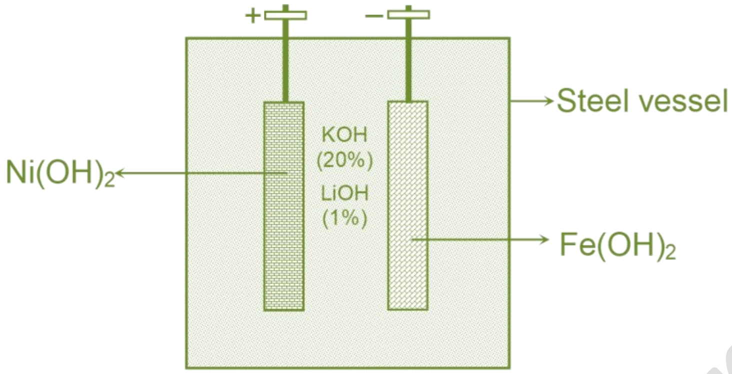
Thus, we find that during the discharging process, the active material of the electrode is converted into $PbSO_4$ and the sulphuric acid is slowly converted into water. Hence, the density of the acid falls and the emf of the cell falls to about 1.08 V.

The emf of a fully charged lead acid accumulator is about 2.2 V.

(iii) Edison cell or Alkali accumulator (Ni – Fe)

It consists of steel vessel constraining a 20% solution potassium hydroxide (KOH) in distilled water and 1% lithium hydroxide (LiOH). KOH acts as the electrolyte of the cell while LiOH makes it conducting. Two perforated steel grids acts as the electrodes of the cell.

The holes of the anode grid are stuffed with Ni $(OH)_2$ and traces of nickel to make it conducting. The holes of the cathode grid are stuffed with $Fe(OH)_2$ and traces of mercury oxide to decrease the internal resistance shown in the figure.



Working: Potassium hydroxide (KOH) dissociates into K^+ ions and OH^- ions.

During charging: The cell is connected to a dc charger battery such that the anode of the cell is connected to the positive terminal of the charger and the cathode to the negative terminal of the charger. A current flows from the anode to the cathode inside the cell. As a result, OH^- ions are attracted by the anode and K^+ ions by the cathode. On reaching their respective electrodes, the ions loose their charge and react with them. Following reactions occur at the electrodes.

Cathode: $Fe(OH)_2 + 2K^+ + 2e^- \longrightarrow Fe + 2KOH$

Anode: $Ni(OH)_2 + 2OH^{-1} - 2e^- \longrightarrow Ni(OH)_4$

Thus complete reaction occurring inside the cell during charging is

$$Ni(OH)_2 + Fe(OH)_2 \longrightarrow Ni(OH)_4 + Fe$$

Hence, during charging, the density of electrolyte (KOH) remains the same but electrons move from anode to cathode, raising the potential difference between the two electrodes of the cell. The emf of a fully charged Edison cell is 1.36 V.

During discharging: When the two terminals of the cell are connected to an external resistance, a current flows from the anode to the cathode through the external resistance and from cathode to anode inside the cell. Hence the cell begins to discharge. During the process, K^+ ions are attracted by the anode and OH^- ions by the cathode.

Following reactions occur at the electrodes.

Cathode: $Fe + 2OH^- - 2e^- \longrightarrow Fe(OH)_2$

Anode: $Ni(OH)_4 + 2K^+ + 2e^- \longrightarrow Ni(OH)_4 + 2KOH$

Thus, complete reaction occurring inside the cell during charging is

$$Ni(OH)_4 + Fe \longrightarrow Ni(OH)_2 + Fe(OH)_2$$

Hence, during discharging the electrons move from cathode to anode, decreasing the potential difference between the two electrodes. When the emf of the cell becomes less than 1.1 V, it requires recharging.

18.12 SOLID STATE CELL

Solid state cells are very small sized dry cells used in wrist watches, video games, calculators, hearing aids etc. Since they look like a button in shape, they are also known as bottom cells.

Although different solid state cells used positive and negative electrode of different size and material, they have the same basic structure in their construction.

The basic geometry of a solid state cell is given in the figure (i) using a solid electrolyte with mobile cation M^+ and anion X^-. Either one of these ions or both can move.

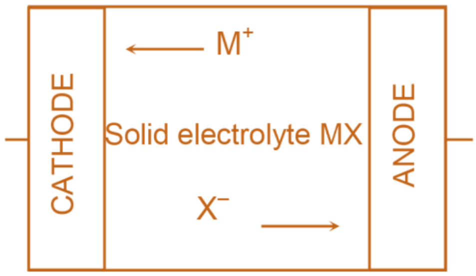
Solid electrolytes are generally available in the form of gels, polymers, composites, polycrystalline solids or thin solid films.

In a lithium solid state cell, the basic electrochemical reaction with the electrode (say I_2) is

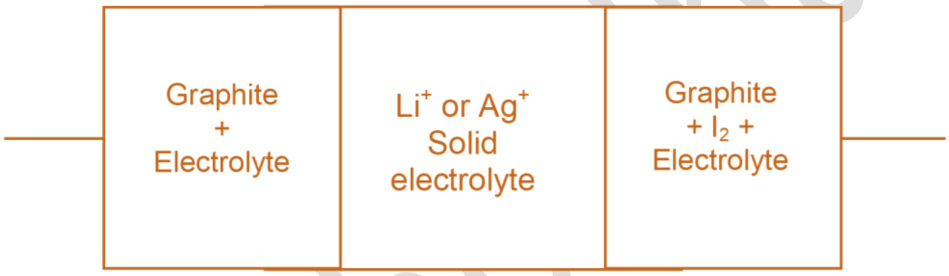
$$2Li^+ + I_2 \Leftrightarrow 2LiI - 2e^-$$

Some electrolyte is also mixed in the cathode or anode to decrease polarisation.

1. Solid state cell



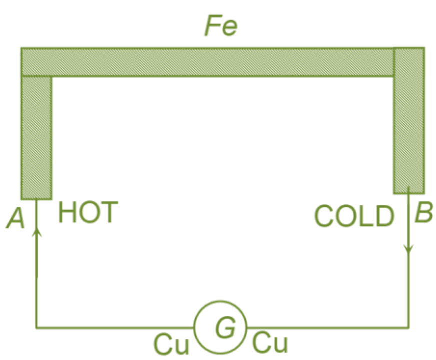
2. Simple lithium/silver solid state cell



19 THERMOELECTRIC EFFECT OF CURRENT

19.1 SEEBECK EFFECT

Seebeck in 1821 found that if two wires of different metals, say copper and iron, are joined at their ends *A* and *B*, through a low resistance galvanometer *G* to form a closed circuit, and if one of the junctions, say *A*, is heated and the other junction *B* is kept cold, the galvanometer shows a deflection shown in the figure. This must be due to a current in the circuit called thermo electric current which must further be due to certain emf called thermo emf. The assembly of two different metals joined at their ends to have two junctions in a circuit, is called a thermocouple. The phenomenon is known as thermo electric effect as electricity has been produced from heat.



Thus Seebeck effect is the phenomenon of generation of an electric current in a thermocouple by keeping its two junctions at different temperature.

Seebeck also found that for a given difference of temperature of two junctions, the larger is the gap in Seebeck series between the metals forming the thermo couple, the greater will be the thermo emf generated.

19.2 ORIGIN OF THERMO EMF

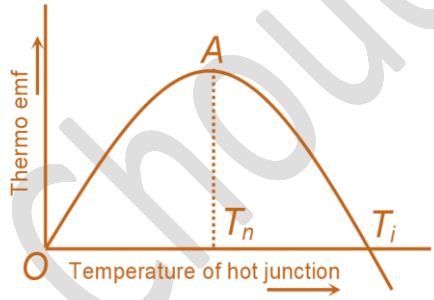
We know that number of electrons per unit volume (i.e. electron density) of a conductor depends on material of the conductor. In general, it is different for different conductors.

When two different metals are brought into contact, at the junction, the free electrons tend to diffuse from the metal with greater free electron density to the other with lower free electron density. Due to this diffusion, a potential difference is developed at the junction of the two metals called contact potential. When both the junctions are at the same temperature, the contact potentials at the two junctions will be the same. Hence no current flows in the thermocouple. But if one junction is heated up, the rate of diffusion of free electrons at that junction will change. As a result of it, the contact potentials at the two junctions will becomes different and there will be an effective potential difference emf in the circuit, called thermo emf.

19.3 EFFECT OF TEMPERATURE ON THERMO EMF

(i) When the two junctions of the thermocouple are at same temperature (say 0^0C), galvanometer shows no deflection i.e. thermo emf is zero.

(ii) As the temperature of the hot junction increases, keeping the cold junction at constant temperature 0^0C, the thermo emf increases with the increase in temperature till it becomes maximum at a certain temperature.



The temperature of the hot junction at which thermo emf. in a thermocouple is maximum is called neutral temperature. It is represented by T_n in the graph.

The value of neutral temperature

(a) is constant for a thermocouple

(b) depends upon the nature of materials forming the thermocouple

(c) is independent of the temperature of cold junction

For Cu-Fe thermocouple, neutral temperature is 270^0C, whatever may be the temperature of cold junction.

(iii) when hot junction is heated beyond neutral temperature, thermo emf starts decreasing instead of increasing.

(vi) At another particular temperature of hot junction, the value of thermo emf becomes zero. On heating slightly further, the direction of thermo emf is reversed. It is due to the number densities and rates of diffusion of electrons in the two metals used are reversed.

The temperature of the hot junction at which the thermo emf in a thermocouple becomes zero and just beyond, it reverses its direction, is called temperature of inversion. It is represented by T_i. The value of temperature of inversion depends upon.

(a) the temperature of the cold junction and

(b) the nature of materials forming the thermo –couple.

Thus for a given thermocouple, there will be different values of temperature of inversion corresponding to different values of temperature of cold junction.

19.4 RELATION BETWEEN T_n and T_i

It is found that temperature of inversion (T_i) is as much above the neutral temperature (T_n) as neutral temperature is above the temperature of the cold junction (T_0, say) i.e.

$$T_i - T_n = T_n - T_0 \text{ or } T_i = 2T_n - T_0$$

or $$T_n = \frac{T_i + T_0}{2} \quad \text{... (19)}$$

19.5 THERMO-ELECTRIC POWER

Thermo electric power is defined as the rate of change of thermo emf with temperature. It is also called Seebeck coefficient and is denoted by S.

From experimental study, it was concluded that the variation of thermo emf E with the temperature T of the hot junction, when cold junction is at 0^0C is a parabolic curve represented by the equation

$$E = \alpha T + \frac{1}{2}\beta T^2 \quad \text{(i)}$$

when α and β are constants which depend upon the nature of the metals forming the thermocouple and the temperature difference of the two junctions.

The thermoelectric power (called Seebeck coefficient) is given by

$$S = \frac{dE}{dT} = \alpha + \beta T \quad \text{(ii)}$$

It means, $S \propto T$

Hence the graph between $S = \left[\frac{dE}{dT}\right]$ and T will be a straight line. Since neutral temperature (T_n) is that temperature of the hot junction at which thermo emf in a thermocouple is maximum, therefore at neutral temperature

$$\frac{dE}{dT} = 0 \text{ and } T = T_n$$

From (ii), $0 = \alpha + \beta T_n$ or $T_n = -\alpha/\beta$

If cold junction is at 0^0C then $T_i = -2\alpha/\beta$.

Illustration 20

Question: **The cold junction of thermo couple is kept at 9^0C. Calculate the temperature at which thermo emf would be maximum. Given that the thermo emf changes sign at 800 K.**

Solution: Here, $\theta_0 = 10^0$C;

$\theta_I = 800 \text{ K} = 800 - 273 = 527^0$C

$\theta_n = ?$

we known, $\theta_n = \frac{\theta_i + \theta_0}{2} = \frac{527 + 9}{2} = \mathbf{268\ ^0C}$

Illustration 21

Question: **The e.m.f. E (in mV) of a certain thermocouple is found to vary with θ in accordance with the relation. $E = 40\theta - \frac{\theta^2}{20}$. Where θ is the temperature of the hot junction, the cold junction being at 0^0C. What is the neutral temperature of the thermocouple.**

Solution: At neutral temperature, θ_n, thermo emf becomes maximum.

Hence, $\left(\frac{dE}{d\theta}\right)_{at\theta_n} = 0$

or $\frac{d}{d\theta}\left(\theta - \frac{\theta^2}{20}\right)_{at\theta_n} = 0$

or $40 - 2\theta_n / 20 = 0$

or $\theta_n = \frac{40 \times 20}{2} = \mathbf{400^0C}$

19.6 PELTIER EFFECT

If a current is passed through a junction of two different metals, the heat is either evolved or absorbed at that junction. This effect is known as Peltier effect. The quantity of heat absorbed or evolved at a junction is proportional to the quantity of charge crossing that junction. If the direction of current is reversed, the heating effect at that junction is also reversed. Thus Peltier effect is reversible effect.

Peltier co-efficient. Peliter co-efficient is defined as the amount of heat energy absorbed or evolved at a function of two different metals when one coulomb charge passes through that junction. It is denoted by π and is given by

$$\pi = \frac{\text{Peltier heat}}{\text{charge flowing}}$$

S.I. unit of π is JC^{-1}

Peliter co –efficient depends upon (i) the nature of the two metals forming the junction and (ii) temperature of the junction. Peltier effect has different values for hot and cold junctions.

19.7 THOMSON'S EFFECT

If two parts of a single conductor are maintained at different temperatures, an emf is developed between them. The emf so produced is called Thomson's emf. If the steady current is passed through an unequally heated conductor, an absorption or evolution of heat in excess of Joule's heat, takes place in the conductor.

Thus Thomson's effect is the absorption or evolution of heat in excess of Joule heat when current is passed through an unequally heated conductor. Thomson effect is reversible effect.

Thomson's coefficient: Thomson's co-efficient is defined as the emf that exists between the two points of a uniform conductor which has a temperature difference of 1^0C (or 1K). It is denoted by σ.

Let dV = potential difference between two points of a metal rod.

dT = temperature difference between the same two points of rod

Then Thomson's co-efficient of the rod is given by

$$\sigma = \frac{dV}{dT} \quad \text{or} \quad dV = \sigma\, dT$$

Total Thomson's emf between temperature T_1 and T_2 of a metal rod is given by

$$V = \int_{T_2}^{T_1} \sigma\, dT \qquad \ldots (\mathbf{20})$$

Thomson's co-efficient is also defined as the amount of heat energy evolved or absorbed between the two points of a conductor maintained at a unit temperature difference when unit current is passed for one second through the conductor.

19.8 APPLICATIONS OF THERMOELECTRIC EFFECTS

Important applications of thermoelectric effects are as follows:

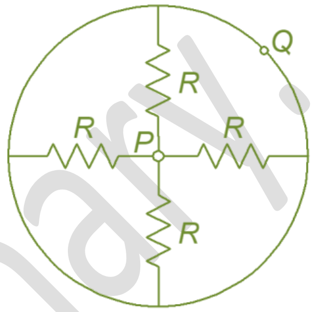
(i) To measure temperature; using thermoelectric thermometers
(ii) To detect heat radiation; using thermopile
(iii) Thermoelectric refrigerator
(iv) Thermoelectric generator

PROFICIENCY TEST

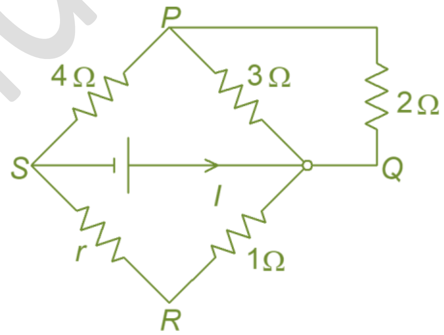
The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. Two wires, when connected in series, have an equivalent resistance of 18 Ω and when connected in parallel, have an equivalent resistance of 4 Ω. Find their resistances.

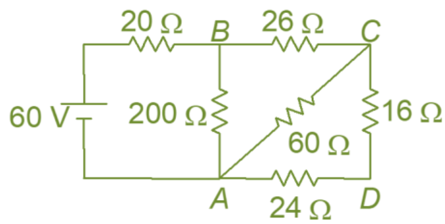
2. If each resistance is R ohms, what is the resistance across PQ? (take $R = 4\Omega$)



3. Find the value of r if $I = 1$ A and potential difference across PQ is 1 V.



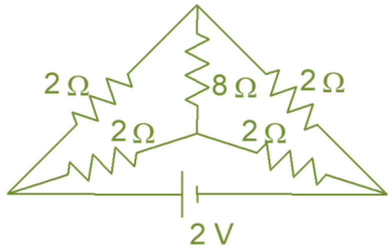
4. Find the current drawn from the battery in the circuit.



5. A wire has a resistance of 2 Ω at 25°C and 2.5 Ω at 100°C. The temperature coefficient of resistance of the wire is $x \times 10^{-6}$ /^{0}C. Find x

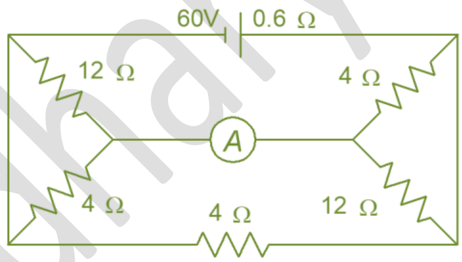
6. A battery of 24 accumulators of emf 2.5 V each is charged from 240 V d.c at 3 A through an external resistance. Assuming nil internal resistance for accumulators, calculate the external resistance.

7. Find out the current through the cell.

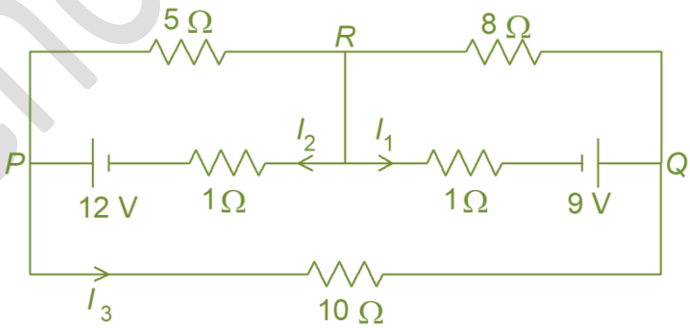


8. Two cells of same emf but differing internal resistances r_1 = 4Ω and r_2 = 2Ω are connected in series with an external resistance R. The potential drop across first cell is zero. Find the value of external resistance R.

9. In the circuit given, find the reading of the ammeter.



10. (a) Calculate the three currents I_1, I_2 and I_3 indicated in the following circuit diagram in mA.
(b) Also find the potential differences between the points P and R and R and Q in mV.



ANSWERS TO PROFICIENCY TEST

1. 12 Ω, 6 Ω

2. 1 Ω

3. 25 Ω

4. 1 A

5. 3600

6. 60 Ω

7. 1 A

8. 2Ω

9. 8 A

10. (a) I_1 = 850 mA, I_2 = 2140 mA, I_3 = 171 mA

(b) V_{PR} = – 9850 mV, V_{RQ} = 8170 Mv

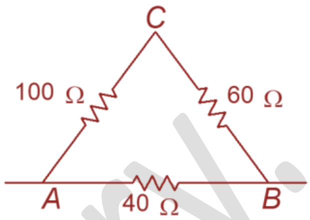
SOLVED OBJECTIVE EXAMPLES

***Example* 1:**

Three resistors are connected to form the sides of a triangle *ABC*. The resistance of the side *AB* is 40 Ω, of side *BC* is 60 Ω and of side *CA* is 100 Ω. The effective resistance between points *A* and *B* in ohm is

(a) 32 **(b) 50** **(c) 64** **(d) 200**

Solution:



Between the junctions *A* and *B* two resistances 160 ohms and 40 ohms are in parallel.

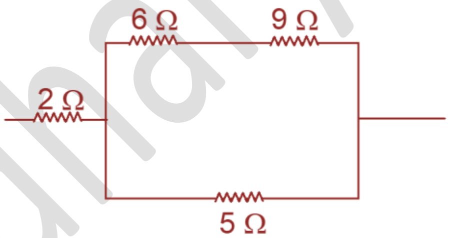
$$\frac{160\times40}{160+40} = \mathbf{32\,\Omega}$$

∴ **(a)**

***Example* 2:**

In the circuit shown in the figure the 5-Ω resistor develops heat at the rate of 13.5 cal/s. The heat developed per second in the 2-Ω resistor is

(a) 1.2 Cal **(b) 4.8 Cal**
(c) 9.6 Cal **(d) 10.8 Cal**



Solution:

If current in 2A is I then current in the 5Ω branch = $\frac{15}{20}i = \frac{3}{4}i$

$$13.5 = \left(\frac{3}{4}i\right)^2 5$$

$$i^2 = \frac{16\times13.5}{5\times9}$$

Heat developed per second in 2Ω is $\frac{16\times13.5}{5\times9}\times2 = 9.6$ Cal

∴ **(c)**

***Example* 3:**

A cell sends a current through a resistance R_1 for time *t* and next the same cell sends a current through another resistance R_2 for the same time *t*. If same quantity of heat is developed in both the resistances, then the internal resistance of the cell is

(a) $\frac{R_1+R_2}{2}$ **(b) $\frac{R_1-R_2}{2}$** **(c) $\sqrt{R_1R_2}$** **(d) $\frac{\sqrt{R_1R_2}}{2}$**

Solution:

$$i_1 = \frac{E}{R_1+r}; i_2 = \frac{E}{R_2+r}$$

$$H = i_1^2R_1t = i_2^2R_2t$$

$$\left(\frac{E}{R_1+r}\right)^2R_1t = \left(\frac{E}{R_2+r}\right)^2R_2t, \quad \frac{R_2+r}{R_1+r} = \sqrt{\frac{R_2}{R_1}}$$

$$\frac{R_2-R_1}{R_1+r} = \frac{\sqrt{R_2}-\sqrt{R_1}}{\sqrt{R_1}}$$

$$R_1+r = \sqrt{R_1}\frac{(R_2-R_1)}{\sqrt{R_2}-\sqrt{R_1}} = \sqrt{R_1}\left(\sqrt{R_2}+\sqrt{R_1}\right)$$

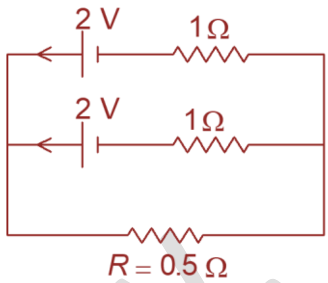
$R_1 + r = \sqrt{R_1 R_2} + R_1$

$r = \sqrt{R_1 R_2}$

$\therefore$ **(c)**

Example 4:

Two identical batteries each of e.m.f 2 V and internal resistance 1 Ω are connected to a resistance R = 0.5 Ω as shown in circuit. The maximum power that can be developed across R is



(a) 1.28 W **(b) $\frac{8}{9}$ W**

(c) 2 W **(d) 3.2 W**

Solution:

$2 = (i_1 + i_2)\,0.5 + 1 i_2$

$i_1 = i_2$

$2 = 2i_1\,(0.5) + i_1$

$= 2i_1$

$i_1 = 1\,A, \quad i_1 = 1$ A

$\therefore$ the current through 0.5 Ω, resistor $i = i_1 + i_1 = 2\,A$

Maximum power developed across $R = i^2R = 2^2\,(0.5) =$ **2 W**

$\therefore$ **(c)**

Example 5:

A current of 2 A is supplied by a cell of emf 1.5 V having internal resistance 0.15 Ω. The potential difference, in volts across the ends of the cell will be

(a) 1.35 **(b) 1.5** **(c) 1.0** **(d) 1.2**

Solution:

Potential difference across the ends of the cell $= \varepsilon - iR = 1.5 - (2)\,(0.15)$

$= 1.5 - 0.3 =$ **1.2 V**

$\therefore$ **(d)**

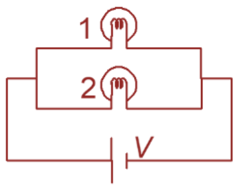
Example 6:

Two electric bulbs whose resistances are in the ratio 1 : 2 are connected in parallel to a constant voltage source. The power dissipated in them have the ratio

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

Solution:

$\frac{R_1}{R_2} = \frac{1}{2}$



Ratio of power dissipated in electric bulbs $\frac{P_1}{P_2} = \frac{V^2}{R_1} \times \frac{R_2}{V^2} = \frac{2}{1}$

$\therefore$ **(c)**

Example 7:

A piece of fuse wire is about to melt when the current passing through it is 5 A. When carrying this current it dissipates 2.5 J of energy per sec. What is the resistance of the fuse wire?

(a) 0.5 Ω **(b) 10 Ω** **(c) 0.1 Ω** **(d) 2 Ω**

Solution:

When the fuse wire melts energy dissipated, $P = i^2R$

$= 5^2R = 2.5$ J

Resistance of the fuse wire $R = \frac{2.5}{25} = 0.1\ \Omega$

$\therefore$ **(c)**

Example **8:**

Two identical heaters produce heat H_1 in time 't' when connected in parallel across the main supply. They produce heat H_2 in time 't' when connected in series. Then $\frac{H_1}{H_2}$ is

(a) $\frac{1}{4}$ **(b) 4** **(c) $\frac{1}{2}$** **(d) 2**

Solution:

When connected in parallel, heat produced $H_1 = \frac{V^2}{R_{eq}}t = \frac{V^2}{\frac{R}{2}}t = \frac{2V^2}{R}t$

When connected in series, heat produced $H_2 = I^2 R_{eq}\, t$

$$= \left(\frac{V}{2R}\right)^2 (2R)t$$

$$\frac{H_1}{H_2} = \left(\frac{2V^2 t}{R}\right)\left(\frac{2R}{V^2 t}\right) = \mathbf{4}$$

∴ **(b)**

Example **9:**

The electrical installation in a building is protected by a 15 A fuse. If the supply voltage is 220 V, the maximum number of 60 W bulbs that can be used in the building is

(a) 44 **(b) 55** **(c) 88** **(d) 66**

Solution:

Current through each bulb $I = \frac{60}{220} = \frac{3}{11}$ A

⇒ Number of bulbs, $n = \frac{15}{\frac{3}{11}} = \frac{15 \times 11}{3} = \mathbf{55}$

∴ **(b)**

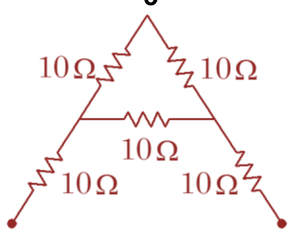
Example **10:**

Letter A is constructed using a uniform wire of resistance 1 Ω per cm, the sides of the letter being of length 20 cm each, the cross piece of length 10 cm and the angle at the apex being 60°. The effective resistance between two legs of the letter is

(a) $\frac{80}{3}$ Ω **(b) 12 Ω** **(c) $\frac{13}{3}$ Ω** **(d) $\frac{70}{3}$ Ω**

Solution:

The distribution of resistances are as shown.



Effective resistance $R = \frac{20 \times 10}{20 + 10} + 10 + 10$

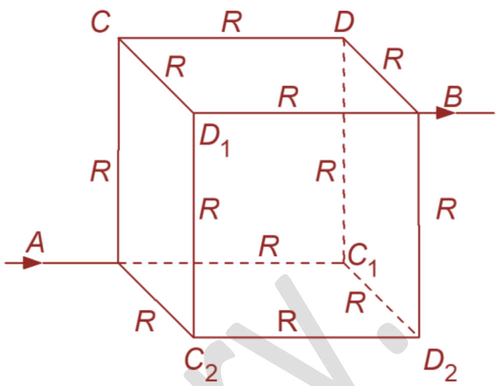
$$= \frac{20}{3} + 20 = \mathbf{\frac{80}{3}\ \Omega}$$

∴ **(a)**

SOLVED SUBJECTIVE EXAMPLES

***Example* 1:**

The Figure shows a cube made of wires each having a resistance $R = 6\Omega$. The cube is connected into a circuit across a body diagonal AB as shown. Find the equivalent resistance of the network in this case.



Solution:

Let us search the points of same potential. Since the three edges of the cube from A viz., AC, AC_1 and AC_2 are identical in all respects the circuit points C, C_1 and C_2 are at the same potential. Similarly for the point B the sides BD, BD_1 and BD_2 are symmetrical and the points D, D_1 and D_2 are at the same potential.

Next let us bring together the points C, C_1 and C_2 and also D, D_1 and D_2.

Then the cube will look as follows.

The resistance between A and $C = \frac{R}{3}$

The resistance between C and $D = \frac{R}{6}$

The resistance between D and $B = \frac{R}{3}$

The circuit is equivalent to $\frac{R}{3}$, $\frac{R}{6}$ and $\frac{R}{3}$ in series which is equal to $\frac{5}{6}R = \mathbf{5\,\Omega}$

***Example* 2:**

12 cells each of negligible internal resistance and having the same emf are connected in series and are kept in a closed box. Some of the cells are wrongly connected. This box is connected in series with an ammeter and two cells (in series combination) identical with the other cells. The current is 3A when the cells and box aid each other and is 2A when the cells and the box oppose each other. How many cells in the box are wrongly connected?

Solution:

Let x cells be connected correctly and y cells be connected wrongly. According to the given condition

$$x + y = 12 \quad \ldots \text{(i)}$$

Let E be the emf of each cell and R be the external resistance

Then, $\frac{(x-y)E + 2E}{R} = 3$ … (ii)

And $\frac{(x-y)E - 2E}{R} = 2$ … (iii)

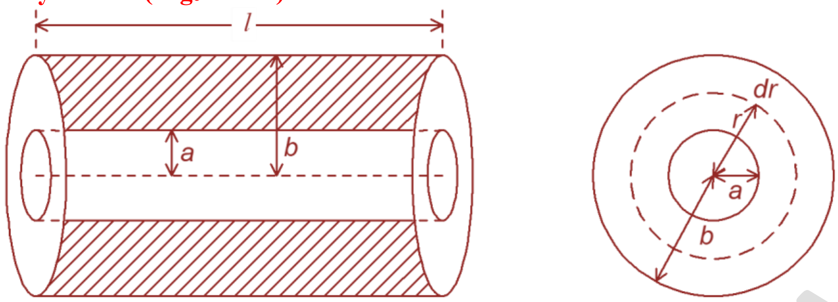
From equation (i), (ii) and (iii),

x = 11 and y = **1**

Hence 1 cell is wrongly connected.

Example 3:

A homogeneous poorly conducting medium of resistivity ρ = 20 π SI unit fills up the space between two thin coaxial ideally conducting cylinders. The radii of the cylinders are equal to a and b with *a* < *b* (*b* = *2a)*, the length of each cylinder is *l*= 1 m. Neglecting the edge effects, find the resistance of the medium between the cylinders. ($\log_e 2 = 0.7$)



Solution:

The current will be conducted radially outwards from the inner conductor to the outer conductor. The area of cross-section for the conduction of the current is therefore the area of an elementary cylindrical shell which varies with radius. The length of the conducting shell is measured radially from radius a to radius *b*.
Consider an elementary cylindrical shell of radius *r* and thickness *dr*. Its area of cross-section (normal to flow of current) = $(2\pi rl)$ and its length = *dr*.

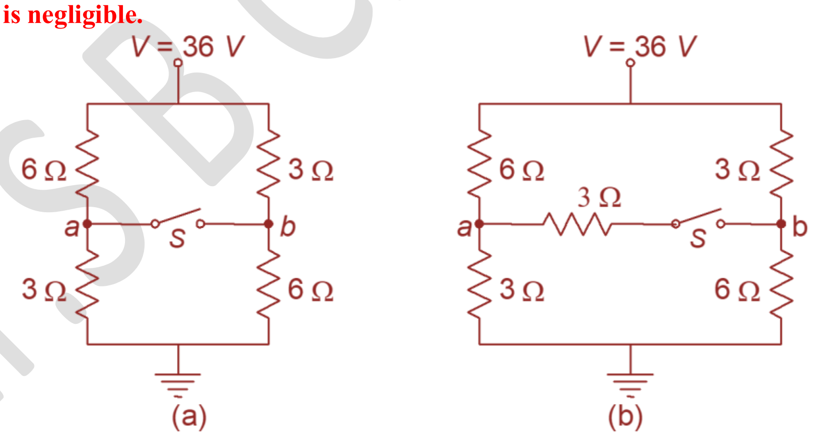
Hence the resistance of the elementary cylindrical shell of the medium is $dR = \frac{\rho dr}{2\pi rl} = \frac{\rho}{2\pi l}\left[\frac{dr}{r}\right]$

The resistance of the medium is obtained by integrating for r from *a* to *b*.
Hence required resistance

$$R = \frac{\rho}{2\pi l}\int_a^b \frac{dr}{r} = \frac{\rho}{2\pi l}\left[\log_e r\right]_a^b \left(\frac{\rho}{2\pi l}\right)\log_e \frac{b}{a} = 7\,\Omega$$

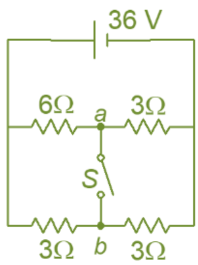
Example 4:

A convention is often employed in circuit diagrams where the battery (or other power source) is not shown explicitly but the points connected to the source are indicated by voltage and ground respectively. The following two circuit diagrams are drawn on this convention. Assume the battery resistance is negligible.



(a) In Figure (a), what is the potential difference V_{ba} when the switch *S* is open?
(b) In Figure (b), what is the potential difference V_{ba} when switch *S* is open?

Solution:



The given circuit is equivalent to

(a) Potential at the point *a* = $V_a = 36 - \left(\frac{6}{9}\times 36\right) = 12V$

Potential at the point *b* = $V_b = 36 - \left(\frac{3}{9}\times 36\right) = 24V$

Hence V_{ba} = Potential difference between *b* and *a*

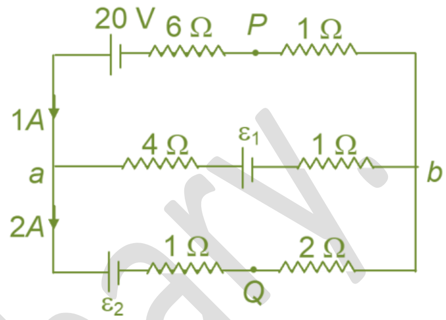
$= V_b - V_a = 24 - 12 =$ **12 V**

(b) In figure (b) we have a resistance of 3 Ω added to the switch circuit. However this will **NOT** affect the current and potential distributions when the switch *S* is open.
Hence the potential difference V_{ba} = **12 V** (as in the case (a) above).

***Example* 5:**

Find the emfs ε_1 and ε_2 in the circuit of the following diagram and the potential difference between the points *a* and *b*.

Solution:



(a) It is clear that 1 A current flows in the circuit from *b* to *a*.
Applying Kirchhoff's law to the loop *PabP*,

$$20 - E_1 = 6 + 1 - 4 - 1 = 2$$

Hence $\quad$ $\mathbf{E_1 = 18\ V}$

Also applying Kirchhoff's law to the loop *PaQbP*,

$$20 - E_2 = 6 + 1 + (1 \times 2) + (2 \times 2) = 13$$

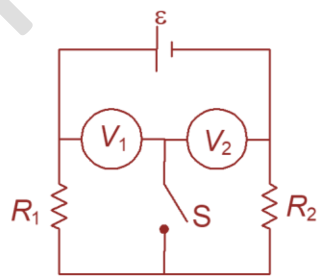
Hence $\quad$ $\mathbf{E_2 = 7\ V}$

Thus the potential difference between the points *a* and *b* is

$$V_{ab} = 18 - 1 - 4 = \mathbf{13\ V}$$

***Example* 6:**

In the circuit V_1 and V_2 are two voltmeters of resistances 3000 ohm and 2000 ohm respectively. The resistances R_1 = 2000 ohm and R_2 = 3000 ohm and the emf of the battery ε = 200 V. The battery has negligible internal resistance. Find the readings of the voltmeters V_1 and V_2 when
(i) the switch *S* is open and
(ii) the switch *S* is closed.



Solution:

(i) When *S* is open
V_1 and V_2 in series have a resistance

$$= 3000 + 2000 = 5000\ \Omega$$

R_1 and R_2 in series have a resistance

$$= 2000 + 3000 = 5000\ \Omega$$

5000 ohm and 5000 ohm in parallel are equivalent to

$$\frac{5000 \times 5000}{10000} = 2500\ \Omega$$

$$\text{Circuit current} = \frac{200}{2500} = \frac{2}{25}\ \text{A}$$

Current in the branch of V_1 and V_2

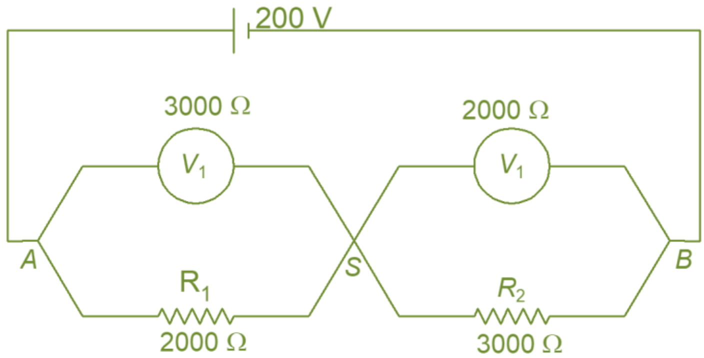
$$= \frac{1}{2}\left(\frac{2}{25}\right) = \frac{1}{25}A$$

$$\text{p.d. across } V_1 = \left(\frac{1}{25}A\right)(3000\ \text{ohm}) = 120\ \text{V}$$

$$\text{p.d. across } V_1 = \left(\frac{1}{25}A\right)(2000\ \text{ohm}) = 80\ \text{V}$$

∴ the voltmeters V_1 and V_2 read **120 V and 80 V respectively.**
(ii) V_1 and R_1 are in parallel.
Similarly V_2 and R_2 in parallel have an equivalent resistance of 1200 ohm.
As these two equivalent resistances are same

p.d. across AS = p.d. across SB
$\therefore$ p.d. across AS = **100 V**
This is registered by V_1 SB
Similarly p.d. across = **100 V**
This is registered by V_1
Similarly p.d. across SB = **100 V**
This is registered by V_2.



***Example* 7:**

A fuse made of lead wire has an area of cross-section 0.2 mm². On short circuiting, the current in the fuse wire reaches 30 amp. How long (in 10^{-4} s) after the short circuiting will the fuse begin to melt?
Specific heat capacity of lead = 134.4 J kg⁻¹ K⁻¹.
Melting point of lead = 327°C
Density of lead = 11340 kg/m³
Resistivity of lead = 22 × 10⁻⁸ ohm-m
Initial temperature of the wire = 20°C
Neglect heat loss.

Solution:

If L be the length of the wire, its resistance

$$R = \frac{\rho L}{A} = \frac{(22 \times 10^{-8})L}{(0.2 \times 10^{-6})m^2}$$

Heat produced in the wire in one second = $I^2R = (30)^2 R$ J
Heat required to raise the temperature of the wire to 327°C

$$Q = ms\Delta T$$
$$= (LAd)(134.4)(307) \text{ J}$$

Time required to melt the wire

$$= \frac{Q}{I^2R} = \frac{LAd \times 134.4 \times 307}{I^2 \times \rho L} \times A$$

$$= \frac{A^2}{I^2}\frac{d}{\rho} \times 134.4 \times 307$$

$$= \frac{(0.2 \times 10^{-6})^2}{900} \times \frac{11340}{22 \times 10^{-8}} \times 134.4 \times 307$$

$= 0.0945 =$ **945** $\times 10^{-4}$ **s**

***Example* 8:**

What amount of heat will be generated in a coil of resistance R = 30 Ω due to a charge q = 1C passing through it if the current in the coil decreases down from maximum to zero uniformly in a time internal of t_0 = 10 s.

Solution:

Since current is a uniform function of time, we can write

$i = \alpha t + \beta$ where α and β are constant.

at t = 0, $i = i_0$ (maximum current) and
at $t = t_0$ $i = 0$

$$\therefore \quad \alpha = -\frac{i_0}{t_0}, \; \beta = i_0$$

$$\Rightarrow \quad i = i_0 - \frac{i_0}{t_0}t$$

Amount of heat generated in the resistor is $H = \int_0^{t_0} i^2 R dt$

$$= i_0^2 R \int_0^{t_0} dt + \frac{i_0^2}{t_0^2} R \int_0^{t_0} t^2 dt - \frac{2i_0^2}{t_0} R \int_0^{t_0} t dt$$

$$H = \frac{i_0^2 R t_0}{3} \qquad \dots \text{(i)}$$

Also $i = \frac{dq}{dt} = i_0 - \frac{i_0}{t_0} t$

$$\int_0^{q_0} dq = i_0 \int_0^{t_0} dt - \frac{i_0}{t_0} \int_0^{t_0} t dt \Rightarrow q_0 = \frac{i_0 t_0}{2}$$

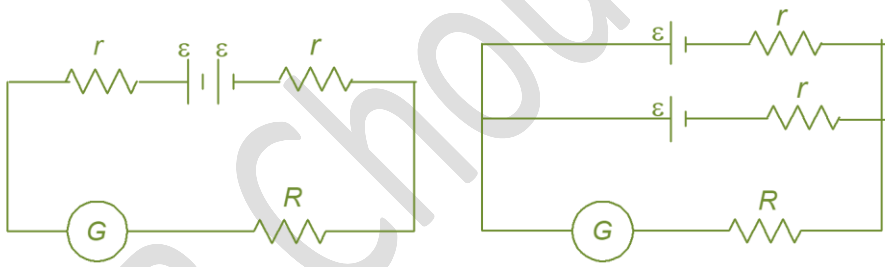
Putting value of i_0 in (i)

$$H = \frac{4q_0^2 R}{3t_0} = \mathbf{4\ J}$$

Example 9:

A galvanometer together with an unknown resistance in series is connected across two identical batteries each of 9 V. When the batteries are connected in series the galvanometer records a current of 1 ampere and when the batteries are in parallel the current is 0.6 ampere. What is the internal resistance of the battery?

Solution:



Emf of each cell is ε = 9 V
Let the internal resistance of each cell be r.
Let the resistance of the galvanometer be G.
Let the unknown resistance in series with the galvanometer be R.
(i) Let the cells be in series.
The emf of the circuit = 2ε = 18 V
The resistance of the circuit = $(R + G + 2r)\ \Omega$

The current in the circuit $\frac{18}{R+G+2r} = 1A$ (given) … (i)

(ii) When the cells are in parallel the emf of the circuit = ε = 9 V

The resistance of the circuit $= R + G + \frac{r \cdot r}{r + r}$

$$= \left(R + G + \frac{r}{2}\right)\Omega$$

The current in the circuit $\frac{9}{R+G+\frac{r}{2}} = 0.6A$ … (ii)

From equations (1) and (2), we get

$R + G + 2r = 18$

and $R+G+\frac{r}{2} = \frac{9}{0.6} = 15$

Subtracting these two equations, we get

$$\frac{3}{2}r = 3 \qquad \Rightarrow r = 2\,\Omega$$

Internal resistance of each cell = **2Ω**

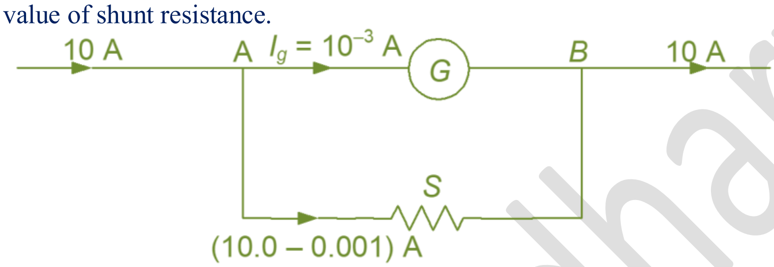
***Example* 10:**

(i) **A galvanometer having a coil of resistance of 100 ohms gives a full scale deflection when a current of one milliampere is passed through it. What is the value of the resistance (in mΩ) which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 amperes?**

(ii) **When this modified galvanometer is connected across the terminals of a battery it shows a current of 4 ampere. The current drops to 1 ampere when a resistance of 1.5 ohm is connected in series with the modified galvanometer. Find the emf of the battery.**

Solution:

(i) The value of shunt resistance.



Let the shunt resistance required be S Ω. The galvanometer permits the full-scale deflection current of $I_g = 1 \times 10^{-3}$ A through it. When the current is 10 A.

Then, (10 – 0.001) S = 0.001 × 100

$$S = \frac{0.1}{\frac{9999}{1000}} = \frac{100}{9999} \approx \frac{1}{100}\,\Omega = \mathbf{10\ m\Omega}$$

(ii) Emf of the battery and its internal resistance: The combined resistance of the galvanometer and the shunt is given by $\dfrac{\frac{1}{100}\times 100}{\frac{1}{100}+100}\,\Omega \approx \dfrac{1}{100}\,\Omega$

This combined resistance and the internal resistance of the battery in series give a total resistance of $\left(\frac{1}{100} + r\right)$ ohm to the circuit.

If ε be the emf of the battery, then

$$\frac{\varepsilon}{r + 0.01} = 4A \qquad \text{… (i)}$$

Now with an additional resistance of 1.5 Ω in series

$$\frac{\varepsilon}{r + 0.01 + 1.5} = 1A \qquad \text{… (ii)}$$

From equations (1) and (2), we get $\dfrac{r + 1.51}{r + 0.01} = 4$

$3r = 1.47$

Internal resistance $r = 0.49$ Ω

Substituting this value of r in equation (1),

ε = 4 × 0.5 = **2 V**

MIND MAP

CURRENT ELECTRICITY

1. Electric current

$$I = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$$

2. Ohm's law

$V = IR$

where R is called the resistance

3. (i) Resistance

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

(ii) **Effect of temperature**

$R = R_0 (1 + \alpha\theta)$

(iii) **Grouping of resistors**

(a) When reistors are in series

$R = R_1 + R_2 + R_3$ …..

(b) When resistors are in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

4. Kirchhoff's law

(i) 1st law:

at any junction of circuit elements

$\sum I = 0$

(ii) 2nd law:

around any close loop

$\sum V = 0$

5. (a) When a cell of emf (ε) is in a circuit

(i) $I = \frac{E}{R + r}$

where r is internal resistance of the cell

(ii) $V_{AB} = E - Ir$

(b) **Grouping of cells**

(i) When cells are in series

$$I = \frac{nE}{R + nr}$$

(ii) When cells are in parallel

$$I = \frac{m\varepsilon}{mR + r}$$

(iii) cells are in multiple arc

$$I = \frac{mn\varepsilon}{mR + nr}$$

(iv) For maximum current $mR = nr$

6. Voltmeter: is used in parallel in a circuit and should have very high resistance

7. Ammeter: is used in series in a circuit and should have very small resistance.

8. Potentiometer: is a method of measurement involving a condition of no current flow and e.m.f.s are compared independent of the internal resistance of the source

9. Wheatstone bridge

is an arrangement of four resistances used for measuring one of them in terms of others.

For a balanced Wheat stone bridge $\frac{P}{Q} = \frac{R}{S}$

10. Heating effect of current

(i) Joules law

$H = I^2Rt$

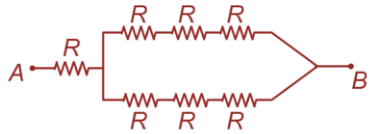
(ii) Electrical power

$p = VI = I^2R = V^2/R$

EXERCISE – I

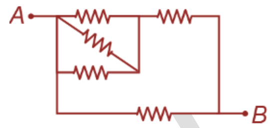
NEET-SINGLE CHOICE CORRECT

1. The effective resistance of the network between points A and B



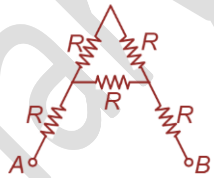
(a) $4R$ (b) $2R$
(c) $10R$ (d) $5R/2$

2. Five identical resistances are connected in a network as shown. The resistance measured between A and B is 1 Ω. Each resistance is



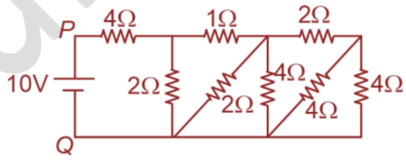
(a) 1/4 Ω (b) 4/7 Ω
(c) 7/4 Ω (d) 8/7 Ω

3. What is the effective resistance between A and B



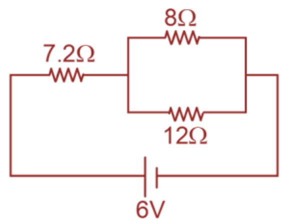
(a) $\frac{2R}{3}$ (b) $\frac{R}{3}$
(c) $\frac{6R}{3}$ (d) $\frac{8R}{3}$

4. Find the equivalent resistance between P and Q



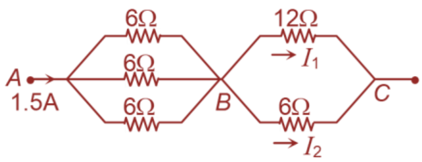
(a) 10 Ω (b) 5 Ω
(c) 15 Ω (d) 20 Ω

5. In the circuit shown,



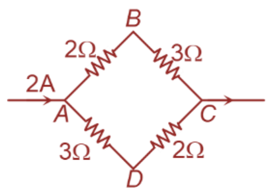
(a) the pd across 8 Ω is 3.6 V
(b) the pd across 12 Ω is 2.4 V
(c) the pd across 7.2 Ω is 5.6 V
(d) the current drawn from the battery is 1.5 A

6. In the network shown,



(a) $V_{AB} = +3.0$ V (b) $V_{CB} = +6.0$ V
(c) $I_1 = 1.5$ A (d) $I_2 = 0.5$ A

7. In the network shown,



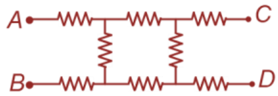
(a) $V_{AB} = +2$ V (b) $V_{DA} = +3$ V
(c) $V_{BD} = +2$ V (d) $V_{CD} = -3$ V

8. EMF represents
(a) potential energy (b) a force
(c) work done per unit charge (d) potential difference

9. When a cell is undergoing charging process
(a) there is no voltage drop in its internal resistance
(b) its terminal potential is less than its EMF
(c) its terminal potential is more than its EMF
(d) its terminal potential is zero

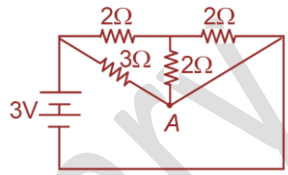
10. The specific resistance of a wire
(a) varies with its length
(b) varies with its cross-section
(c) varies with its mass
(d) does not depend on its length, cross-section and mass

11. In the given circuit, each resistance is 10Ω. The equivalent resistance between A and D is



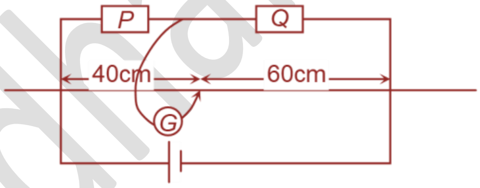
(a) 40 Ω (b) 30 Ω
(c) 20 Ω (d) 10 Ω

12. The current in branch AB is



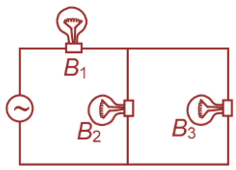
(a) 1.5 A (b) 2 A
(c) 1.33 A (d) infinite

13. In a metre bridge, the gaps are closed by two resistances P and Q and the balance point is obtained at 40 cm. When Q is shunted by a resistance of 10Ω, the balance point shifts to 50 cm. The values of P and Q are



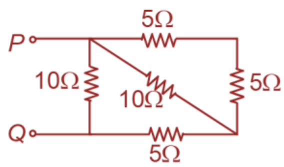
(a) $\frac{10}{3}$Ω, 5Ω (b) 20Ω, 30 Ω (c) 10 Ω, 15 Ω (d) 5Ω, $\frac{15}{2}$ Ω

14. Three bulbs B_1, B_2 and B_3 are connected to the mains as shown in figure. How will the incandescence of the bulb B_1 be affected, if one of the bulbs B_2 or B_3 is disconnected from the circuit?



(a) no change in the incandescence
(b) bulb B_1 will become brighter
(c) bulb B_1 will become less brighter
(d) the bulb B_1 may become brighter or dimmer depending upon wattage of the bulb which is disconnected.

15. The effective resistance between the terminals P and Q in following circuit is



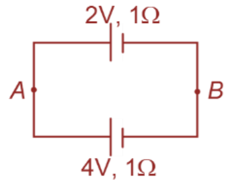
(a) 5 Ω (b) 10 Ω
(c) 25 Ω (d) 30 Ω

16. Five resistances are connected as shown in figure. The effective resistance between the points A and B is

(a) $\frac{10}{3}$Ω (b) $\frac{20}{3}$Ω
(c) 15 Ω (d) 6 Ω

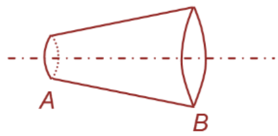
17. There are n exactly identical resistors each having resistance R. The resultant resistance when joined in parallel is λ, then on connecting them is series the resistance will come out be
(a) $\frac{\lambda}{n^2}$ (b) $n^2\lambda$
(c) $\frac{\lambda}{n^3}$ (d) $n^3\lambda$

18. Find the potential difference between A and B



(a) 6V (b) 2 V
(c) 3 V (d) 1 V

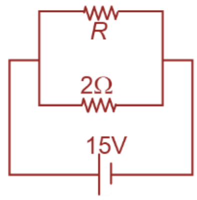
19. A wire has a nonuniform cross-section as shown. A steady current is flowing through it. Then the drift speed of the electrons



(a) is constant throughout the wire (b) decreases from A to B
(c) increases from A to B (d) varies randomly

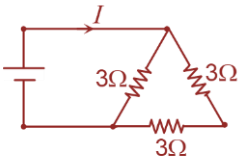
20. 24 identical cells, each of internal resistance 0.5 Ω, are arranged in a parallel combination of n rows, each row containing m cells in series. The combination is connected across resistor of 3Ω. In order to send maximum current through the resistor, we should have
(a) $m = 12$, $n = 2$ (b) $m = 8$, $n = 3$
(c) $m = 2$, $n = 12$ (d) $m = 3$, $n = 8$

21. If in the circuit power dissipation is 150 W. Then R is



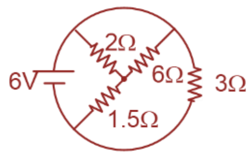
(a) 2Ω (b) 6Ω
(c) 5Ω (d) 4Ω

22. A 3 volt battery with negligible internal resistance is connected in circuit as shown in the figure. The current I in the circuit will be



(a) 1.5 A (b) 2 A
(c) 1/3 A (d) 1 A

23. The total current supplied to the circuit by the battery is



(a) 1 A (b) 2 A
(c) 4 A (d) 6 A

24. The resistance of the series combination of two resistances is S. When they are joined in parallel the total resistance is P. If $S = nP$ then the minimum possible value of n is
(a) 4 (b) 3
(c) 2 (d) 1

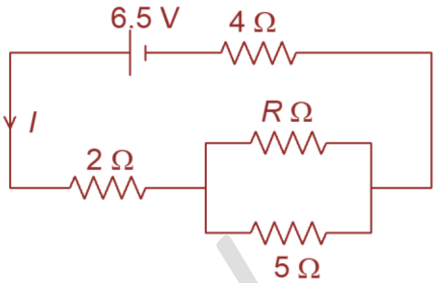
25. In a meter bridge experiment null point is obtained at 20 cm from one end of the wire when resistance X is balanced against another resistance Y. If $X < Y$, then where will be the new position of the null point from the same end, if one decides to balance a resistance of $4X$ against Y?
(a) 50 cm (b) 80 cm
(c) 40 cm (d) 70 cm

EXERCISE – II

IIT-JEE- SINGLE CHOICE CORRECT

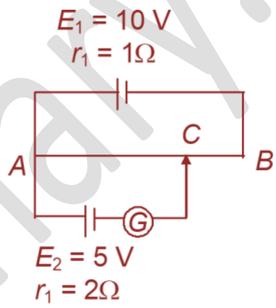
1. In the network shown, the current I is equal to $\frac{2}{3}$ A. Neglecting the internal resistance of the cell, the value of R is

(a) 3.75 (b) 10
(c) 15 (d) 19.5



2. In the figure shown, the potentiometer wire of length l = 100 cm and resistance 9Ω is joined to a cell of emf E_1 = 10V and internal resistance r_1 = 1Ω. Another cell of emf E_2 = 5V and internal resistance r_2 = 2Ω is connected as shown. The galvanometer G will show no deflection when the length AC is

(a) 50 cm (b) 55.55 cm
(c) 52.67 cm (d) 54.33 cm

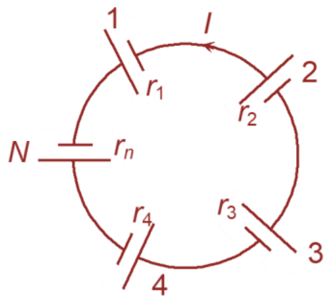


3. There are two concentric spheres of radius a and b respectively. If the space between them is filled with medium of resistivity ρ, then the resistance of the inter gap between the two spheres will be

(a) $\frac{\rho}{4\pi(b+a)}$ (b) $\frac{\rho}{4\pi}\left(\frac{1}{b}+\frac{1}{a}\right)$ (c) $\frac{\rho}{4\pi}\left(\frac{1}{a^2}-\frac{1}{b^2}\right)$ (d) $\frac{\rho}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)$

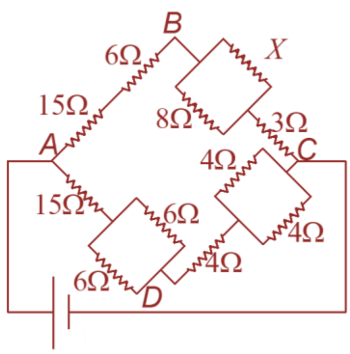
4. In a group of N cells, emf of each varies directly with its internal resistance as per the equation $E_N = 1.5\, r_N$. They are connected as shown in the figure. The current l in the circuit is

(a) 0.51 amp (b) 5.1 amp
(c) 0.15 amp (d) 1.5 amp



5. In the circuit shown in the figure, the value of resistance X, when the potential difference between the points B and D is zero, will be

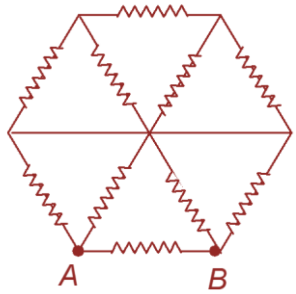
(a) 9 Ω (b) 8 Ω
(c) 6 Ω (d) 4 Ω



6. An electron in the potentiometer wire experiences a force of 2.4 × 10^{-19} N. The length of the potentiometer wire is 4m. The emf of the battery connected across the wire is

(a) 6.0 V (b) 4.8 V (c) 4.0 V (d) 2.4 V

7. In the network shown in figure, each resistance is R. The equivalent resistance between A and B is



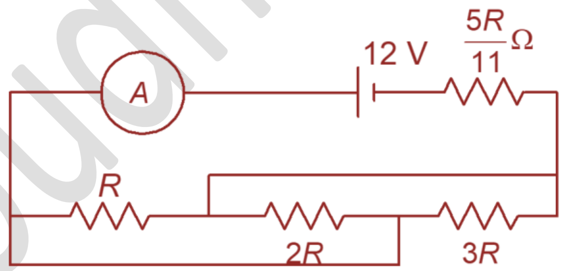
(a) $\frac{20}{11}R$ (b) $\frac{19}{20}R$
(c) $\frac{8}{15}R$ (d) $\frac{R}{2}$

8. An ammeter and a voltmeter are joined in series to a cell. Their readings are A and V respectively. If a resistance is now joined in parallel with the voltmeter, then
(a) both A and V will increase (b) both A and V will decrease
(c) A will decrease, V will increase (d) A Will increase, V will decrease

9. Value of each resistance in the circuit is r. The equivalent resistance between A and B is

(a) $\frac{r}{4}$ (b) $4r$ (c) $\frac{2r}{5}$ (d) 0

10. In the circuit shown, the ammeter reads 2 A. The resistance of ammeter is negligible. What is the value of R?

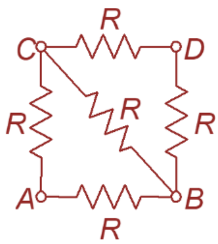


(a) 2 Ω (b) 3 Ω
(c) 5 Ω (d) 6 Ω

11. A galvanometer together with unknown resistance in series is connected to two identical batteries each of emf 1.5 V. When the batteries are in series the galvanometer registers a current of 1 ampere. When the batteries are in parallel the current is 0.6 ampere. What is the internal resistance of the battery?

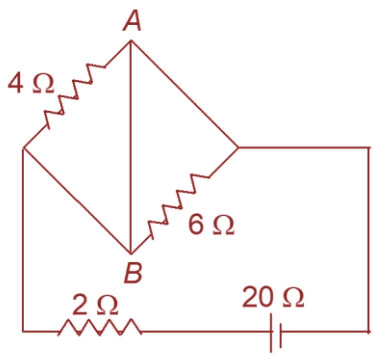
(a) 5Ω (b) $\frac{1}{3}$ Ω (c) 0.2 Ω (d) 0.8 Ω

12. The resistance across AB is

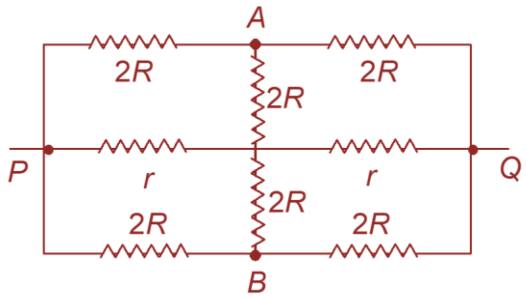


(a) $\frac{5}{8}R$ (b) $\frac{7}{8}R$
(c) 1 R (d) 2 R

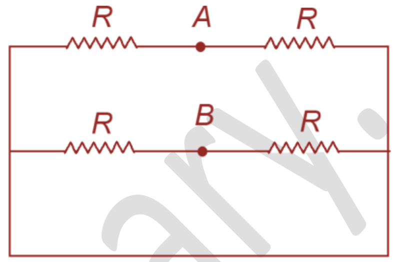
13. In the circuit shown in figure, the current in 2Ω resistor is
(a) 4 A (b) 10 A
(c) 5 A (d) none



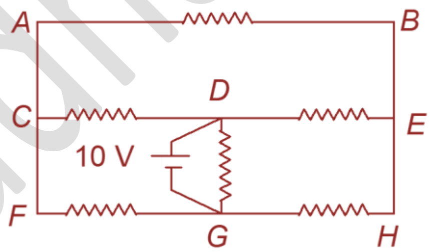
14. The effective resistance between point P and Q of the electrical circuit shown in the figure is
(a) $2Rr / (R + r)$
(b) $8R(R + r) / (3R + r)$
(c) $2r + 4R$
(d) $5R / 2R + 2r$



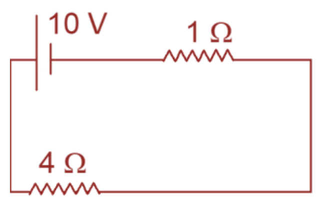
15. The equivalent resistance between point A and B is
(a) R (b) $R/4$
(c) $4R$ (d) $\frac{2R}{3}$



16. All resistance shown in circuit are 2Ω each. The current in the resistance between D and E is
(a) 5 A (b) 2.5 A
(c) 1 A (d) 7.5 A

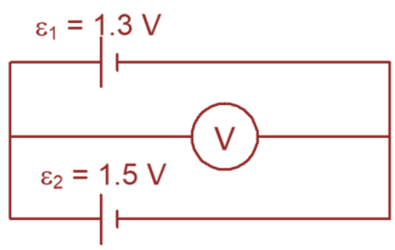


17. In the circuit shown in figure, power supplied by the battery is
(a) 16 W (b) 20 W
(c) 4 W (d) 18 W



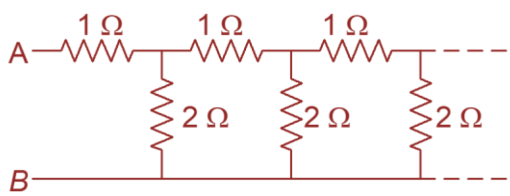
18. A milliammeter of range 10 mA has a coil of resistance 1 Ω. To use it as an ammeter of range 1 A, the required shunt must have a resistance of
(a) $\frac{1}{101}\Omega$ (b) $\frac{1}{100}\Omega$ (c) $\frac{1}{99}\Omega$ (d) $\frac{1}{9}\Omega$

19. Two cells with emfs $\varepsilon_1 = 1.3$ V and $\varepsilon_2 = 1.5$ V are connected as shown. The voltmeter reads 1.45 V. If r_1 and r_2 be the internal resistance of the cells, then the ratio $\frac{r_1}{r_2}$ is



(a) 1: 1 (b) 3 : 1 (c) 1 : 2 (d) none

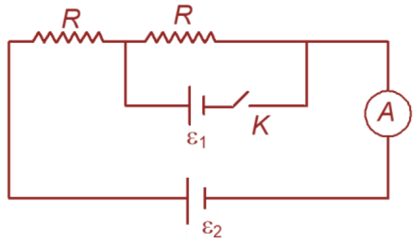
20. An infinite ladder network consisting of 1 Ω and 2 Ω resistors is shown in the figure. The effective resistance of the network across AB is



(a) 5 Ω (b) 3.5 Ω (c) 2 Ω (d) none

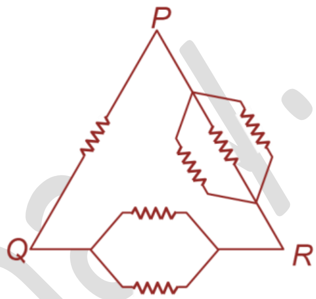
MORE THAN ONE CHOICE CORRECT

1. In the given circuit, when key K is open, reading of ammeter is I. Now key K is closed. Then the correct statement is:



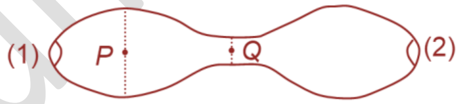
(a) If $\varepsilon_1 = IR$, reading of the ammeter is I.
(b) If $IR < \varepsilon_1 < 2IR$, reading of the ammeter is greater than I.
(c) If $\varepsilon_1 = 2IR$, reading of the ammeter will be zero.
(d) Reading of ammeter will not change.

2. Six equal resistances are connected between points P, Q, and R as shown in the figure. Then the net resistance will be



(a) maximum between P and Q
(b) maximum between P and R
(c) minimum between P and Q
(d) minimum between P and R

3. A metallic conductor of irregular cross-section is as shown in the figure. A constant potential difference is applied across the ends (1) and (2). Then



(a) the current at the cross-section P equals to the current at the cross-section Q.
(b) the electric field intensity at P is less than that at Q.
(c) the rate of heat generated at Q is greater than that at P.
(d) the number of electrons crossing per unit area of cross-section at P is less than that of Q.

4. When no current is passed through a conductor, then
(a) the free electrons do not move.
(b) the average speed of a free electron over a large period of time is zero.
(c) the average velocity of a free electron over a large period of time is zero.
(d) the average of the velocities of all the free electrons at an instant is zero.

5. When the terminals of a cell of e.m.f. 1.5 V are connected to an ammeter of resistance 4Ω. The ammeter reads 0.30 amp. Which of the following statements is/are correct?
(a) The cell is non-ideal.
(b) If a 4Ω resistor is also connected across terminals of the cell, the ammeter will read 0.50 amp
(c) If a 4Ω resistor is also connected across the terminals of the cell, one-third of the electrical power generated will dissipate as heat within the cell.
(d) If a voltmeter of resistance 4Ω is used after removing ammeter from circuit to measure potential difference between terminals of the cell, it will read 1.2V.

6. The charge flowing in a conductor varies with time as $q = at - bt^2$, where a and b are positive constants. The current in the conductor
(a) decreases linearly with time
(b) increases linearly with time
(c) changes at the rate of $-2b$
(d) becomes zero after time $= a/b$

7. Two bulbs have same specified voltage but different power ratings. When they are connected individually across a source of voltage V, both produce H amount of heat in time t_1 and t_2 respectively. When used together across the same source, they produce H amount of heat in time t. Then
(a) if they are in series, $t = t_1 + t_2$
(b) if they are in series, $t = 2(t_1 + t_2)$
(c) if they are in parallel, $t = \dfrac{t_1 t_2}{t_1 + t_2}$
(d) if they are in parallel, $t = \dfrac{t_1 t_2}{2(t_1 + t_2)}$

8. A galvanometer has a resistance of 100 Ω and a full scale range of 50 μA. If a resistance is added to it, it can be used as a voltmeter or as a high range ammeter. Then
(a) If 10 kΩ resistance is added in series, it can be used as a voltmeter of range 50 V
(b) If 200 kΩ resistance is added in series, it can be used as a voltmeter of range 10 V
(c) If 1 Ω resistance is added in parallel, it can be used as a ammeter of range 5 mA
(d) If 1 Ω resistance is added in parallel, it can be used as a ammeter of range 10 mA

9. A uniform wire is shaped into a regular n-sided polygon (n is even). The resistance of total wire is R. Then
(a) The maximum resistance of the polygon between any two corners is $R/4$
(b) The maximum resistance of the polygon between any two corners is R/n
(c) The minimum resistance of the polygon between any two corners is $\frac{R(n-1)}{n^2}$
(d) The minimum resistance of the polygon between any two corners is R/n

10. A wire of non-uniform cross-section is connected through a potential source. The quantities that will remain independent of area of cross section are
(a) the charge flowing per unit time
(b) current density
(c) drift speed
(d) free electron density

EXERCISE – III

MATCH THE FOLLOWING

Note: Each statement in column – I has one or more than one match in column –II.

1. Match the following

Column -I	Column -II
I. Electric conductivity of a conductor depends on	**A.** length of conductor.
II. Conductance of a conductor depends on	**B.** Temperature
III. For a given conductor and at a given temperature, current density depends on	**C.** Nature of conductor
IV. For a given potential difference applied across a conductor, current in it will depend on	**D.** Electric field strength **E.** Area of cross section of conductor

REASONING TYPE

Directions: Read the following questions and choose

(A) If both the statements are true and statement-2 is the correct explanation of **statement-1**.
(B) If both the statements are true but statement-2 is not the correct explanation of **statement-1**.
(C) If statement-1 is True and **statement-2** is False.
(D) If statement-1 is False **and statement-2** is True.

1. **Statement-1**: There is no current in the metals in the absence of electric field.
Statement-2: Motion of free electrons are random.
(a) (A) (b) (B) (c) (C) (d) (D)

2. **Statement-1**: In meter bridge experiment, a high resistance is always connected in series with a galvanometer.
Statement-2: As resistance increases current through the circuit increases.
(a) (A) (b) (B) (c) (C) (d) (D)

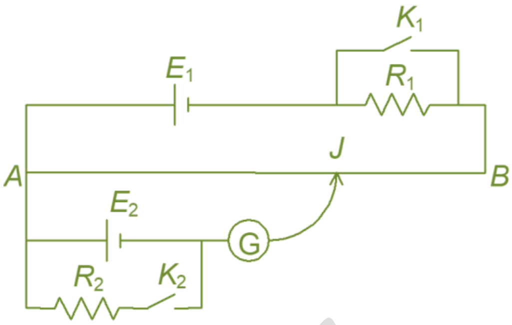
3. **Statement-1**: A potentiometer of longer length is used for accurate measurement.
Statement-2: The potential gradient for a potentiometer of longer length with a given source of emf becomes small.
(a) (A) (b) (B) (c) (C) (d) (D)

4. **Statement-1**: Potential difference across the battery is always equal to emf of the battery.
Statement-2: Work done by the battery per unit charge is the emf of the battery.
(a) A (b) B (c) C (d) D

5. **Statement-1**: In a simple battery circuit the point at the lowest potential is positive terminal of the battery.
Statement-2: The current flows towards the point of the lower potential in the circuit, but it does not flow in a cell from positive to the negative terminal.
(a) (A) (b) (B) (c) (C) (d) (D)

LINKED COMPREHENSION TYPE

In the circuit shown AB is a 10 Ω uniform slide wire 50 cm long. E_1 is 2 V accumulator of negligible internal resistance. R_1 and R_2 are 15 Ω and 5 Ω respectively. When K_1 and K_2 are both open, the galvanometer shows no deflection when AJ = 31.25 cm. When K_1 and K_2 are both closed the balance length AJ = 5 cm.



1. The emf of the cell E_2,

(a) 0.5 V (b) 1 V
(c) 1.5 V (d) 2 V

2. The internal resistance of the cell E_2,

(a) 7.5 Ω (b) 8 Ω
(c) 10 Ω (d) 2 Ω

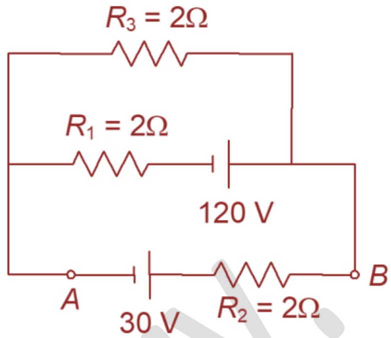
3. The balance length AJ when K_2 is open and K_1 is closed

(a) 12.5 cm (b) 13.5 cm
(c) 14.5 cm (d) 15.5 cm

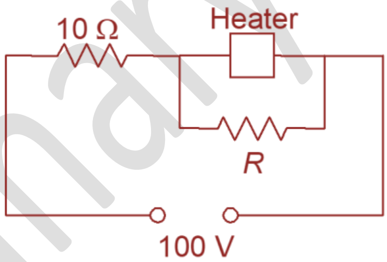
EXERCISE – IV

SUBJECTIVE PROBLEMS

1. In the circuit shown find the potential difference ($V_B - V_A$) and the rate of production of heat across R_1.



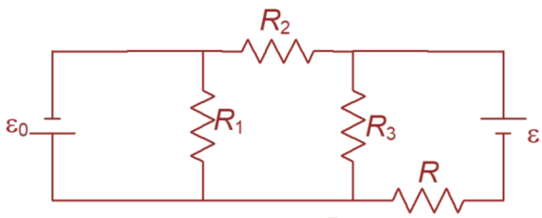
2. A heater is designed to operate with a power of 1000 W in a 100 V line. It is connected in combination with a resistance of 10 ohm and a resistance R to a 100 volt mains as shown in the circuit. What should be the value of R so that the heater operates with a power of 62.5 watt?



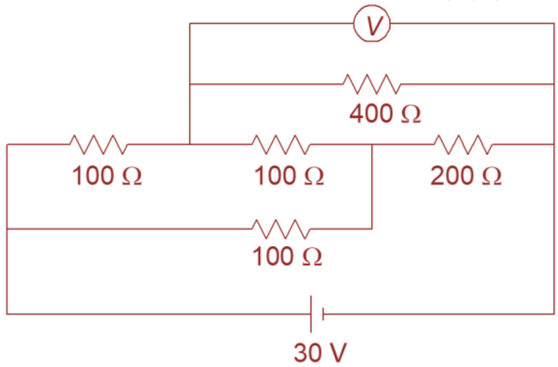
3. A wire of resistance 0.1 ohm/cm is bent to form a square *ABCD* of side 10 cm. A similar wire is connected between the corners B and D to form the diagonal BD. If 2 volt battery of negligible internal resistance is connected across A and C, calculate the total power dissipated.

4. The current i through a rod of a certain metallic oxide is given by $i = 0.2V^{1/2}$, where V is potential difference across it. The rod is connected in series with a resistance to a 6 volt battery of negligible internal resistance. What should be series resistance in Ω so that power dissipated in the resistance is twice that of rod. ($\sqrt{2}$ =1.4)

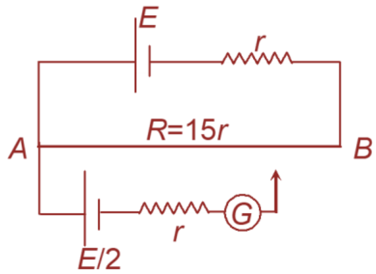
5. Find the current flowing in the resistor R in the circuit shown.
The internal resistance of the batteries are negligible.
(given ε_0 = 20 V, ε = 60V, R_2 =10 Ω, R_3 =5Ω and R = 10Ω)



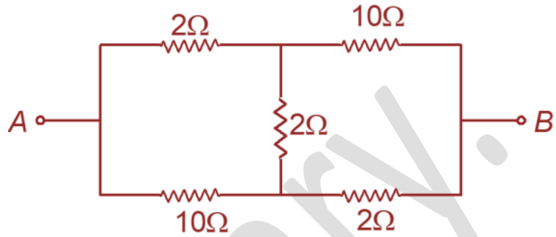
6. An electrical circuit is as shown in the Figure. Calculate the potential difference across the resistor of 400 ohm, as will be measured by the voltmeter V of resistance 400 ohm, either by applying Kirchhoff's rules or otherwise.



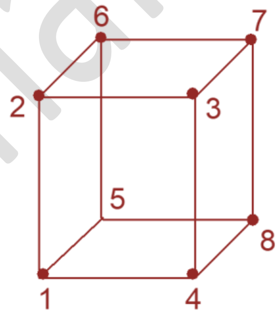
7. Consider the potentiometer circuit arranged as in figure. The potentiometer wire is 600 cm long. At what distance (in cm) from the point *A* should the jockey touch the wire to get zero deflection in the galvanometer?



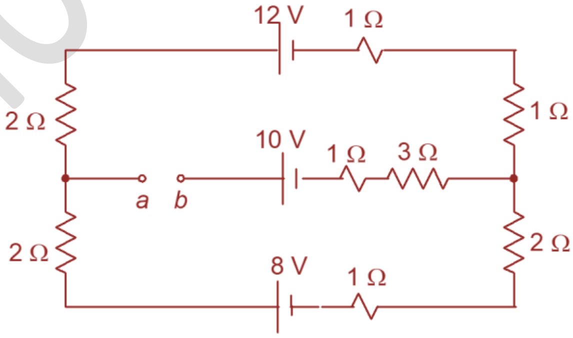
8. Find the effective resistance between the points *A* and *B* of the following network.



9. Find the resistance of a wire frame shaped as a cube as in figure when measured between points
(a) 1-2; (b) 1-3
The resistance of each edge of the frame is 12 Ω



10. If *a* and *b* are connected, find the current (in mA) in the 12 V cell in the given circuit.



ANSWERS

EXERCISE – I

NEET-SINGLE CHOICE CORRECT

1. (d)	2. (c)	3. (d)	4. (b)	5. (b)
6. (a)	7. (a)	8. (c)	9. (c)	10. (d)
11. (b)	12. (a)	13. (a)	14. (c)	15. (a)
16. (a)	17. (b)	18. (c)	19. (b)	20. (a)
21. (b)	22. (a)	23. (c)	24. (a)	25. (a)

EXERCISE – II

IIT-JEE-SINGLE CHOICE CORRECT

1. (c)	2. (b)	3. (d)	4. (d)	5. (b)
6. (a)	7. (d)	8. (d)	9. (c)	10. (d)
11. (b)	12. (a)	13. (b)	14. (a)	15. (a)
16. (b)	17. (b)	18. (c)	19. (b)	20. (c)

MORE THAN ONE CHOICE CORRECT

1. (a,c)	2. (a,d)	3.(a,b,c,d)	4. (c,d)	5. (a,c,d)
6. (a,c)	7. (a,c)	8. (b,c)	9. (a,c)	10. (a,d)

EXERCISE – III

MATCH THE FOLLOWING

1. I – B, C; II – A, B, C, E; III – D; IV – A, B, C, E

REASONING TYPE

1. (a)	2. (c)	3. (a)	4. (d)	5. (d)

LINKED COMPREHENSION TYPE

1. (a)	2. (a)	3. (a)

EXERCISE – IV

SUBJECTIVE PROBLEMS

1. 50 V, 2450 W

2. 5 ohm

3. 4 W

4. 14 Ω

5. 5 A

6. 20 V

7. 320 cm

8. 4 Ω

9. (i) 7Ω (ii) 9 Ω

10. 464 mA

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1

Q.1 A current of 5 Amp exist on a 10 ohm resistance for 4 min. How much charge pass through any cross-section of the resistor in this time ?
(1) 12 coulombs (2) 120 coulombs
(3) 1200 coulombs (4) 12000 coulombs

Q.2 The electric current in a liquid is due to the flow of -
(1) electron only
(2) positive ions only
(3) negative and positive ions both
(4) electrons and positive ions both

Q.3 The electric current in a discharge tube containing a gas is due to -
(1) electron only
(2) positive ions only
(3) negative ion and positive ions both
(4) electrons and positive ions both

Q.4 A steady current is passing through a linear conductor of non-uniform cross-section. The net quantity of charge crossing any cross-section per second is -
(1) independent of area of cross-section
(2) directly proportional to the length of conductor
(3) directly proportional to the area of cross-section
(4) inversely proportional to the lengths of conductor

Q.5 A current (I) flows through a uniform wire of diameter (d) when the mean drift velocity is v. The same current will flow through a wire of diameter d/2 made of the same material if the mean drift velocity of the electron is -
(1) v/4 (2) v/2 (3) 4v (4) 2v

Q.6 A wire of non-uniform cross-section is carrying a steady current. Along the wire -
(1) current and current density are constant
(2) only current is constant
(3) only current density is constant
(4) neither current nor current density is a constant

Q.7 When a potential difference (V) is applied across a conductor , the thermal speed of electrons is -
(1) zero (2) proportional to $\sqrt{T}$
(3) proportional to (T) (4) proportional to V

Q.8 Specific resistance of a wire depends on the
(1) length of the wire
(2) area of cross–section of the wire
(3) resistance of the wire
(4) material of the wire

Q.9 A cross–sectional area of a copper wire is 3×10^{-6} m^2. The current of 4.2 amp is flowing through it. The current density in amp/m^2 through the wire is –
(1) 1.4×10^3 (2) 1.4×10^4
(3) 1.4×10^5 (4) 1.4×10^6

Q.10 The resistance of some substances become zero at very low temperature , then these substances are called –
(1) good conductors (2) super conductors
(3) bad conductors (4) semi conductors

Q.11 The resistance of wire is 20Ω. The wire is stretched to three times its length. Then the resistance will now be –
(1) 6.67 Ω (2) 60 Ω
(3) 120 Ω (4) 180 Ω

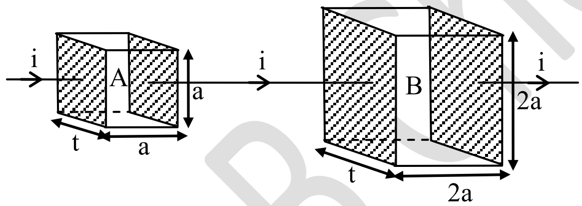
Q.12 The dimensions of a mangnin block are 1 cm × 1 cm × 100 cm. The electrical resistivity of mangnin is 4.4×10^{-7} ohm–meter. The resistance between the opposite rectangular faces is –
(1) 4.4×10^{-7} ohm (2) 4.4×10^{-3} ohm
(3) 4.4×10^{-5} ohm (4) 4.4×10^{-1} ohm

Q.13 If the temperatures of iron and silicon wires are increased from 30ºC to 50ºC, the correct statement is–
(1) resistance of both wires increase
(2) resistance of both wires decrease
(3) resistance of iron wire increases and the resistance of silicon wire decreases
(4) resistance of iron wire decreases and the resistance of silicon wire increases

Q.14 When the resistance of copper wire is 0.1Ω and the radius is 1 mm, then the length of the wire is (specific resistance of copper is 3.14×10^{-8} ohm × m) -
(1) 10 cm (2) 10 m (3) 100 m (4) 100 cm

Q.15 When the resistance wire is passed through a die the cross–section area decreases by 1%, the change in resistance of the wire is -
(1) 1% decrease (2) 1% increase
(3) 2% decrease (4) 2% increase

Q.16 In the following diagram two parallelopipedA and B are of the same thickness. The arm of B is double that of A. Compare these resistances and find out the value of R_A/R_B is –



(1) 1 (2) 2 (3) $\frac{1}{2}$ (4) 4

Q.17 When the temperature of a metallic conductor is increased its resistance -
(1) always decreases
(2) always increases
(3) may increase or decrease
(4) remains the same

Q.18 The resistance of a semi-conductors -
(1) increases with increase of temperature
(2) decreases with increase of temperature
(3) does not charge with charge of temperature
(4) first decreases and then increases with increase of temperature

Q.19 Ohm's law is valid when the temperature of the conductor is -
(1) constant (2) very high
(3) very low (4) varying

Q.20 A certain piece of copper is to be shared into a conductor of minimum resistance . Its length and diameter should be respectively -

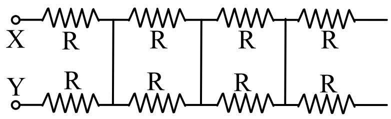
(1) ℓ , d (2) 2ℓ , d (3) $\ell/2$, 2d (4) 2ℓ , d/2

Q.21 A wire has a resistance of 10Ω . A second wire of the same material is having length double and radius of cross-section half that of the wire. The resistance of the second wire is -
(1) 20Ω (2) 40Ω (3) 80Ω (4) 10Ω

Q.22 A cylindrical copper rod is reformed to twice its original length with no change in volume. The resistance between its ends before the change was (R). Now its resistance -
(1) 8R (2) 6R (3) 4R (4) 2R

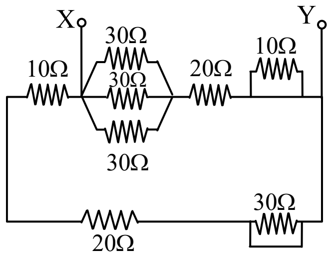
Q.23 The length of a conductor is halved. Its conductance will be -
(1) halved (2) unchanged
(3) doubled (4) quadrupled

Q.24 Net resistance between X and Y is –



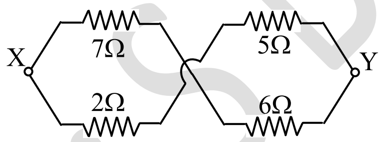
(1) R (2) 2R (3) $\frac{R}{2}$ (4) 4R

Q.25 Net resistance between X and Y is -



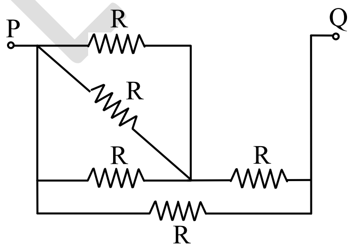
(1) 5 Ω (2) 10 Ω (3) 15 Ω (4) 60 Ω

Q.26 Net resistance between X and Y is -



(1) 4 Ω (2) 4.55 Ω (3) 2 Ω (4) 20 Ω

Q.27 The equivalent resistance between the terminal point P and Q is 4Ω in the given circuit, then find out the resistance of R in ohms -

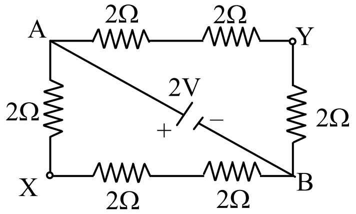


(1) 7 (2) 4 (3) 2 (4) 5

Q.28 At a point $\Sigma i = 0$ in a circuit with one emf source, then-
(1) the resistance of the circuit is zero
(2) the point is the junction point
(3) the emf of the source is infinity

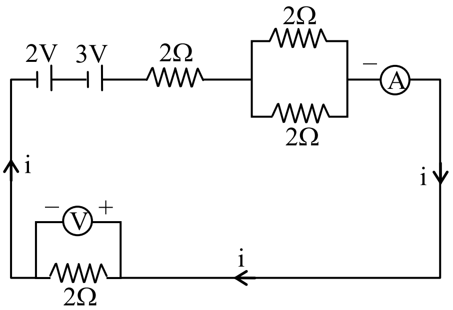
(4) this is not possible

Q.29 For the following circuits, the potential difference between X and Y in volt is –



(1) $\frac{2}{3}$ (2) $\frac{4}{3}$ (3) $\frac{8}{9}$ (4) $\frac{5}{3}$

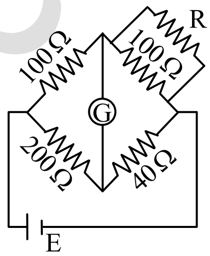
Q.30 Reading of ideal .ammeter in ampere for the following circuit is –



(1) 1 (2) 2 (3) 3 (4) 4

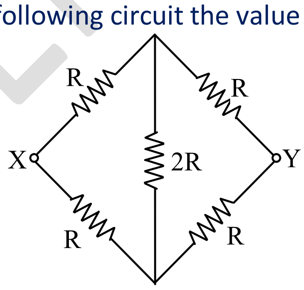
Q.31 In a closed circuit the sum of total emf is equal to the sum of the –
(1) currents
(2) resistances
(3) products of current and the resistances
(4) none of the above

Q.32 For following diagram the galvanometer shows zero deflection, then the value of R is -



(1) 52 Ω (2) 50 Ω (3) 100 Ω (4) 25 Ω

Q.33 For following circuit the value of total resistance between X and Y in ohm is -



(1) R (2) 4 R (3) 5 R (4) 6 R

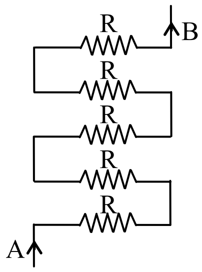
Q.34 The equivalent resistance in series combination is-
(1) smaller than the largest resistance
(2) larger than the largest resistance

(3) smaller than the smallest resistance
(4) larger than the smallest resistance

Q.35 The equivalent resistance of resistors in parallel is always -
(1) higher than the highest of component resistor
(2) less than the lowest of component resistors
(3) in between the lowest and the highest of component resistors
(4)equal to the sum of the component resistors

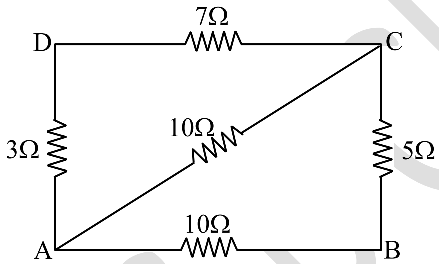
Q.36 When n identical resistances of value 'r' each are connected in parallel, the equivalent resistance is x. The resultant resistance when they are connected in series is-
(1) n x (2) n^2x (3) r n x (4) r^2 x/n

Q.37 Five identical resistance are connected as shown in fig. The equivalent resistance between point (A) and (B) is -



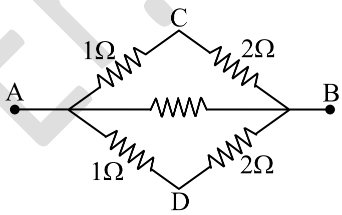
(1) R (2) 5R (3) R/5 (4) 2R/5

Q.38 Five resistance are connected as shown in the adjoining figure. The equivalent resistance between A and B is -



(1) 35Ω (2) 5Ω
(3) 15/4Ω (4) 25Ω

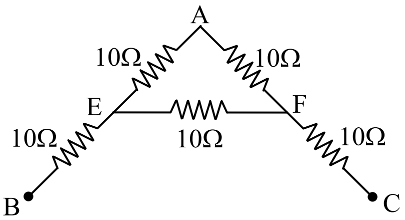
Q.39 The equivalent resistance between points (A) and (B) in the adjoining fig. is one ohm. What is the value of middle resistance -



(1) 9Ω (2) 1Ω (3) 6Ω (4) 3Ω

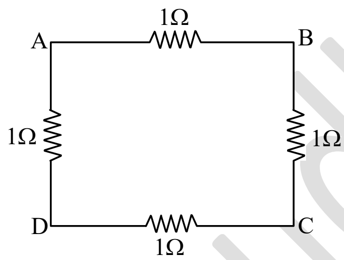
Q.40 Four wires of equal length and of resistance 5 ohm each are connected in the form of a square. The equivalent resistance between the diagonally opposite corners of the square is-
(1) 5 ohm (2) 10 ohm
(3) 20 ohm (4) 5/4 ohm

Q.41 The effective resistance (in Ω) between (B) and (C) of letter (A), containing resistance as shown in fig. as



(1) 60 (2) 40
(3) 80/3 (4) 160/9

Q.42 Four identical resistances are joined as shown in fig. The equivalent resistance between points (A) and (B) is R_1. The equivalent resistance between points A and C is R_2 then ratio of R_1/R_2 is -

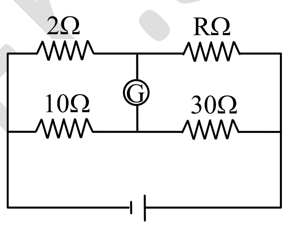


(1) 1 : 1 (2) 4 : 3 (3) 3 : 4 (4) 1 : 2

Q.43 Kirchhoff's first law is Σi = 0 at a junction deals with -
(1) conservation of charge
(2) conservation of energy
(3) conservation of momentum
(4) conservation of angular momentum

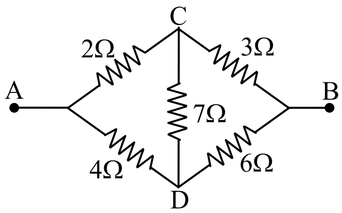
Q.44 Kirchhof's second law is based on law of conservation of -
(1) charge
(2) energy
(3) momentum
(4) sum of mass and energy

Q.45 In the adjoining fig. there is no deflection in the galvanometer . Then R is equal to -



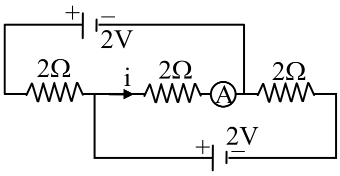
(1) 2Ω (2) 30Ω (3) 6Ω (4) (2/3)Ω

Q.46 Five resistances are connected as shown in fig. The effective resistance between the points A and B is -



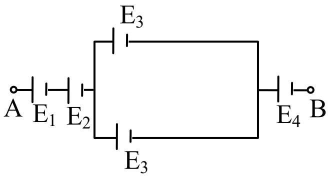
(1) 10/3Ω (2) 20/3 Ω (3) 15Ω (4) 6Ω

Q.47 Reading of ammeter is -



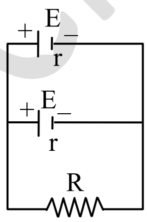
(1) 1 (2) 2 (3) $\frac{2}{3}$ (4) 3

Q.48 In the following circuit the resultant emf between AB is -



(1) $E_1 + E_2 + E_3 + E_4$
(2) $E_1 + E_2 + 2E_3 + E_4$
(3) $E_1 + E_2 + (E_3/2) + E_4$
(4) $E_1 + E_2 + (E_3/4) + E_4$

Q.49 Two cells of same emf E and internal resistance r are connected in parallel with a resistance of R. To get maximum power in the external circuit, the value of R is -



(1) R = $\frac{r}{2}$ (2) R = r
(3) R = 2 r (4) R = 4r

Q.50 A cell of e.m.f (E) and internal resistance (r) is connected in series with an external resistance (nr.) then the ratio of the terminal p.d. to E.M.F is -
(1) 1/n (2) 1/(n+1)
(3) n/(n+1) (4) (n+1)/n

Q.51 The terminal potential difference of a cell, when short circuited is -
(1) E (2) E/2
(3) zero (4) E/3

Q.52 Five dry cell each of e.m.f 1.5V are connected in parallel. The e.m.f of the combination is -
(1) 7.5 V (2) 0.3 V
(3) 3V (4)1.5 V

Q.53 Two bulbs , one of 50 watt and another of 25 watt are connected in series to the mains , the ratio of the current through them is -
(1) 2 : 1
(2) 1 : 2
(3) 1 : 1
(4) can't be determined without the p.d. of the main supply

Q.54 Constant voltage is applied between the two ends of a uniform metallic wire. The heat developed is doubled if -
(1) both the length and radius of the wire are halved
(2) both the length and radius of the wire are doubled
(3) the radius of wire is doubled
(4) the length of the wire is doubled

Q.55 Two electric bulbs rated P_1 watt V volt and P_2 watt V volt are connected in parallel across V volt mains then the total power is -
(1) $P_1 + P_2$ (2) $\sqrt{P_1P_2}$
(3) $\frac{P_1P_2}{(P_1+P_2)}$ (4) $\frac{(P_1+P_2)}{P_1P_2}$

Q.56 Lamps used for the house lightening are connected in -
(1) series (2) parallel
(3) mixed grouping (4) arbitrary manner

Q.57 Two electric bulbs whose resistances are in the ratio of 1 : 2 are connected in parallel to a constant voltage source. The power's dissipated in them have the ratio -
(1) 1 : 2 (2) 1 : 1 (3) 2 : 1 (4) 1 : 4

Q.58 An electric bulb is rated 220 volt and 100 watt. The resistance of the filament of the electric bulb is -
(1) 2.2 Ω (2) 2.2×10^4 Ω
(3) 484 Ω (4) 100 Ω

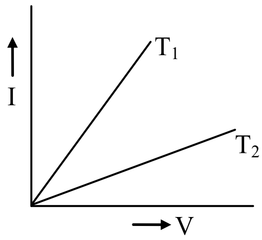
Q.59 Three electric bulbs 40W , 60W and 100W are designed to work on a 220V mains. Which bulb will burn most brightly if they are connected in series across 220V mains -
(1) 100W bulb
(2) 60W bulb
(3) 40 W bulb
(4) all bulbs will burn equally brightly

Q.60 If the current in a electric bulb drops by 2% then the power decreases by -
(1) 1% (2) 2% (3) 4% (4) 16%

Q.61 If the current in an electric bulb decreases by 0.5 percent, then the power in the bulb decreases approximately by -
(1) 0.5 percent (2) 1 percent
(3) 2 percent (4) 0.25 percent

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2

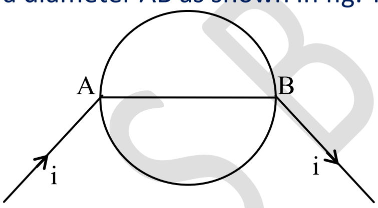
Q.1 The current (I) and voltage (V) graphs for a given metallic wire at two different temperature (T_1) and (T_2) are shown in fig. It is concluded that -



(1) $T_1 > T_2$ (2) $T_1 < T_2$
(3) $T_1 = T_2$ (4) $T_1 = 2T_2$

Q.2 A 3ºC rise in temperature is observed in a conductor by passing a certain current. When the current is doubled, the rise in temp -
(1) 15ºC (2) 12ºC (3) 9ºC (4) 3ºC

Q.3 A wire of resistance $0.5\Omega\ m^{-1}$ is bent into a circle of radius 1m. The same wire is connected across a diameter AB as shown in fig. The equivalent resistance is -



(1) $\pi\ \Omega$ (2) $\frac{\pi}{\pi+2}\ \Omega$
(3) $\frac{\pi}{\pi+4}\ \Omega$ (4) $(\pi + 1)\ \Omega$

Q.4 You have three equal resistance. How many different combination can you have with these resistances -
(1) 2 (2) 3 (3) 4 (4) 6

Q.5 An electron charge (e) is revolving in a circular orbit of radius (r) round a nucleus of charge (Ze) with speed (v). The equivalent current is -
(1) zero (2) $e.v/2\pi r$
(3) $Ze\ .\ v/2\pi r$ (4) $e.\ 2\pi r/v$

Q.6 In Wheat stone's bridge P = 9 ohm , Q = 11 ohms, R = 4 ohm and S = 6 ohms. How much resistance must be put in parallel to the resistance (S) to balance the bridge

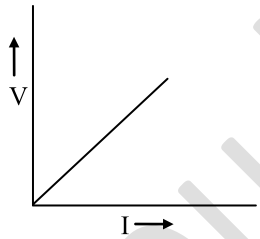
(1) 24 ohms (2) (44/9) ohm
(3) 26.4 ohms (4) 18.7 ohms

Q.7 A wire of resistance 2Ω is redrawn so that its length becomes four times. The resistance of the redrawn wire is –
(1) 2Ω (2) 8Ω (3) 16Ω (4) 32Ω

Q.8 Two wires of equal lengths and of material (x) and (y) have same resistance. The ratio of the radii of two wires is 1 : 2. The ratio of the specific resistance of the two materials is –
(1) 1 : 1 (2) 1 : 2 (3) 1 : 4 (4) 4 : 1

Q.9 A wire is cut into 4 pieces, which are put together side by side to obtain one conductor. If the original resistance of the wire was (R). The resistance of the bundle will be -
(1) R/4 (2) R/8
(3) R/16 (4) R/32

Q.10 The current -voltage variation for a wire of copper of length (L) and area (A) is shown in fig. The slope of the line will be -



(1) less if experiment is done at a higher temperature
(2) more if a wire of silver of same dimensions is used
(3) will be doubled if the lengths of the wire is doubled
(4) will be halved if the length is doubled

Q.11 The internal resistance of cell is 0.1Ω and its emf is 2V. When a current of 2A is being drawn from it, the potential difference across its terminals will be -
(1) more than 2V (2) 2V
(3) 1.8V (4) none of the above

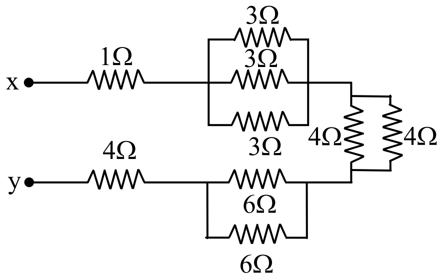
Q.12 A dry cell has an e.m.f of 1.5V and internal resistance 0.5Ω. If the cell sends a current of 1A through an external resistance the p.d. of the cell will be -
(1) 1.5V (2) 1V
(3) 0.5V (4) 0V

Q.13 Twelve wires of equal resistance (R) are connected to form a cube. The effective resistance between two diagonal ends will be -
(1) 5/6 R (2) 6/5 R
(3) 3R (4) 12 R

Q.14 A wire has resistance 12 ohms. It is bent in the form of a circle. The effective resistance between the two points on any diameter of the circle is -
(1) 12 Ω (2) 24Ω (3) 6 Ω (4) 3Ω

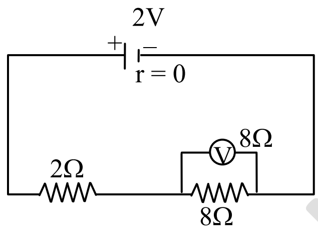
Q.15 Five cells each of e.m.f (E) and internal resistance (r) are connected in series. If due to oversight one cell is connected wrongly ,then the equivalent e.m.f and internal resistance of the combination is -
(1) 5E and 5r (2) 3E and 3r
(3) 3E and 5r (4) 5E and 4r

Q.16 In fig the equivalent resistance between points (x) and (y) -



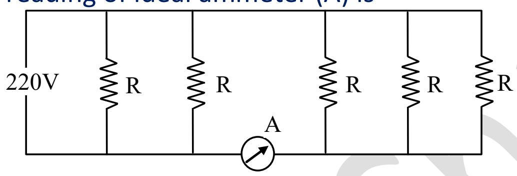
(1) 16Ω (2) 14 Ω (3) 11Ω (4) 18Ω

Q.17 In the circuit shown in fig, the reading of voltmeter is -



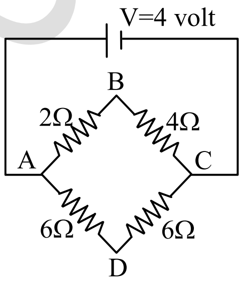
(1) 1.33 V (2) 0.8 V
(3) 2.0 V (4) 1.6V

Q.18 Five identical lamps each resistance R = 1100Ω are connected to 220V as shown in fig. The reading of ideal ammeter (A) is -



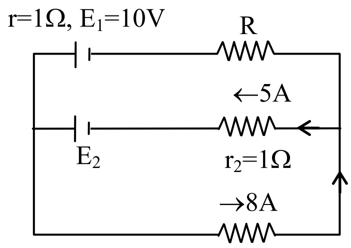
(1) 1/5 A (2) 2/5 A
(3) 3 /5 A (4) 1 A

Q.19 If fig. the difference of potential between (B) and (D) is -



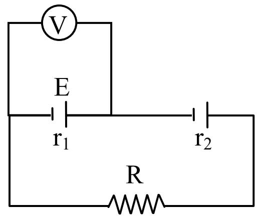
(1) + 0.67V (2) –0.67V
(3) 2V (4) 1.33V

Q.20 In fig the current through resistance (R) is -



(1) 3A (2) 13A
(3) 6.5 A (4) 9A

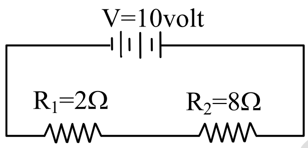
Q.21 In the adjoining figure, the reading of an ideal voltmeter (V) is zero. Then the relation between R , r_1 , and r_2 is -



(1) $R = r_2 - r_1$ (2) $R = r_1 - r_2$

(3) $R = r_1 + r_2$ (4) $R = \frac{r_1 . r_2}{r_1 + r_2}$

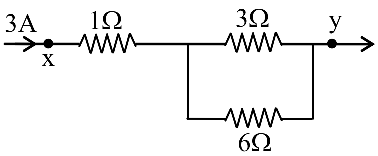
Q.22 In fig the ratio of power dissipated in resistors R_1 and R_2 is -



(1) 1 : 4 (2) 4 : 1

(3) 1 : 2 (4) 2 : 1

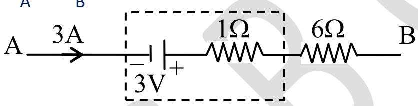
Q.23 In fig the ratio of current in 3Ω and 1Ω resistance is -



(1) 1 (2) 1/3

(3) 2/3 (4) 3

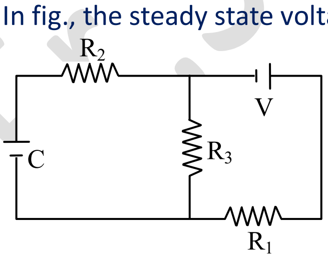
Q.24 Fig represents a part of a closed circuit. The potential difference between (A) and (B) i.e. $V_A - V_B$ is -



(1) 24 V (2) 0V

(3) 6V (4) 18 V

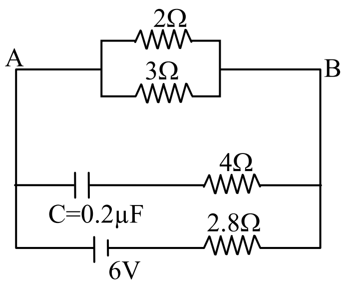
Q.25 In fig., the steady state voltage drop across capacitor (C) is -



(1) V (2) $\frac{VR_1}{\left[R_3\left(\frac{R_1.R_3}{R_1+R_3}\right)\right]}$

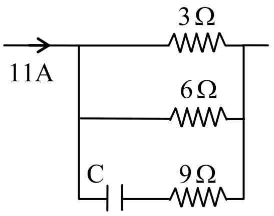
(3) $\frac{VR_3}{R_1+R_3}$ (4) $\frac{VR_1}{R_1+R_3}$

Q.26 In fig the steady state current in 2Ω resistance is-



(1) 1.5 A (2) 0.9 A
(3) 0.6 A (4) zero

Q.27 In fig the current in 3Ω and 6Ω resistance are respectively-



(1) 7.33 A , 3.067A (2) 3.67A , 7.33 A
(3) 6A , 3A (4) 3A , 6A

Q.28 A battery of 20 cells (each having e.m.f 1.8V and internal resistance 0.1ohm) is charged by 220 volts and the charging current is 15A. The resistance to be put in the circuit is -
(1) 10.27 ohm (2) 12.27 ohm
(3) 8.62 ohms (4) 16.24 ohms

Q.29 A battery is connected in series with an external resistance. The current in circuit is 1amp. and 0.7 amp When external resistance equals 5Ω and 8Ω respectively the internal resistance of the battery is -
(1) 0.2Ω (2) 0.5Ω
(3) 2Ω (4) 0.6 Ω

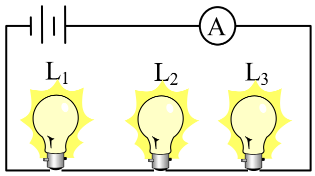
Q.30 In the above question the maximum current is -
(1) 8 amp (2) 4 amp
(3) 3.5 amp. (4) 1 amp

Q.31 A house is served by a 220V supply line . In a circuit protected by a fuse marked 9A. The maximum number of 60W lamps in parallel that can be turned on is -
(1) 44 (2) 20 (3) 22 (4) 33

Q.32 The two head lamps of a car are in parallel and they together consume 48 watts with the help of a 6V battery. The resistance of each bulb is -
(1) 0.67 ohm (2) 3.0 ohms
(3) 4.0 ohms (4) 1.5 ohms

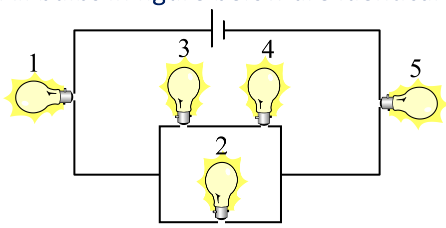
Q.33 A 25 watt , 220 volt bulb and a 100 watt, 220 volt bulb are connected in series across a 440 volt line -
(1) only 100 watt bulb will fuse
(2) only 25 watt bulb will fuse
(3) both bulbs will fuse
(4) none of the bulb will fuse

Q.34 In the circuit below, ammeter (A) reads 0.5A. Bulbs L_1 and L_2 are brightly lit, but L_3 is not lit. What is the reason for L_3 not being lit ?



(1) the ammeter is faulty
(2) the filament of L_3 is broken
(3) the resistance of L_3 is much lower than that of L_1 and L_2
(4) there is a break in the connecting wire between L_2 and L_3

Q.35 All bulbs in figure below are identical which, bulbs light most brightly -



(1) 1 only (2) 2 only
(3) 3 and 4 only (4) 1 and 5

Q.36 A cell of e.m.f (E) volt and internal resistance (r) ohms is connected to an external resistance of (r) ohms. The potential difference across the terminals of the cell will be
(1) E volt (2) E/2 Volt
(3) E/4 volt (4) 2E volt

Q.37 When a cell is connected to 1 ohm resistance, 1 ampere current flows through the circuit. When 3 ohm resistance issued then 0.5 amp current flows, then internal resistance of the cell is -
(1) 1Ω (2) $1.5\ \Omega$ (3) $2\ \Omega$ (4) $2.5\ \Omega$

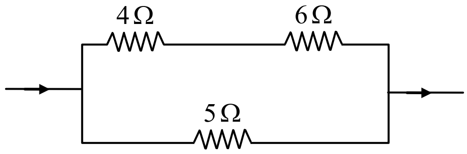
Q.38 An electric kettle has two coils. When one of these is switched on, the water in the kettle boils in 6 minutes. When the other coil is switched on, the water boils in 3 minutes. If the two coils are connected in series, the time taken to boil the water in the kettle is-
(1) 2 min. (2) 3 min.
(3) 6 min. (4) 9 min.

Q.39 In question 39, if the two coils are connected in parallel, then the total time taken to boil the water in kettle is -
(1) 2 minutes (2) 3 minutes
(3) 6 minutes (4) 9 minutes.

Q.40 A resistance coil of $60\ \Omega$ is immersed in 42 kg of water. A current of 7 A is passed through it. The rise in temperature of water per minutes is -
(1) 4ºC (2) 8ºC
(3) 1ºC (4) 12ºC

Q.41 A coil of wire of resistance 50Ω is embedded in a block of ice and a potential difference of 210 V is applied across it. the amount of ice which melts in 1 second is -
(1) 0.262 g (2) 2.62 g
(3) 26.2 g (4) 0.0262 g

Q.42 In the circuit shown in fig. the heat produced in 5 Ω resistor due to a current flowing in it is 10 cal/s. The heat produced in 4 Ω resistor is -



(1) 4 cal/s (2) 1 cal/s
(3) 2 cal/s (4) 3 cal/s

Q.43 'N' equal resistors connected in series across a source of e.m.f together dissipate 4 watts of power. The power dissipated when the same resistors are connected in parallel across the same source of e.m.f is 64 watts. The number of resistors 'N' is equal to -
(1) 8 (2) 4
(3) 16 (4) 2

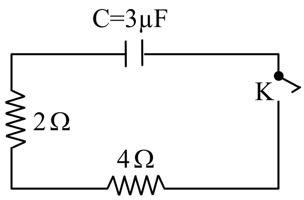
Q.44 The same mass of copper is drawn into two wires 1 mm thick and 2 mm thick. If the two wires are connected in series and the current is passed, the heat produced in the wires will be in the ratio -
(1) 2 : 1 (2) 4 : 1
(3) 1 : 16 (4) 16 : 1

Q.45 Forty 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 percentage with which the illumination of the bulbs will change will be -
(1) 10.25% (2) 7%
(3) 5% (4) 2.5%

Q.46 A cell of e.m.f. E and internal resistance r supplies currents for the same time t through external resistance R_1 = 100 Ω and R_2 = 40 Ω separately. If the heat developed in both the cases is the same, then the internal resistance of the cell is given by -
(1) 28.6 Ω (2) 70 Ω
(3) 63.3 Ω (4) 140 Ω

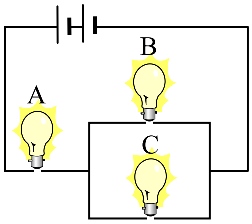
Q.47 Two bulbs of 500 watt and 200 watt are manufactured to operate on 220 volt line. The ratio of heat produced in 500 watt and 200 watt, in two cases, when first they are joined in series and secondly in parallel, will be -
(1) $\frac{5}{2}, \frac{2}{5}$ (2) $\frac{5}{2}, \frac{5}{2}$
(3) $\frac{2}{5}, \frac{5}{2}$ (4) $\frac{2}{5}, \frac{2}{5}$

Q.48 A capacitor of capacitance 3μF is first charged by connecting across a 10 V battery, then it is allowed to get discharged through 2Ω and 4Ω resistor by closing the key K fig. The total energy dissipated in 2Ω resistor is equal to -



(1) 0.15 mJ (2) 0.5 mJ
(3) 0.05 mJ (4) 1.0 mJ

Q.49 The bulbs A, B and C are connected as shown in fig. The bulbs B and C are identical. If the bulb C is fused -



(1) both A and B will glow more brightly
(2) both A and B will glow less brightly
(3) A will glow less brightly and B will glow more brightly
(4) A will glow more brightly and B will glow less brightly.

Q.50 How much electrical energy in kilo-watt hour is consumed in operating ten 50 watt bulbs for 10 hours per day in a month of 30 days ?
(1) 1500 (2) 15000 (3) 15 (4) 150

Q.51 A charge of 2×10^{-2} C moves at 30 revolution per second in a circle of diameter 0.80 m. The current linked with the circuit will be -
(1) 0.1 A (2) 0.2 A
(3) 0.4 A (4) 0.6 A

Q.52 The current in a copper wire is increased by increasing the potential difference between its end. Which one of the following statements regarding n, the number of charge carriers per unit volume in the wire and v the drift velocity of the charge carriers is correct -
(1) n is unaltered but v is decreased
(2) n is unaltered but v is increased
(3) n is increased but v is decreased
(4) n is increased but v is unaltered

Q.53 A wire of resistance 32 Ω is melted and drawn into a wire of half of its original length. The resistance of new wire and percentage decrease in resistance -
(1) 8Ω, 75% (2) 8Ω, 50%
(3) 16Ω, 75% (4) 16Ω, 50%

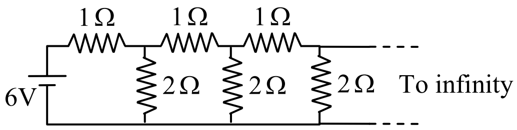
Q.54 Consider two conducting wires of same length and material, one wire is solid with radius r. The other is a hollow tube of outer radius 2r while inner r. The ratio of resistance of the two wires will be -
(1) 1 : 1 (2) 1 : 2 (3) 1 : 3 (4) 1 : 4

Q.55 A carbon and an aluminium wire connected in series. If the combination has resistance of 30 ohm at 0°C, what is the resistance of carbon and aluminium wire at 0°C so that the resistance of the combination does not change with temperature - [$\alpha_c = -0.5 \times 10^{-3}$ $(C°)^{-1}$ and $\alpha_{Al} = 4 \times 10^{-3}$ $(C°)^{-1}$]
(1) $\frac{10}{3}\Omega, \frac{80}{3}\Omega$ (2) $\frac{80}{3}\Omega, \frac{10}{3}\Omega$
(3) 10 Ω, 80 Ω (4) 80 Ω, 10 Ω

Q.56 A resistance R_2 is connected in parallel with a resistance R_1 what resistance R_3 must be connected in series with the combination of R_1 and R_2 so that the equivalent resistance is equal to the resistance R_1 -
(1) $\frac{R_1^2}{R_1 + R_2}$ (2) $\frac{(R_1 + R_2)^2}{R_1}$

(3) $\frac{R_2^2}{R_1+R_2}$ (4) $\frac{R_1^2}{R_2}$

Q.57 An infinite ladder network of resistance is constructed with 1Ω and 2Ω resistance. The 6V battery between A and B has negligible internal resistance. The current that passes through 2Ω resistance nearest to the battery is -



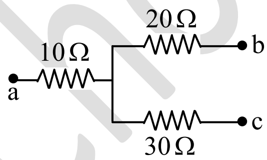
(1) 1A (2) 1.5 A
(3) 2 A (4) 2.5 A

Q.58 A potential difference of 200 V is applied to a coil at a temperature of 15°C and the current is 10A. What will be the mean temperature of the coil when the current has fallen to 5A, the applied voltage being the same as before -

(Given $\alpha = \frac{1}{234}$ C^{-1} at 0°C)

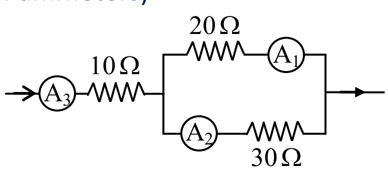
(1) 254° (2) 256°
(3) 258° (4) 264°

Q.59 In a given electric circuit the potentials at the points a, b and c are 30 V, 12 V and 2 V respectively. The current through resistors 10 Ω, 20 Ω and 30 Ω are -



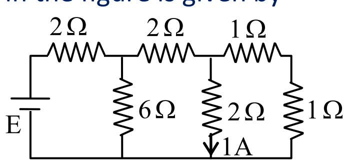
(1) 1, 0.4, 0.6 (2) 2, 0.8, 1.2
(3) 0.6 A, 0.4 A, 1A (4) None of these

Q.60 If the reading of ammeter A_1, in figure is 2.4 A, what will the ammeter A_2 and A_3 read ? (Neglecting the resistances of ammeters) -



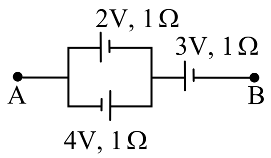
(1) 1.6 A, 2.3 A (2) 1.6 A, 4.0 A
(3) 4.0 A, 1.6 A (4) 2.3 A, 1.6 A

Q.61 The emf of the battery shown in the figure is given by -



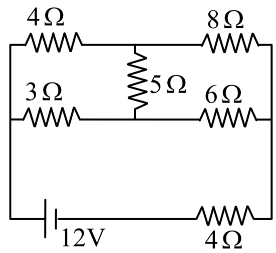
(1) 6 V (2) 12 V (3) 18 V (4) 8 V

Q.62 The potential difference between points A and B is -



(1) 2 V (2) 6 V (3) 4 V (4) 3 V

Q.63 In the given figure the ratio of current in 8Ω and 3Ω will be -



(1) $\frac{8}{3}$ (2) $\frac{3}{8}$ (3) $\frac{4}{3}$ (4) $\frac{3}{4}$

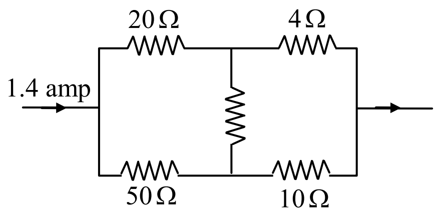
Q.64 Through an electrolyte, an electric current is due to drift of -
(1) Free electrons
(2) Free electrons and holes
(3) Positive and negative ions
(4) Protons

Q.65 A current flows in a wire of circular cross-section with the free electrons travelling with a mean drift velocity $\vec{v}$. If an equal current flows in a wire of twice the radius, new mean drift velocity is -
(1) $\vec{v}$ (2) $\vec{v}/2$
(3) $\vec{v}/4$ (4) None of these

Q.66 If a copper wire is stretched to make its radius decrease by 0.1%, then the percentage increase in resistance is approximately -
(1) 0.1% (2) 0.2%
(3) 0.4% (4) 0.8%

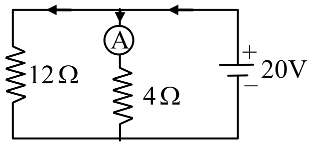
Q.67 There is a current of 1.344 amp in a copper wire whose area of cross-section normal to the length of the wire is 1mm^2. If the number of free electrons per cm^3 is 8.4 × 10^{22}, then the drift velocity would be -
(1) 1.0 mm per sec (2) 1.0 metre per sec
(3) 0.1 mm per sec (4) 0.01 mm per sec

Q.68 In the following figure the current through 4 ohm resistor is -



(1) 1.4 amp (2) 0.4 amp
(3) 1.0 amp (4) 0.7 amp

Q.69 In the following figure, the reading of the ammeter A when the internal resistance of the battery is zero, is -



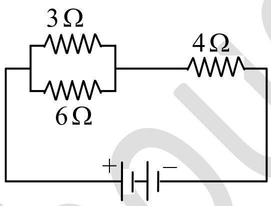
(1) $\frac{20}{3}$ amp (2) $\frac{20}{12}$ amp

(3) $\frac{20}{4}$ amp (4) $\left(\frac{20}{3}+\frac{20}{12}\right)$amp

Q.70 The number of dry cells, each of e.m.f. 1.5 volt and internal resistance 0.5 Ω that must be joined in series with a resistance of 20 ohm so as to send a current of 0.6 ampere through the circuit is -
(1) 2 (2) 8 (3) 10 (4) 12

Q.71 Two batteries of different e.m.f. and internal resistance are connected in series with each other and with an external load resistor. The current is 3.0 amp. When the polarity of one battery is reversed, the current becomes 1.0 amp. The ratio of the e.m.f. of the two batteries is -
(1) 2.5 (2) 2.0 (3) 1.5 (4) 1.0

Q.72 In the following figure, current through 3Ω resistor is 0.8 amp; then the potential drop through 4Ω resistor is -



(1) 9.6 V (2) 2.6 V
(3) 4.8 V (4) 1.2 V

Q.73 A cell supplies a current I_1 through a resistor of resistance R_1 and a current I_2 through a resistor of resistance R_2, then internal resistance of the cell is -
(1) $R_1 - R_2$ (2) $R_1 + R_2$
(3) $\frac{I_1R_2+I_1R_1}{I_1+I_1}$ (4) $\frac{I_2R_2-I_1R_1}{I_1-I_2}$

Q.74 The sides of a rectangular block are 2cm, 3cm and 4 cm. The ratio of maximum to minimum resistance between its parallel faces is -
(1) 4 (2) 3 (3) 2 (4) 1

Q.75 The current in a conductor varies with time t is $I = 2t + 3t^2$ where I is in ampere and t in seconds. Electric charge flowing through a section of conductor during t = 2 sec to t = 3 sec. is -
(1) 10 C (2) 24 C (3) 33 C (4) 44 C

Q.76 Two wires of resistance R_1 and R_2 have temperature coefficient of resistance α_1 and α_2, respectively. These are joined in series. The effective temperature coefficient of resistance is-
(1) $\frac{\alpha_1+\alpha_2}{2}$ (2) $\sqrt{\alpha_1\alpha_2}$
(3) $\frac{\alpha_1R_1+\alpha_2R_2}{R_1+R_2}$ (4) $\frac{\sqrt{R_1R_2\alpha_1\alpha_2}}{\sqrt{R_1^2+R_2^2}}$

Q.77 A long resistance wire is divided into 2n parts. Then n parts are connected in series and the other n parts in parallel separately. Both combinations are connected to identical supplies. Then the ratio of heat produced in series to parallel combinations will be -
(1) 1 : 1 (2) $1 : n^2$
(3) $1 : n^4$ (4) $n^2 : 1$

Q.78 Two bulbs 100 W, 250 V and 200 W, 250 V are connected in parallel across a 500 V line. Then-
(1) 100 W bulb will fused
(2) 200 W bulb will fused
(3) Both bulbs will be fused
(4) No bulb will fused

Q.79 A bulb rated 220 V, 100 W is connected across 160 V line. The power dissipated will be -
(1) 100 W (2) 75 W (3) 52 W (4) 26 W

Q.80 A uniform wire connected across a supply produces heat H per second. If the wire is cut into n equal parts and all the parts are connected in parallel across the same supply, the heat produced per second will be -
(1) $\frac{H}{n}$ (2) nH (3) n^2H (4) $\frac{H}{n^2}$

Q.81 Two electric bulbs 40 W, 200 V and 100 W, 200 V are connected in series. Then the maximum voltage that can be applied across the combination, without fusing either bulb is -
(1) 280V (2) 400V (3) 3000V (4) 200V

Q.82 The resistance of 3Ω and 6Ω are joined in series and connected across a battery of emf 10 V and internal resistance 1Ω. The power dissipated by battery is -
(1) 3 W (2) 8 W (3) 9 W (4) 10 W

Q.83 A 24 V battery of internal resistance 4Ω is connected to a variable resistor. The rate of heat production in the resistor is maximum when the current in the circuit is –
(1) 2 A (2) 3 A (3) 4 A (4) 6 A

Q.84 In the Bohr's model of hydrogen atom, the electron moves around the nucleus in a circular orbit of radius 5×10^{-11} m. Its time period is
1.5×10^{-16} s. The current associated with the electron motion is-
(1) zero (2) 1.6×10^{-19} A
(3) 0.17 A (4) 1.07×10^{-3} A

Q.85 Three copper wire of lengths and cross-sectional areas are (ℓ, A) ; $\left(2\ell, \frac{A}{2}\right)$ and $\left(\frac{\ell}{2}, 2A\right)$.
Resistance is minimum is-
(1) wire of cross-sectional area $\frac{A}{2}$
(2) wire of cross-sectional area A
(3) wire of cross-sectional area 2A
(4) same is all the three cases

Q.86 When a piece of aluminium wire of finite length is drawn through a series of dies to reduce its diameter to half its original value, its resistance will become-
(1) two times (2) four times
(3) eight times (4) sixteen times

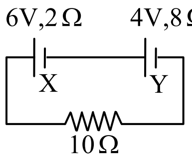
Q.87 Assume that each atom of copper contributes one free electron. The density of copper is $9 gcm^{-3}$ and atomic weight of copper is 63. If the current flowing through a copper wire of 1mm diameter is 1.1 ampere, the drift velocity of electrons will be-

(1) 0.01 mm/s (2) 0.02 mm/s
(3) 0.2 mm/s (4) 0.1 mm/s

Q.88 A metal wire of resistance R is cut into three equal pieces that are then connected side by side to form a new wire, the length of which is equal to one third of the original length. The resistance of this new wire is-

(1) R (2) 3R (3) $\frac{R}{9}$ (4) $\frac{R}{3}$

Q.89 Two cells X and Y are connected to a resistance of 10Ω as shown in the figure. The terminal voltage of cell Y is-



(1) zero (2) 2V (3) 4V (4) 10V

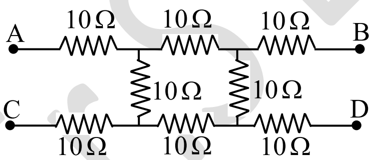
Q.90 Masses of three wires of same metal are in the ratio 1 : 2 : 3 and their lengths in the ratio 3 : 2 : 1. Electrical resistance of these wires will be in the ratio of -

(1) 1 : 1 : 1 (2) 1 : 2 : 3
(3) 9 : 4 : 1 (4) 27 : 6 : 1

Q.91 As the temperature of a metallic resistor is increased, the product of resistivity and conductivity-

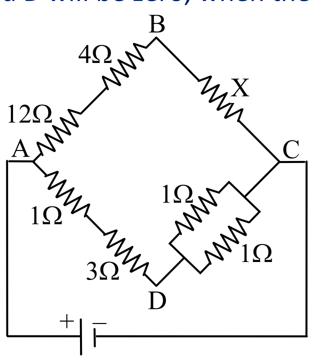
(1) increases
(2) decreases
(3) may increase or decrease
(4) remains constant

Q.92 What will be the equivalent resistance between the A and D ?



(1) 10 Ω (2) 20 Ω (3) 30 Ω (4) 40Ω

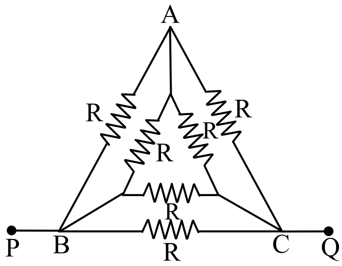
Q.93 In the arrangement of resistances shown in the circuit, the potential difference between points B and D will be zero, when the unknown resistance X is –



(1) 4Ω (2) 3Ω (3) 2Ω (4) 1Ω

Q.94 It is observed in a potentiometer experiment that no current passes through the galvanometer, when the terminals of the cell are connected across a certain length of the potentiometer wire. On shunting the cell by a 2Ω resistance, the balancing length is reduced to half. The internal resistance of the cell is-
(1) 4Ω (2) 2Ω (3) 9Ω (4) 18Ω

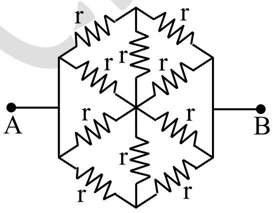
Q.95 The resistance across P and Q in the given figure is-



(1) $\frac{R}{3}$ (2) $\frac{R}{2}$
(3) 2R (4) 6R

Q.96 When no current, is passed through conductor-
(1) the free electrons do not move
(2) the average speed of a free electron over a large period of time is zero
(3) the average velocity of a free electron over a large period of time is zero
(4) the average of square of velocities of all the free electrons at an instant is zero

Q.97 The resistance of the circuit between A and B is-



(1) r (2) 0.5 r (3) 2r (4) 3r

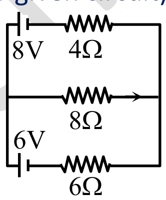
Q.98 The number of free electrons per 10 mm of an ordinary copper wire is about 2×10^{21}. The average drift speed of the electrons is 0.25 mm/sec. The current flowing is-
(1) 0.8 A (2) 8 A
(3) 80 A (4) 5 A

Q.99 The potential difference between the terminals of a cells is found to be 3 volts when it is connected to a resistance equal to its internal resistance. The e.m.f. of the cell is-
(1) 3V (2) 6V
(3) 1.5V (4) 4.5V

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3

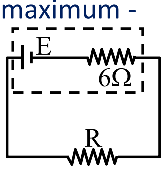
Q.1 Resistance of a galvanometer coil is 8Ω and 2Ω shunt resistance is connected with it. If main current is 1A then the current flow through 2Ω resistance will be-
(1) 0.2 A (2) 0.8 A (3)0.1 A (4) 0.4 A

Q.2 The current in 8Ω resistance is- (as per given circuit)



(1) 0.69 A (2) 0.92 A
(3) 1.30 A (4) 1.6 A

Q.3 The value of R for which power in it is maximum -



(1) 3Ω (2) 6Ω (3) 12Ω (4) 9Ω

Q.4 The current conduction in a discharge tube is due to-
(1) electrons only
(2) + ve ions and – ve ions
(3) (– ve) ions and electrons
(4) (+ ve) ions and electrons

Q.5 A car battery of e.m.f. 12V and internal resistance 5×10^{-2}Ω, receives a current of 60 A from an external source, then terminal potential difference of battery is -
(1) 32 V (2) 10 V (3) 15 V (4) 50 V

Q.6 If specific resistance of a potentiometer wire is $10^{-7}\Omega$m and current flow through it is 0.1 amp., cross-sectional area of wire is $10^{-6}m^2$ then potential gradient will be -
(1) 10^{-2} volt/m (2) 10^{-4} volt/m
(3) 10^{-6} volt/m (4) 10^{-8} volt/m

Q.7 The resistance of each arm of the wheat stone bridge is 10Ω. A resistance of 10Ω is connected in series with galvanometer then the equivalent resistance across the battery will be -
(1) 10 Ω (2) 15 Ω
(3) 20 Ω (4) 40 Ω

Q.8 Copper and silicon are cooled from 300 K to 60K, the specific resistance -
(1) decrease in copper but increase in silicon
(2) increase in copper but decrease in silicon
(3) increase in both
(4) decrease in both

Q.9 Specific resistance of a conductor increases with-
(1) increase in temperature
(2) increase in cross-section area
(3) increase in cross-section and decrease in length.
(4) decrease in cross-section area.

Q.10 For a cell terminal potential difference is 2.2 V when circuit is open and reduces to 1.8 V when cell is connected to a resistance of R = 5Ω then determine internal resistance of cell is -
(1) $\frac{10}{9}\Omega$ (2) $\frac{9}{10}\Omega$
(3) $\frac{11}{9}\Omega$ (4) $\frac{5}{9}\Omega$

Q.11 To convert a galvanometer into a voltmeter one should connect a -
(1) high resistance in series with galvanometer.
(2) low resistance in series with galvanometer.
(3) high resistance in parallel with galvanometer.
(4) low resistance in parallel with galvanometer

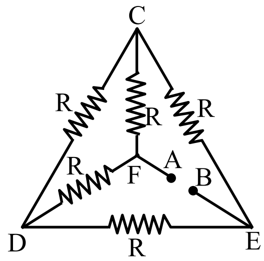
Q.12 The electric resistance of a certain wire of iron is R. If its length and radius both are doubled, then-
(1) the resistance will be halved and the specific resistance will remain unchanged
(2) the resistance will be halved and the specific resistance will be doubled
(3) the resistance and the specific resistance, will both remain unchanged
(4) the resistance will be doubled and the specific resistance will be halved

Q.13 A galvanometer acting as a voltmeter will have-
(1) a high resistance in series with its coil
(2) a low resistance in parallel with its coil
(3) a low resistance in series with its coil
(4) a high resistance in parallel with its coil

Q.14 A bullet of mass 2 g. is having a charge of 2μC. Through what potential difference must it be accelerated, starting from rest, to acquire a speed of 10 m/s ?
(1) 50 kV (2) 5 V (3)50 V (4) 5 kV

Q.15 A battery is charged at a potential of 15V for 8 hours when the current flowing is 10A. The battery on discharge supplies a current of 5 A for 15 hours. The mean terminal voltage during discharge is 14 V. The ''Watt hour'' efficiency of the battery is -
(1) 80% (2) 90% (3)87.5% (4) 82.5%

Q.16 Five equal resistances each of resistance R are connected as shown in the figure. A battery of V volts is connected between A and B. The current flowing in AFCEB will be -

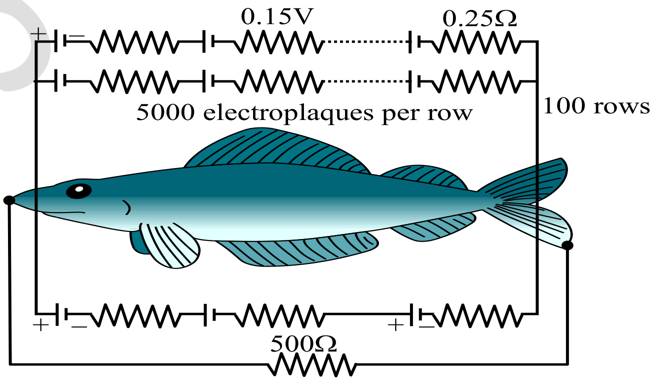


(1) V/R (2) V/2R (3) 2V/R (4) 3V/R

Q.17 A galvanometer of 50 ohm resistance has 25 divisions. A current of 4×10^{-4} ampere gives a deflection of one division. To convert this galvanometer into a voltmeter having a range of 25 volts, it should be connected with a resistance of -
(1) 245 Ω in parallel (2) 2550 Ω in series
(3) 2450 Ω in series (4) 2500 Ω in parallel

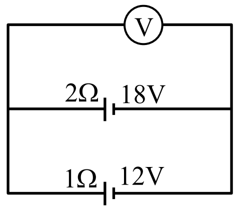
Q.18 A 6 volt battery is connected to the terminals of a three metre long wire of uniform thickness and resistance of 100 ohm. The difference of potential between two points on the wire separated by a distance of 50 cm will be -
(1) 3 volt (2) 1 volt
(3) 1.5 volt (4) 2 volt

Q.19 Eels are able to generate current with biological cells called electroplaques. The electroplaques in an Eel are arranged in 100 rows, each row stretching horizontally along the body of the fish containing 5000 electroplaques. The arrangement is suggestively shown below. Each electroplaques has an emf of 0.15 V and internal resistance of 0.25Ω. The water surrounding the Eel completes a circuit between the head and its tail. If the water surrounding it has a resistance of 500Ω, the current an Eel can produce in water is about -



(1) 1.5 A (2) 3.0 A
(3) 15 A (4) 30 A

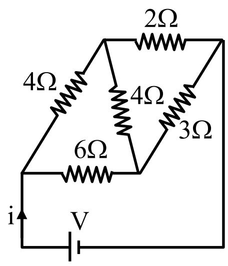
Q.20 Two batteries, one of emf 18 volts and internal resistance 2Ω and the other of emf 12 volt and internal resistance 1Ω, are connected as shown. The voltmeter V will record a reading of -



(1) 18 V (2) 30 V (3)14 V (4) 15 V

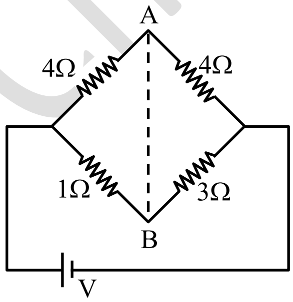
Q.21 When a wire of uniform cross-section a, length ℓ and resistance R is bent into a complete circle, resistance between any two of diametrically opposite points will be -
(1) R/2 (2) R/4 (3)R/8 (4) 4R

Q.22 For the network shown in the figure the value of the current i is -



(1) 18V/5 (2) 5V/9
(3) 9V/35 (4) 5V/18

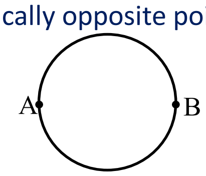
Q.23 In the circuit shown, if a conducting wire is connected between points A and B, the current in this wire will -



(1) flow from A to B
(2) flow in the direction which will be decided by the value of V
(3) be zero
(4) flow from B to A

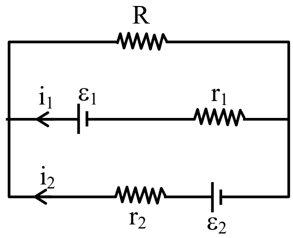
Q.24 The resistance of an ammeter is 13Ω and its scale is graduated for a current upto 100 amps. After and additional shunt has been connected to this ammeter it becomes possible to measure currents upto 750 amperes by this meter. The value of shunt resistance is -
(1) 2 kΩ (2) 20Ω (3) 2Ω (4) 0.2Ω

Q.25 A wire of resistance 12 ohms per meter 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 -



(1) 6Ω (2) 0.6πΩ (3) 3Ω (4) 6πΩ

Q.26 See the electrical circuit shown in this figure. Which of the following equations is a correct equation for it ?

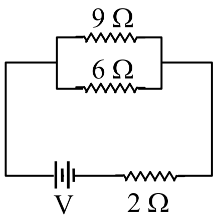


(1) $\varepsilon_1 - (i_1 + i_2)R + i_1r_1 = 0$
(2) $\varepsilon_1 - (i_1 + i_2)R - i_1r_1 = 0$
(3) $\varepsilon_2 - i_2r_2 - \varepsilon_1 - i_1r_1 = 0$
(4) $-\varepsilon_2 - (i_1 + i_2)R + i_2r_2 = 0$

Q.27 A galvanometer having a coil resistance of 60Ω shows full scale deflection when a current of 1.0 amp passes through it. It can be converted into an ammeter to read currents upto 5.0 amp by -
(1) putting in parallel a resistance of 15Ω
(2) putting in parallel a resistance of 240Ω
(3) putting in series a resistance of 15Ω
(4) putting in series a resistance of 240Ω

Q.28 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, then respectively, equal -
(1) –ε and r (2) ε and –r
(3) –r and ε (4) r and –ε

Q.29 If power dissipated in the 9Ω resistor in the circuit shown is 36 Watt, the potential difference across the 2 Ω resistor is :



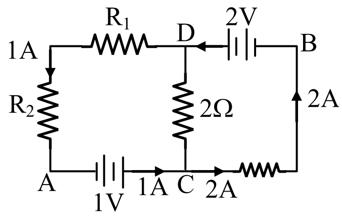
(1) 2 Volt (2) 4 Volt
(3) 8 Volt (4) 10 Volt

Q.30 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 :
(1) 1 Ω (2) 0.5 Ω
(3) 1/3 Ω (4) 1/4 Ω

Q.31 The rate of increase of thermo-e.m.f. with temperature at the neutral temperature of a thermocouple :
(1) is negative

(2) is positive
(3) is zero
(4) depends upon the choice of the two materials of the thermocouple.

Q.32 In the circuit shown in the figure, if the potential at point A is taken to be zero, the potential at point B is



(1) +1 V (2) – 1 V
(3) +2 V (4) – 2 V

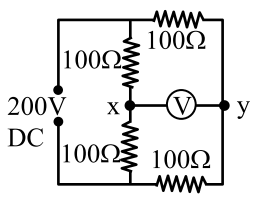
Q.33 A galvanometer of resistance, G, is shunted by a resistance S ohm. To keep the main current in the circuit unchanged the resistance to be put in series with the galvanometer is

(1) $\frac{G}{(S+G)}$ (2) $\frac{S^2}{(S+G)}$
(3) $\frac{SG}{(S+G)}$ (4) $\frac{G^2}{(S+G)}$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM - 4

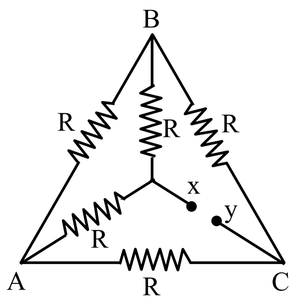
Q.1 There are eight resistances of R ohm each. Two-two resistances are connected in parallel to form couples and these couples are connected in series, then the total resistance of this combination is
(1) R/2 (2) 2R
(3) 4R (4) 8R

Q.2 For the following circuit the potential difference between x and y in volt is -



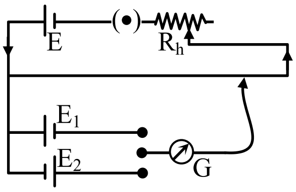
(1) 10 (2) 50
(3) 100 (4) 0

Q.3 The value of total resistance between x and y in ohm is -



(1) R (2) 3R
(3) 4R (4) 5R

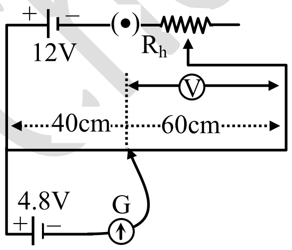
Q.4 The following diagram shows the circuit for the comparison of e.m.f. of the cells. The circuit can be corrected by -



(1) Reversing the terminals of E
(2) Reversing the terminals of E_1
(3) Reversing the terminals of E_2
(4) Reversing the current in Rh.

Q.5 Two similar cells are connected first in series and then in parallel, the ratio of balancing length on the potentiometer wire will be -
(1) 1 : 2 (2) 2 : 1
(3) 1 : 4 (4) 4 : 1

Q.6 In the following circuit, the reading of the voltmeter will be - (in volt)

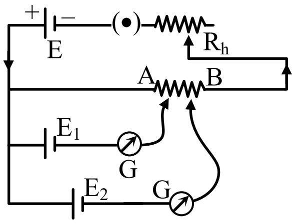


(1) 7.2 (2) 4.8
(3) 6 (4) 4

Q.7 The resistance of a wire is 50 ohm. Then the graph between log V and log I is -
(1) straight line (2) parabola
(3) hyperbola (4) circle

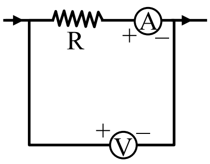
Q.8 The resistance of wire is 20 ohm. The wire is stretched to three times of its length. Then the resistance will be-
(1) 6.67 Ω (2) 60 Ω
(3) 120 Ω (4) 180 Ω

Q.9 In the following diagram, the deflection in the galvanometer in a potentiometer circuit is zero, then -



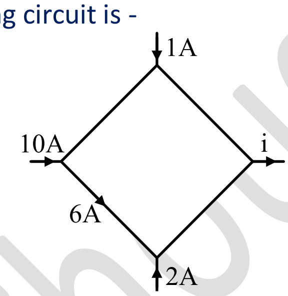
(1) $E_1 > E_2$ (2) $E_2 > E_1$
(3) $E_1 = E_2$ (4) $E_1 + E_2 = E$

Q.10 In the following circuit, the resistance of a voltmeter is 10,000 Ω and that of an ammeter is 20Ω. If the reading of an ammeter is 0.1 amp. and that of voltmeter is 12 volt, then the value of R is -



(1) 122 Ω (2) 100 Ω
(3) 118 Ω (4) 116 Ω

Q.11 Value of current i in the following circuit is -

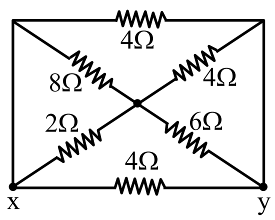


(1) 13 A
(2) 12 A
(3) 9 A
(4) none of the above

Q.12 Which of the following wires of the same material will have higher resistance-
(1) radius is 1 mm and the length is 40 m.
(2) radius is 2 mm and the length is 40 m.
(3) radius is 1 mm and the length is 80 m.
(4) radius is 2 mm and the length is 80 m.

Q.13 The resistance of galvanometer is G ohm and the range is 1 volt. The value of resistance used to convert it into a voltmeter of range 10 volt is-
(1) 9G (2) G
(3) $\frac{1}{9}$ G (4) 10 G

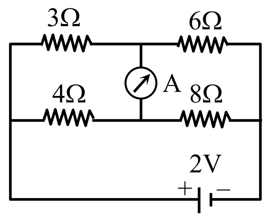
Q.14 The total resistance between x and y in ohm is -



(1) 1Ω (2) 4Ω

(3) $\frac{4}{3}\Omega$ (4) $\frac{2}{3}\Omega$

Q.15 The reading of Ammeter in ampere for following circuit is -



(1) 1 (2) 1.5
(3) zero (4) 2

Q.16 The emf of a standard cell is balanced at 150 cm length of a potentiometer wire. When this cell is shunted by a 2 ohm resistance, the null point is obtained at 100 cm. The value of internal resistance of the cell is -
(1) 0.1 ohm (2) 1 ohm
(3) 2 ohm (4) 0.5 ohm

Q.17 There are two wires of same material but length and diameter of first wire are double of the second wire. Then the resistance of first wire will be -
(1) double of the resistance of the second wire.
(2) half of the resistance of the second wire.
(3) equal to the resistance of the second wire.
(4) fourth times the resistance of the second wire.

Q.18 If the length of the wire is doubled, then the specific resistance will be -
(1) two times (2) $\frac{1}{2}$ times
(3) four times (4) same

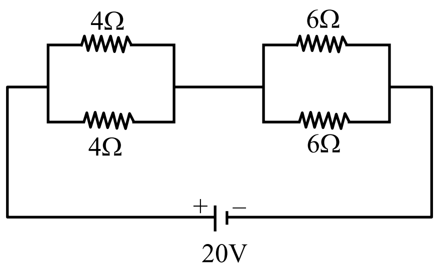
Q.19 The resultant resistance of n resistance wires each of r ohm is R, when they are connected in parallel. When these n resistance are connected in series, the resultant resistance will be -
(1) $\frac{R}{n}$ (2) $\frac{R}{n^2}$ (3) nR (4) n^2R

Q.20 A galvanometer of resistance 100Ω gives full defection for a current 10^{-5}A. The value of shunt required to convert it into a ammeter of range 1 ampere, is -
(1) 1Ω (2) $10^{-3}\Omega$
(3) $10^{-5}\Omega$ (4) 100Ω

Q.21 20% of the main current passes through the galvanometer. If the resistance of the galvanometer is G, then the resistance of the shunt will be -
(1) G/50 (2) G/4 (3) 50G (4) 9G

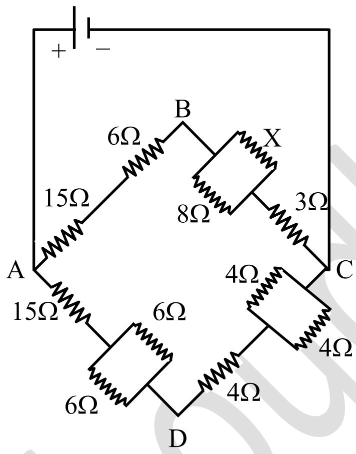
Q.22 Kirchhoff's first and second law shows the conservation of -
(1) linear momentum and angular momentum.
(2) charge and energy.
(3) mass and energy.
(4) charge and linear momentum.

Q.23 Four resistances are connected in a circuit as shown in the following diagram. The value of the current in ampere in 4 ohm and 6 ohm resistance are -



(1) 2 and 4 (2) 1 and 2
(3) 1 and 1 (4) 2 and 2

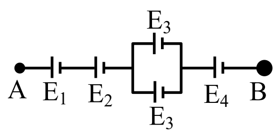
Q.24 In the following circuit diagram the value of resistance X for the potential difference between B and D is zero -



(1) 4 ohm (2) 6 ohm
(3) 8 ohm (4) 9 ohm

Q.25 The e.m.f. of a cell is 2.0 volt and the internal resistance is 0.1 ohm. It is connected with a resistance of 3.9 ohm. Then potential difference across the cell is -
(1) 0.20 V (2) 1.90 V
(3) 1.95 V (4) 2.00 V

Q.26 In the following circuit the resultant e.m.f. between AB is -



(1) $E_1 + E_2 + E_3 + E_4$
(2) $E_1 + E_2 + 2E_3 + E_4$
(3) $E_1 + E_2 + \frac{E_3}{2} + E_4$
(4) $E_1 + E_2 + \frac{E_3}{4} + E_4$

Q.27 The sensitivity of a potentiometer is increased by -
(1) increasing the emf of the cell.
(2) increasing the length of the potentiometer wire.
(3) decreasing the length of potentiometer wire.
(4) none of the above.

Q.28 A potential gradient is created in the wire by a standard cell for the comparison of emf's of two cells in a potentiometer experiment. Which possibility of the following will cause failure of the experiment ?
(1) the emf of the standard cell is higher than that of the other cells.
(2) the diameter of the wires is equal and similar.
(3) the number of wires is ten.
(4) the emf of the standard cell is less than those of both the cells.

Q.29 A voltmeter of 998 ohm resistance is connected to a cell of emf 2 volt, having internal resistance of 2 ohms. The error in measuring emf will be -
(1) 4×10^{-1}V (2) 2×10^{-3}V
(3) 4×10^{-3} V (4) 2×10^{-1} V

Q.30 The specific resistance of a metal wire is 64×10^{-6} $\Omega \times$ cm., the length is 198 cm and the resistance is 7Ω. The radius of wire is
(1) 2.4 cm (2) 0.24 cm
(3) 0.024 cm (4) 24 cm

Q.31 Which of the following statement is wrong -
(1) the resistance of a voltmeter is high.
(2) the resistance of an ammeter is low.
(3) an ammeter is connected in parallel with a conductor in the circuit.
(4) a voltmeter is connected in parallel with a resistance in the circuit.

Q.32 The resistance of the galvanometer is 25Ω it gives a full scale deflection when a current of 10mA is passed through it. The value of resistance R used in series to convert it into voltmeter of range 100 volt is -
(1) 10,000 Ω (2) 10025 Ω
(3) 975 Ω (4) 9975 Ω

Q.33 Which of the statement is wrong -
(1) when all resistance are equal, then the sensitivity of Wheatstone bridge is maximum.
(2) when the galvanometer and the cell are interchanged, then the balancing of wheat stone bridge will be effected.
(3) Kirchoff's first law for the currents meeting at the Junctions in an electric circuit shows the conservation of charge.
(4) Rheostat can be used as potential divider.

Q.34 In a meter bridge the null point is obtained at the middle point of the wire. If in one gap the resistance is 10Ω, then the value of resistance in the other gap is -
(1) 10 Ω (2) 5 Ω
(3) $\frac{1}{5}$ Ω (4) 500 Ω

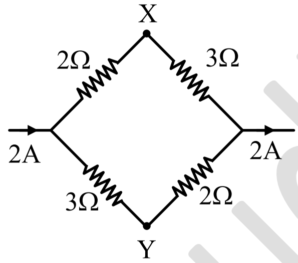
Q.35 A new electric store house of 1.5 emf of a flash gives a current of 15A, when it is connected with an electric ammeter of 0.04Ω, then the value of internal resistance of the electric store house is -
(1) 0.04Ω (2) 0.06Ω
(3) 0.10Ω (4) 10Ω

Q.36 In a torch there are two cells each of 1.45 volt and 0.15Ω. Each cell gives a current to filament of a lamp of 1.5Ω, then the value of current in ampere is -
(1) 16.11 (2) 1.611
(3) 0.1611 (4) 2.6

Q.37 In a potentiometer experiment a voltage source is balanced at 60 cm length where as a 3 volt battery is balanced at 45cm length. What is the voltage of unknown voltage source-
(1) 3V (2) 4V
(3) 4.5V (4) 6V

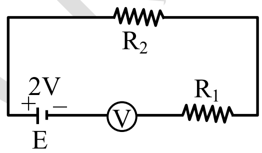
Q.38 A potential difference V is applied across a copper wire of diameter d and length L. When only d is doubled, the drift velocity -
(1) increases two times
(2) decreases $\frac{1}{2}$ times
(3) does not change
(4) decreases $\frac{1}{4}$ times

Q.39 Find the potential difference between X and Y in volt is -



(1) 1 (2) –1 (3)2 (4) –2

Q.40 A cell of e.m.f. 2V and negligible internal resistance is connected to resistor R_1 and R_2 as shown in the figure. The resistance of the voltmeter, R_1 and R_2 are 80Ω, 40Ω and 80Ω respectively. The reading of the voltmeter is -

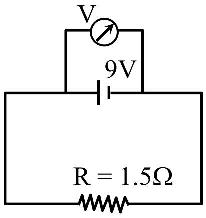


(1) 1.78 V (2) 1.60 V
(3)0.80 V (4) 1.33 V

Q.41 Potentiometer wire length is 10 m, having a total resistance of 10Ω. If a battery of emf 2 volt (negligible internal resistance) and a rheostat is connected to it then potential gradient is 20mV/m find the resistance applied through rheostat -
(1) 90Ω (2) 990Ω
(3) 40Ω (4) 190Ω

Q.42 In a potentiometer, a standard cell of 1.1V is balanced through a length of 7.04m For calibration of ammeter the resistance of 1Ω is balanced through a length of 0.64m if the reading of ammeter is 0.11 amp. Then error in measurement is -
(1) 0.01 A (2) – 0.01 A
(3) 1.0 A (4) – 1.0 A

Q.43 When a voltmeter is connected across the terminals of a cell, it measure 9 volt. If a resistance of 1.5Ω is connected across the terminals of a cell as shown in figure. Then current flowing through this resistance is

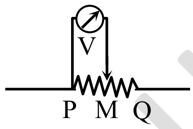


(1) 1.3 A (2) 6 A
(3) 9 A (4) 12 A

Q.44 The resistance of a coil in a platinum resistance thermometer at 0°C is 5 ohm and at 100°C it is 5.75 ohm. Its resistance at an unknown temperature is 5.15 ohm. Then the unknown temperature will be -
(1) 40°C (2) 10°C (3)15°C (4) 20°C

Q.45 Eight identical cells each of potential E and internal resistance r are connected in series to form a closed circuit. An ideal voltmeter connected across 2 cells will read-
(1) 13 E (2) zero (3) 2 E (4) 10 E

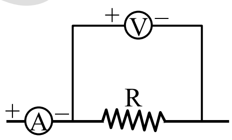
Q.46 P, Q is a uniform wire of resistance 2000 Ω and M the mid point of PQ. A voltmeter of resistance 1000 Ω is connected between P and M. The reading of the voltmeter, when, the potential difference applied between PQ is 150 volt will be -



(1) 150 V (2) 100 V (3) 75 V (4) 50 V

Q.47 Two rods A and B made up of same metal have same length. The ratio of their resistances is 1 : 2. If these rods are immersed in water then loss in weight will be -
(1) more in A (2) more in B
(3) same in A and B (4) in the ratio 1 : 2

Q.48 A student connects a voltmeter, ammeter and resistance according to the circuit given. If the voltmeter reading is 20 V and ammeter reading is 4 A, then the resistance will be -

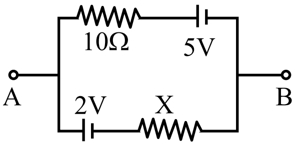


(1) equal to 5Ω
(2) more than 5Ω
(3) less than 5Ω
(4) more of less depending on the material of wire

Q.49 A potentiometer wire of 10 m length and having a resistance of 1 ohm/m is connected to an accumulator of emf 2.2 volt and a high resistance box. To obtain a potential gradient of 2.2mV/m, the value of resistance used from the resistance box is -
(1) 790 ohm (2) 810 ohm
(3) 990 ohm (4) 1000 ohm

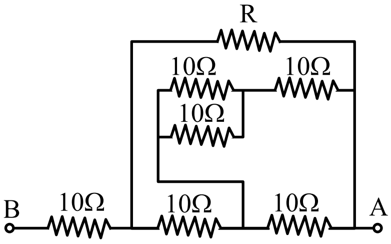
Q.50 For two wires A and B of same material and of same mass, the radius of A is double that of B. If the resistance of wire A is 34 Ω, then that of B will be -
(1) 544 Ω (2) 272 Ω
(3) 68 Ω (4) 17 Ω

Q.51 In the following circuit if V_{AB} = 4V, then the value of resistance X in ohms will be -



(1) 5 (2) 10 (3) 15 (4) 20

Q.52 For the network of resistance shown in the figure the equivalent resistance of the network between the points A and B is 18 Ω. The value of unknown resistance R is -



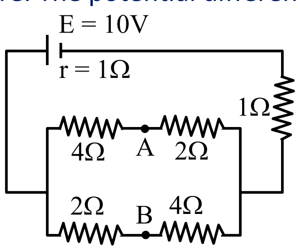
(1) 8 Ω (2) 10 Ω
(3) 16 Ω (4) 24 Ω

Q.53 When a potential difference is applied across the ends of a linear metallic conductor -
(1) the free electrons are accelerated continuously from the lower potential end to the higher potential end of the conductor
(2) the free electrons are accelerated continuously from the higher potential end to the lower potential end of the conductor
(3) the free electrons acquire a constant drift velocity from the lower potential end to the higher potential end of the conductor
(4) the free electrons are set in motion from their position of rest

Q.54 A current of 2A is flowing through a cell of e.m.f. 5 V and internal resistance 0.5Ω from negative to positive electrode. If the potential of negative electrode is 10 V, the potential of positive electrode will be -
(1) 5V (2) 14V
(3) 15V (4) 16V

Q.55 100 cells, each of e.m.f. 5V and internal resistance 1Ω, are to be arranged so as to produce maximum current in a 25Ω resistance. Each row is to contain equal number of cells. The number of rows should be -
(1) 2 (2) 4
(3) 5 (4) 10

Q.56 In the circuit shown below, the cell has an e.m.f. of 10 V and internal resistance of 1 Ω. The other resistance are shown in the figure. The potential difference $V_A - V_B$ is

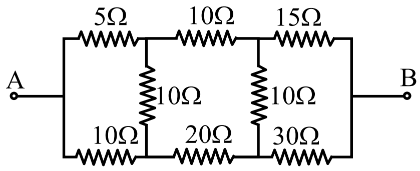


(1) 6V (2) 4V (3) 2V (4) −2V

Q.57 Two resistance R_1 and R_2 are made of different materials. The temperature coefficient of the material of R_1 is α and of the material of R_2 is $-\beta$. The resistance of the series combination R_1 and R_2 will not change with temp., then ratio of resistance of two wire at 0°C will be -

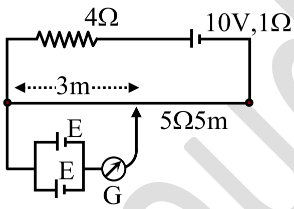
(1) $\frac{\alpha}{\beta}$ (2) $\frac{\alpha+\beta}{\alpha-\beta}$ (3) $\frac{\alpha^2+\beta^2}{\alpha\beta}$ (4) $\frac{\beta}{\alpha}$

Q.58 In the arrangement of resistances shown below. The effective resistance between point A and B is -



(1) 20 Ω (2) 30 Ω
(3) 90 Ω (4) 110 Ω

Q.59 A resistance of 4Ω and a wire of length 5 m and resistance 5Ω are joined in series and connected to a cell of e.m.f. 10V and internal resistance 1Ω. A parallel combination of two identical cells is balanced across 300 cm of the wire. The e.m.f. E of each cell is -



(1) 1.5V (2) 3.0V (3)0.67V (4) 1.33V

Q.60 The resistance of a galvanometer is 50Ω and the current required to give full scale deflection is 100μA. In order to convert it into an ammeter, reading upto 10A, it is necessary to put a resistance of -

(1) 5×10^{-3} Ω in parallel
(2) 5×10^{-4} Ω in parallel
(3) 10^5 Ω in series
(4) 99, 950 Ω in series

Q.61 The resistivity of a wire depends on its -

(1) length (2) area of cross section
(3) shape (4) material

Q.62 The conductivity of a super conductor is -

(1) infinite (2) very large
(3) very small (4) zero

Q.63 Electromotive force of a cell is basically a -

(1) force (2) power
(3) work (4) current capacity

Q.64 A battery of 10V and internal resistance 0.5Ω is connected across a variable resistance R. The value of R for which the power delivered in its maximum state, is equal to -

(1) 0.5Ω (2) 1Ω (3) 1.5Ω (4) 2Ω

Q.65 A galvanometer has a resistance G and current i_a flowing in it, produces full scale deflection. If S_1 is the value of shunt which converts it into an ammeter of range 0 – i and S_2 is the value of the shunt for the range 0 – 2i. Then the ratio $\frac{S_1}{S_2}$ will be -

(1) 1 (2) 2

(3) $\frac{1}{2}\left(\frac{i-i_a}{2i-i_a}\right)$ (4) $\left(\frac{2i-i_a}{i-i_a}\right)$

Q.66 Constanton wire is used in making standard resistances, because its -
(1) specific resistance is low
(2) density is high
(3) temperature coeff. of resistance is negligible
(4) melting point is high

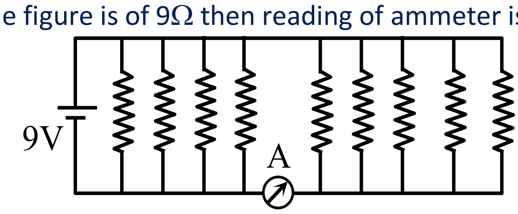
Q.67 When a resistance of 2 ohm is connected across the terminals of a cell, the current is 0.5A. When the resistance is increased to 5 ohm, the current is 0.25A. The e.m.f. of the cell is -
(1) 1.0 V (2) 1.5 V
(3) 2.0 V (4) 2.5 V

Q.68 Two non ideal batteries are connected in parallel consider the following statements:
(A) The equivalent emf is smaller than either of the two emfs
(B) The equivalent internal resistance is smaller than either of the two internal resistances
(1) both A and B are correct
(2) A is correct but B is wrong
(3) B is correct but A is wrong
(4) both A and B are wrong

Q.69 Equivalent resistance of series combination -
(1) is equals to mean of individual resistors
(2) is less than the lesser one
(3) is in between the smaller and bigger resistors
(4) is sum of individual resistors

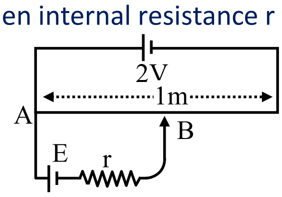
Q.70 The net resistance of a voltmeter should be large to ensure that -
(1) it does not get over heated
(2) it does not draw excessive current
(3) it can measure large potential difference
(4) it does not appreciably change the potential difference to be measured

Q.71 If each resistance in the figure is of 9Ω then reading of ammeter is -



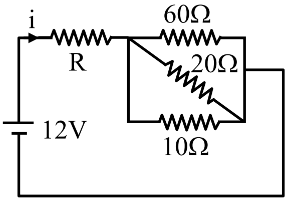
(1) 5A (2) 8A (3) 2A (4) 9A

Q.72 In figure battery E is balanced on 55 cm length of potentiometer wire but when a resistance of 10 Ω is connected in parallel with the battery then it balances on 50cm length of the potentiometer wire then internal resistance r of the battery is -



(1) 1 Ω (2) 3 Ω (3) 10 Ω (4) 5 Ω

Q.73 If i = 0.25 amp. in figure then value of R is -

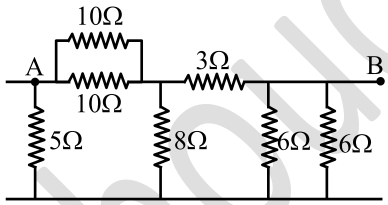


(1) 48 Ω (2) 12 Ω
(3) 120 Ω (4) 42 Ω

Q.74 A copper wire stretched so as to make it 0.1% longer. The percentage increase in the resistance of the wire is -
(1) 1.0 (2) 2.0
(3) 0.1 (4) 0.2

Q.75 10,000 electrons are passing per minute through a tube of radius 1 cm. The resulting current is -
(1) 10,000 A (2) 0.25×10^{-16} A
(3) 10^{-9} A (4) 0.5×10^{-19} A

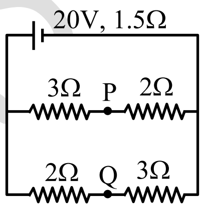
Q.76 Seven resistances are connected as shown in the figure. The equivalent resistance between A and B is -



(1) 3 Ω (2) 4 Ω
(3) 4.5 Ω (4) 5 Ω

Q.77 At what temperature will the resistance of a copper wire become three times its value at 0°C? [Temperature coefficient of resistance for copper = 4×10^{-3} per °C]
(1) 400°C (2) 450°C
(3) 500°C (4) 550°C

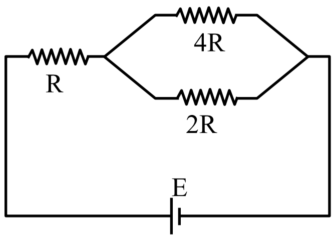
Q.78 In the circuit shown below, the internal resistance of the battery is 1.5 Ω and V_P and V_Q are the potentials at P and Q respectively. What is the potential difference between the points P and Q -



(1) zero (2) 4 volt ($V_P > V_Q$)
(3) 4 volt ($V_Q > V_P$) (4) 2.5 volt ($V_Q > V_P$)

Q.79 A cylindrical wire is stretched such that its length gets doubled but volume remains same, the resistance of wire becomes -
(1) four times (2) remains same
(3) half (4) becomes double

Q.80 In a network as shown in the figure the potential difference across the resistance 2R is (the cell has an emf of E and has no internal resistance) -

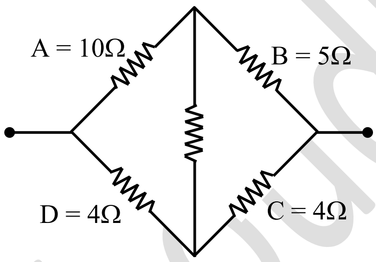


(1) 2E (2) 4E/7
(3) E/7 (4) E

Q.81 There are 8.4×10^{22} free electrons per cm^3 in copper. The current in the wire is 0.21 A ($e = 1.6 \times 10^{-19}$ C). Then the drifts velocity of electrons in a copper wire of 1 mm^2 cross section, will be -

(1) 2.12×10^{-5} m/s (2) 0.78×10^{-5} m/s
(3) 1.56×10^{-5} m/s (4) none of these

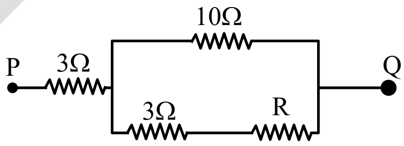
Q.82 In a typical wheatstone network the resistance in cyclic order are A = 10Ω, B = 5Ω, C = 4Ω and D = 4Ω for the bridge to be balanced -



(a) 10 Ω should be connected in parallel with A
(b) 10 Ω should be connected in series with A
(c) 5 Ω should be connected in series with B
(d) 5 Ω should be connected in parallel with B

(1) a, b (2) b, c
(3) a, c (4) all

Q.83 In the circuit shown here, what is the value of the unknown resistor R so that the total resistance of the circuit between points 'P' and 'Q' is also equal to R -

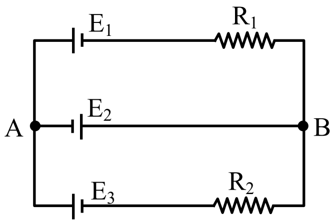


(1) 3 Ω (2) $\sqrt{39}$ Ω (3) $\sqrt{69}$ Ω (4) 10 Ω

Q.84 A battery has e.m.f. 4V and internal resistance 'r'. When this battery is connected to an external resistance of 2 ohms, a current of 1 amp. flows in the circuit. How much current will flow if the terminals of the battery are connected directly ?

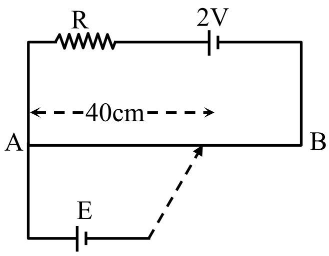
(1) 1A (2) 2A
(3) 4A (4) infinite

Q.85 In the circuit shown here, $E_1 = E_2 = E_3 = 2V$ and $R_1 = R_2 = 4$ ohms. The current flowing between points A and B through battery E_2 is -



(1) zero (2) 2 amp from A to B
(3) 2 amp from B to A (4) none of the above

Q.86 AB is a potentiometer wire of length 100 cm and its resistance is 10 ohm. It is connected in series with a resistance R = 40 ohm and a battery of e.m.f. 2V and negligible internal resistance. If a source of unknown e.m.f. E is balanced by 40 cm length of the potentiometer wire, the value of E is -



(1) 0.8 V (2) 1.6 V (3) 0.08 V (4) 0.16 V

Q.87 Three resistance of values 2Ω, 3Ω and 6Ω are to be connected to produce an effective resistance of 4Ω. This can be done by connecting -
(1) 3Ω resistance in series with the parallel combination of 2Ω and 6Ω
(2) 6Ω resistance in series with the parallel combination of 2Ω and 3Ω
(3) 2Ω resistance in series with the parallel combination of 3Ω and 6Ω
(4) 2Ω resistance in parallel with the parallel combination of 3Ω and 6Ω

Q.88 A battery of electro motive force E is connected in series with a resistance R and a voltmeter. An ammeter is connected in parallel with the battery -
(1) neither the ammeter nor the voltmeter will be damaged.
(2) both ammeter and voltmeter are likely to be damaged.
(3) only voltmeter is likely to be damaged
(4) only ammeter is likely to be damaged.

Q.89 Two resistance wires on joining in parallel the resultant resistance is $\frac{6}{5}$ ohm. One of the wire breaks, the effective resistance is 2 ohm. The resistance of the broken wire was -
(1) $\frac{3}{5}$ ohm (2) 2 ohm
(3) $\frac{6}{5}$ ohm (4) 3 ohm

Q.90 The temperature coefficient of resistance of a wire is 0.00125 per degree celcius. At 300 K its resistance is 1 ohm. The resistance of the wire will be 2 ohm at following temperature -
(1) 1154 K (2) 1127 K
(3) 600 K (4) 1400 K

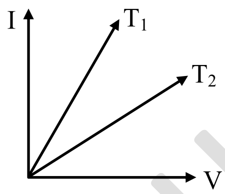
Q.91 There is a current of 40 ampere in a wire of 10^{-6} m^2 area of cross-section. If the number of free electron per m^3 is 10^{29}, then the drift velocity will be -

(1) 1.25×10^{3} m/s (2) 2.50×10^{-3} m/s
(3) 25.0×10^{-3} m/s (4) 250×10^{-3} m/s

Q.92 An ammeter and a voltmeter are joined in series to a cell. Their readings are A and V respectively. If a resistance is now joined in parallel with the voltmeter-
(1) both A and V will decrease
(2) both A and V will increase
(3) A will increase, V will decrease
(4) A will decrease, V will increase.

Q.93 A cell supplies a current of 0.9 A through a 2Ω resistor and a current of 0.3 A through a 7Ω resistor. The internal resistance of the cell is -
(1) 1.0 Ω (2) 0.5 Ω
(3) 2.0 Ω (4) 1.2 Ω

Q.94 The current voltage graph for a given metallic conductor at two different temperatures T_1 and T_2 are as shown in the figure. Then -



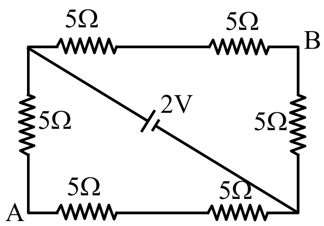
(1) $T_1 > T_2$
(2) $T_1 = T_2$
(3) nothing can be said about T_1 and T_2
(4) $T_1 < T_2$

Q.95 A galvanometer of 100Ω resistance gives complete deflection on flowing 10 mA current. What should be the value of shunt so that it can measure 100 mA -
(1) 11.11 Ω (2) 9.9 Ω
(3) 1.1 Ω (4) 4.4 Ω

Q.96 For changing the range of a galvanometer with G ohm resistance from V volt to nV, what will be the value of resistance connected in series to it -
(1) $(n-1)G$ (2) $\frac{G}{n}$
(3) nG (4) $\frac{G}{n-1}$

Q.97 N identical cells whether joined together in series or in parallel, give the same current, when connected to an external resistance of 'R'. The internal resistance of each cell is
(1) r = nR (2) r = R
(3) $r = \frac{R}{n}$ (4) $r = n^2R$

Q.98 The potential difference between the point A and B in the following circuit shown in the figure -



(1) $\frac{2}{3}$ volt (2) $\frac{4}{5}$ volt

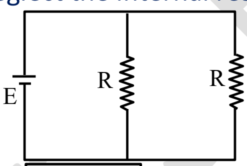
(3) $\frac{8}{9}$ volt (4) 2 volt

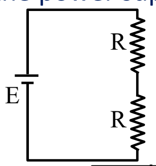
Q.99 In the potentiometer experiment if deflection in galvanometer is measured zero then current will becomes zero in
(1) potentiometer wire
(2) galvanometer circuit
(3) main circuit
(4) cell

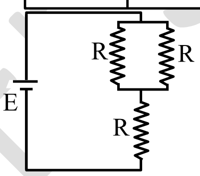
Q.100 Length of a potentiometer wire is kept more and uniform to active -
(1) uniform and more potential gradient
(2) non-uniform and more potential gradient
(3) uniform and less potential gradient
(4) non-uniform and less potential gradient

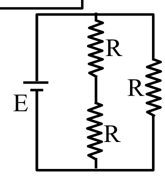
Q.101 The balancing length is obtained at 78.4 cm length while measuring the potential difference at the ends of a resistance wire. When same potential difference is measured with a voltmeter, it shows 1.20 volt. If a standard cell of emf 1.018 volt is balanced at 63.2 cm, the error in voltmeter reading in volt will be -
(1) – 0.06 (2) + 0.06
(3) – 0.03 (4) + 0.03

Q.102 Consider four circuits shown in the figure below. In which circuit power dissipated is greater (Neglect the internal resistance of the power supply) -

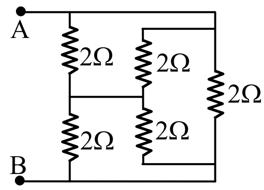
(1) 

(2) 

(3) 

(4) 

Q.103 The equivalent resistance across AB is-

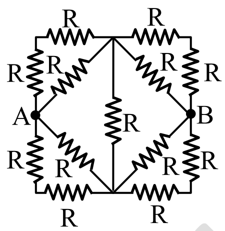


(1) 1Ω (2) 2Ω
(3) 3Ω (4) 4Ω

Q.104 There are three voltmeters of the same range but of resistance 10000 Ω, 8000 Ω and 4000 Ω respectively. The best voltmeter among these is the one whose resistance is-
(1) 10000 Ω
(2) 8000 Ω
(3) 4000 Ω
(4) all are equally good

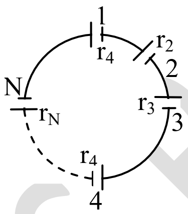
Q.105 When a voltmeter and an ammeter are connected respectively across the terminals of a cell, measures 5V and 10A. Now only a resistance of 2Ω is connected across the terminal of the cell. The current flowing through this resistance is-
(1) 7.5 A (2) 5.0 A
(3) 2.5 A (4) 2.0 A

Q.106 Thirteen resistance each of resistance R ohm are connected in the circuit as shown in the figure. The effective resistance between A and B is-



(1) $\frac{4R}{3}\Omega$ (2) 2RΩ
(3) R Ω (4) $\frac{2R}{3}\Omega$

Q.107 A group of N cells whose emf varies directly with the internal resistance as per the equation $E_N = 1.5\ r_N$ are connected as shown in the figure. The current I in the circuit is-



(1) 5.1 A (2) 0.51 A
(3) 1.5 A (4) 0.15 A

Q.108 A galvanometer has resistance 36Ω. If a shunt of 4Ω is added with this, then fraction of current that passes through galvanometer is-
(1) $\frac{1}{4}$ (2) $\frac{1}{9}$
(3) $\frac{1}{10}$ (4) $\frac{1}{40}$

Q.109 If 10^6 electrons/s are flowing through an area of cross section of 10^{-4} m^2 then the current will be-
(1) 1.6×10^{-7} A (2) 1.6×10^{-13} A
(3) 1×10^{-6} A (4) 1×10^{2} A

Q.110 The terminal voltage is $\frac{E}{2}$ when a current of 2A is flowing through 2Ω resistance, then the internal resistance of cell is-
(1) 1Ω (2) 2Ω (3) 3Ω (4) 4Ω

Q.111 A 1Ω voltmeter has range 1V. Find the additional resistance which has to join in series in voltmeter to increase the range of voltmeter to 100 V -

(1) 10 Ω (2) $\frac{1}{99}$ Ω (3) 99 Ω (4) 100 Ω

Q.112 The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be-

(1) 300% (2) 200%
(3) 100% (4) 50%

Q.113 The length of a wire of a potentiometer is 100 cm, and the emf of its standard cell is E volt. It is employed to measure the e.m.f. of a battery whose internal resistance is 0.5 Ω. If the balance point is obtained at ℓ = 30 cm from the positive end, the e.m.f. of the battery is-

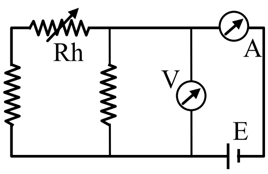
(1) $\frac{30\,E}{100}$ (2) $\frac{30\,E}{100.5}$

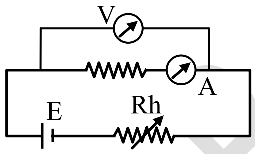
(3) $\frac{30\,E}{(100-0.5)}$ (4) $\frac{30\,(E-0.5)}{100}$

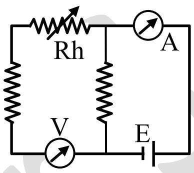
Q.114 Three unequal resistors in parallel are equivalent to a resistant 1 ohm. If two of them are in the ratio 1 : 2 and if no resistance value is fractional, the largest of the three resistance in ohms is-

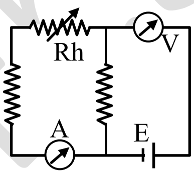
(1) 4 (2) 6
(3) 8 (4) 12

Q.115 Express which of the following setups can be used to verify Ohm's law-

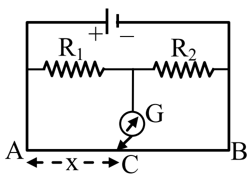
(1)


(2)


(3)


(4)


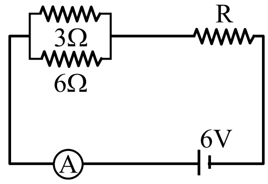
Q.116 In the shown arrangement of the experiment of the meter bridge if AC corresponding to null deflection of galvanometer is x, what would be its value if the radius of the wire AB is doubled-



(1) x (2) $\frac{x}{4}$

(3) 4x (4) 2x

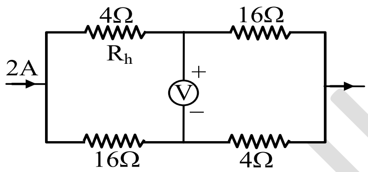
Q.117 If the ammeter in the given circuit reads 2A, the resistance R is-



(1) 1 ohm (2) 2 ohm
(3) 3 ohm (4) 4 ohm

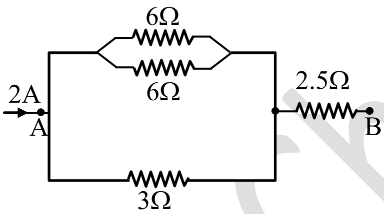
Q.118 Resistance in the two gaps of a meter bridge are 10 ohm and 30 ohm respectively. If the resistances are interchanged the balance point shifts by -
(1) 33.3 cm (2) 66.67 cm
(3) 25 cm (4) 50 cm

Q.119 In the circuit shown below. The reading of the voltmeter V is -



(1) 12 V (2) 8 V
(3) 20 V (4) 16 V

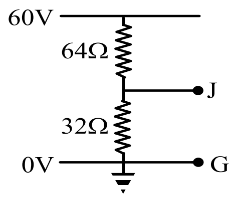
Q.120 The equivalent resistance and potential difference between A and B for the circuit is respectively-



(1) 4Ω, 8V (2) 8Ω, 4V
(3) 2Ω, 2V (4) 16Ω, 8V

Q.121 Resistance of an ideal voltmeter is -
(1) zero (2) less than 1 ohm
(3) more than 1 ohm (4) infinite

Q.122 Find potential of J with respect to G –



(1) 40 V (2) 60 V
(3) 20 V (4) 30 V

Q.123 In potentiometer experiment when terminals of the cell is at distance of 52 cm, then no current flows through it. When 5Ω shunt resistance is connected in it then balance length is at 40 cm. the internal resistance of the cell is -

(1) 5 (2) $\frac{200}{52}$ (3) $\frac{52}{8}$ (4) 1.5

Q.124 A potentiometer wire has resistance 40Ω and its length is 10m. It is connected by a resistance of 760 Ω in series. If emf of battery is 2V then potential gradient is -
(1) 0.5×10^{-6}V/m (2) 1×10^{-6} V/m
(3) 1×10^{-2} V/m (4) 2×10^{-6} V/m

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.
(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion:** The resistance of a copper wire varies directly as the length and diameter.
Reason : Because the resistance varies directly the area of cross-section.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** When cells are connected in parallel to the external load, the effective e.m.f increases.
Reason : Because effective internal resistance of cells decreases.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** The total resistance in series combination of resistors increases and in parallel combination of resistors decreases.
Reason : In series combination of resistors, the effective length of resistors increases and in parallel combination of resistors, the area of cross-section of the resistors increases.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** In parallel combination of electrical appliance, total power consumption is equal to the sum of the powers of the individual appliances.
Reason : In parallel combination, the voltage across each appliance is the same, as required for the proper working of electrical appliance.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** In series combination of electrical bulbs of lower power emits more light than that of higher power bulb.
Reason : The lower power bulb in series gets more current than the higher power bulb.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** Each bulb in a frill of 20 bulbs in series when connected to supply voltage will emit more light than each bulb in frill of 19 bulbs in series when connected to same supply voltage.
Reason : Each bulb in a frill of 20 bulbs in series will get less voltage than that in frill of 19 bulbs.
(1) A (2) B (3) C (4) D

Q.7 **Assertion:** When a wire is not connected to battery, then no current is flow.
Reason: Electrons moves randomly or does not move in particular direction.
(1) A (2) B (3) C (4) D

Q.8 **Assertion:** Electric field inside a current carrying wire is zero.
Reason: Net charge on wire is non zero.
(1) A (2) B (3) C (4) D

Q.9 **Assertion:** A voltmeter must be connected in parallel in a circuit and it should have a high resistance.
Reason: The introduction of the voltmeter in the circuit must not effect the P.D. it is to measure.
(1) A (2) B (3) C (4) D

Q.10 **Assertion:** For the same e.m.f. the availability of current from the secondary cell is greater as compared to the primary cell.
Reason: Generally the resistance of secondary cell is less than of primary cell.
(1) A (2) B (3) C (4) D

Q.11 **Assertion:** Electric field outside the wire due to steady current carrying wire is zero.
Reason: Net charge present on current carrying wire is zero.
(1) A (2) B (3) C (4) D

Q.12 **Assertion:** Kirchhoff's voltage law indicates that electro static field is conservative.
Reason: Potential difference between two points in a circuit does not depends on path.
(1) A (2) B (3) C (4) D

Q.13 **Assertion:** Terminal potential difference of a cell is always less than its emf.
Reason: Potential drop on internal resistance of cell increases terminal potential difference.
(1) A (2) B (3) C (4) D

Q.14 **Assertion:** When Wheatstone bridge is balanced then current through cell depends on resistance of galvanometer.
Reason: At balanced condition current through galvanometer is non zero.
(1) A (2) B (3) C (4) D

Q.15 **Assertion:** Potentiometer measures correct value of emf of a cell.
Reason: Because no current flows through cell at null point.
(1) A (2) B (3) C (4) D

Q.16 **Assertion:** When identical cells are connected in parallel to the external load, the effective e.m.f increases.
Reason: All the cells will be sending unequal current to the external load in the same direction.
(1) A (2) B (3) C (4) D

Q.17 **Assertion:** Potentiometer is an ideal instrument to measure the potential difference.
Reason: Potential gradient along the potentiometer wire can be made very small.
(1) A (2) B (3) C (4) D

Q.18 **Assertion:** An ammeter is always connected in series whereas a voltmeter is connected in parallel.
Reason: An ammeter is a low-resistance galvanometer while a voltmeter is high-resistance galvanometer
(1) A (2) B (3) C (4) D

Q.19 **Assertion:** The potentiometer wire is made of manganin.
Reason: For manganin, the temperature coefficient of resistance is almost zero and its resistivity very less.
(1) A (2) B (3) C (4) D

Q.20 **Assertion:** Current is a scalar quantity.
Reason: Electric current arises due to continuous flow of charged particles or ions.
(1) A (2) B (3) C (4) D

Q.21 **Assertion:** A larger dry cell has higher emf.
Reason: The emf of a dry cell is proportional to its size.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	3	4	1	3	2	2	4	4	2	4	1	3	2	4	1	2	2	1	3
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	3	3	2	3	2	1	2	1	1	3	4	1	2	2	2	2	2	4	1
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	3	1	2	3	1	3	1	1	3	3	4	3	2	1	2	3	3	3	3
Q.No.	61																			
Ans.	2																			

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	2	3	3	2	3	4	3	3	3	3	2	1	4	3	3	1	3	1	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	3	4	3	2	1	1	3	3	4	4	2	3	4	2	1	4	1	3
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	2	3	2	4	4	3	3	3	3	4	4	2	1	3	2	1	2	4	1	2
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	1	4	3	3	3	3	3	3	3	2	3	4	1	2	3	2	3	3	3
Q.No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	
Ans.	1	4	2	4	3	4	4	3	1	4	4	3	3	2	1	3	2	2	2	

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	1	2	4	3	1	1	1	1	1	1	1	1	1	3	2	3	2	1	3
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33							
Ans.	2	4	4	3	2	2	1	3	4	3	3	1	4							

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	4	1	3	2	1	1	4	2	2	1	3	1	3	3	2	2	4	4	2
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	2	4	3	3	1	2	4	3	3	3	4	2	1	2	2	2	3	1	3
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	1	2	4	2	4	1	2	3	1	4	3	3	2	1	4	4	1	2	2
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	4	1	3	1	4	3	2	3	4	4	1	1	4	4	2	2	3	4	1	2
Q.No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	3	3	2	2	4	3	4	4	2	2	3	2	4	1	1	2	1	2	3
Q.No.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	1	1	1	1	4	4	3	3	2	2	3	1	1	2	2	1	1	4	1	1
Q.No.	121	122	123	124																
Ans.	4	3	4	3																

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	4	1	1	3	4	1	4	1	1	1	1	4	4	1
Q.No.	16	17	18	19	20	21									
Ans.	4	2	1	1	2	4									