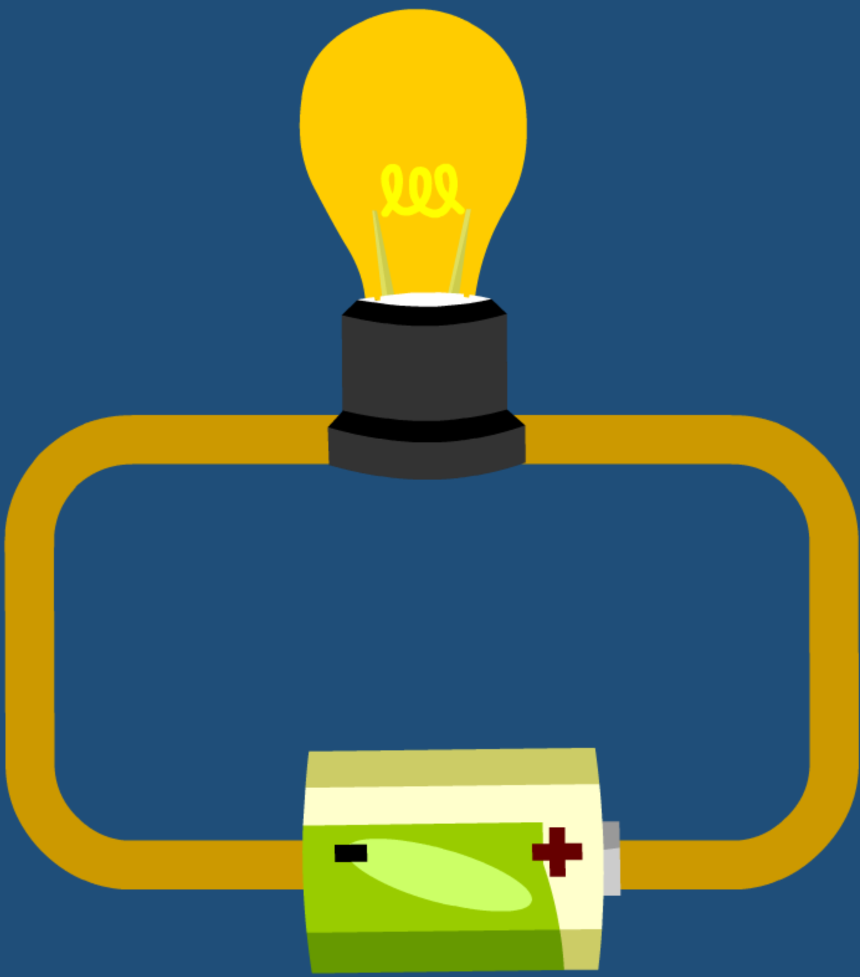
3.CURRENT ELECTRICITY



Physics Smart Booklet

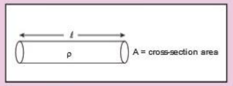
Theory + NCERT MCQs + Topic Wise Practice MCQs + NEET PYQs

Electric Current

Resistance depending on temperature

- Resistivity of conductor increase with increase in tempreature.
- Resistivity of semiconductor decreases with increases in temperature

• Resistance, (R)



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

- Unit of Resistance Ohm (Ω)
- Dependency of R on temperature (T)

  $R_2 = R_1(1 + \alpha (T_2 - T_1))$

  α = Temperature coefficient of resistance
- Symbol

- Rheostate is variable resistance

Resistance colour code
R = 1st digit – 2nd digit × 3rd digit + 4th digit%

Conductance, $C = \frac{1}{\text{Resistance}} = \frac{1}{R}$

Unit is mho (Ω^{-1})

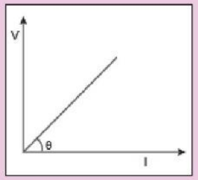
Conductivity (σ)

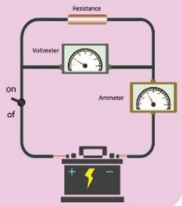
$\sigma = \frac{1}{\text{Resistivity}} = \frac{1}{\rho}$

Unit $= \frac{1}{\Omega m} = \frac{1}{\text{ohm} \cdot m}$ or $\frac{\text{mho}}{m}$

Ohm's Law

- If physical condition remain same current I α V ⇒ V = IR
- R-electric resistance substances which obey Ohm's law called Ohmic and that do not obey called non-ohmic substances.
- Ohm's law is not valid for semi-conductor
- For Ohmic substances $\tan\theta = \frac{V}{I} = R$

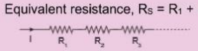




Grouping of Resistance

Series grouping of resnstance

- Equivalent resistance, $R_S = R_1 + R_2 + R_3$ .....

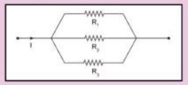


- Current flow through each resistance is same.
- Potential difference, $V \propto R$

Parallel grouping of resistance

- Equivalent resistance.

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$



- Potential difference across each resistance same

current distribution, in each resistance. $I \propto \frac{1}{R}$

Some Important Formula

- After stretching, it length increases by n times then resistance will increase by n2 times i.e.,

  If radius be reduced to $\frac{1}{n}$ times then area of cross-section decreases $\frac{1}{n^2}$ time so the
- resistance become n^4 times i.e., $R_2 = n^4 R_1$

  Using n conductors of equal resistance, the number of possible combination is 2^{n-1}.

  If the resistance of n conductors are totally different, then the numbers of possible
- combination will be 2^n.

Electric Cell :

Source of energy that maintains continuous flow of charge in a circuit.

EMF of cell, $\varepsilon = \frac{W}{q}$

Cells in series and parallel

i.e., mixed current in the circuit, $I = \frac{n\varepsilon}{\frac{nr}{m} + R}$

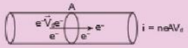
Rate of flow

S.I. Unit Ampere
(A) Coulomb Second

Instaneous, $i = \frac{d\theta}{dt}$ Average, $i = \frac{\Delta\theta}{\Delta t}$

By convection, direction of flow of positive charge is taken as direction of flow of current. Drift velocity (Vd)

Drift velocity (Vd)



$i = neAV_d = \frac{ne^2 A \tau E}{m} = neAl_e E = neA\mu_e \frac{V}{\ell}$

Average uniform velocity acquired by free electron.

$$\boxed{V_d = \frac{i}{neA} = \frac{J}{ne} = \frac{V}{\rho \ell ne} \text{ or } \frac{eE}{m}\tau}$$

$V_d = \mu_e E$ (τ is avg. time between collisions)

mobility, $\mu_e = \frac{V_d}{E}$ (ρ is resistivity unit is Ω.m)

In terms of relaxation time τ_1

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

n, τ, and ρ are properties of material.

Electric Energy and Power

Principle of bulb

- Resistance of bulb, $R = \frac{V^2}{P}$ or $R \propto \frac{1}{P}$ (V and P is rated value on bulb)
- In parallel, $P = P_1 + P_2$
- In Series, $\frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2}$
- In parallel a bulb having more rated power glows more brightly.
- In series a bulb having less rated power glows more brightly.

- Heat energy developed across a resistor

  $H = I^2Rt$; t = time
- Power, $P = I^2R = \frac{V^2}{R}$
- For transmission cable, power loss, $\rho_c = I^2R_c = \frac{P^2R_c}{V_c^2}$, P = const.

Grouping of cells

Cell in Series.

Current in the circuits, $I = \frac{n\varepsilon}{R + nr}$

Cell in Parallel

Current in the circuit, $I = \frac{\varepsilon}{R + \frac{r}{m}}$

Current, $I = \frac{q}{t} = \frac{ne}{t}$

- In case of electron revolving in a circle of radius r with speed V,
- Period of revolution, $T = \frac{2\pi r}{V}$
- Frequency of revolution, $f = \frac{V}{2\pi r}$
- Current at any point of orbit is $I = \frac{e}{T} = \frac{eV}{2\pi r}$

Current density, (J)

Current per unit cross-section area perpendicular to current flow.

$J = \frac{I}{A1} = \frac{E}{\rho}$

Potentiometer

Used to
(i) compare emfs $\frac{E_1}{E_2} = \frac{\ell_1}{\ell_2}$
(ii) final internal resistance of cell $r = \left(\frac{E}{V} - 1\right)S$

Kirchoff's laws

1st law/ Junction law

- Algebraic sum of all the current meeting at junction is zero. i.e., $\Sigma I = 0$

2nd law/loop rule

Algebraic sum in potential around any closed loop is zero

Meter bridge

Based on wheat stone bridge

$\frac{P}{Q} = \frac{R}{S} = \frac{\ell}{100 - \ell} = \frac{R}{S}$

Balanced condition of wheat stone bridge

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

Potential gradient (x)

Potential difference per unit length of wire

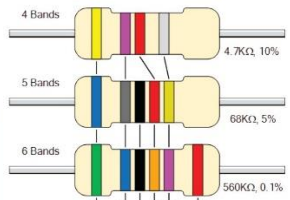
$x = \frac{V}{L} = \frac{\text{Volt}}{m}$

where, $V = IR = \left(\frac{e}{(R + R_n + r)}\right) \times \frac{R}{L}$

Sensitivity of potentiometer

- A potentiometer is more sensitive, if it measures a small potential difference more accurately.

Resistance colour code



1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Temperature Coefficient
			0.01	10%	
			0.1	5%	
0	0	0	1		
1	1	1	10	1%	100ppm
2	2	2	100	2%	50ppm
3	3	3	1k		15ppm
4	4	4	10k		25ppm
5	5	5	100k	0.5%	
6	6	6	1M	0.25%	
7	7	7	10M	0.1%	
8	8	8		0.05%	
9	9	9			

When cell is discharging

When cell is discharging current inside the cell is from cathode to anode current $I = \frac{E}{r + R}$

or $E = IR + Ir = V + Ir$ or $V = E - Ir$

When cell charging

When cell is charging current inside the cell is from anode to cathode.

Current, $I = \frac{V - E}{r}$ or $V = E + Ir$

When cell is open circuit

$R = \infty$

$I = \frac{E}{R + r} = 0$ and $V = E$

When cell is short circuited

$R = 0$ and $I = \frac{-E}{R + r}$ and $V = IR = 0$

Power transferred to load by cell

$P = I^2R = \frac{E^2R}{(r + R)^2}$ and $P = P_{max}$

if $\frac{dP}{dR}$ and $P = P_{max}$ if r = R

$P_{max} = \frac{E^2}{4r} = \frac{E^2}{4R}$

Current Electricity

Charges in motion constitute an **electric current**. A conductor offers a path for current. Application of potential difference across a conductor causes current. Potential difference can be provided using a cell or a battery (group of cells).

Current in a circuit in a single direction is called a direct current (dc), while a current whose direction keeps reversing at regular intervals and whose magnitude keeps changing continuously is called alternating current (ac).

Current carriers (mobile charge carriers): The charged particles whose drift in a definite direction constitutes the electric current are called current carriers.

Conventional current in a metallic conductor: In metallic conductors, negatively charged particles, namely electrons, drift under the influence of applied potential difference. This constitutes an **electron current**.

The direction of drift of positive charges is the direction of current. This current is called conventional current. The direction of conventional current is opposite to that of drift of electrons.

Strength of electric current: Electric current is the net flow of charge per second across a surface.

If ΔQ is the amount of charge that passes through an area in a time interval Δt, then the average current in the given time interval is, $I_{av} = \dfrac{\Delta Q}{\Delta t}$.

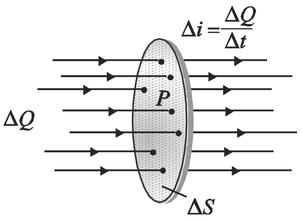
The instantaneous current is given by $I = \lim\limits_{\Delta t \to 0} \dfrac{\Delta Q}{\Delta t} = \dfrac{dQ}{dt}$

If the current is steady, then $I = \dfrac{Q}{t}$ where Q is the charge flowing across a section of a conductor in an interval of time t.

- The SI unit of current is ampere (A). 1 ampere = 1 coulomb per second.
- Since 1 coulomb = 6.25×10^{18} electrons, a flow of 6.25×10^{18} electrons per second is equal to 1 ampere of current.

Material	Mobile charge carriers
• Metallic conductors	Free electrons
• Liquid conductors	Positive ions and Negative ions
• Semiconductors	Free electrons and Holes
• Gaseous conductors	Positive ions and free electrons
• Super conductors	Cooper pairs (a pair of electrons with opposite spins)

Current density $(\vec{J})$



- If current i is uniformly distributed over an area S and is perpendicular to it, then $j = \dfrac{i}{S}$.
- Current density is a vector quantity. The direction of current density is the same as the direction of motion of positive charges.
- SI unit of current density is Am^{-2}.
- Relation between current and current density is $i = \int di = \int_S \vec{j} \cdot \overrightarrow{dS}$ over a finite area S.

Drift velocity of free electrons

- Drift velocity of **electrons** is given by $\vec{v}_d = -\dfrac{e\vec{E}}{m}\tau$ where $e \to$ charge on the electron, $m \to$ mass of the electron, $E \to$ electric field, $\tau \to$ relaxation time.

- The random speed of free electrons in a metallic conductor depends on the temperature and is of the order of 10^6 ms^{-1}. The drift speed of the free electrons is of the order of 10^{-4} ms^{-1}.

Relaxation time and mean free path: The average time elapsed between two successive collisions of a free electron with the metal ions in a conductor is called **relaxation time**, denoted by τ. The average distance traveled by an electron between two successive collisions is called the **mean free path**, denoted by λ.

Mobility (μ)

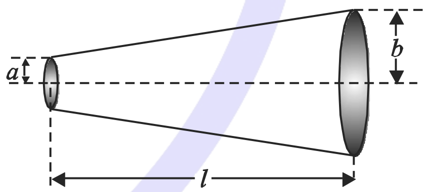
- The mobility (μ) of charge carriers is given by $\mu = v_d / E$ and its unit is $m^2V^{-1}s^{-1}$.
- The mobility of electrons and conductivity of a material are related by the expression $\sigma = ne\mu$ for a metallic conductor and $\sigma = n_e e\, \mu_e + n_h e\, \mu_h$ for a semiconductor
  where n_e is electron density, n_h is hole density, μ_e is electron mobility, μ_h is hole mobility.

Expression for current and current density in terms of drift speed

- $I = nAev_d$ and $\vec{J} = ne\vec{v}_d$
  where n is the number of electrons per unit volume of a metallic conductor of cross sectional area A and e is the charge on the electron.

Ohm's law: Mathematically Ohm's law is expressed as $V = IR$
where, R is a constant of proportionality called resistance of the conductor.

- We have $R = \frac{V}{I}$. The SI unit of resistance is ohm (Ω). 1 ohm = 1 volt per ampere.
- The dimensional formula is $[I^{-2}ML^2T^{-3}]$.
  At a given temperature, $R \propto \frac{l}{A}$ or $R = \rho\frac{l}{A}$ where ρ = specific resistance or resistivity of the material of the conductor.
  $R = \frac{m}{ne^2\tau} \times \frac{l}{A} = \frac{\rho l}{A}$ where ρ is the specific resistance of the material and



- For a conductor of length l having a circular cross-section, the resistance of the conductor is $R = \frac{\rho l}{\pi ab}$
  (Here the radius of cross-section varies linearly from a to b and $(b - a) << l$).

Resistivity or specific resistance (ρ)

- The resistivity of a material is defined as numerically equal to the resistance across the opposite faces of a cube of the given material of unit length and unit area of cross section.
- $\rho = \frac{RA}{L}$, R is in ohm, A is in square meter and L is in meter.
- The SI unit of ρ is ohm meter (Ω m). The dimensional formula for ρ is $[I^{-2}M^1L^3T^{-3}]$.
- The resistivity of a material is related to microscopic quantities by the relation, $\rho = \frac{m}{ne^2\tau}$.
- Resistivity of a conductor depends on the nature of the material and temperature.
- Resistivity is independent of the physical dimensions (i.e., size and shape) of the conductor. Its value is different for different materials.
- Good conductors have low resistivity while insulators have very high resistivity. Semiconductors have resistivity lying between that of good conductors and insulators.
- Alloys have resistivity which is greater than the resistivity of its constituent metals.

Conductivity (σ)

- It is the reciprocal of resistivity. The SI unit of σ is siemen m^{-1}
- The dimensional formula for σ is $[I^2M^{-1}L^{-3}T^3]$.

Conductance (G)

- It is the reciprocal of resistance i.e. $G = \frac{1}{R} \Rightarrow G = \frac{A}{\rho l} = \frac{\sigma A}{l}$. The SI unit of G is siemen (S).
- The dimensional formula is $[I^2M^{-1}L^{-2}T^3]$.

Relation between J, σ and E (Ohm's law in vector form)

Current density, conductivity and electric field are related by J = σE. In vector form, $\vec{J} = \sigma\vec{E}$.

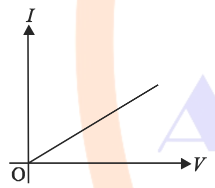
Limitations of Ohm's Law

1. Ohm's law is applicable only to metallic conductors at moderate temperatures and moderate potential differences.
2. Ohm's law cannot be applied

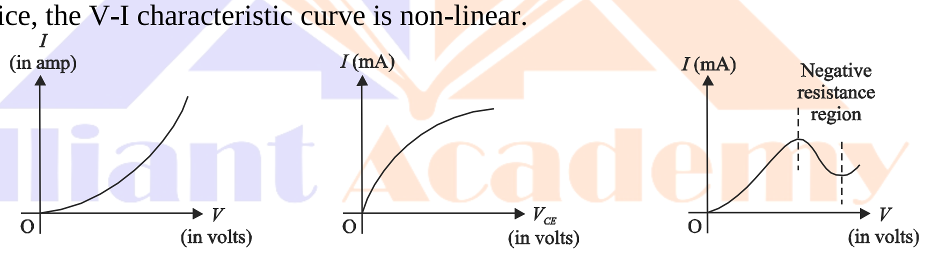
- to conductors maintained at very high temperatures or very low temperatures.
- to semiconductors and semi conducting devices.
- to conductors across which very high pd or very low pd is applied.

V-I characteristics

- The variation of current (I) with voltage (V) at various temperatures for any device is called its V-I characteristics.
- For an ohmic device, V-I characteristic is linear.
- For a non-ohmic device, the V-I characteristic curve is non-linear.



V-I characteristic of Ohmic device – Metal conductor

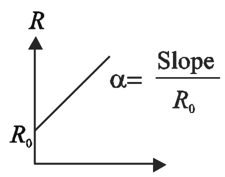


V-I characteristic of some non-ohmic devices

Effect of temperature on resistance

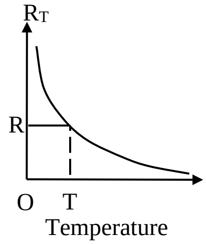
- The resistivity ρ of a material depends on its temperature. For a small variation of temperature, $\rho = \rho_0(1+\alpha(T-T_0))$, where α = temperature coefficient of resistance of the material.
- The resistance of a conductor at absolute temperature T is given by the relation $R_T = R_0(1+\alpha(T-T_0))$
- $\alpha = \frac{(R_T - R_0)}{R_0(T-T_0)} = \frac{1}{R_0}\left(\frac{\Delta R}{\Delta T}\right)$
- SI unit of α is $\frac{1}{kelvin}$ (K^{-1}).
- R versus t (°C) graph; y-intercept $\rightarrow$ R_0, slope = $R_0\alpha$

$$\Rightarrow \alpha = \frac{slope}{y\text{-}intercept}$$



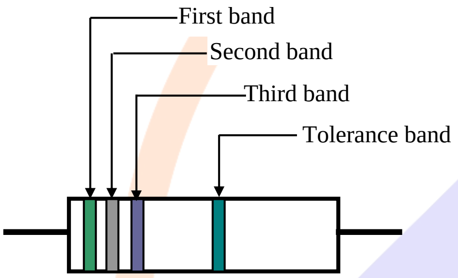
- Alloys generally have a low temperature coefficient of resistance. In other words, their resistance values do not vary appreciably with change of temperature. It is for this reason that manganin and constantan coils are used in resistances boxes.
- Semiconductors have negative temperature coefficient of resistance while metals have positive temperature coefficient of resistance.

Thermistor



- Thermistors are made of semiconducting oxides of metals and hence it is a non-ohmic device.
- The resistance of a thermistor is given by $R = ae^{b/T}$
  where a and b are constants for a material.
- The temperature coefficient of resistance of material of a thermistor is given by $\alpha = -\frac{b}{T^2}$
- If R_1 and R_2 are resistances of a thermistor at two temperatures $T_1\,K$ and $T_2\,K$ respectively, then it can be shown that $\alpha = \frac{2.303(\log R_1 - \log R_2)}{(T_1 - T_2)}$.

Colour code for resistors



Colour code for resistors

Colour	First band	Second band	Third band (multiplier)	Fourth band Tolerance
Black	0	0	$10^0 = 1$	
Brown	1	1	$10^1 = 10$	
Red	2	2	$10^2 = 100$	
Orange	3	3	$10^3 = 1000$	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Grey	8	8	10^8	
White	9	9	10^9	
Gold	-	-	10^{-1}	± 5 %
Silver	-	-	10^{-2}	± 10 %
No colour	-	-	-	± 20 %

In the carbon composition resistor the coloured bands are marked near one end. Colours of the bands are used to identify the value of the resistance according to the colour code.

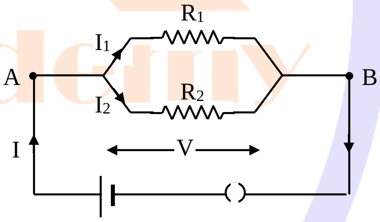
The first and the second bands indicate the first and the second significant digits. The third band indicates the number of zeros that follow (or multiplication factor). The fourth band indicates the tolerance. If the fourth band is not marked, the tolerance is assumed to be 20%.

☞ **Memory tip: B.B.ROY** of **G**reat **B**ritain had a **V**ery **G**ood **W**ife.
The bold letters indicate the first letters of the colours in the sequence 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9.
For resistors of value less than 10 ohm, the third band is either gold or silver such that the multiplying factor will be 0.1 or 0.01 respectively.

	Resistors in series	Resistors in parallel
1.	Current is same through all the resistors.	Voltage is same across each resistor.
2.	$V = V_1 + V_2 + V_3 + ...$	$I = I_1 + I_2 + I_3 + ...$
3.	$R_s = R_1 + R_2 + R_3 + ...$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$
4.	R_s is greater than the greatest of the individual resistances.	R_p is smaller than the smallest of the individual resistances.

5.	The applied voltage divides across the resistors according to the ratio $V_1 : V_2 : V_3 = R_1 : R_2 : R_3$ and hence the series combination is an voltage divider.	The current divides through the resistors in the ratio $I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3}$. Hence, the parallel combinations is called the current divider.
6.	If n identical resistors, each of resistance R are connected in series, then their effective resistance is $R_s = nR$.	For n identical resistors in series $R_S = nR$. Therefore $\frac{R_s}{R_p} = \frac{nR}{\left(\frac{R}{n}\right)} = n^2$ If n identical resistors, each of resistance R are connected in parallel, then their effective resistance is given by $\frac{1}{R_p} = \frac{n}{R}$ $\therefore$ $R_p = \frac{R}{n}$
7.	When a series combination of resistors is connected to a supply voltage, higher resistance dissipates more power, since $P = I^2R$; I is the common current through the resistors.	If there are two resistors R_1 and R_2 in parallel, then their effective resistance. $R_p = \frac{R_1R_2}{R_1 + R_2}$ When a parallel combination of resistors is connected to a supply voltage, the lower resistance dissipates more power. $P = \frac{V^2}{R}$; V is common potential across the resistors.

Branch current



Current in one branch = $\frac{\text{main current} \times \text{resistance in the other branch}}{\text{sum of the resistances}}$

$I = I_1 + I_2 \Rightarrow I_1 = \frac{IR_2}{R_1 + R_2}$ and $I_2 = \frac{IR_1}{R_1 + R_2}$

Cell

- An energy source used to drive charges and hence establish electric current in a circuit.
- A combination of cells is called a **battery.**

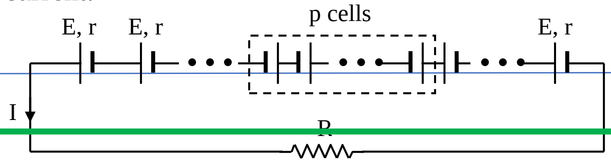
Ohm's law applied to a closed circuit

- When the cell drives a current through a circuit, work has to be done to drive current through (1) the external resistance and (2) the internal resistance.
  E = pd across R + pd across r $= I(R + r)$
- $I = \frac{E}{R + r}$.
- Terminal pd across the cell, $V = IR = \frac{ER}{R + r}$. Also $V = E - Ir$

State of cell in a circuit	Terminal pd (V)	Current (I)	Resistance (R)
Open	V = E	I = 0	R = ∞
Closed	$V = E - Ir$ (During discharge) $V = E + Ir$ (During charging)	I = finite	R = finite
Short	V = 0	I = ∞	R = 0

Grouping of cells

Cells are grouped to get the necessary voltage and current.



Cells in series

For m identical cells in series, $E_{eff} = mE$

$R_{eff} = R + mr = R + mr$ and $I = \dfrac{mE}{R + mr}$

For m non-identical cells in series conjunction,

$E_{eff} = E_1 + E_2 + \dots + E_m = \Sigma E_i$

$R_{eff} = R + (r_2 + \dots + r_m) = R + \Sigma r_i$; $I = \dfrac{\Sigma E_i}{R + \Sigma r_i}$

If p cells in a group of m identical cells are connected wrongly then

$E_{eff} = (m - 2p)E$

$r_{eff} = mr$; $I = \dfrac{(m-2p)E}{R + mr}$

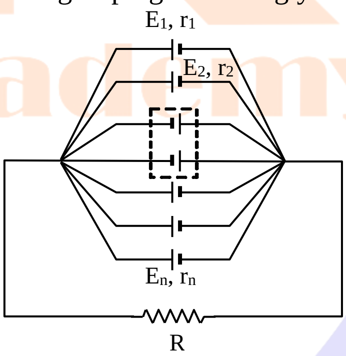
Cells in parallel

1. For n identical cells in parallel, $E_{eff} = E$ and $r_{eff} = \dfrac{r}{n}$; $I = \dfrac{nE}{nR + r}$
2. For n non identical cells in parallel,

$$E_{eff} = \frac{\left(\frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3} + \frac{E_4}{r_4} + \frac{E_5}{r_5} + \dots + \frac{E_n}{r_n}\right)}{\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4} + \dots + \frac{1}{r_n}\right)}, \quad r_{eff} = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \dots + \frac{1}{r_n}}$$

3. In a parallel grouping of n non identical cells if some cells in parallel grouping are wrongly connected then

$$E_{eff} = \frac{\Sigma \frac{E_i}{r_i} - \Sigma \frac{E_j}{r_j}}{\Sigma\left(\frac{1}{r_i} + \frac{1}{r_j}\right)} = \frac{\left(\frac{E_1}{r_1} + \frac{E_2}{r_2} - \frac{E_3}{r_3} - \frac{E_4}{r_4} + \frac{E_5}{r_5} + \dots + \frac{E_n}{r_n}\right)}{\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4} + \dots + \frac{1}{r_n}\right)},$$



$$r_{eff} = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \dots + \frac{1}{r_n}}$$

Example: If any two cells are in parallel then

$$E_{eff} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}, \quad r_{eff} = \frac{r_1 r_2}{r_1 + r_2}$$

Mixed grouping of cells

Let m identical cells each of emf E and internal resistance r be connected in series. Let n such rows of series cells be connected in parallel. Let the combination be connected across the resistance R.

1. $I = \dfrac{mnE}{nR + mr}$
2. The condition for maximum current in mixed grouping of cells is
   External resistance = effective internal resistance $R = mr/n$
3. Maximum current given by mixed grouping of cells, $I_{max} = \dfrac{mnE}{2\sqrt{mnrR}}$.

☞	▪ When $R >> r_{eff}$, series grouping is preferred. ▪ When $R << r_{eff}$, parallel grouping is preferred.

- To get more power, cells must be connected in mixed grouping.

Maximum power transfer theorem

Whenever internal resistance is equal to the external resistance, the power transferred by a cell is maximum. This is called maximum power transfer theorem.

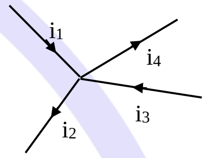
$$P_{max} = I^2R = \left(\frac{E}{R+r}\right)^2 R = \frac{E^2}{(2R)^2}R = \frac{E^2}{4R} \quad or \quad P_{max} = \frac{E^2}{4r}$$

Electrical energy and power

Heat dissipated in a conductor is $H = VIt = (V^2/R)t = I^2Rt$ and $P = VI = (V^2/R) = I^2R$

Kirchhoff's Law

(1) **Kirchhoff's first law:** This law is also known as junction rule or current law (KCL). According to this, the algebraic sum of currents meeting at a junction zero, i.e., $\sum I = 0$. In a circuit, at any junction the sum of the currents entering the junction must equal the sum of the currents leaving the junction $i_1 + i_3 = i_2 + i_4$.



This law is simply a statement of "conservation of charge".

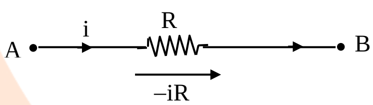
(2) **Kirchhoff's second law:** This law is also known as loop rule or voltage law (KVL) and according to this, "the algebraic sum of the changes in potential in complete traversal of a mesh (closed loop) is zero", i.e, $\sum V = 0$.

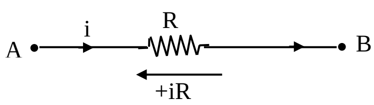
(i) This law represents "conservation of energy"

(ii) If there are n meshes in a circuit, the number of independent equations in accordance with loop rule will be (n – 1).

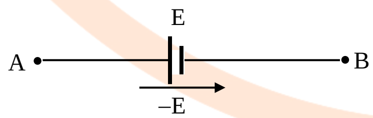
(3) **Sign convention for the application of Kirchhoff's law:** For the application of Kirchhoff's laws following sign convention is to be considered:

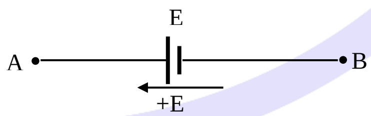
(i) The change in potential in traversing a resistance in the direction of current is – iR while in the opposite direction is + iR.





(ii) The change in potential in traversing an emf source from negative to positive terminal is +E while in the opposite direction – E irrespective of the direction on current in the circuit.





(iii) The change in potential in traversing a capacitor from the negative terminal to the positive terminal is $+\frac{q}{C}$ while in opposite direction $-\frac{q}{C}$.

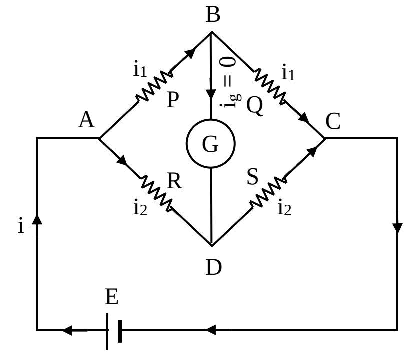
(iv) The change in voltage in traversing an inductor in the direction of current is $-L\frac{di}{dt}$ while in opposite direction it is $+L\frac{di}{dt}$.

Measurement of resistance

The resistance of a wire can be determined using Wheatstone's network (bridge).

Principle of Wheatstone's bridge

Wheatstone's bridge consists of an arrangement of four resistances which can be used to measure one of the resistance in terms of the other resistances.



The bridge is said to be balanced when deflection in the galvanometer is zero. i.e., $i_g = 0$.

This will happen when $\dfrac{P}{Q} = \dfrac{R}{S}$

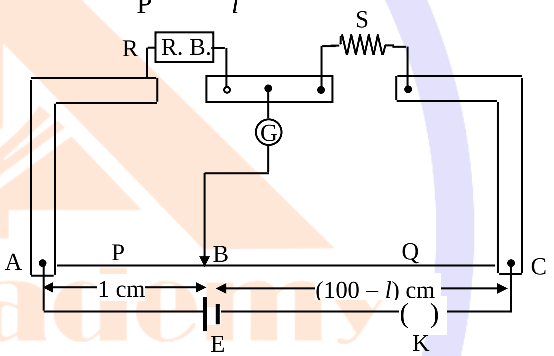
i. In Wheatstone bridge, cell and galvanometer arms are interchangable.

ii. If bridge is not balanced, current will flow from D to B if, PS > RQ

Meter bridge

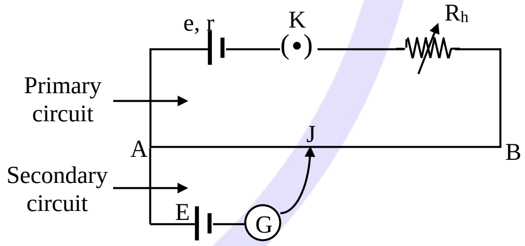
In case of meter bridge, the resistance wire AC is 100 cm long. Varying the position of tapping point B, bridge is balanced. If in balanced position of bridge AB = l, BC = $(100 - l)$ so that $\dfrac{Q}{P} = \dfrac{(100-l)}{l}$. Also

$$\frac{P}{Q} = \frac{R}{S} \Rightarrow S = \frac{(100-l)}{l} R$$



Potentiometer

Potentiometer is a device mainly used to measure emf of a given cell and to compare emf's of cells. It is also used to measure internal resistance of given cell.



Potential gradient (x)

Potential difference (or fall in potential) per unit length of wire is called potential gradient i.e.,

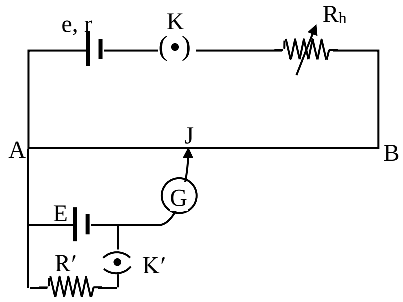
$$x = \frac{V}{L}\frac{\text{volt}}{\text{m}} \quad \text{where } V = iR = \left(\frac{e}{R + R_h + r}\right).R.$$

$$\text{So } x = \frac{V}{L} = \frac{iR}{L} = \frac{i\rho}{A} = \frac{e}{(R + R_h + r)}.\frac{R}{L}$$

Application of Potentiometer

(1) To determine the internal resistance of a primary cell

(i) Initially in secondary circuit key K′ remains open and balancing length (l_1) is obtained. Since cell E is in open circuit so its emf balances on length l_1 i.e., $E = xl_1$

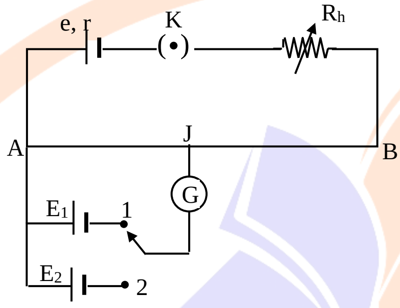


(ii) Now key K′ is closed so that cell E is in closed circuit. If the process of balancing is repeated again then potential difference V balances on length l_2 i.e., $V = xl_2$.

(iii) By using formula internal resistance $r = \left(\frac{E}{V} - 1\right).R'$

$$r = \left(\frac{l_1 - l_2}{l_2}\right).R'$$

(2) **Comparison of emf's of two cells:** Let l_1 and l_2 be the balancing lengths with the cells E_1 and E_2 respectively, then $E_1 = xl_1$ and $E_2 = xl_2 \Rightarrow \frac{E_1}{E_2} = \frac{l_1}{l_2}$



Let $E_1 > E_2$ and both are connected in series. If balancing length is l_1 when cells assist each other and it is l_2 when they oppose each other as shown then:

$(E_1 + E_2) = xl_1$ $(E_1 - E_2) = xl_2$

$$\Rightarrow \frac{E_1 + E_2}{E_1 - E_2} = \frac{l_1}{l_2} \quad \text{or} \quad \frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}$$

Illustrations

1. In a current carrying metallic conductor, current density $\vec{J}$ and drift velocity $\vec{v_d}$ will be such that

(A) $\vec{J}$ and $\vec{v_d}$ will have opposite directions

(B) $\vec{J}$ and $\vec{v_d}$ will have the same direction

(C) the direction of $\vec{J}$ is determined by the number of free electrons undergoing drift motion, where as the direction of $\vec{v_d}$ remains same.

(D) the direction of $\vec{v_d}$ is determined by the number of free electrons undergoing drift motion, where as the direction of $\vec{J}$ remains same.

Ans (A)

Current and drift velocity are related by $I = nAe\,\vec{v_d}$

Current density at a point, $J = \frac{I}{A}$ $\therefore$ $\vec{J} = ne\,\vec{v_d}$

For positive charges ne is positive. Then $\vec{J}$ and $\vec{v_d}$ will be in the same direction.

For negative charges, ne is negative. Then $\vec{J}$ and $\vec{v_d}$ will be in opposite directions. This is the case in a metallic conductor in which charge carries are negative.

2. The charge flowing through a conductor varies with time as $Q = at - bt^2$. Then, the current

(A) decreases linearly with time (B) reaches a maximum and then becomes zero

(C) falls to zero after time $t = \frac{2b}{a}$ (D) changes at the rate $\frac{b}{a}$

Ans (A)

- $I = \frac{dQ}{dt} = a - 2bt$

  'I' versus 't' graph will be a straight line with 'a' as x – intercept and '–2b' as slope.

  It follows that I decreases linearly with time.

- $I = 0$ for $t = \frac{a}{2b}$
- Rate of change of current, $\frac{dI}{dt} = -2b$

3. A material B has twice the specific resistance of the material A. A circular wire made of B has twice the diameter of the wire made of A. Then, for the two wires to have the same resistances, the ratio of their respective lengths must be

   (A) 1/4 (B) 2 (C) 1 (D) 1/2

Ans (D)

Given that, $R_A = R_B$ or $\rho_A \frac{l_A}{\frac{\pi D_A^2}{4}} = \rho_B \frac{l_B}{\frac{\pi D_B^2}{4}}$

$$\Rightarrow \frac{l_A}{l_B} = \frac{\rho_B}{\rho_A} \cdot \frac{D_A^2}{D_B^2} = \frac{2}{1} \times \left(\frac{1}{2}\right)^2 = \frac{1}{2}$$

4. The resistance of a thin wire of silver is = 1.0 Ω at 20 °C. The wire is placed in a liquid bath and its resistance rises to 1.2 Ω. The temperature of the bath in °C is [$\alpha_{silver} = 3.8 \times 10^{-3}$/°C]

   (A) 72.6 °C (B) 345.6 °C (C) 102.6 °C (D) 200.4 °C

Ans (A)

We know that, $R(t) = R_0[(1 + \alpha(T - T_0)]$

$R(T) = 1.2\ \Omega$, $R_0 = 1.0\ \Omega$; $\alpha = 3.8 \times 10^{-3}$/°C, T = 20 °C

$\therefore$ $1.2 = 1.0\ [1 + 3.8 \times 10^{-3}\ (T - 20)]$

Solving this we get, T = 72.6 °C

5. A resistor develops 400 J of heat in 10 s when a current of 2 A is passed through it. The resistance and the energy developed in 10 s. If the current is doubled is

   (A) 10 J, 1600 Ω (B) 10 Ω, 1600 j (C) 10 Ω, 1600 J (D) 1 Ω, 160 J

Ans (C)

Hint: We know that Heat energy = i^2 Rt

$\therefore$ $R = \frac{H}{i^2 t} = \frac{400}{4 \cdot 10}$

$\therefore$ R = 10 Ω

If current is doubled, then energy developed is,

$H = (4)^2 \times (10)\ (10)$

$\therefore$ H = 1600 J

$\therefore$ Increase in the current by two times will increase the heat developed by 4 times

6. Two resistors are connected across a battery. Consider the following two statements.

   (a) The current through the circuit remains same and potential difference also remains same.

(b) The current through each branch varies depending on the resistor used, where as voltage applied remains same.

Choose the correct option

(A) a is true when 2 resistors are connected in series

(B) b is true when 2 resistors are connected in parallel

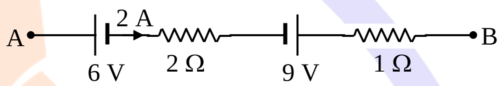
(C) both a and b are wrong

(D) a is true when 2 resistors are connected in parallel

Ans (B)

Hint: When 2 resistors are connected in parallel current through each resistor varies and potential difference remains the same.

7. The potential difference between the points A and B is



(A) 2 V (B) 20 V

(C) –3 V (D) –20 V

Ans (C)

Hint: $V_{AB} = -6 + (-2 \times 2) + 9 + (-2 \times 1) = -6 - 4 + 9 - 2 = -3$ V

(Convention: Rise in potential is positive and full in potential is negative

8. In a metre bridge the balancing point is found to be at 39.5 cm from A, when the resistor Y = 12.5 Ω. The value of X is

(A) 8.16 Ω (B) 1.68 Ω (C) 6.18 Ω (D) 12.5 Ω

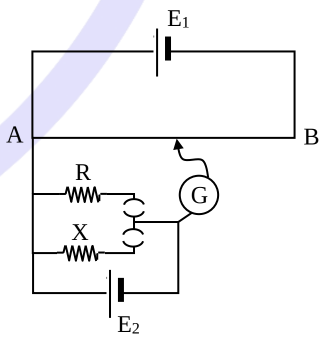
Ans (A)

Hint: The balance condition for wheatstone's network is

$$\frac{X}{Y} = \frac{l_1}{100 - l_1}$$

$$\therefore X = \frac{l_1 Y}{100 - l_1} = \frac{39.5}{100 - 39.5} \times 12.5 \qquad \therefore X = 8.16\ \Omega$$

9. Figure shows a potentiometer circuit for comparison of 2 resistors. The balancing point with standard resistor R = 100 Ω is found to be 58.3 Ω, while that of unknown resistance X is 68.5 cm. The value of X is



(A) 41.7 Ω

(B) 11.75 Ω

(C) 68.5 Ω

(D) 100 Ω

Ans (B)

We know that

$$\frac{E_2}{E_1} = \frac{l_2}{l_1}$$

$$\text{Also } \frac{R_2}{R_1} = \frac{E_2}{E_1} = \frac{l_2}{l_1} \qquad \therefore \frac{X}{R} = \frac{l_2}{l_1}$$

$$\therefore X = \left(\frac{l_1}{l_2}\right) R = \frac{68.5}{58.3} \times 10 \qquad \therefore X = 11.75\ \Omega$$

10. A galvanometer coil has a resistance 12 Ω and the metre shows full scale deflection for a current of 3 mA. To convert the galvanometer into a voltmeter of range 0 – 18 V, we need to

(A) Connect 5898 Ω in series with the Galvanometer

(B) Connect 5988 Ω in series with the Galvanometer

(C) Connect 5988 Ω in parallel with the Galvanometer

(D) Connect 5898 Ω in parallel with the Galvanometer

Ans (B)

Hint: We know that, $V = I_g (R + G)$

$$\therefore\ R = \frac{V}{I_g} - G = \frac{18}{3\times10^{-3}} - 12 = 5988\ \Omega$$

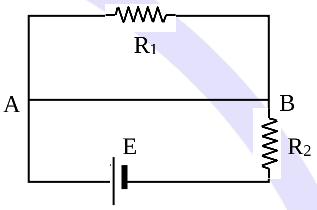
11. The potential at the points A and B in the following figure is

(A) $V_A = V_B = 0$

(B) $V_A = +E$, $V_B = -E$

(C) $V_A = +E$, $V_B = +E$

(D) none



Ans (C)

Hint: A and B are at same potential, due to the fact that they have been connected by a common wire

This process is called as short circuiting

The potential difference across AB is zero.

12. A total of 6×10^{16} electrons pass through any cross-section of a conducting wire per second. The equivalent current is

Solution

$$i = \frac{ne}{t} = \frac{6\times10^{16}\times1.6\times10^{-19}}{1} = 9.6\ \text{mA}$$

13. In a hydrogen atom, an electron moves in an orbit of radius 0.5 Å with a speed of $2.2 \times 10^6\ \text{ms}^{-1}$. Calculate the equivalent current.

Solution

$$i = \frac{q}{t} = \frac{qV}{2\pi r} = \frac{1.6\times10^{-19}\times2.2\times10^{6}}{2\times\pi\times5\times10^{-11}} = 1.12\ \text{mA}$$

14. The current through a wire depends on time as $i = i_0 + \alpha t$ where $i_0 = 10$ A and $\alpha = 4\ \text{As}^{-1}$. Find the charge that crosses through a section of wire in 10 second.

Solution

$$q = \int_{t_1}^{t_2} i\, dt = \int_0^{10} (i_0 + \alpha t)dt = \left[i_0 t + \alpha\frac{t^2}{2}\right]_0^{10}$$

$$\Rightarrow\ q = (10\times10) + \left[\frac{4\times100}{2}\right] = 300\,\text{C}$$

15. The area of cross section, length and density of a piece of metal of atomic mass 60 are $10^{-6}\ \text{m}^2$, 1.0 m and 5×10^3 kg m^{-3}. Find the number of free electrons per unit volume and drift velocity when a current of 16 A pass through it. [Take $N = 6 \times 10^{23}$ and assume one free electron per atom]

Solution

Mass of metal = $V \times d = 10^{-6} \times 1 \times 5 \times 10^3 = 5 \times 10^{-3}$ kg

$\therefore$ Number of atoms in 5 g of metal are $\dfrac{5\times N}{60} = 5\times10^{22}$

Number of free electrons = 5×10^{22}

Number of free electrons per unit volume = $5 \times 10^{28}\ m^{-3}$

$$\therefore\ V_d = \frac{i}{neA} = \frac{16}{5\times10^{28}\times1.6\times10^{-19}\times10^{-6}} = 2\times10^{-3}\ ms^{-1}$$

16. The amount of charge passing through cross section of wire is $q(t) = at^2 + bt + c$.
(i) write dimensions of a, b and c
(ii) If the values of a, b and c in S.I. units are 5, 3 and 1 respectively, find the value of current at t = 5 s.

Solution

$q = at^2 + bt + c$

(i) According to principle of homogeneity, $[a] = \frac{q}{t^2} = [AT^{-1}]$

$[b] = \frac{q}{t} = [A];$

$[c] = q = [AT]$

(ii) Current $i = \frac{dq}{dt} = \frac{d}{dt}[at^2 + bt + c]$

$\Rightarrow i = 10t + 3.$

At t = 5 s, i = 53 A

17. A wire of resistance 4 Ω is used to wind a coil of radius 7 cm. The wire has a diameter of 1.4 mm and the resistivity of wire is 2×10^{-7} Ω m. Find number of turns in coil.

Solution

If N be number of turns in coil then total length of wire is $l = 2\pi rN$

Resistance $R = \frac{\rho l}{A} \Rightarrow l = \frac{RA}{\rho} = \frac{R\pi d^2}{4\rho}$

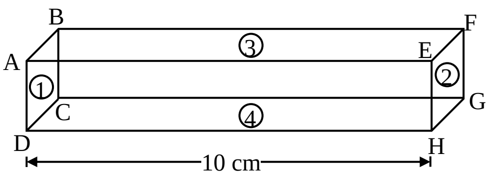
$\therefore\ 2\pi rN = \frac{R\pi d^2}{4\rho} \Rightarrow N = \frac{R\pi d^2}{4\rho.2\pi r}$

$\Rightarrow\ N = \frac{Rd^2}{8\rho r} = \frac{4\times1.96\times10^{-6}}{8\times2\times10^{-7}\times7\times10^{-2}} = \frac{1.96\times10^3}{28}$

$\Rightarrow N = 70$

18. A rectangular block has dimensions 5 cm × 5 cm × 10 cm if its resistivity is 3.5×10^{-5} Ω m, calculate the resistance between two square ends and between two rectangular ends.

Solution



$R_{12} = \frac{\rho l}{A} = \frac{3.5\times10^{-5}\times10^{-1}}{25\times10^{-4}}$

$R_{12} = 1.4 \times 10^{-3}\ \Omega$

$R_{34} = \frac{\rho l}{A'} = \frac{3.5\times10^{-5}\times5\times10^{-2}}{50\times10^{-4}} = 3.5\times10^{-4}\ \Omega$

Each of the following questions consists of a statement–I and a Statement–II. Examine both of them and select one of the options using the following codes

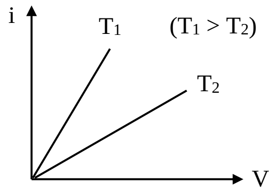
(A) Statement-I and Statement-II are true and Statement-II is the correct explanation of Statement-I.

(B) Statement-I and Statement-II are true, but Statement-II is not the correct explanation of Statement -I

(C) Statement-I is true, but Statement -II is false

(D) Statement-I is false, but Statement -II is true

19. **Statement-I:** i-V graph for a conductor at two different temperatures T_1 and T_2 is as shown. Then $T_2 > T_1$



Statement-II: Resistance of a conductor increases with rise in temperature.

Ans (A)

We know $R = \frac{V}{I} = \frac{1}{\text{slope}}$

$\therefore R_2 > R_1$. Hence $T_2 > T_1$

20. **Statement-I:** A resistance wire is broken into 4 pieces and all are connected in parallel. The net resistance becomes $\frac{1}{16}$ times the earlier value.

Statement-II: In parallel net resistance is less than the smallest value of individual resistance.

Ans (B)

$$\frac{1}{R_{eff}} = \frac{4}{R} + \frac{4}{R} + \frac{4}{R} + \frac{4}{R} \qquad \therefore\ R_{eff} = \frac{R}{16}$$

21. **Statement-I:** Potential difference across the terminals of a battery is always less than emf of the battery.

Statement-II: During discharging of a battery potential difference across the terminals of a battery is less than its emf.

Ans (D)

Hint: During charging of a battery $V = E + iR$

$\therefore\ V > E$

22. **Statement-I:** Two identical bulbs when connected in parallel across a battery consume a total power 'P'. When thxey are connected across the same in series total power consumed is $\frac{P}{4}$.

Statement-II: In parallel $P = P_1 + P_2$ and in series $P = \frac{P_1P_2}{P_1 + P_2}$

Ans (A)

23. **Statement-I:** Resistance of an ammeter is less than the resistance of a milli ammeter

Statement-II: Value of shunt required in case of ammeter is more than a milli ammeter.

Ans (C)

In case of ammeter more current should pass through the shunt. Thus shunt resistance should be less or overall resistance of ammeter should be less.

24. **Statement-I:** kVA is the unit of electrical power and kWh is the unit of electrical energy.

Statement-II: Both kVA and kWh have same dimensions

Ans (C)

kVA is unit of power and kWh is unit of energy

25. **Statement-I:** If by mistake a voltmeter is connected in series it gets burnt

Statement-II: Current will drastically decrease in the circuit.

Ans (D)

Resistance of voltmeter is high. If it is connected in series then current will decrease but it will not be burnt.

26. **Statement-I:** Net power supplied by a non-ideal battery is $Ei - i^2r$

Statement-II: Power consumed by internal resistance of a battery is i^2r.

Ans (A)

27. **Statement-I:** For metallic conductors $\frac{V}{I} = R$, a constant.

Statement-II: V – I graph is always straight line passing through origin, for metallic conductors

Ans (A)

28. **Statement-I:** In our houses when we start switching on different light buttons, main current goes on increasing.

Statement-II: Different connections in houses are in parallel. When we start switching on different light buttons, net resistance of the circuit decreases. Therefore main current increases.

Ans (A)

Hint: In our houses, all intermediate connections are parallel connections, thus both are true and statement-II is the cause of statement-I.

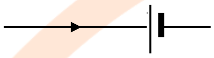
29. **Statement-I:** Current between two points in an electrical circuit always flows from higher potential to lower potential.

Statement-II: During discharging of a battery current inside the battery flows from higher potential to lower potential.

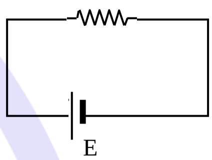
Ans (C)

Current through a resistance wire flows from higher potential to power potential.

During charging of a battery current flows from [+ to negative] as shown in the figure.



30. **Statement-I:** In the circuit shown in the figure, battery is ideal. If a resistance R_0 is connected in parallel with R. Power across R will decrease



Statement-II: Current drawn from the battery will increase.

Ans (D)

In both the cases potential difference across R is E

$\therefore \quad P = \dfrac{E^2}{R}$

In second case, net resistance will decrease

$\therefore$ Main current will increase

NCERT LINE BY LINE QUESTIONS

1. Estimate the average drift speed of conduction electrons in a conductor of cross-sectional area 10^{-7} m² carrying current of 1.5 A. The number density of conduction electrons is 8.5×10^{28} m^{-3}. [NCERT Pg. 99]

(a) 2.2 mm s^{-1} (b) 1.1 mms^{-1}
(c) 3.3 mm s^{-1} (c) 0.1 mm s^{-1}

2. Average collision time for electrons in a conductor under a certain potential difference is found to be 10^{-15} s. The mobility of electron in metal conductor is [NCERT Pg. 101]

(a) 1.5×10^{-3} m²/Vs (b) 2.2×10^{-3} m²/Vs
(c) 2.9×10^{-3} m²/Vs (c) 1.75×10^{-4} mWs

3. A charged particle is having drift velocity of 7.5×10^{-4} m s^{-1} in an electric field of 3×10^{-9} V m^{-1}. The electron mobility is [NCERT Pg. 101]

(a) $2.5\times10^{4}\,m^2V^{-1}s^{-1}$ (b) $2.5\times10^{5}\,m^2V^{-1}s^{-1}$
(c) $2.25\times10^{-13}\,m^2V^{-1}s^{-1}$ (c) $4.1\times10^{3}\,m^2V^{-1}s^{-1}$

4. Arrange following materials in correct order of their conductivity. Nichrome, Copper, Germanium, Silver. [NCERT Pg. 102]

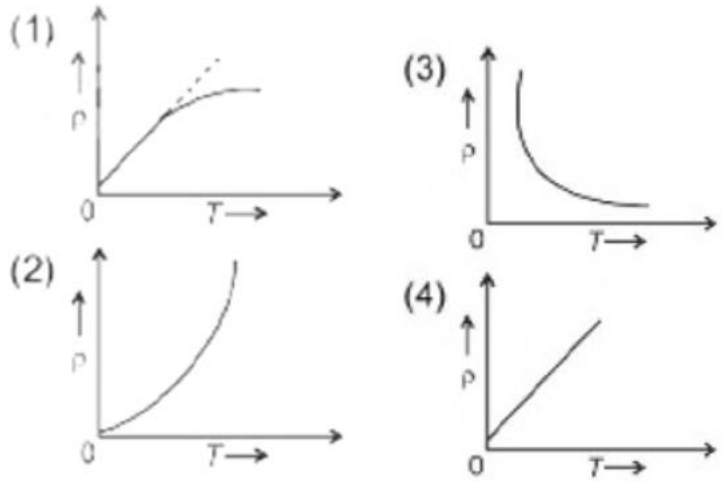
(a) Silicon > Germanium > Nichrome > Copper
(b) Silver > Copper > Germanium > Nichrome
(c) Silver > Copper > Nichrome > Germanium
(c) Germanium > Nichrome > Copper > Silver

5. The resistivity of alloy manganin [NCERT Pg 102]

(a) Increases rapidly with increase of temperature

(b) Decreases linearly with increase in temperature
(c) Increases rapidly with decrease in temperature
(c) Is nearly independent of temperature

6. The graph of resistivity versus temperature for copper is best represented by graph shown below. The correct graph is [NCERT Pg. 104]



7. A resistor is marked with rings coloured as brown, black, green and gold. The resistance in ohm is [NCERT Pg. 103]
(a) $(3\times10^6 \pm 5\%)\Omega$ (b) $(1.10\times10^5 \pm 5\%)\Omega$
(c) $(10^6 \pm 5\%)\Omega$ (c) $(8.5\times10^6 \pm 5\%)\Omega$

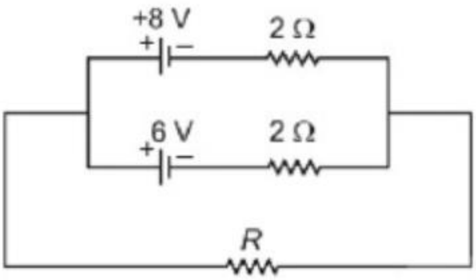
8. Which among the following statements is correct? [NCERT Pg. 104]
(a) In a metal, number density is independent of temperature
(b) With increase in temperature, relaxation time in metal decreases
(c) For semiconductors and insulators number density increases with increase in temperature
(c) All the above

9. Nichrome has resistance of 75.3 Ω at 30°C. The resistance of nichrome becomes 85.8 Ω when current passes through it, if average temperature coefficient of resistance of nichrome is $1.7\times10^{-4}C^{-1}$. The temperature of nichrome now is [NCERT Pg. 105]
(a) 700°C (b) 750 °C (c) 850 °C (c) 900°C

10. The incorrect statement among the following statements is [NCERT Pg. 111]
(a) Emf of a cell is the potential difference between its positive and negative electrodes in an open circuit
(b) Internal resistance of dry cells is much higher than common electrolyte cells.
(c) The terminal potential difference of a cell can be zero
(c) When current passes from positive to negative terminal of a cell inside it, terminal potential difference is less than its emf.

11. When a current of 2 A flows in a battery from its negative to positive terminal, the potential difference across it is 12 V. If a current of 3 A is flowing in opposite direction it produces a potential difference of 15 V. the emf of the battery is [NCERT Pg. 111]
(a) 12.6 V (b) 13.5 V (c) 14.0V (c) 13.2 V

12. In the combination of two cells **in** parallel by joining positive terminals together and similarly two negative ones, the value of $\frac{E_{eq}}{r_{eq}}$ in circuit is [NCERT Pg. 115]

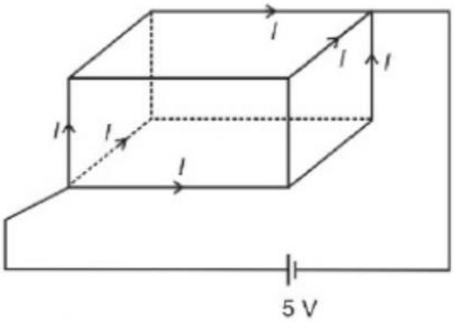


1) 7A 2) 10A 3) 2A 4) 8A

13. When a metal conductor connected to right gap of meter bridge is heated, the balancing point from left end [NCERT Pg. 120]
(a) Shifts towards left (b) Shifts towards right
(c) Remains unchanged (c) Shift to zero position

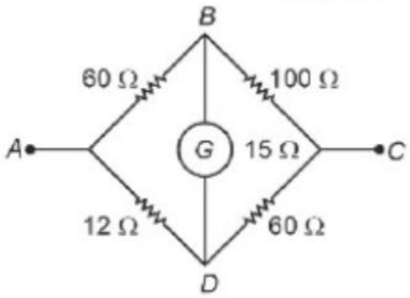
14. Resistance P, Q, S and *R* are arranged in clockwise cyclic order to form a balanced wheatstone bridge. The ratio of electric power consumed in the branches (P + Q) and (R + S) is, [NCERT Pg 109]
1) 1 : 1 2) R : P 3) $R^2 : P^2$ 4) Q:S

15. A battery of e.m.f. 5 V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors of network each of resistance 1 Ω . The current along one edge of the cube is [NCERT Pg. 116]



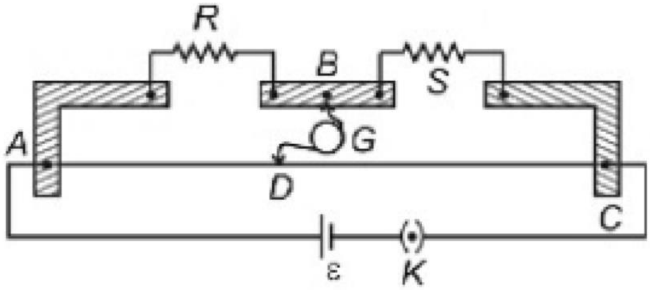
1) 1A 2) 2A 3) 3A 4) 4A

16. Four arms of wheat-stone bridge have the following resistances. AB - 60 Ω , BC = 100 Ω , CD = 60 Ω , DA= 12 Ω . A galvanometer of 15 Ω is connected across BD. Calculate the value of additional resistance connected across CD to balance the bridge. [NCERT Pg. 119]



(a) 12 Ω (b) 15 Ω (c) 18 Ω (c) 30 Ω

17. In a Meter Bridge null point is found to be at 30 cm from end A. If now a resistance of 10 Ω is connected in parallel with S, the null point occurs at 65 cm, value of S is nearly [NCERT Pg 121)



(a) 20 Ω (b) 28 Ω (c) 33 Ω (c) 38 Ω

18. In a potentiometer of 8 wires, the balance point is obtained on fifth wire. To Shift balance point to 6th wire, we should [NCERT Pg. 122]

(a) Decrease resistance in main circuit

(b) Increase resistance in main driver circuit

(c) Decrease resistance in series with cell whose emf is tc measure

(c) Taking driver battery with higher emf

19. A potentiometer with driver battery of emf 2 V is used for determination of internal resistance of 1.5 V cell. The balance point of the cell in open circuit is 225 cm. When a resistance of 7.0 Ω is used in external circuit across of the cell, the balance point shifts to 210 cm length of potentiometer wire. The internal resistance of the cell is [NCERT Pg. 131]

(a) 1 Ω (b) 0.5 Ω (c) 2 Ω (c) 5 Ω

20. Pick out wrong statement about the KirchhofTs laws of electric circuit. [NCERT Pg. 116]

(a) Outgoing currents adds up and are equal to incoming currents at a junction

(b) Electric potential in electric circuit is position dependent. Starting with any point if we come back to same point, total potential change must be zero

(c) Junction rule is based on conservation of energy law

(c) Bending or reorienting the wire does not change the validity of KirchhofTs junction rule.

21. The rate of flow of an electric charge is known as :

(a) electric potential (b)electric conductance

(c)electric current (d)none of these

22. The SI unit of electric current is :

(a)ohm (b)ampere (c)volt (d)faraday

23. The instrument used for measuring electric current is :

(a)ammeter (b)galvanometer (c)voltmeter (d)potentiometer

24. The amount of work done in joules, when one unit electric charge moves from one point to another point in an electric circuit is called :

(a)electric current (b)electric resistance

(c)electric conductance (d)potential difference

25. The unit of potential difference is :

(a)volt (b)ohm (c)ampere (d)faraday

26. The relation between potential difference (V) and current (I) is :

(a) $V \propto I^2$ (b) $V \propto 1/I$ (c) $V^2 \propto I$ (d) $V \propto I$

27. The relation between potential difference (V) and current (I) was discovered by :

(a)Newton (b) Ampere (c) Ohm (d) Volta

28. The obstruction offered by material of conductor to the passage of electric current is known as :

(a)Resistance (b) Conductance (c) Inductance (d) None of these

29. The SI unit of resistance is :

(a) Newton (b) Ohm (c) Watt (d) Joule

30. The resistance of a conductor is directly proportional to :
(a) its area of cross-section (b) density
(c) melting point (d) length

31. The resistance of a conductor is inversely proportional to its :
(a) area of cross-section (b) length
(c) specific heat capacity (d) density

32. A current of 2A flows trough a conductor whose ends are at a p.d of 4V. The resistance of the conductor is :
(a) 8 Ω (b) 0.5 Ω (c) 6 Ω (d) 2 Ω

33. The rheostat is used in the circuit to :
(a) increase the magnitude of current only
(b) decrease the magnitude of current only
(c) increase or decrease the magnitude of current
(d) none of these

34. During the verification of Ohm's law :
(a) ammeter and voltmeter should be connected in series
(b) ammeter should be connected in series and voltmeter in parallel
(c)ammeter should be connected in parallel and voltmeter in series
(d) ammeter and voltmeter should be connected in parallel

35. Which of the following laboratory apparatus is not used during the verification of Ohm's law :
(a) Voltmeter (b) Ammeter (c) Galvanometer (d)Rheostat

36. A voltmeter is used to find p.d. in any electrical circuit which of the statement given below is true
(a) A voltmeter is a high resistance instrument and is connected in series circuit
(b) A voltmeter is a low resistance instrument and is connected in series circuit
(c) A voltmeter is a high resistance instrument and is connected in parallel circuit
(d)A voltmeter is a low resistance instrument and is connected in series circuit

37. Which of the following statement is not true, regarding the electrical set-up for the verification of Ohm's law:
(a) The voltmeter is connected in parallel with the known resistance
(b) The ammeter is connected in series circuit
(c) The rheostat can only increase the resistance in electric circuit
(d)The single key is used to switch on/off the electric circuit

38. When a 20V battery is connected across an unknown resistor there is a current of 50 mA in the circuit. Find the value of the resistance of the resister:
(a) 2500 Ω (b) 400 Ω (c) 0.4 Ω (d) none of these

39. A battery of 12V is connected in series with resisters of 0.2 ohm , 0.3 ohm,0.4 ohm,0.5 ohm and 12 ohm. How much current would flow through the 0.3 ohm resister:
(a) 0.895A (b) 1.11A (c) 0.5A (d)none of these

40. Among which of the following resistance does not depend :
(a) length of conductor (b) area of cross-section
(c) temperature (d)density

41. Electricity constituted by electric charges at rest on the surface of a conductor is called
(a) Electricity (b) Potential difference
(c) Current electricity (d) Static electricity

42. The closed path between two points at different potentials, to make the electric current flow is called
(a) Electric circuit (b) Electric current (c) Electric potential (d) Electric cell.
43. Direction of conventional current is taken from
(a) Negative to positive (b) Positive to negative
(c) It could be from positive to negative or negative to positive
(d) None of these.
44. With increase in temperature, resistance of a conductor
(a) Decreases (b) Increases
(c) May decreases or increases depending on temperature
(d) It does not depend on temperature.
45. In series combination, resistance increases due to increase in
(a) Temperature (b) Humidity (c) Length (d) Area of cross-section.
46. In parallel combination, resistance decreases due to increase in
(a) Temperature (b) Humidity (c) Area of cross-section (d) Length.
47. The rate at which electricity is dissipated or consumed by an appliance is called electrical
(a) current (b) Power (c) Potential (d) Energy.
48. The unit of electrical power is
(a) watt (b) ampere (c) joule (d) ohm.
49. In series combination of electrical appliances, total electrical power
(a) Increases (b) Decreases
(c) May increases or decreases (d) Does not changes.
50. In parallel combination of electrical appliances, total electrical power
(a) Increases (b) Decreases
(c)Does not change (d)Remain same.
51. The total work done by an electrical appliance during its operation, is called electrical
(a) Current (b) Power (c) Energy (d) Potential
52. The number of joules in 1kWh is
(a) $3.6\text{x}10^7$ (b) $3.6\text{x}10^6$ (c) $3.6\text{x}10^5$ (d) $3.6\text{x}10^4$
53. When electric current flows through a conductor, it
(a) Gains electrons (b) Loose electrons
(c) Becomes hot (d) No change is observed.
54. Heating of a current carrying conductor is due to
(a) Loss of kinetic energy by atoms
(b) Loss of kinetic energy by electrons
(c) Attraction between electrons
(d) Repulsion between electrons& protons
55. The correct relation between heat produced &electric current flowing
(a) $H \mu I$ (b) $H\mu I^2$ (c) $H\mu 1/I$ (d) $H\mu 1/I^2$
56. The relation between H&I is called
(a) Newton' s law (b) Faraday' s law (c) Joule's law (d) Ohm' s law
57. In electric heating appliances, the material of heating element is
(a) Brass (b) Nichrome (c) Silver (d) Copper.
58. Formula for electric power is
(a) $P= V^2 I$ (b)$P=V I$ (c)$P=I/V$ (d) $P=V/I$.

59. In a circuit containing two unequal resistors connected in parallel
(a) The current is same in both resistors
(b) The current is large in the resistance having more value
(c) The voltage is same across both the resistors
(d) The voltage drops is larger across both the resistors.

60. The equivalent resistance in series combination is
(a) Smaller than the resistance having high value
(b)Larger than the largest resistance
(c) Smaller than the smallest resistance
(d) Larger than the smallest resistance.

61. Lamps of 40 watt&60 watt are connected in parallel, the total power of combination is
(a) 40 watt (b)60 watt (c) 24 watt (d)100 watt

62. A fuse wire is always inserted in the
(a) Live wire (b) In the neutral wire
(c) In the earth wire (d) May be connected in any line.

63. Two bulbs in a house, one glow brighter than the other. The bulb with large resistance is
(a) Dim bulb (b) The brighter bulb
(c) Both has same resistance (d) None of these.

64. The characteristics of fuse wire is
(a) High melting point (b) Low melting point
(c) Low resistivity & high melting point (d) High restivity & low melting point.

65. The unit of specific resistance is
(a) Ohm/m^2 (b) Ohm-m (c) Ohm m^3 (d) Ohm/m^3

66. In series combination total resistance:
(a) Decreases (b) Increases
(c) May decrease or increase according to the situation
(d) No particular observation

67. The condition required to measure electric charge is:
(a) Electric circuit (b) Electric current (c) Potential difference (d) Cell

68. A neutral body has:
(a) Both types of positive and negative charges (b) Only positive charge
(c) Only negative charge (d) No charge at all

69. Work done in moving a unit positive test charge from infinity to a point inside an electric field, is called:
(a) Potential (b) Field (c) Field intensity (d) Potential difference

70. Work done in moving a unit positive test charge from one point to other inside an electric field, is called:
(a) Potential (b) Field
(c) Field intensity (d) Potential difference

71. How does resistance depend upon the length if a conductor?
(a) The resistance is directly proportional to the length of a conductor
(b) The resistance is inversely proportional to the length of a conductor
(c) Both of the above (d) None of the above

72. What is the unit of resistivity?
(a) Ohm-metre (b) Ohm-cm (c) Ohm-km (d) None of the above

73. Why is a metric bridge so called?

(a) Since the bridge uses one metre long wire
(b) Since the bridge contains many metre wire
(c) Since the old name of the metre bridge is metre bridge
(d) None of the above

74. Why the metric bridge is suitable for measuring moderate resistances?
(a) The bridge is more sensitive for moderate values
(b) The bridge is not sensitive for moderate values
(c) The bridge is less sensitive for moderate values
(d) None of the above

75. Why should current be passed for a short time?
(a) Continuous current will increase the cost of consumption
(b) Continuous current will cause unnecessary heating effecting values of resistances used
(c) Both of the above (d) None of the above

76. In series combination of electrical appliances, total electric power:
(a) Increases (b) Decreases
(c) May increase or decrease according to the situation
(d) No definite observation

77. The rate of work done or electric energy developed or consumed by a generator or appliance is called electric:
(a) Current (b) Power (c) Potential (d) Energy

78. Heating of current carrying conductor is due to:
(a) Loss of kinetic energy of moving atoms
(b) Loss of kinetic energy of moving electrons
(c) Attraction between electrons and atoms
(d) Repulsion between electrons and atoms

79. In parallel combination, total resistance:
(a) Decreases (b) Increases
(c) May decrease or increase according to the situation
(d) No particular observation

80. The decrease of resistance in parallel combination is due to:
(a) The effective area of the cross-section decreases
(b) The effective area of the cross-section increases
(c) The effective area of the cross-section sometime increases, sometime decreases
(d) None of the above

81. In parallel combination of electrical appliances, total electric power:
(a) Increases (b) Decreases
(c) May increase or decrease according to the situation
(d) No definite observation

82. The electric appliances are connected in domestic line (Houseline):
(a) In series (b) In parallel
(c) Sometimes series, sometimes parallel (d) None of the above

83. Voltmeter is always connected with circuit in:
(a) Serie (b) Parallel
(c) Sometimes series sometimes parallel (d) None of the above

84. In which combination, Ammeter is connected with circuit:
(a) Series (b) Parallel
(c) Sometime series, sometimes parallel (d) None of the above

TOPIC WISE PRACTICE QUESTIONS

Topic 1: Electric Current, Drift of Electrons and Ohm's Law

1. A flow of 106 electrons per second in a conducting wire constitutes a flow of current of
(1) 1.6×10^{-15}A (2) 1.6×10^{-11}A (3) 1.6×10^{-12}A (4) 1.6×10^{-13}A

2. Relation between drift velocity (vd) of electron and thermal velocity (vt) of electron at room temp is expressed as
(1) $v_d = v_t$ (2) $v_d > v_t$ (3) $v_d < v_t$ (4) $v_d = v_t = 0$

3. For which of the following dependence of drift velocity v_d on electric field E, is Ohm's law obeyed?
(1) $v_d \propto E^2$ (2) $v_d = E^{1/2}$ (3) v_d = constant (4) $v_d = E$

4. A current of 1 mA flows through a copper wire. How many electrons will pass through a given point in each second
(1) 6.25×10^8 (2) 6.25×10^{31} (3) 6.25×10^{15} (4) 6.25×10^{19}

5. A conducting wire of cross-sectional area 1 cm^2 has 3×10^{23} charge carriers per m^3. If wire carries a current of 24 mA, then drift velocity of carriers is
(1) 5×10^{-2} m/s (2) 0.5 m/s (3) 5×10^{-3} m/s (4) 5×10^{-6} m/s

6. At room temperature, copper has free electron density of 8.4×10^{28} per m^3. The copper conductor has a cross-section of 10^{-6} m^2 and carries a current of 5.4 A. The electron drift velocity in copper is
(1) 400 m/s (2) 0.4 m/s (3) 0.4 mm/s (4) 72 m/s

7. The number of free electrons per 100 mm of ordinary copper wire is 2×10^{21}. Average drift speed of electrons is 0.25 mm/s. The current flowing is
(1) 5 A (2) 80 A (3) 8 A (4) 0.8 A

8. Two wires A and B of the same material, having radii in the ratio 1: 2 and carry currents in the ratio 4 : 1. The ratio of drift speed of electrons in A and B is
(1) 16 : 1 (2) 1 : 16 (3) 1 : 4 (4) 4 : 1

9. An Aluminium (Al) rod with area of cross-section 4×10^{-6} m^2 has a current of 5 ampere. Flowing through it. Find the drift velocity of electron in the rod. Density of Al = 2.7×10^3 kg/m^3 and Atomic wt. = 27. Assume that each Al atom provides one electron
(1) 8.6×10^{-4} m/s (2) 1.29×10^{-4} m/s (3) 2.8×10^{-2} m/s (4) 3.8×10^{-3} m/s

10. The belt of an electrostatic generator is 50 cm wide and travels at 30 cm/sec. The belt carries charge into the sphere at a rate corresponding to 10–4 ampere. What is the surface density of charge on the belt.
(1) $6.7\times10^{-5}Cm^{-2}/s$ (2) $6.7\times10^{-4}Cm^{-2}/s$ (3) $6.7\times10^{-7}Cm^{-2}/s$ (4) $6.7\times10^{-8}Cm^{-2}/s$

11. In a neon gas discharge tube Ne^+ ions moving through a cross-section of the tube each second to the right is 2.9×10^{18}, while 1.2×10^{18} electrons move towards left in the same time; the electronic charge being 1.6×10^{-19} C, the net electric current is
(1) 0.27 A to the right (2) 0.66 A to the right (3) 0.66 A to the left (4) zero

12. A conductor carries a current of 50 μA. If the area of cross section of the conductor is 50 mm^2, then value of the current density in Am^{-2} is
(1) 0.5 (2) 1 (3) 10^{-3} (4) 10^{-6}

13. When the current *i* is flowing through a conductor, the drift velocity is *v*. If 2*i* current flows through the same metal but having double the area of cross-section, then the drift velocity will be
(1) $v \backslash 4$ (2) $v/2$ (3) v (4) $4v$

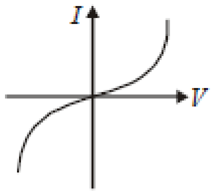
Topic 2: Resistance, Conductance and Resistivity

14. The electric resistance of a certain wire of iron is *R*. If its length and radius are both doubled, then
(1) the resistance and the specific resistance, will both remain unchanged
(2) the resistance will be doubled and the specific resistance will be halved
(3) the resistance will be halved and the specific resistance will remain unchanged
(4) the resistance will be halved and the specific resistance will be doubled

15. If N, e, τ and m are representing electron density, charge, relaxation time and mass of an electron respectively, then the resistance of wire of length ℓ and cross-sectional area A is given by

(1) $\frac{m\ell}{Ne^2A^2\tau}$ (2) $\frac{2m\tau A}{Ne^2\ell}$ (3) $\frac{Ne^2\tau A}{2m\ell}$ (4) $\frac{Ne^2A}{2m\tau\ell}$

16. The *I-V* characteristics shown in figure represents



(1) ohmic conductors
(2) non-ohmic conductors
(3) insulators
(4) superconductors

17. If a negligibly small current is passed through a wire of length 15 m and of resistance 5Ω having uniform cross section of $6 \times 10^{-7} m^2$, then coefficient of resistivity of material, is

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

18. Two copper wires have their masses in the ratio 2 : 3 and the lengths in the ratio 3 : 4. The ratio of their resistances is

(1) 4 : 9 (2) 27 : 32 (3) 16 : 9 (4) 27 : 128

19. The masses of the three wires of copper are in the ratio of 1 : 3 : 5 and their lengths are in the ratio of 5 : 3 : 1. The ratio of their electrical resistance is

(1) 1 : 3 : 5 (2) 5 : 3 : 1 (3) 1 : 25 : 125 (4) 125 : 15 : 1

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

(1) ℓ, d (2) 2ℓ, d (3) ℓ/2, 2 d (4) 2ℓ, d/2

21. Two wires have lengths, diameters and specific resistances all in the ratio of 1: 2. The resistance of the first wire is 10 ohm. Resistance of the second wire in ohm will be

(1) 5 (2) 10 (3) 20 (4) infinite

22. 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) 200% (2) 100% (3) 50% (4) 300%

23. A wire has a resistance of 3.1Ω at 30ºC and a resistance 4.5Ω at 100ºC. The temperature coefficient of resistance of the wire

(1) 0.0064 $^\circ C^{-1}$ (2) 0.0034 $^\circ C^{-1}$ (3) 0.0025 $^\circ C^{-1}$ (4) 0.0012 $^\circ C^{-1}$

24. The resistance of a wire at room temperature 30°C is found to be 10Ω. Now to increase the resistance by 10%, the temperature of the wire must be [The temperature coefficient of resistance of the material of the wire is 0.002 per °C]

(1) 36°C (2) 86°C (3) 63°C (4) 33°C

25. Two resistors A and B have resistances R_A and R_B respectively with $R_A < R_B$. The resistivities of their materials are ρ_A and ρ_B. Then

(1) $\rho_A > \rho_B$ (2) $\rho_A = \rho_B$ (3) $\rho_A < \rho_B$

(4) The information is not sufficient to find the relation between ρ_A and ρ_B.

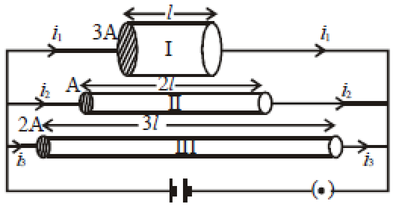
26. A 6 volt battery is connected to the terminals of the three metre long wire of uniform thickness and resistance of 100 ohm. The difference of potential between two points on the wire separated by a distance of 50 cm will be

(1) 1.5 volt (2) 3 volt (3) 3 volt (4) 1 volt

27. Two resistances R_1 and R_2 are made of different materials. The temperature coefficient of the material of R_1 is α and that of material of R_2 is $-\beta$. The resistance of the series combination of R_1 and R_2 will not change with temperature if $\frac{R_1}{R_2}$ equal to

(1) $\frac{\alpha}{\beta}$ (2) $\frac{\alpha+\beta}{\alpha-\beta}$ (3) $\frac{\alpha^2+\beta^2}{2\alpha\beta}$ (4) $\frac{\beta}{\alpha}$

28. The figure shows three conductors I, II and III of same material, different lengths l, $2l$ and $3l$ and of different areas of cross-section 3A, A and 2A respectively. Arrange them in the increasing order of current drawn from battery.

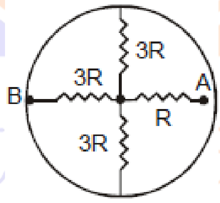


(1) $i_1 < i_2 < i_3$ (2) $i_3 < i_2 < i_1$ (3) $i_2 < i_1 < i_3$ (4) $i_2 < i_3 < i_1$

Topic 3: Combination of Resistors

29. You have been provided with four 100 ohm resistors each with a tolerance of 2%. The number of ways in which these can be combined to have different equivalent resistances is
(1) seven different combinations and seven different equivalents
(2) eight different combinations and seven different equivalents resistances
(3) nine different combinations and eight different resistances
(4) ten different combinations and nine different resistances

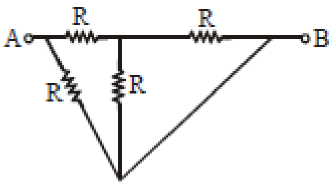
30. In the network shown below, the ring has zero resistance. The equivalent resistance between the point A and B is



(1) 2R (2) 4R (3) 7R (4) 10R

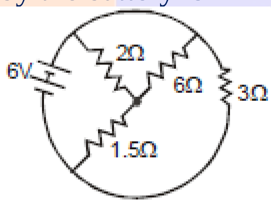
31. You are given two resistances R_1 and R_2. By using them singly, in series and in parallel, you can obtain four resistances of 1.5Ω, 2Ω, 6Ω and 8Ω. The values of R_1 and R_2 are
(1) $1\Omega, 7\Omega$ (2) $1.5\Omega, 6.5\Omega$ (3) $3\Omega, 5\Omega$ (4) $2\Omega, 6\Omega$

32. The equivalent resistance between points A and B is



(1) 2R (2) (3/4) R (3) (4/3) R (4) (3/5) R

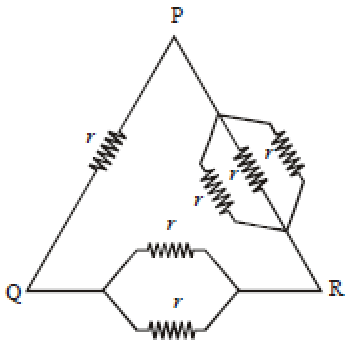
33. The total current supplied to the circuit by the battery is



(1) 4 A (2) 2 A (3) 1 A (4) 6 A

34. A letter 'A' is constructed of a uniform wire with resistance 1.0Ω per cm, The sides of the letter are 20 cm and the cross piece in the middle is 10 cm long. The apex angle is 60. The resistance between the ends of the legs is close to:
(1) 50.0Ω (2) 10Ω (3) 36.7Ω (4) 26.7Ω

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

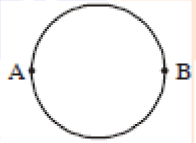


(1) P and R (2) P and Q (3) Q and R (4) Any two points

36. Two metal wires of identical dimension are connected in series. If σ_1 and σ_2 are the conductivities of the metal wires respectively, the effective conductivity of the combination is:

(1) $\frac{\sigma_1+\sigma_2}{2\sigma_1\sigma_2}$ (2) $\frac{\sigma_1+\sigma_2}{\sigma_1\sigma_2}$ (3) $\frac{\sigma_1\sigma_2}{\sigma_1+\sigma_2}$ (4) $\frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$

37. 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) 3Ω (2) $6\pi\ \Omega$ (3) 6Ω (4) $0.6\pi\ \Omega$

38. Three resistances each of 4Ω are connected to form a triangle. The resistance between any two terminals is

(1) 12Ω (2) 2Ω (3) 6Ω (4) $8/3\Omega$

39. Two wires of the same metal have same length, but their cross-sections are in the ratio 3:1. They are joined in series. The resistance of thicker wire is 10Ω. The total resistance of the combination will be

(1) 10Ω (2) 20Ω (3) 40Ω (4) 100Ω

Topic 4: Kirchhoff's Laws and Cells

40. Kirchhoff's first law, i.e., $\sum i=0$ at a junction, deals with the conservation of

(1) charge (2) energy (3) momentum (4) angular momentum

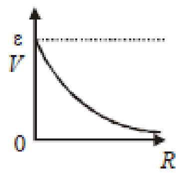
41. A battery of emf 10V and internal resistance 30hm is connected to a resister. The current in the circuit is 0.5 amp. The terminal voltage of the battery when the circuit is closed is

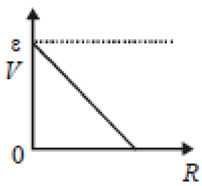
(1) 10V (2) zero (3) 1.5V (4) 8.5V

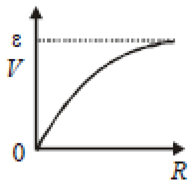
42. Five cells each of emf *E* and internal resistance *r* send the same amount of current through an external resistance *R* whether the cells are connected in parallel or in series. Then the ratio $\left(\frac{R}{r}\right)$ is

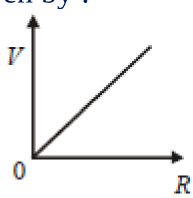
(1) 2 (2) 1/2 (3) 1/5 (4) 1

43. Cell having an emf e and internal resistance *r* is connected across a variable external resistance *R*. As the resistance *R* is increased, the plot of potential difference *V* across *R* is given by :

(1) 

(2) 

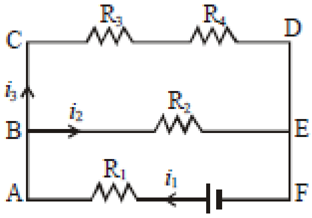
(3) 

(4) 

44. The potential difference between the terminals of a cell in an open circuit is 2.2 V. When a resistor of 5Ω is connected across the terminals of the cell, the potential difference between the terminals of the cell is found to be 1.8 V. The internal resistance of the cell is

(1) $\frac{7}{12}\Omega$ (2) $\frac{10}{9}\Omega$ (3) $\frac{9}{10}\Omega$ (4) $\frac{12}{7}\Omega$

45. Which of the following is the correct equation when Kirchhoff's loop rule is applied to the loop BCDEB in clockwise direction?



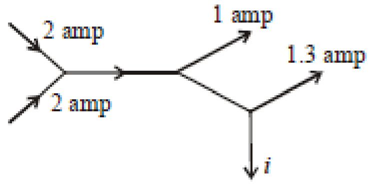
(1) $-i_3R_3 - i_3R_4 - i_2R_2 = 0$

(2) $-i_3R_3 - i_3R_4 + i_2R_2 = 0$

(3) $-i_3R_3 + i_3R_4 + i_2R_2 = 0$

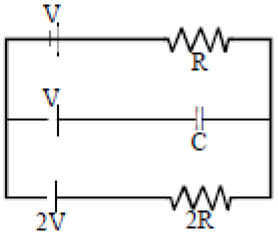
(4) $i_3R_3 + i_3R_4 + i_2R_2 = 0$

46. The figure below shows currents in a part of electric circuit. The current i is



(1) 1.7 amp (2) 3.7 amp (3) 1.3 amp (4) 1 amp

47. In the circuit shown in figure, with steady current, the potential drop across the capacitor must be



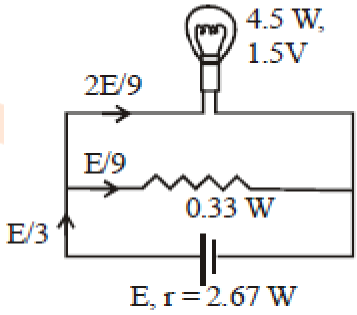
(1) V (2) V/2 (3) V/3 (4) 2V/3

Topic 5: Electrical Energy, Power and Heating Effect of Current

48. A heater of 220 V heats a volume of water in 5 minutes. The same heater when connected to 110 V heats the same volume of water in (minutes)

(1) 5 (2) 20 (3) 10 (4) 2.5

49. A torch bulb rated as 4.5 W, 1.5 V is connected as shown in fig. The e.m.f. of the cell, needed to make the bulb glow at full intensity is

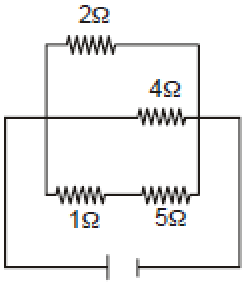


(1) 4.5 V (2) 1.5 V (3) 2.67 V (4) 13.5 V

50. A electric tea kettle has two heating coils. When first coil of resistance R_1 is switched on, the kettle begins to boil tea in 6 minutes. When second coil of resistance R_2 is switched on, the boiling begins in 8 minutes. The value of R_1/R_2 is

(1)3/7 (2)7/3 (3) 4/3 (4) 3/4

51. A current of 3 amp flows through the $2\,\Omega$ resistor shown in the circuit. The power dissipated in the $5\,\Omega$ resistor is:



(1) 4 watt (2) 2 watt (3) 1 watt (4) 5 watt

52. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 Ω and 200 V lamp when not in use?

(1) 20 Ω (2) 40 Ω (3) 200 Ω (4) 400 Ω

53. Ten identical cells connected in series are needed to heat a wire of length one meter and radius '*r*' by 10ºC in time '*t*'. How many cells will be required to heat the wire of length two meter of the same radius by the same temperature in time '*t*'?

(1) 10 (2) 20 (3) 30 (4) 40

54. Two 220 volt, 100 watt bulbs are connected first in series and then in parallel. Each time the combination is connected to a 220 volt a.c. supply line. The power drawn by the combination in each case respectively will be

(1) 50 watt, 200 watt (2) 50 watt, 100 watt
(3) 100 watt, 50 watt (4) 200 watt, 150 watt

55. A 100-W bulb and a 25-W bulb are designed for the same voltage. They have filaments of the same length and material. The ratio of the diameter of the 100-W bulb to that of the 25-W bulb is

(1) 4 : 1 (2) 2 : 1 (3) $\sqrt{2}:1$ (4) 1 : 2

56. Water boils in the electric kettle in 15 minutes after switching on. If the length of heating wire is decreased to 2/3 of its initial value, then the same amount of water will boil with the same supply voltage in

(1) 8 minutes (2) 10 minutes (3) 12 minutes (4) 15 minutes

Topic 6: Wheatstone Bridge and Different Measuring Instruments

57. 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 4 X against Y

(1) 40 cm (2) 80 cm (3) 50 cm (4) 70 cm

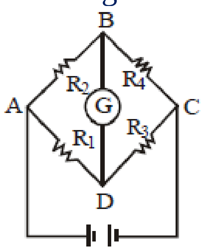
58. The current in the primary circuit of a potentiometer is 0.2 A. The specific resistance and cross-section of the potentiometer wire are 4×10^{-7} ohm metre and 8×10^{-7} m^2, respectively. The potential gradient will be equal to

(1) 1 V /m (2) 0.5 V/m (3) 0.1 V/m (4) 0.2 V/m

59. The resistance of an ammeter is 13 Ω and its scale is graduated for a current upto 100 amps. After an 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

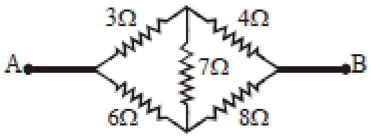
(1) 2 Ω (2) 0.2 Ω (3) 2 kΩ (4) 20 Ω

60. In the figure in balanced condition of Wheatstone bridge



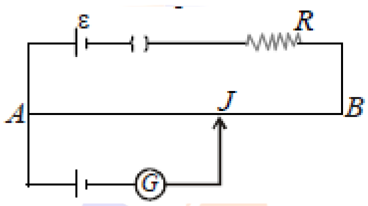
(1) *B* is at higher potential.
(2) *D* is at higher potential.
(3) Any of the two *B* or *D* can be at higher potential than other arbitrarily.
(4) *B* and *D* are at same potential.

61. Five resistances have been connected as shown in the figure. The effective resistance between A and B is



(1) $\frac{14}{3}\Omega$ (2) $\frac{20}{3}\Omega$ (3) 14Ω (4) 21Ω

62. *AB* is a wire of potentiometer with the increase in value of resistance *R*, the shift in the balance point *J* will be



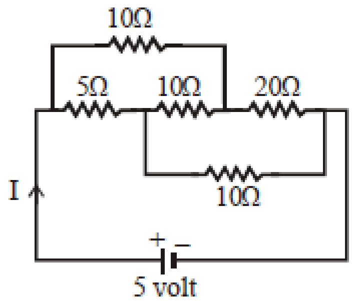
(1) towards *B*
(2) towards *A*
(3) remains constant
(4) first towards *B* then back towards *A*

63. 125 cm of potentiometer wire balances the emf. of a cell and 100 cm of the wire is required for balance, if the poles of the cell are joined by a 2Ω resistor. Then the internal resistance of the cell is
(1) 0.25Ω (2) 0.5Ω (3) 0.75Ω (4) 1.25Ω

64. A potentiometer is connected across A and B and a balance is obtained at 64.0 cm. When the potentiometer lead at B is moved to C, a balance is found at 8.0 cm. If the potentiometer is now connected across B and C, a balance will be found at

(1) 8.0 cm (2) 56.0 cm (3) 64.0 cm (4) 72.0 cm

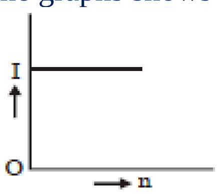
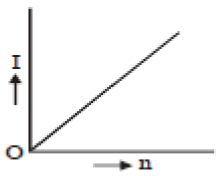
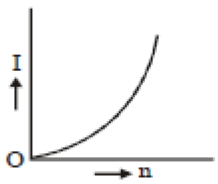
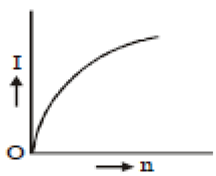
65. The current I drawn from the 5 volt source will be



(1) 0.33 A (2) 0.5 A (3) 0.67 A (4) 0.17 A

NEET PREVIOUS YEARS QUESTIONS

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

(1) 
(2) 
(3) 
(4) 

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

(1) 10 (2) 11 (3) 9 (4) 20

3. A carbon resistor of (47 ± 4.7) kW is to be marked with rings of different colours for its identification. The colour code sequence will be **[2018]**

(1) Violet – Yellow – Orange – Silver
(2) Yellow – Violet – Orange – Silver
(3) Green – Orange – Violet – Gold
(4) Yellow – Green – Violet – Gold

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

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

5. A potentiometer is an accurate and versatile device to make electrical measurements of E.M.F. because the method involves **[2017]**

(1) Potential gradients
(2) A condition of no current flow through the galvanometer
(3) A combination of cells, galvanometer and resistances
(4) Cells

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

(1) 5 : 1 (2) 5 : 4 (3) 3 : 4 (4) 3 : 2

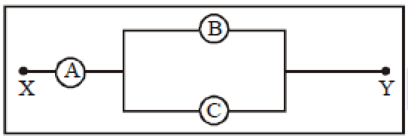
7. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is: **[2016]**

(1) $\frac{a^3R}{6b}$ (2) $\frac{a^3R}{3b}$ (3) $\frac{a^3R}{2b}$ (4) $\frac{a^3R}{b}$

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

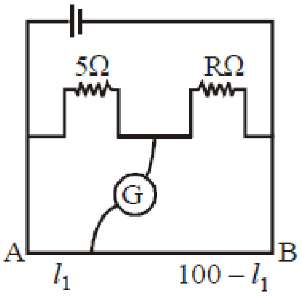
(1) 0.25 A (2) 2A (3) 1 A (4) 0.5 A

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



(1) $V_A \neq V_B = V_C$
(2) $V_A = V_B \neq V_C$
(3) $V_A \neq V_B \neq V_C$
(4) $V_A = V_B = V_C$

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



(1) $10\,\Omega$ (2) $15\,\Omega$ (3) $20\,\Omega$ (4) $25\,\Omega$

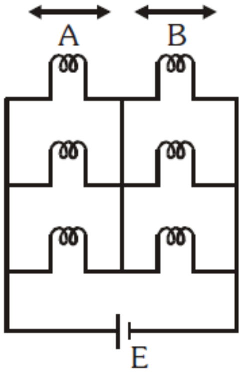
11. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is $0.5\,\Omega$. The power loss in the wires is : **[2014]**

(1) 19.2 W (2) 19.2 kW (3) 19.2 J (4) 12.2 kW

12. Six similar bulbs are connected as shown in the figure with a DC source of emf E, and zero internal resistance. The ratio of power consumption by the bulbs when **[NEET – 2019]**

(i) all are glowing and

(ii) in the situation when two from section A and one from section B are glowing, will be :

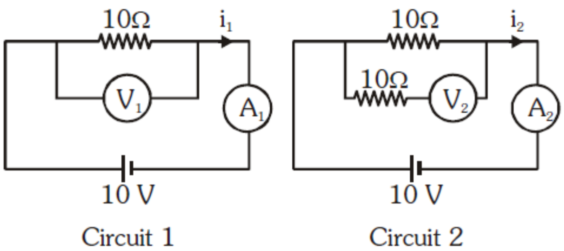


(1) 4 : 9 (2) 9 : 4 (3) 1 : 2 (4) 2 : 1

13. Which of the following acts as a circuit protection device? **[NEET – 2019]**

(1) conductor (2) inductor (3) switch (4) fuse

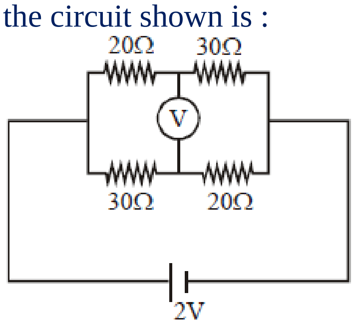
14. In the circuits shown below, the readings of the voltmeters and the ammeters will be : **[NEET – 2019]**



(1) $V_2 > V_1$ and $i_1 = i_2$ (2) $V_1 = V_2$ and $i_1 > i_2$

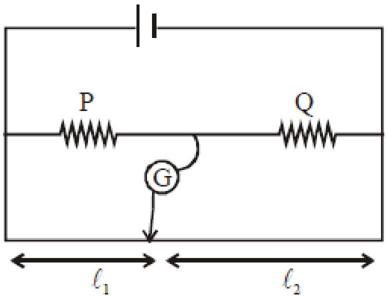
(3) $V_1 = V_2$ and $i_1 = i_2$ (4) $V_2 > V_1$ and $i_1 > i_2$

15. The reading of an ideal voltmeter in the circuit shown is : **[NEET – 2019 (ODISSA)]**



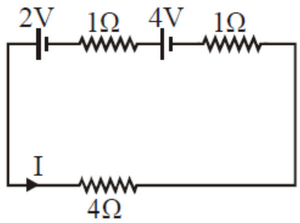
(1) 0.6 V (2) 0 V (3) 0.5 V (4) 0.4 V

16. The metre bridge shown is in balanced position with $\frac{P}{Q}=\frac{\ell_1}{\ell_2}$. If we now interchange the positions of galvanometer and cell, will the bridge work ? If yes, what will be balance condition ? **[NEET – 2019 (ODISSA)]**



1) $yes, \frac{P}{Q}=\frac{\ell_2-\ell_1}{\ell_2+\ell_1}$ 2) no, no null point 3) $yes, \frac{P}{Q}=\frac{\ell_2}{\ell_1}$ 4) $yes, \frac{P}{Q}=\frac{\ell_1}{\ell_2}$

17. For the circuit shown in the figure, the current I will be **[NEET-2020(COVID-19)]**

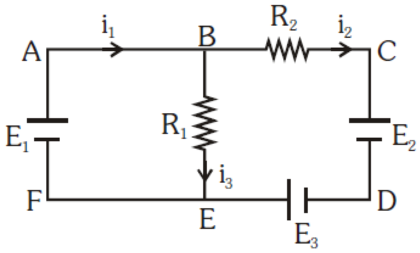


(1) 0.75 A (2) 1 A (3) 1.5 A (4) 0.5 A

18. Two solid conductors are made up of same material, have same length and same resistance. One of them has a circular cross section of area $A_1$and the other one has a square cross section of area A_2. The ratio A_1/A_2 is **[NEET-2020(COVID-19)]**

(1) 1.5 (2) 1 (3) 0.8 (4) 2

19. For the circuit given below, the Kirchhoff's loop rule for the loop BCDEB is given by the equation **[NEET-2020(COVID-19)]**



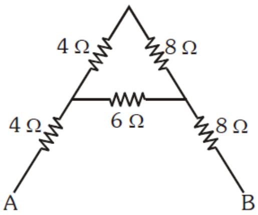
(1) $-i_2R_2+E_2-E_3+i_3R_1=0$

(2) $i_2R_2+E_2-E_3-i_3R_1=0$

(3) $i_2R_2+E_2+E_3+i_3R_1=0$

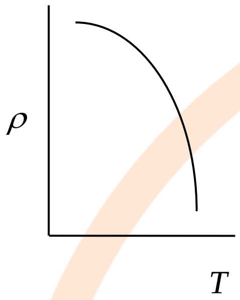
(4) $-i_2R_2+E_2+E_3+i_3R_1=0$

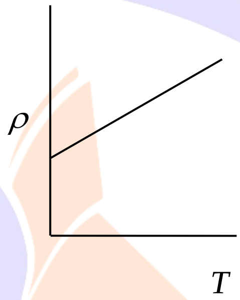
20. The equivalent resistance between A and B for the mesh shown in the figure is**[NEET-2020COVID-19)]**

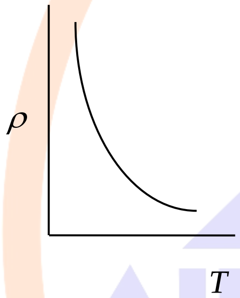


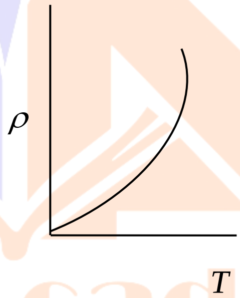
(1) 7.2 Ω (2) 16 Ω (3) 30 Ω (4) 4.8 Ω

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

1) 

2) 

3) 

4) 

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

1) $1.5\times10^{-2}m$ 2) $1.0\times10^{-2}m$ 3) $1.0\times10^{-1}m$ 4) $1.5\times10^{-1}m$

23. A charged particle having drift velocity of $7.5\times10^{-4}ms^{-1}$ in an electric field of $3\times10^{-10}Vm^{-1}$, has a mobility in $m^2V^{-1}s^{-1}$ of: **[NEET-2020]**

1) 2.25×10^{-15} 2) 2.25×10^{15} 3) 2.5×10^{6} 4) 2.5×10^{-6}

24. The color code pf a resistance is given below **[NEET-2020]**

The values of resistance and tolerance, respectively, are

1) 470Ω, 5% 2) $470\,k\Omega$, 5% 3) $47\,k\Omega$, 10% 4) $4.7\,k\Omega$, 5%

25. The solids which have the negative temperature coefficient of resistance are **[NEET-2020 (CODE-H4)]**

1) insulators and semiconductors 2) metals
3) Insulators only 4) Semiconductors only

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

Column-I	**Column-II**
(1) Drift Velocity	P) $\frac{m}{ne^2\rho}$
(2)ElectricalResistivity	Q) $ne\upsilon_d$

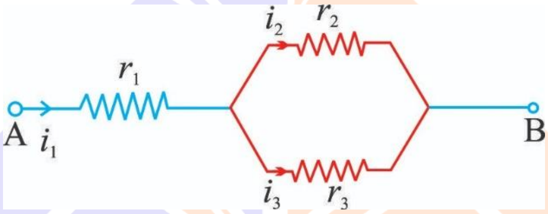
I Relaxation Period	R) $\frac{eE}{m}\tau$
(4) Current Density	S) $\frac{E}{J}$

1) (1)-I, (2)-(S), (3)-(Q), (4)-(P)
2) (1)-I, (2)-(P), (3)-(S), (4)-(Q)
3) (1)-I, (2)-(P). (3)-(S), (4)-(P)
4) (1)-I, (2)-(S), (3)-(P), (4)-(Q)

27. Ina potentiometer circuit a cell of EMF 1.5V gives balance point at 36 cm length of wire. If another cell of EMF 2.5 V replaces the first cell, then at what length of the wire, the balance point occurs? **[NEET-2021]**
1) 21.6 cm 2) 64 cm 3) 62 cm 4) 60 cm

28. The effective resistance of a parallel connection that consists of four wires of equal length, equal area of cross-section and same material is 0.25 Ω. What will be the effective resistance if they are connected in series? **[NEET-2021]**
1)0.5 Ω 2) 1 Ω 3) 4 Ω 4) 0.25 Ω

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

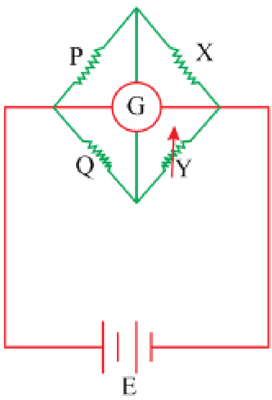


1) $\frac{r_2}{r_2+r_3}$ 2) $\frac{r_1}{r_1+r_2}$ 3) $\frac{r_2}{r_1+r_3}$ 4) $\frac{r_2}{r_2+r_3}$

30. A copper wire of length 10 m and radius $\left(10^{-2}/\sqrt{\pi}\right)$m has electrical resistance of 10Ω. The current density in the wire for an electric field strength of 10(V / m) is: **[NEET-2022]**
1) 10^4 A/ m^2 2) 10^6 A/ m^2 3) 10^{-5} A/ m^2 4) 10^5 A/ m^2

31. Two resistors of resistance 100W and 200W are connected in a parallel in an electrical circuit the ratio of the thermal energy developed in 100W to that in 200W in a given time is: **[NEET-2022]**
(1) 1 : 2 (2) 2 : 1 (3) 1 : 4 (4) 4 : 1

32. A Wheatstone bridge is used to determine the value of unknown resistance X by adjusting the variable resistance Y as shown in the figure. For the most precise measurement of X, the resistances P and Q **[NEET-2022]**



1) should be approximately equal to 2X
2) should be approximately equal and are small
3) should be very large and unequal

4) do not play any significant role

NCERT LINE BY LINE QUESTIONS – ANSWERS

1)	b	2)	d	3)	b	4)	c	5)	d
6)	b	7)	c	8)	d	9)	c	10)	d
11)	d	12)	a	13)	a	14)	b	15)	b
16)	d	17)	c	18)	b	19)	b	20)	c
21	c	22	b	23	a	24	d	25	a
26	d	27	c	28	a	29	b	30	d
31	a	32	d	33	c	34	b	35	c
36	c	37	c	38	b	39	a	40	d
41	d	42	a	43	b	44	b	45	c
46	c	47	b	48	a	49	b	50	a
51	c	52	b	53	b	54	b	55	b
56	c	57	b	58	b	59	c	60	b
61	c	62	a	63	a	64	d	65	b
66	B	67	B	68	A	69	A	70	D
71	D	72	A	73	B	74	A	75	B
76	A	77	B	78	B	79	A	80	B
81	A	82	B	83	B	84	A		

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1)	4	2)	3	3)	4	4)	3	5)	3	6)	3	7)	4	8)	1	9)	2	10)	2
11)	2	12)	2	13)	3	14)	3	15)	1	16)	2	17)	2	18)	2	19)	4	20)	3
21)	2	22)	4	23)	1	24)	2	25)	4	26)	4	27)	4	28)	4	29)	4	30)	1
31)	4	32)	4	33)	1	34)	4	35)	2	36)	4	37)	1	38)	4	39)	3	40)	1
41)	4	42)	4	43)	3	44)	2	45)	2	46)	1	47)	3	48)	2	49)	4	50)	3
51)	4	52)	2	53)	2	54)	1	55)	2	56)	2	57)	3	58)	3	59)	1	60)	4
61)	1	62)	1	63)	2	64)	2	65)	2										

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1)	1	2)	1	3)	2	4)	2	5)	2	6)	4	7)	1	8)	4	9)	4	10)	2

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

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

1. **(4)** $I = ne = 10^6 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-13}\ A$

2. **(3)** The value of drift velocity of electrons = 10^{-5} m/s and that of thermal velocity = 10^5 m/s.

3. **(4)** $v_d = \frac{1}{nAe} = \frac{j}{ne} = \left(\frac{\sigma}{ne}\right)E \Rightarrow v_d \propto E$

4. **(3)** Current $I = \frac{Charge}{Time}$

as charge $q = n \times 1.6 \times 10^{-19}$

$10^{-3}amp = \frac{n \times 1.6 \times 10^{-19}}{1sec} \Rightarrow n = 6.25 \times 10^{15}$

5. **(3)** $v_d = \frac{I}{neA} = \frac{24 \times 10^{-3}}{3 \times 10^{23} \times 1.6 \times 10^{-19} \times 10^{-4}} = 5 \times 10^{-3} m/sec$

6. **(3)** $v_d = \frac{I}{neA}$ Here, $I = 5.4A, n = 8.4 \times 10^{28}$, per m^3

$A = 10^{-6} m^2, e = 1.6 \times 10^{-19} C$

$\therefore v_d = \frac{5.4}{8.4 \times 10^{28} \times 1.6 \times 10^{-19} \times 10^{-6}} = 0.4 mm/s$

7. **(4)** $I = neAv_d = 2 \times 10^{21} \times 1.6 \times 10^{-19} \times 10 \times 0.25 \times 10^{-3}$

$= 2 \times 1.6 \times 0.25 = \frac{8}{10} = 0.8A$

8. **(1)** Current flowing through the conductor,
I = n e v A. Hence

$\frac{4}{1} = \frac{nev_{d_1}\pi(1)^2}{nev_{d_2}\pi(2)^2}$ or $\frac{v_{d_1}}{v_{d_2}} = \frac{4 \times 4}{1} = \frac{16}{1}$

9. **(2)** Electron density, $n = \frac{d \times N}{M}$

So, $n = \frac{2.7 \times 10^3 \times 6.02 \times 10^{26}}{27}$

$= 6.02 \times 10^{28}$ electrons/m^3

$\therefore$ Drift velocity $= 1.29 \times 10^{-4} m/s$

10. **(2)** $J = I/A = 10^{-4}/(0.30 \times 0.50)$

$= 6.7 \times 10^{-4} Cm^{-2}/s = 6.7 \times 10^{-4} Am^{-2}$

11. **(2)** Current $I = (2.9 \times 10^{28} + 1.2 \times 10^{18}) \times 1.6 \times 10^{-19}$ towards right

12. **(2)** Current density J = I/A
$= 50 \times 16^{-6} / 50 \times 10^{-6} = 1 Am^{-2}$

13. **(3)** $v_d = \frac{J}{ne} \Rightarrow v_d \propto J$ (current density)

$J_1 = \frac{i}{A}$ and $J_2 = \frac{2i}{2A} = \frac{1}{A} J_1$;

$\therefore (v_d)_1 = (v_d)_2 = v$

14. **(3)** $R = \dfrac{\rho \ell_1}{A_1}$, now $\ell_2 = 2\ell_1$

$A_2 = \pi(r_2)^2 = \pi(2r_1)^2 = 4\pi r_1^2 = 4A_1$

$\therefore R_2 = \dfrac{\rho(2\ell_1)}{4A_1} = \dfrac{\rho \ell_1}{2A_1} = \dfrac{R}{2}$

$\therefore$ Resistance is halved, but specific resistance remains the same.

15. **(1)** Since average drift velocity $= \dfrac{1}{2}\dfrac{eE}{m} \times (\tau)$

Now, $I = NeA \times$ (avg. drift velocity)

$= \dfrac{ne^2 AE}{2m\ell} \times \tau = \dfrac{Ne^2 AV}{2m\ell} \times \tau$

$R = \dfrac{V}{I} = \dfrac{m\ell}{Ne^2 \tau A^2}$, where N is electron density.

16. **(2)** The figure is showing $I - V$ characteristics of non ohmic or non-linear conductors.

17. **(2)** Given : Length of wire (l) = 15m

Area (1) = 6×10^{-7} m^2

Resistance (R) = 5W.

We know that resistance of the wire material

$R = \rho \dfrac{l}{A} \Rightarrow 5 = \rho \times \dfrac{15}{6 \times 10^{-7}} = 2.5 \times 10^7 \rho$

$\Rightarrow \rho = \dfrac{5}{2.5 \times 10^7} = 2 \times 10^{-7} \Omega - m$

18. **(2)** Given $\dfrac{m_1}{m_2} = \dfrac{2}{3}, \dfrac{l_1}{l_2} = \dfrac{3}{4}$

$\dfrac{m_1}{m_2} = \dfrac{2}{3} = \dfrac{A_1 l_1 d}{A_2 l_2 d} \Rightarrow \dfrac{2}{3} = \dfrac{A_1}{A_2} \times \dfrac{3}{4} \therefore \dfrac{A_1}{A_2} = \dfrac{8}{9}$

As we know,

$R = \rho \dfrac{l}{A} \dfrac{R_1}{R_2} = \dfrac{l_1}{A_1} \times \dfrac{A_2}{l_2} = \dfrac{3}{4} \times \dfrac{9}{8} = \dfrac{27}{32}$; $R_1 : R_2 = 27 : 32$

19. **(4)** $\mathrm{m} = \ell \times \text{area} \times \text{density}$

$\text{Area} \propto \dfrac{\mathrm{m}}{\ell}$

$R \propto \dfrac{l}{\text{Area}} \propto \dfrac{l^2}{m}$

$R_1 : R_2 : R_3 = \dfrac{l_1^2}{m_1} : \dfrac{l_2^2}{m_2} : \dfrac{l_3^2}{m_3}$

$R_1 : R_2 : R_3 = \dfrac{25}{1} : \dfrac{9}{3} : \dfrac{1}{5} = 125 : 15 : 1$

20. **(3)** Since $R = \dfrac{\rho \ell}{A} = \dfrac{\rho \ell}{\pi (d/2)^2} = \dfrac{4\rho \ell}{\pi d^2}$

If ℓ becomes $\ell/2$ & d becomes 2d, the new resistance is

$R^{|} = \dfrac{\rho \ell / 2}{\pi (2d/2)^2} = \dfrac{\rho \ell}{2 \times \pi d^2} = \dfrac{R}{8}$

21. **(2)** Resistance of the wire $R = \rho\frac{1}{A}$, where $A = \frac{\pi d^2}{4}$

$$\Rightarrow \frac{R_2}{R_1} = \frac{\rho_2}{\rho_1}\frac{l_2}{l_1}\frac{d_1^2}{d_2^2}$$

$$\therefore \frac{R_2}{10} = \frac{1}{2} \times \frac{1}{2} \times \frac{2^2}{1^2} = 1$$

$$\Rightarrow R_2 = 10\Omega$$

22. **(4)** Here the total volume of the wire is constant .

Resistance $R = \frac{\rho l^2}{V}$ or $R \propto l^2$

let, initial length $l_1 = l_0$ and final length $l_2 = l_0 + l_0 \times \frac{100}{100} = 2l_0$

$$\frac{R_2}{R_1} = \frac{l_2^2}{l_1^2} = \frac{4l_0^2}{l_0^2} = 4$$

The change in resistance $= \frac{R_2 - R_1}{R_1} \times 100 = \left[\frac{R_2}{R_1} - 1\right]100 = (4-1)100 = 300\%$

23. **(1)** $R_1 = 3.1\Omega$ at $t = 30^0 C$

$R_2 = 4.5\Omega$ at $t = 100^0 C$

We have, $R = R_0(1 + \alpha t)$

$\therefore R_1 = R_0[1 + \alpha(30)]$

$R_2 = R_0[1 + \alpha(100)]$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1+30\alpha}{1+100\alpha} \Rightarrow \frac{3.1}{4.5} = \frac{1+30\alpha}{1+100\alpha} \Rightarrow \alpha = 0.0064^0 C^{-1}$$

24. **(2)** $R_t = R_0 (1 + at)$

Initially, $R_0 (1 + 30\alpha) = 10\Omega$

Finally, $R_0 (1 + \alpha t) = 11\Omega$

25. **(4)** Resistance $= \frac{\rho l}{A}$, from this relation we can understand that the resistance also depends on length and area of the conductor. because in question it is not given that area and length are constant or any dependence of them over resistance. So we cannot deduce the values of resistivity directly from the values of the resistance.

26. **(4)** $R \propto \ell$

For 300 cm, $R = 100\Omega$

For 50 cm, $R^{|} = \frac{100}{300} \times 50 = \frac{50}{3}\Omega$

$$\therefore IR = 6 \Rightarrow IR^{|} = \frac{6}{R} \times R^{|} = \frac{6}{100} \times \frac{50}{3} = 1 \text{ volt}$$

27. **(4)** $R_1 + R_2$ = Constant, R_1 will increase, R_2 will decrease.

$R_1\alpha\Delta T - R_1\beta\Delta T = 0 \Rightarrow R_1\alpha\Delta T = R_2\beta\Delta T$

$$\therefore \frac{R_1}{R_2} = \frac{\beta}{\alpha}$$

28. **(4)** $i_2 < i_3 < i_1$

29. **(4)** ten different combinations and nine different resistances

30. **(1)** As the ring has no resistance, the three resistances of 3R each are in parallel.

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

$\therefore$ between point A and B equivalent resistance = R+ R = 2R.

31. **(4)** $R_1 = 2\,\Omega$ and $R_2 = 6\,\Omega$

In series, $R = R_1 + R_2 = 8\,\Omega$

In parallel, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2} + \frac{1}{6} = \frac{4}{6}$

$$\therefore R = \frac{6}{4} = 1.5\Omega$$

$\therefore$ We can get $1.5\Omega, 2\Omega, 6\Omega$ and 8Ω resistors by $2\,\Omega$ and $6\,\Omega$ resistors.

32. **(4)** Formula for equivalent resistance in series R=R1+R2

Formula for equivalent resistance in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

Now, given circuit can be rearrange as in figure 2

Using formula for equivalent resistance in parallel

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

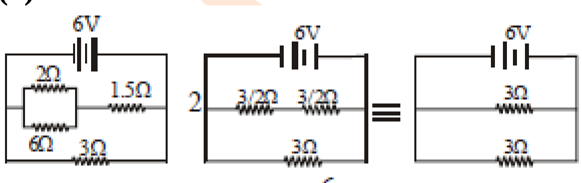
Equivalent resistance between B and C $= \frac{R}{2}$

and it is in series with resistance(AC), So resistance of lower branch $= \frac{3R}{2}$

Now, equivalent resistance between A and B

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{2}{3R} \Rightarrow R_{eq} = \frac{3R}{5}$$

33. **(1)**



hence $R_{eq} = 3/2$; $\therefore I = \frac{6}{3/2} = 4A$

34. **(4)** For ADE $\frac{1}{R'} = \frac{1}{2x} + \frac{1}{10}$ or $R' = \frac{20x}{10+2x}$

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

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

Solving we get $x = 10\,\Omega$

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

We get

$$R_{BC}=\frac{20\times10}{10+2\times10}+20-10+20-10=\frac{80}{3}=26.7\Omega$$

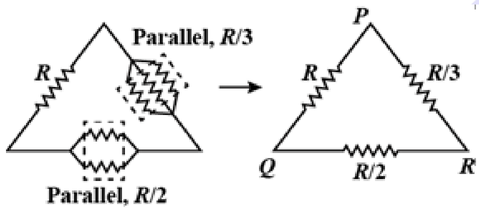
35. (2) The combination of resistances is shown in figure.
Maximum resistance will be between P and Q.

$$R_{PQ}=\frac{R\left(\frac{R}{3}+\frac{R}{2}\right)}{R+\frac{R}{3}+\frac{R}{2}}=\frac{5R^2/6}{11R/6}=\frac{5R}{11}$$

$$R_{QR}=\frac{\frac{R}{2}\left(R+\frac{R}{3}\right)}{11R/6}=\frac{2R^2/3}{11R/6}=\frac{4R}{11}$$

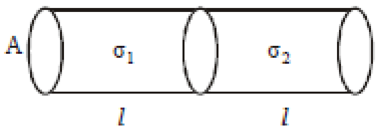
$$R_{PR}=\frac{\frac{R}{3}\left(R+\frac{R}{2}\right)}{11R/6}$$

$$=\frac{R^2/2}{11R/6}=\frac{3R}{11}.$$



Hence, the maximum value lies between P and Q.

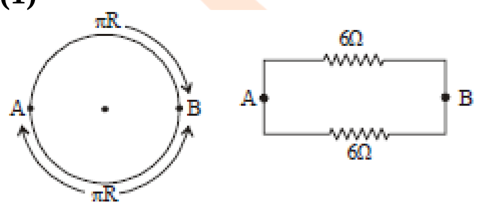
36. **(4)** In figure, two metal wires of identical dimension are connected in series



$$R_{eq}=\frac{l}{\sigma_1 A}+\frac{l}{\sigma_2 A}=\frac{l_{eq}}{\sigma_{eq}A_{eq}}$$

$$\frac{2l}{\sigma_{eq}A}=\frac{l}{A}\left(\frac{\sigma_1+\sigma_2}{\sigma_1\sigma_2}\right)\therefore\sigma_{eq}=\frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$$

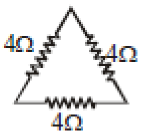
37. **(1)**



The resistance of length $2\pi R$ is 12Ω. Hence the resistance of length πR is 6Ω. Thus two resistances of 6Ω can be represented as shown in fig. 2.

$\therefore$ Equivalent resistance $R=\frac{6\times6}{12}=3\Omega$

38. **(4)** The two resistances are connected in series and the resultant is connected in parallel with the third resistance.



$\therefore R^{|}=4\Omega+4\Omega=8\Omega$ and $\frac{1}{R^{||}}=\frac{1}{8}+\frac{1}{4}=\frac{3}{8}$ or $R^{||}=\frac{8}{3}\Omega$

39. **(3)** Length of each wire = ℓ ; Area of thick wire (A_1) = 3A; Area of thin wire (A_2) = A and resistance of thick wire (R_1) = $10\,\Omega$. Resistance $(R) = \rho\frac{\ell}{A} \propto \frac{1}{A}$ (if ℓ is constant)

$$\therefore \frac{R_1}{R_2} = \frac{A_2}{A_1} = \frac{A}{3A} = \frac{1}{3} \text{ or } R_2 = 3R_1 = 3\times 10 = 30\Omega$$

The equivalent resistance of these two resistors in series

$$= R_1 + R_2 = 30 + 10 = 40\Omega$$

40. **(1)** Kirchhoff's first law is based one the law of conservation of charge.

41. **(4)** Given: E = 10V, r = 3 Ω, I = 0.5 A, R = ?, V = ?

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

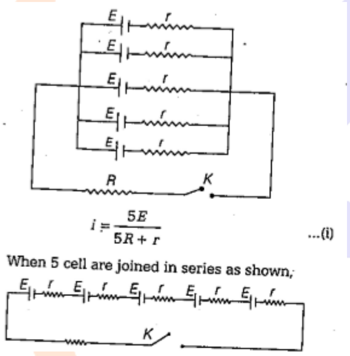
$\Rightarrow \quad R + r = \frac{E}{I} = \frac{10}{0.5} = 20$

or $\quad R = 20 - r$

$R = 20 - 3 = 17\,\Omega$

(ii) $V = IR = 0.5 \times 17 = 8.5$ V

42. **(4)** When 5 cell are joined in parallel as shown,



$$i = \frac{\text{net emf}}{\text{total resistance}}$$

$$i = \frac{5E}{5R + r} \text{ ----------(i)}$$

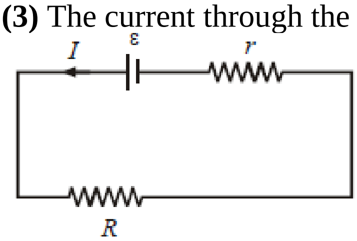
When 5 cell are joined in series as shown,

$$i = \frac{5E}{5r + R}$$

So, according to the questions

$$i = \frac{5E}{5r + R} \text{ or } 4R = 4r \Rightarrow \frac{R}{r} = \frac{4}{4};\ \frac{R}{r} = 1$$

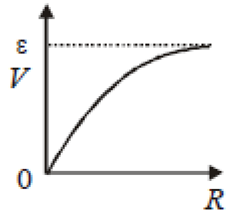
43. **(3)** The current through the resistance R



$$I = \left(\frac{\varepsilon}{R + r}\right)$$

The potential difference across R

$$V = IR = \left(\frac{\varepsilon}{R+r}\right)R$$



$$V = \frac{\varepsilon}{\left(1+\frac{r}{R}\right)}$$

when $R = 0$, $V = 0$, $R = \infty$, $V = \varepsilon$

Thus V increases as R increases upto certain limit, but it does not increase further.

44. **(2)** $E = V + ir$

$$2.2 = 1.8 + \frac{1.8}{5} \times r \Rightarrow r = \frac{10}{9}\Omega$$

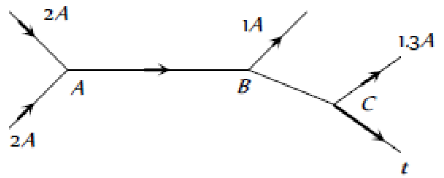
45. **(2)** $-i_3R_3 - i_3R_4 + i_2R_2 = 0$

46. **(1)** According to Kirchhoff's law

At junction A, $i_{AB} = 2+2=4$ A

At junction B, $i_{AB} = i_{BC} - 1 = 3$ A

At junction C, $i = i_{BC} - 1.3 = 3 - 1.3 = 1.7$ amp



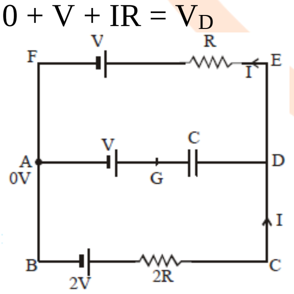
47. **(3)** Applying Kirchhoff's law in BCDEFAB we get,

$$I = \frac{V}{3R}$$

Let A be at 0 V. Then potential at G is V.

Applying Kirchhoff's law for AFED, we get

$0 + V + IR = V_D$



$$\therefore \text{potential different across capacitor} = \frac{4V}{3} - V = \frac{V}{3}$$

48. **(2)** $W = \text{Power} \times \text{time} = \dfrac{V^2t}{R}$

R is the same.

$\therefore V^2t = \text{constant.}\ \ V_1^2t_1 = V_2^2t_2$

$220^2 \times 5 = 110^2 t_2$

$\therefore t_2 = 20\,\text{min}$

49. **(4)** Resistance of bulb is $\frac{1.5\times1.5}{4.5}\Omega=0.5\Omega$

Resistance of parallel combination,

$$R=\frac{1\times\frac{1}{2}}{1+\frac{1}{2}}\Omega=\frac{1}{3}\Omega$$

Now, $r=\frac{E-V}{V}R\ \frac{8}{3}=\frac{E-1.5}{1.5}\times\frac{1}{3}$ or $E=13.5V$

50. **(3)** Heat supplied $==\frac{V^2}{R}\times t$

$$\Rightarrow\frac{t_1}{R_1}=\frac{t_2}{R_2}\Rightarrow\frac{6}{R_1}=\frac{8}{R_2}\Rightarrow\frac{R_1}{R_2}=\frac{3}{4}$$

51. **(4)** Clearly, 2Ω , 4Ω and (1 + 5) Ω resistors are in parallel.
Hence, potential difference is same across each of them.

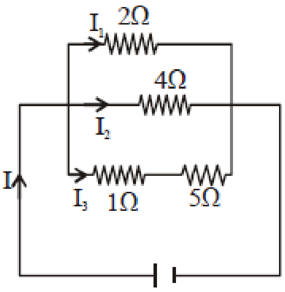
$\therefore I_1\times2=I_2\times4=I_3\times6$

Given $I_1=3A$ $\therefore I_1\times2=I_3\times6$

Given $I_1=3A$.

$\therefore I_1\times2=I_3\times6$ provides

$$I_3=\frac{I_1\times2}{6}=\frac{3\times2}{6}=1A$$



Now, the potential across the 5Ω resistor is
V = I_3 × 5 = 1 × 5 = 5V.
$\therefore$ The power dissipated in the 5Ω resistor

$$P=\frac{V^2}{R}=\frac{5^2}{5}=5\text{watt}$$

52. **(2)** $P=Vi=\frac{V^2}{R}$

$$R_{hot}=\frac{V^2}{P}=\frac{200\times200}{100}=400\Omega$$

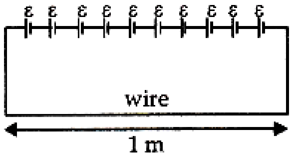
$$R_{cold}=\frac{400}{10}=40\Omega$$

53. **(2)** Let ρ be resistivity of the material of the wire and r be radius of the wire. Therefore, resistance of l m wire

$$R=\frac{\rho(1)}{\pi r^2}=\frac{\rho}{\pi r^2}\quad\left(\because R=\frac{\rho l}{A}\right)$$

Let ε be emf of each cell.

In first case,



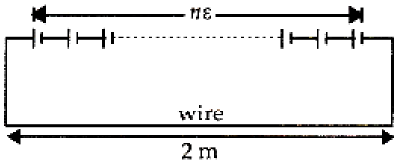
10 cells each of emf ε are connected in series to heat the wire of length l m by $\Delta T(=10°C)$ in time t.

$$\therefore\ \frac{(10\varepsilon)^2}{R}t=ms\Delta T \qquad \ldots(i)$$

In second case,

Resistance of same wire of length 2 m is

$$R'=\frac{\rho(2)}{\pi r^2}=\frac{2\rho}{\pi r^2}=2R$$



Let n cells each of emf ε are connected in series to heat the same u, ire of length 2 m, by the same temperature $\Delta T(=10°C)$ in time same time t.

$$\therefore\ \frac{(n\varepsilon)^2 t}{2R}=(2m)s\Delta T \qquad \ldots(ii)$$

Divide (ii) by (i), we get

$$\frac{n^2}{200}=2 \Rightarrow n^2=400 \quad \therefore\ n=20$$

54. **(1)** Power $\propto \frac{1}{\text{Resistance}}$

In series combination, resistance doubles. Hence, power will be halved.

In parallel combination, resistance halves. Hence, power will be doubled.

55. **(2)** $\frac{R_1}{R_2}=\frac{V^2/P_1}{V^2/P_2}=\frac{P_2}{P_1}$

$$=\frac{\rho\ell/\pi(d_1/2)^2}{\rho\ell/\pi(d_2/2)^2}=\frac{d_2^2}{d_1^2}=\frac{100W}{25W}\Rightarrow\frac{d_2}{d_1}=\frac{10}{5}=\frac{2}{1}$$

56. **(2)** $H=\frac{V^2}{R}\times15\times60=\frac{V^2}{(2/3)R}\times t$

or $t=\frac{2}{3}\times15\times60=600s=10\text{ minutes}$

57. **(3)** $\frac{R_1}{R_2}=\frac{\ell_1}{\ell_2}$ where $\ell_2=100-\ell_1$

In the first case $\frac{X}{Y}=\frac{20}{80}$

In the second case

$$\frac{4X}{Y}=\frac{\ell}{100-\ell}\Rightarrow\ell=50$$

58. (3) Potential Gradient (x) = Potential drop per unit length $x=\frac{v}{l}$

V = Potential Difference

L = length. $\Rightarrow R=\frac{\rho l}{A}$

ρ = specific resistance

A = Area

$$x=\frac{ir}{l}=\frac{i\rho l}{la}=\frac{i\rho}{l}$$

$$x=\frac{0.2\times4\times10^{-7}}{8\times10^{-7}}=0.1\,\text{units}$$

59. **(1)** We know

$$\frac{I}{I_S}=1+\frac{G}{S}\Rightarrow\frac{750}{100}=1+\frac{13}{S}\Rightarrow S=2\Omega$$

60. **(4)** In balance condition, since no current flows through the galvanometer therefore *B* and D are at the same potential.

61. **(1)** It is a balanced Wheatstone bridge $\left(\because\frac{3}{4}=\frac{6}{8}\right)$, so the $7\,\Omega$ resistance is ineffective.

Equivalent resistance of $3\,\Omega$ and $4\,\Omega$ = 3 + 4 = $7\,\Omega$ (series)
Equivalent resistance of $6\,\Omega$ and $8\,\Omega$ = 6 + 8 = $14\,\Omega$ (series)
Equivalent resistance of $7\,\Omega$ and $14\,\Omega$ (parallel)

$$=\frac{7\times14}{7+14}=\frac{14}{3}\Omega$$

62. **(1)** Due to increases in resistance *R* the current through the wire will decrease and hence the potential gradient also decreases, which results in increase in balancing length. So. *J* will shift towards *B*.

63. **(2)** $r=\frac{\ell_1-\ell_2}{\ell_2}\times R\Omega$

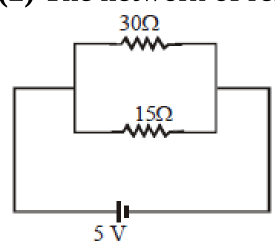
Here, $\ell_1=125\text{cm},\ell_2=100\text{cm},R=2\Omega$

$\therefore r=0.5\Omega$

64. **(2)** $E_1\propto64$ $\quad E_1-E_2\propto8$ $\quad E_2\propto l$

$\therefore 64-l=8$ or $l=64-8=56cm$

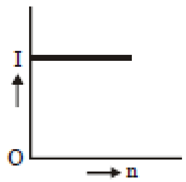
65. **(2)** The network of resistors is a balanced Wheatstone bridge. The equivalent current is



$$R_{eq}=\frac{15\times30}{15+30}=10\Omega$$

$$\Rightarrow I=\frac{V}{R}=\frac{5}{10}=0.5A$$

1. **(1)** Short circuited current, $I = \frac{n\varepsilon}{nr} = \frac{\varepsilon}{r}$



So, I is independent of n and I is constant.

2. **(1)** In series grouping equivalent resistance $R_{series} = nR$

In parallel grouping equivalent resistance

$$R_{parallel} = \frac{R}{n};\ I = \frac{E}{nR+R} \text{-------(i)}$$

$$10I = \frac{E}{\frac{R}{n}+R} \text{------------(ii)}$$

Dividing eq. (ii) by (i),

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

Solving we get, n = 10

3. **(2)**

4. **(2)** We know that, $R = \frac{\rho\ell}{A}$ or $R = \frac{\rho\ell^2}{Volume} \Rightarrow R \propto \ell^2$

According to question $\ell_2 = n\ell_1$

$$\frac{R_2}{R_1} = \frac{n^2 l_1^2}{l_1^2} \text{ or } \frac{R_2}{R_1} = n^2 \Rightarrow R_2 = n^2 R_1$$

5. **(2)** Reading of potentiometer is accurate because during taking reading it does not draw any current from the circuit.

6. **(4)** When two cells are connected in series i.e., $E_1 + E_2$ the balance point is at 50 cm. And when two cells are connected in opposite direction i.e., $E_1 - E_2$ the balance point is at 10 cm. According to principle of potential

$$\frac{E_1+E_2}{E_1-E} = \frac{50}{10} \Rightarrow \frac{2E_1}{2E_2} = \frac{50+10}{50-10} \Rightarrow \frac{E_1}{E_2} = \frac{3}{2}$$

7. **(1) Given:** Charge $Q = at - bt^2$

$$\therefore \text{Current } i = \frac{\partial Q}{\partial t} = a - 2bt \quad \left\{\text{for } i = 0 \Rightarrow t = \frac{a}{2b}\right\}$$

From joule's law of heating, heat produced $dH = i^2 Rdt$

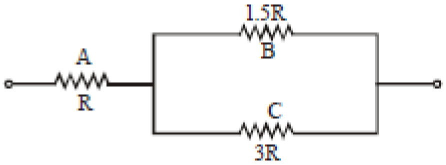
$$H = \int_0^{a/2b} (a-2bt)^2 Rdt\ H = \left.\frac{(a-2bt)^3}{-3\times 2b}\right|_0^{\frac{a}{2b}} = \frac{a^3 R}{6b}$$

8. **(4)**

9. **(4)** Effective resistance of B and

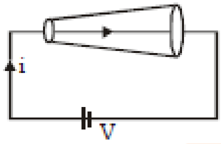
$$= \frac{R_B.R_C}{R_B+R_C} = \frac{1.5R\times 3R}{1.5R+3R} = \frac{4.5R^2}{4.5R} = R$$

i.e., equal to resistance of voltmeter A.



In parallel potential difference is same so,
$V_B = V_C$ and in series current is same
So, $V_A = V_B = V_C$

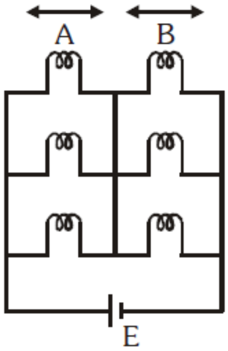
10. **(1)** Here, metallic conductor can be considered as the combination of various conductors connected in series. And in series combination current remains same.



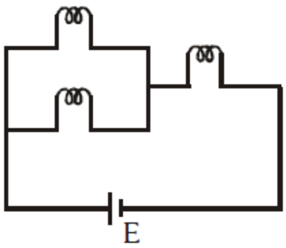
11. **(2)** This is a balanced Wheatstone bridge condition,

$$\frac{5}{R}=\frac{\ell_1}{100-\ell_1} \text{ and } \frac{5}{R/2}=\frac{1.6\ell_1}{100-1.6\ell_1} \Rightarrow R=15\Omega$$

12.



Case-I



Case-II

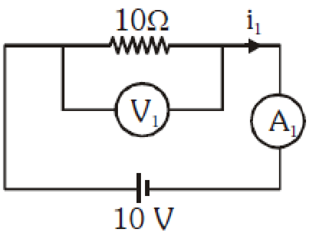
$R_{eq_1}=2R/3$ $\qquad$ $R_{eq_2}=R/2+R=\dfrac{3R}{2}$

$P_{eq_1}=\dfrac{E^2}{2R/3}=\dfrac{3P}{2}$ $\qquad$ $P_{eq_2}=\dfrac{E^2}{3R/2}=\dfrac{2P}{3}$

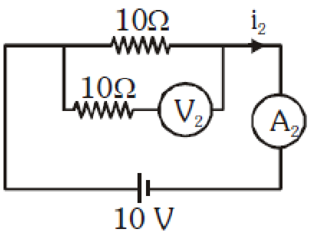
$\therefore\ P_{eq_1}:P_{eq_2}=9:4$

13. Fuse is used for protection

14.



Circuit 1



Circuit 2

$10\,\Omega$ is in series with ideal voltmeter. Therefore it will not affect the circuit (Circuit-2)
i_1 =10/10== 1A ; i_2 =10/10 = 1A
V1 = 10V :V2 = 10V

15. **Concept based**

16. $\dfrac{E_1}{E_2}=\dfrac{\phi\ell_1}{\phi\ell_2}$; $\dfrac{1.5}{2.5}=\dfrac{36}{\ell_2}$

$$\Rightarrow \ell_2 = 36\times\frac{5}{3} = 60\text{cm}$$

17. $I = \frac{2+4}{4+1+1} = \frac{6V}{6\Omega} = 1A$

18. Resistance of conductor, $R = \frac{\rho\ell}{A} \Rightarrow A = \frac{\rho\ell}{R}$

$$\Rightarrow \frac{A_1}{A_2} = \frac{\rho_1}{\rho_2}\times\frac{\ell_1}{\ell_2}\times\left(\frac{R_2}{R_1}\right) = 1$$

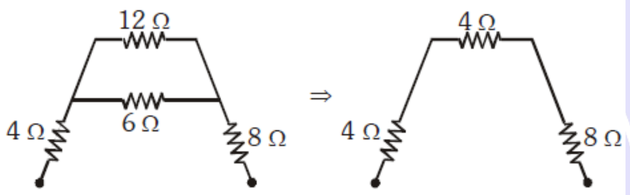
$[\because R_1 = R_2, \ell_1 = \ell_2$ and for same material $\rho_1 = \rho_2]$

19. By KVL

$-I=R_2 - E_2 + E_3 + I_3R_1 = 0$

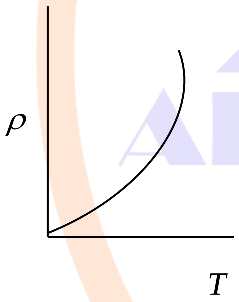
$\Rightarrow I_2R_2 + E_2 - E_3 - I_3R_1 = 0$

20.

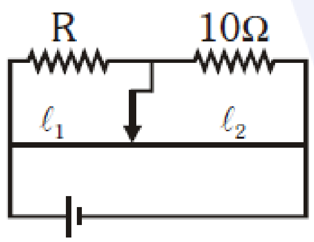


$\Rightarrow R_{AB} = 16\ \Omega$

21. The variation of resistivity of copper with temperature is parabolic in nature



22.



$$\frac{R}{l_1} = \frac{10}{l_2}$$

$$R = \frac{3}{2}\times 10$$

$$R = 15\Omega$$

Given length of R is 1.5 m

length of 1Ω is

$l = 1\times 10^{-1} m$

23. Mobility $\mu = \frac{V_d}{E} = \frac{7.5\times10^{-4}}{3\times10^{-10}} = 2.5\times10^{6}\,m^2V^{-1}S^{-1}$

24. Yellow - 4

Violet - 7

Brown - 10

Gold = 5%

$R = 47 \times 10 \pm 5\% = 470 \pm 5\%\ \Omega$

25. When temperature increases, free electron density increases for semiconductors and insulators
Temperature coefficient of resistance is negative for semiconductors and insulators

26. $V_d = a\tau = \frac{Ee}{m}\tau \qquad j = \frac{i}{A} = nev_d$

$P = \frac{E}{J} \qquad \tau = \frac{m}{ne^2 P}$

27. $\frac{E_2}{E_1} = \frac{l_2}{l_1} \Rightarrow \frac{2.5}{1.5} = \frac{l_2}{36} \Rightarrow l_2 = 60cm$

28.

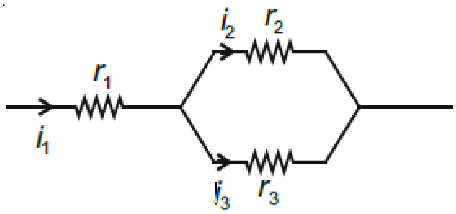
$R_P = \frac{R}{n} = 0.25\Omega$

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

$\Rightarrow R = 1\Omega$

$R_s = nR = 4 \times 1 = 4\Omega$

29.



In parallel combination of resistances r_2 and r_3, potential difference will be equal across both resistance.

$So, i_2 r_2 = i_3 r_3 \Rightarrow i_2 = \frac{i_3 r_3}{r_2}$.........(1)

As per Kirchhoff's first law

$\Rightarrow i_1 = i_2 + i_3$

$\Rightarrow i_1 = \left(\frac{r_3}{r_2} + 1\right) i_3$ (from equation 1)

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

30. $R = \frac{\rho L}{A} \Rightarrow \rho = \frac{RA}{L}$

$J = \sigma E = \frac{E}{\rho} = \frac{EL}{RA}$

$J = \frac{10 \times 10}{10 \times \pi \left[\frac{10^{-2}}{\sqrt{\pi}}\right]^2} = 10^5 A/m^2$

31. $\theta = \frac{V^2}{R}$

$\frac{Q_1}{Q_2} = \frac{R_2}{R_1} = \frac{200}{100} = 2$

32. The value of X can be more precisely measured if the resistances P and Q approximately equal and small.